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16. Abstract

Report 0-4998-1, "A Unit Cost and Construction Specification Framework for Utility Installations," described a prototype framework of construction specifications and corresponding unit cost work items for utility installations at TxDOT and recommendations on how to implement that framework in Texas. That report focused on water and sanitary sewer installations. Report 0-4998-2, "Construction Specification Requirements for Water and Sanitary Sewer Installations," provided a detailed description of the corresponding specification requirements for water and sanitary sewer utility installations that could be used to prepare the construction specifications.

This report is a follow up to the 0-4998-1 and 0-4998-2 reports. It describes a prototype framework of specification requirements and corresponding unit cost work items for communication utilities. The requirements for each specification include a summary table outlining the main characteristics of the proposed specification and provide a listing of bid items, subsidiary items, and units of measurement, followed by a list of specification requirements. This report also summarizes a methodology to develop utility adjustment cost estimates during the early stages of the project development process and a procedure for estimating the uncertainty and likelihood of exceedance of those estimates. The need for that methodology became apparent after realizing the limitations of traditional approaches that simply estimate utility adjustment costs as percentages of the highway construction costs without providing a measure of uncertainty for those estimates.

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SPECIFICATION FRAMEWORK FOR COMMUNICATION UTILITIES AND ESTIMATION OF UTILITY ADJUSTMENT COSTS

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DISCLAIMER

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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

AASHTO	American Association of State Highway and Transportation Officials
ANSI	American National Standards Institute
ASTM	American Society for Testing and Materials
BAMS/DSS	Bid Analysis Management System/Decision Support System
CEC	Controlled Environment Cabinet
CES	Cost Estimation System
CEV	Controlled Environment Vault
CFR	Code of Federal Regulations
CIP	Cast in Place
CIPP	Cured in Place Pipe
CL	Coating or Lining
CSJ	Control Section Job
CUE	Concrete Universal Enclosure
DCIS	Design and Construction Information System
DOT	Department of Transportation
EIA	Electronic Industries Alliance
FDOT	Florida Department of Transportation
FHWA	Federal Highway Administration
FP	Folded Pipe
HAB	Horizontal Auger Boring
HDD	Horizontal Directional Drilling
HDPE	High Density Polyethylene

ICEA	Insulated Cable Engineers Association
IEEE	Institute of Electrical and Electronics Engineers
J	Jacking
MIS	Major Investment Study
MT	Microtunneling
NCTCOG	North Central Texas Council of Governments
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NIBS	National Institute of Building Sciences
NUHC	Non-Utility Highway Cost
OSHA	Occupational Safety and Health Administration
PCES	Project Cost Estimating System
PE	Polyethylene
PES	Proposal and Estimates System
PR	Pipe Replacement
ProtoCost	Projected Total Cost
PVC	Polyvinyl Chloride
PW	Plowing
R	(Pipe) Ramming
ROW	Right of Way
RUS	Rural Utilities Service
SAFETEA-LU	Safe, Accountable, Flexible Efficient Transportation Equity Act – A Legacy for Users
SAI	Serving Area Interface

SDR	Standard Dimension Ratio
SQL	Structured Query Language
SL	Sliplining
STP	Shielded Twisted Pair
T	Tunneling
TIA	Telecommunications Industry Association
TPP	Transportation Planning and Programming
TSPS	Texas Society of Professional Surveyors
TxDOT	Texas Department of Transportation
TUC	Total Utility Cost
UAR	Utility Accommodation Rules
UL	Underwriters Laboratory
UTP	Unshielded Twisted Pair
VDOT	Virginia Department of Transportation

CHAPTER 1. INTRODUCTION

The Utility Accommodation Rules (UAR) and the TxDOT Utility Manual govern the accommodation of utility facilities on the state highway state right of way (ROW) (*1*, *2*). The rules and guidelines are the result of a federal mandate that requires states to submit a statement to the Federal Highway Administration (FHWA) on the authority of utilities to use and occupy the state highway ROW, the power of the state department of transportation (DOT) to regulate such use, and the policies the state DOT uses for accommodating utilities within the ROW of federal aid highways under its jurisdiction (*3*). The rules, which can be traced to utility accommodation policies and guides the American Association of State Highway and Transportation Officials (AASHTO) developed, prescribe minimums relative to the accommodation, location, installation, adjustment, and maintenance of utility facilities within the state ROW (*4*, *5*). However, the rules also establish that where industry or governmental codes, orders, or laws require utilities to provide a higher degree of protection than provided in the UAR, such regulations and laws take precedence (*1*).

Report 0-4998-1 "A Unit Cost and Construction Specification Framework for Utility Installations" described a prototype framework of construction specifications and corresponding unit cost work items for utility installations at TxDOT and recommendations on how to implement that framework in Texas (*6*). That report focused on water and sanitary sewer installations. Report 0-4998-2 "Construction Specification Requirements for Water and Sanitary Sewer Installations" provided a detailed description of the corresponding specification requirements for water and sanitary sewer utility installations that could be used to prepare the construction specifications (*7*).

This report is a follow up to the 0-4998-1 and 0-4998-2 reports, more specifically by applying the prototype framework of specification requirements and corresponding unit cost work items from those reports to communication utilities. The requirements for each specification include a summary table outlining the main characteristics of the proposed specification and provide a listing of bid items, subsidiary items, and units of measurement, followed by a list of specification requirements that follow TxDOT's 2004 standard construction specification style (*8*). This report also summarizes a methodology to develop utility adjustment cost estimates during the early stages of the project development process and a procedure for estimating the uncertainty and likelihood of exceedance of those estimates. The need for that methodology became apparent after realizing the limitations of traditional approaches that simply estimate utility adjustment costs as percentages of the highway construction costs without providing a measure of uncertainty for those estimates.

The report is organized as follows:

- Chapter 1 is this introductory chapter.
- Chapter 2 describes the prototype framework for communication utility specifications.
- Chapter 3 discusses the methodology for developing early utility adjustment cost estimates.
- Chapter 4 summarizes conclusions and recommendations for implementation.

CHAPTER 2. COMMUNICATION UTILITY SPECIFICATIONS

INTRODUCTION

The researchers reviewed a sample of TxDOT specifications (*9*), as well as associated bid items and unit bid prices, with a focus on communication installations. This chapter summarizes the result of the analysis and concludes with a proposed framework for standardized communication utility specifications at TxDOT. Note: This chapter makes frequent references to existing TxDOT specification titles, content, and corresponding bid items. To the extent possible, those references are exact, as they appear in the TxDOT databases, including typographical errors and inconsistencies in wording and formatting.

SPECIAL SPECIFICATION SAMPLE

From the list of special specifications, the researchers identified several special specifications of interest. Table 1 lists the special specification titles gathered along with the corresponding control section job (CSJ) numbers. Table 2 lists the bid items associated with each special specification. Most communication-related special specifications correspond to TxDOT-owned communication infrastructure, e.g., fiber optic cable and communication cabinets, ground boxes, and duct banks. Very few special specifications currently in existence at TxDOT correspond to telecommunication provider-owned installations that require adjustment during the project development process. To the extent possible, Table 1 and Table 2 include references to those specifications. The tables also include some electric installation specifications that have relevance to the development of communication specifications.

Table 1. Special Specification Sample.

Specification	No.	Year	CSJ/Use
Communication Building	6531	2004	4808040
Communication Cabinet	6530	2004	4808040
Communication Cabinet	6402	2004	4706115
Communication Cable	6010	2004	n/a
Communication Hub Enclosure	6568	2004	313601144
Communications Ground Box	6155	2004	92400032
Communications Ground Box	6539	2004	092406280, etc.
Concrete Ground Boxes	6513	2004	237405065
Duct Bank for Surveillance, Communication, and Control (SC&C)	6139	2004	023103089, 001424049, 001507063, 001514112
Duct Bank for Surveillance, Communication, and Control (SC&C)	6394	2004	15109036
Duct Bank for Surveillance, Communication, and Control (SC&C)	6563	2004	313601144
Fiber Communications Hub	6198	2004	000911204, etc.
Fiber Communications Hub	6260	2004	237401153
Fiber Optic Cable	6014	2004	n/a
Fiber Optic Cable	6191	2004	001402014, etc.
Fiber Optic Cable	6222	2004	36303044
Fiber Optic Cable	6418	2004	61701169
Fiber Optic Cable	6490	2004	813208

Table 1. Special Specification Sample (Continued).

Fiber Optic Cable (Single Mode)	6367	2004	52104187
Fiber Optic Cable (Single Mode)	6430	2004	001709072, etc.
Fiber Optic Cable Splicing	6516	2004	911205
Multi-Duct Conduit System	6076	2004	72003084
Multi-Duct Conduit System	6144	2004	002712121, 002802054, etc., 002802044, etc., 017706064, 027104067, etc., 050003475, 050807027, etc., 091200291
Multi-Duct Conduit System	6188	2004	001402014, etc.
Multi-Duct Conduit System	6202	2004	000911204, etc.
Multi-Duct Conduit System	6214	2004	36303044
Multi-Duct Conduit System	6261	2004	237401153
Multi-Duct Conduit System	6277	2004	Dallas District
Multi-Duct Conduit System	6285	2004	002802081, 011004166, 050801166
Multi-Duct Conduit System	6292	2004	059801074, etc.
Multi-Duct Conduit System	6385	2004	52104187
Multi-Duct Conduit System	6393	2004	017705057, 017705058, 017705090
Multi-Duct Conduit System	6421	2004	8614022
Multi-Duct Conduit System	6427	2004	001709072, etc.
Multi-Duct Conduit System	6436	2004	027114197, etc.
Multi-Duct Conduit System	6452	2004	72003095
Multi-Duct Conduit System	6510	2004	1806153
Multi-Duct Conduit System	6515	2004	237405065
Multi-Duct Conduit System	6524	2004	017705091, 050003544, 050004118
Polyethylene Innerduct	6359	2004	91512435
Preparation of Existing Conduit	6382	2004	52104187
Preparation of Existing Conduit	6439	2004	1709072
Preparation of Existing Conduits, Ground Boxes, or Manholes	6086	2004	n/a
Removal of Existing Cables	6489	2004	813208
Removal of Existing Cables	6514	2004	237405065
Remove and Reinstall Existing Fiber Optic Cable	6420	2004	8614022
Remove Ground Box	6235	2004	237402110
Replacement of Existing Ground Box	6180	2004	001402014, etc.
Southwestern Bell Telephone Underground Telephone	3548	1993	068301069, etc.
Southwestern Bell Telephone Underground Telephone	5970	1993	027106088, etc., 027117127, etc., 027107245, 027107247, 027107248, 027107254, 027107249, 027106090, 027107274
Telecommunication Cable	6559	2004	001509147, etc.
Telecommunication Cable	6565	2004	313601144
TXU Electric Delivery - Electrical Transmission & Distribution System	6252	2004	237402110, etc.
Underground Cable Vault for Surveillance, Communication, and Control (SC&C)	6395	2004	15109036
Underground Cable Vault for Surveillance, Communication, and Control (SC&C)	6570	2004	313601144
Underground Telephone Systems	5732	1993	52104236

Table 2. Bid Items Associated with Each Special Specification in Table 1.

Specification	No.	Year	Item Description	Units
Communication Building	6531	2004	COMMUNICATION BUILDING (10' X 15')	EA
Communication Cabinet	6402	2004	COMMUNICATION CABINET (59" X 26")	EA
	6530	2004	COMMUNICATION CABINET (59" X 26")	EA
Communication Cable	6010	2004	COMM CABLE (18 AWG)(6 PAIR)	LF
			COMM CABLE (22 AWG)(12 PAIR)	LF
			COMM CABLE (22 AWG)(25 PAIR)	LF
			COMM CABLE (22 AWG)(6 PAIR)	LF
			COMM CABLE (AERIAL)(19 AWG)(12 PAIR)	LF
			COMM CABLE (AERIAL)(19 AWG)(18 PAIR)	LF
			COMM CABLE (AERIAL)(19 AWG)(25 PAIR)	LF
			COMM CABLE (AERIAL)(19 AWG)(50 PAIR)	LF
			COMM CABLE (AERIAL)(19 AWG)(6 PAIR)	LF
			COMM CABLE (AERIAL)(22 AWG)(12 PAIR)	LF
			COMM CABLE (AERIAL)(22 AWG)(18 PAIR)	LF
			COMM CABLE (AERIAL)(22 AWG)(25 PAIR)	LF
			COMM CABLE (AERIAL)(22 AWG)(50 PAIR)	LF
			COMM CABLE (AERIAL)(22 AWG)(6 PAIR)	LF
			COMM CABLE (DIR BURY)(19 AWG)(12 PAIR)	LF
			COMM CABLE (DIR BURY)(19 AWG)(18 PAIR)	LF
			COMM CABLE (DIR BURY)(19 AWG)(25 PAIR)	LF
			COMM CABLE (DIR BURY)(19 AWG)(50 PAIR)	LF
			COMM CABLE (DIR BURY)(19 AWG)(6 PAIR)	LF
			COMM CABLE (DIR BURY)(22 AWG)(12 PAIR)	LF
			COMM CABLE (DIR BURY)(22 AWG)(18 PAIR)	LF
			COMM CABLE (DIR BURY)(22 AWG)(25 PAIR)	LF
			COMM CABLE (DIR BURY)(22 AWG)(50 PAIR)	LF
			COMM CABLE (DIR BURY)(22 AWG)(6 PAIR)	LF
			COMM CABLE (UNDRGRND)(19 AWG)(12 PAIR)	LF
			COMM CABLE (UNDRGRND)(19 AWG)(18 PAIR)	LF
			COMM CABLE (UNDRGRND)(19 AWG)(25 PAIR)	LF
			COMM CABLE (UNDRGRND)(19 AWG)(50 PAIR)	LF
			COMM CABLE (UNDRGRND)(19 AWG)(6 PAIR)	LF
			COMM CABLE (UNDRGRND)(22 AWG)(12 PAIR)	LF
			COMM CABLE (UNDRGRND)(22 AWG)(18 PAIR)	LF
			COMM CABLE (UNDRGRND)(22 AWG)(25 PAIR)	LF
			COMM CABLE (UNDRGRND)(22 AWG)(50 PAIR)	LF
			COMM CABLE (UNDRGRND)(22 AWG)(6 PAIR)	LF
			COMM CABLE (VOICE COM)(22 AWG)(6 PAIR)	LF
Communication Hub Enclosure	6568	2004	COMMUNICATION HUB ENCL (CONC)(8' X 12')	EA
Communications Ground Box	6155	2004	COMMUN GROUND BOX(TY 1)(483048)W/APRON	EA
			COMMUN GROUND BOX(TY 2)(603648)W/APRON	EA
	6539	2004	COMM GROUND BOX TY-1 (483048) W/APRON	EA
			COMM GROUND BOX TY-2 (603648) W/APRON	EA
Concrete Ground Boxes	6513	2004	CONCRETE GROUND BOX (TY AS)	EA
Duct Bank for Surveillance, Communication, and Control (SC&C)	6139	2004	DUCT BANK (SC&C)	LF
	6563	2004	DUCT BANK (SC&C)	LF
Fiber Communications Hub	6198	2004	FIBER COMMUNICATION HUB (10' X 15')	EA
			FIBER COMMUNICATION HUB (7'X 8')	EA
	6260	2004	FIBER COMM HUB BUILDING (7'X 8')	EA

Table 2. Bid Items Associated with Each Special Specification in Table 1 (Continued).

Specification	No.	Year	Item Description	Units
Fiber Optic Cable	6014	2004	EXTERNAL PATCH PANEL ASSEMBLY	EA
			FIBER OPTIC CABLE ROAD ENCLOSURE	EA
			FIBER OPTIC CABLE ROAD MARKER	EA
			FIBER OPTIC CABLE ROAD MARKER	EA
			FIBER OPTIC CABLE ROAD MARKER	EA
			FIBER OPTIC CBL (MULTI-MODE)(12 FIBER)	LF
			FIBER OPTIC CBL (MULTI-MODE)(144 FIBER)	LF
			FIBER OPTIC CBL (MULTI-MODE)(24 FIBER)	LF
			FIBER OPTIC CBL (MULTI-MODE)(336 FIBER)	LF
			FIBER OPTIC CBL (MULTI-MODE)(36 FIBER)	LF
			FIBER OPTIC CBL (MULTI-MODE)(48 FIBER)	LF
			FIBER OPTIC CBL (MULTI-MODE)(6 FIBER)	LF
			FIBER OPTIC CBL (MULTI-MODE)(72 FIBER)	LF
			FIBER OPTIC CBL (MULTI-MODE)(84 FIBER)	LF
			FIBER OPTIC CBL (SNGLE-MODE)(12 FIBER)	LF
			FIBER OPTIC CBL (SNGLE-MODE)(144 FIBER)	LF
			FIBER OPTIC CBL (SNGLE-MODE)(24 FIBER)	LF
			FIBER OPTIC CBL (SNGLE-MODE)(336 FIBER)	LF
			FIBER OPTIC CBL (SNGLE-MODE)(36 FIBER)	LF
			FIBER OPTIC CBL (SNGLE-MODE)(48 FIBER)	LF
			FIBER OPTIC CBL (SNGLE-MODE)(6 FIBER)	LF
			FIBER OPTIC CBL (SNGLE-MODE)(72 FIBER)	LF
			FIBER OPTIC CBL (SNGLE-MODE)(84 FIBER)	LF
			FIBER OPTIC PATCH PANEL (12 POSITION)	EA
			FIBER OPTIC PATCH PANEL (12 POSITION)	EA
			FIBER OPTIC PATCH PANEL (48 POSITION)	EA
			FIBER OPTIC PATCH PANEL (48 POSITION)	EA
			FIBER OPTIC PATCH PANEL (72 POSITION)	EA
			FIBER OPTIC PATCH PANEL (72 POSITION)	EA
			FIBER OPTIC PIGTAIL (12 FIBER)	LF
			FIBER OPTIC PIGTAIL (12 FIBER)	LF
			FIBER OPTIC PIGTAIL (12 FIBER)	LF
			FIBER OPTIC PIGTAIL (6 FIBER)	LF
			FIBER OPTIC SPLICE ENCLOSURE	EA
			FIBER OPTIC SPLICE ENCLOSURE	EA
			FIBER PATCH PANEL (12 POSITION)	EA
			FIBER PATCH PANEL (48 FIBER)	EA
	6191	2004	FIBER OPTIC CBL (MULTI-MODE)(36 FIB)	LF
			FIBER OPTIC CBL (SINGLE-MODE)(36 FIB)	LF
	6222	2004	FIBER OPTIC CABLE (MULTI-MODE)(36 FIB)	LF
			FIBER OPTIC CABLE (SNGLE-MODE)(36 FIB)	LF
	6418	2004	FIBER OPTIC CABLE (SNGL MODE)(144 FIB)	LF
			FIBER OPTIC CABLE (SNGL MODE)(6 FIB)	LF
	6490	2004	FIBER OPTIC CBL (MULTI-MODE)(36 FIBER)	LF
			FIBER OPTIC CBL (SNGLE-MODE)(36 FIBER)	LF
Fiber Optic Cable (Single Mode)	6367	2004	FIBER OPTIC CBL S/M (144 STRAND)(TY A)	LF
			FIBER OPTIC CBL S/M (6 STRAND)(TY E)	LF
			REMOVE EXIST FIBER OPTIC CABLE (RMC)	LF
	6430	2004	FIB OPT CBL (SGL MD)(TY-D)(12 STR)TMS	EA
			FIB OPT CBL (SGL MD)(TY-E)(6 STR)TMS	EA
			REMOVE EXIST FIBER OPT CBL (12 STR)	LF
Fiber Optic Cable Splicing	6516	2004	FIBER OPTIC CABLE STRAND SPLICING	EA

Table 2. Bid Items Associated with Each Special Specification in Table 1 (Continued).

Specification	No.	Year	Item Description	Units
Multi-Duct Conduit System	6076	2004	MULTI-DUCT COND SYS (4 IN)(BORE)	LF
			MULTI-DUCT COND SYS (4 IN)(PVC)	LF
	6144	2004	MULTI-DUCT COND SYS (PVC)(BORED)	LF
			MULTI-DUCT COND SYSTEM (PVC)	LF
			MULTI-DUCT COND SYSTEM (RMC)	LF
	6188	2004	MULTI-DUCT COND SYS (SCH 40)(4 IN)	LF
	6202	2004	MULTI-DUCT COND (PVC)(SCH 40)(4")	LF
			MULTI-DUCT COND (PVC)(SCH 40)(4")BORE	LF
	6214	2004	MULTI-DUCT COND SYS (SCH 40)(4")	LF
	6261	2004	MULTIDUCT CONDUIT SYS (PVC)(SCHD 40)	LF
			MULTIDUCT CONDUIT SYS (RM)(4")	LF
	6277	2004	MULTIDUCT COND SYS(PVC)(SCHD 40)4"BORE	LF
			MULTIDUCT CONDUIT SYS (PVC)(SCHD 40)	LF
			MULTIDUCT CONDUIT SYS (RM)(4")	LF
	6285	2004	MULTI-DUCT COND SYS (PVC) (BORED)	LF
			MULTI-DUCT COND SYS (RMC)	LF
			MULTI-DUCT CONDUIT SYS (PVC)	LF
	6292	2004	MULTI-DUCT CONDUIT SYSTEM	LF
	6385	2004	CONDT MULTDCT FIB(4") (BRDG) (2-WAY)	LF
			CONDT MULTDCT PVC(4") (BORED)(2-WAY)	LF
			CONDT MULTDCT PVC(4") (RDWY) (2-WAY)	LF
			CONDT MULTDCT PVC(4") CONC ENCL(2-WAY)	LF
	6393	2004	MULTI-DUCT COND SYS (PVC)	LF
			MULTI-DUCT COND SYS (PVC) (BORED)	LF
			MULTI-DUCT COND SYS (RMC)	LF
	6421	2004	MULTI-DUCT COND SYS (4 IN)(BORE)	LF
			MULTI-DUCT COND SYS (4 IN)(PVC)	LF
	6427	2004	MULT-DUCT COND SYS (4")2-WAY(BORE TMS)	LF
			MULT-DUCT COND SYS (4")2-WAY(CONC ENC)	LF
			MULT-DUCT COND SYS (4")4-WAY(BORE TMS)	LF
			MULT-DUCT COND SYS (4")4-WAY(CONC ENC)	LF
	6436	2004	MULTI-DUCT COND SYSTEM (BORED)	LF
	6452	2004	MULTIDUCT CONDUIT (PVC) (BORED)	LF
			MULTIDUCT CONDUIT (PVC) (SCH 40)	LF
			MULTIDUCT CONDUIT (PVC) (SCH 80)	LF
			MULTIDUCT CONDUIT (RM)	LF
	6510	2004	MULTI-DUCT COND SYS (4")(4-WAY)(PVC)	LF
	6515	2004	MULTI-DUCT COND.SYS.(SCHD.40)(4")	LF
	6524	2004	MULTI-DUCT CONDUIT (PVC)	LF
			MULTI-DUCT CONDUIT (PVC)(BORED)	LF
			MULTI-DUCT CONDUIT (RM)	LF
Polyethylene Innerduct	6359	2004	POLYETHYLENE INNERDUCT (3/4 IN)	LF
Preparation of Existing Conduit	6382	2004	PREPARATION OF EXISTING COUNDUIT	EA
	6439	2004	PREP OF EXIST CONDUIT	LF
Preparation of Existing Conduits, Ground Boxes, or Manholes	6086	2004	CABLE RACK ASSEMBLY (INSTALL)	EA
			CONDUIT (PREPARE)	LF
			GROUND BOX (PREPARE)	EA
Removal of Existing Cables	6489	2004	REMOVAL OF EXISTING CABLES (FIBER)	LF
			REMOVAL OF EXISTING CABLES (POWER)	LF
	6514	2004	REMOVAL OF EXISTING CABLES (FIBER)	LF
Remove and Reinstall Existing Fiber Optic Cable	6420	2004	REMOVE & REINSTALL EXIST FIB OPT CABLE	LF
Remove Ground Box	6235	2004	REMOVE GROUND BOX	EA
Replacement of Existing Ground Box	6180	2004	REPLACE EXISTING GROUND BOX	EA

Table 2. Bid Items Associated with Each Special Specification in Table 1 (Continued).

Specification	No.	Year	Item Description	Units
Southwestern Bell Telephone Underground Telephone	3548	93	CONDUIT (DUCT)(PVC)(4 IN)	LF
			TELEPHONE (MANH) (COMPL) (8X4X6)	EA
			TELEPHONE (MANH)(COMPL)(12X6X7)	EA
			TELEPHONE (TRENCH EXCAV PROT)	LF
	5970	93	TELEPHONE (ADJUST EXIST MANHOLE)	EA
			TELEPHONE (CONDUIT)(6-4" PVC)	LF
			TELEPHONE (MH COMPLETE)(12'X 12' X 8')	EA
			TELEPHONE (MH COMPLETE)(12'X 6'X 10')	EA
			TELEPHONE (MH COMPLETE)(12'X 6'X 7')	EA
			TELEPHONE (MH COMPLETE)(12'X6'X10')	EA
			TELEPHONE (MH COMPLETE)(15'X 11' X 14')	EA
			TELEPHONE (MH COMPLETE)(15'X 20' X 12')	EA
			TELEPHONE (MH COMPLETE)(15'X 6'X 12')	EA
			TELEPHONE (MH COMPLETE)(9'X4'X7')	EA
			TELEPHONE (STACK REBUILD COMPLETE)	EA
			TELEPHONE (STEEL PLATE)	LB
			TELEPHONE (TEMPORARY ADJUSTMENT)	LF
Telecommunication Cable	6559	2004	TELECOM CABLE (TWP)(19 AWG)(06 PR)	LF
			TELECOM CABLE (FOC)(SM)(02 COUNT)	LF
			TELECOM CABLE (TMP)(06 PAIR)(19 AWG)	LF
			TELECOM CABLE (TMP)(18 PAIR)(19 AWG)	LF
			TELECOM CABLE (TWP)(SM)(48 COUNT)	LF
TXU Electric Delivery - Electrical Transmission & Distribution System	6252	2004	CONDUCTOR 1000 KCMIL AI (ELEC)	LF
			CONDUCTOR 749 KV (ELEC)	LF
			CONDUIT 6" (ELEC)	LF
			MANHOLE 2-WAY (ELEC)	EA
			MANHOLE 3-WAY (ELEC)	EA
			POLE STEEL (ELEC)	EA
			POLE WOOD (ELEC)	EA
			REMOVAL (ELEC)	EA
			REMOVAL (GAS)	EA
			SWITCHGEAR (ELEC)	EA
Underground Cable Vault for Surveillance, Communication, and Control (SC&C)	6570	2004	UCV (5' X 5')	EA
Underground Telephone Systems	5732	93	ADJUST EXIST MANHOLE (TELEPHONE)	EA
			MODIFY EXIST MANHOLE ENTRY (TELEPHONE)	EA
			TELEPHONE (CONDUIT)(12 MPC)	LF
			TELEPHONE (CUT & RESTORE PAVEMENT)	SY
			TELEPHONE (FLOWABLE BACKFILL)	CY
			TELEPHONE(TRENCH EXCAVATION PROTECTION)	LF

Special Specification Style Issues

Standard construction and maintenance specifications at TxDOT (year 2004 edition) typically use the following article structure (*8*):

XXX.1. Description.
XXX.2. Materials.
XXX 3. Equipment.
XXX.4. Construction or Work Methods.
XXX.5. Measurement.
XXX.6. Payment.

The standard style for year 1993 standard specifications was very similar, except that it did not include a separate article for equipment.

Depending on the specification, it is possible that certain articles may be absent, e.g., Item 100, "Preparing Right of Way" lacks an article on materials. Equipment is the most common article that may be absent from a specification. Likewise, some specifications that contain items that are subsidiary to other items have measurement and payment combined, e.g., in the case of Article 627.4, "Measurement and Payment" under Item 627, "Treated Timber Poles."

A review of some of the special specifications listed in Table 1 revealed a number of variations from the standard specification style:

- Some specifications combined articles or used non-standard article names. For example,
    - Special Specifications 6076, 6421, and 6510 used "Ducts" (as opposed to "Materials") and "Construction Method" (as opposed to "Construction" or "Work Method").
    - Special Specifications 6155 and 6539 merged "Materials" and "Construction" into one article called "Materials and Construction."
    - Special Specifications 6382 and 6439 used "General" (as opposed to "Construction" or "Work Method").
    - Special Specifications 6402 and 6530 merged "Materials" and "Construction" into one article called "Cabinet Design and Requirements."

- Some specifications used the wrong article heading. For example, Special Specification 6516 described construction procedures under "Material."

- Several specifications inserted content that would normally be considered sections within articles or sections as separate, non-standard articles. For example,
    - Special Specifications 6076, 6421, and 6510 inserted Article 4, "Testing."
    - Special Specification 6144 inserted Article 4, "Testing" and Article 3, "References." Note: As a result of a typographical error, this specification had two Article 3 instances (one for "Construction" and another one for "References") and two Article 4 instances (one for "Testing" and another one for "Measurement").
    - Special Specifications 6188, 6202, 6214, 6261, 6277, 6285, 6292, 6385, 6393, 6427, 6436, 6452, 6515, and 6524 inserted Article 4, "Testing" and Article 5, "References."
    - Special Specification 6180 inserted Article 3, "Pre-Test" and Article 4, "Post-installation Tests."
    - Special Specifications 6489 and 6514 inserted Article 3, "Removal, Handling and Storage of Fiber Optic Cables."
    - Special Specifications 6191, 6418, and 6490 inserted Article 4, "Documentation Requirements," Article 5, "Testing," Article 6, "Training," and Article 7, "Warranty."
    - Special Specifications 6367 and 6430 inserted Article 4, "Remove Existing Fiber Optic Cable" and Article 5, "Training Class."

- Special Specifications 6198 and 6260 inserted Article 2, “Electrical Requirements,” Article 3, “Guaranty,” and Article 4, “Testing Requirements.”
- Special Specification 6565 inserted Article 3, “Installation,” Article 4, “Splicing,” Article 5, “Inspection, Testing, and Test Reports,” Article 6, “Training,” and Article 7, “Documentation.”

Special Specification Content, Measurement, and Payment Issues

An analysis of common trends and differences among special specifications in Table 1 and the corresponding bid items in Table 2 yields the following observations:

- Some special specifications included definitions of items. Providing uniform definitions offers several advantages. First, use of uniform definitions helps readers to understand specifications, which is critical to facilitating consistency in the bidding process, as well as for measurement and payment. Second, it provides clarity in the use of terminology, which is critical given the wide range of naming conventions in the telecommunication industry. For example, in product and specification literature, it is common to find references to the term “conduit structure” in the context of either single-conduit structures (for which the terms conduit and duct are also common) or multiple-duct structures (for which the terms multi-duct conduit structures and duct banks are also common). Likewise, there is a wide range of names for boxes that are installed in the ground, including handholes, ground boxes, pull boxes, and junction boxes. Although certain terms are more commonly used than others depending on the specific application, a review of product literature revealed considerable overlap in terminology, suggesting that specifics terms used depend to a large degree on individual vendor preference.

  Providing uniform definitions is also advantageous in situations where terms might be confusing or incorrectly used. An example of this type of situation was the use of the term “stabilized encasement” (or “stabilized easement”) in Special Specification 5970, “Southwestern Bell Telephone Underground Telephone.” Without a definition, which clarified that either term referred to concrete or flowable backfill to protect the conduit structure, it would have been very difficult to understand what the specification writer meant. Another example of potentially confusing terminology was “modify existing manhole entry,” which at first sight could be interpreted as referring to the top of the manhole, but, in reality, after reading the definition, referred to the connection between conduit and manhole.

  While providing item definitions is advantageous, the potential downside to providing definitions in specifications is the risk of multiple item definition versions among various specifications. In general, it would be preferable to develop a separate reference document containing a glossary of standardized bid item definitions.

- There were inconsistencies in the application of bid item naming conventions. In the long run, this practice could make the analysis of historical unit cost data more difficult. For example, in the case of multi-duct conduit system specifications, the researchers found references to a wide range of bid item names (Table 2), including CONDT

MILTDCT, MULT-DUCT COND SYS, MULTI-DUCT COND, MULTI-DUCT COND SYS, MULTIDUCT COND SYS, MULT-DUCT COND.SYS., MULTI-DUCT CONDUIT, MULTIDUCT CONDUIT, MULTIDUCT CONDUIT SYS, and MULTI-DUCT CONDUIT SYSTEM. Most of these bid items were further disaggregated by material, conduit size, and construction method.

- There were several cases where the specification was vague in the description, construction procedure, or measurement of an item. For example,

  - Special Specification 5970 included a bid item for "temporary adjustments" (or "short-term adjustments") to resolve conflicts found during construction between the proposed installation and any other existing installations owned by the same telephone provider. While the specification indicated that temporary adjustments to existing installations were not permanent and would be performed to avoid construction delays (the telephone provider would design and undertake permanent solutions to the conflicts), the specification was nonetheless vague for several reasons. First, it did not clarify when the design and construction of the permanent conflict solution would take place, which could add uncertainty to the utility adjustment and construction bidding process. Second, the temporary adjustments would be paid by linear foot of adjustment from the point of connection to the existing duct on either side of the adjustment, but it was not clear whether the item would be a plans quantity measurement item. Interestingly, the construction requirement specified that the contractor had to "trench back as far back as required in each direction," therefore adding uncertainty to the bidding and measurement of the temporary adjustment item.

    Temporary adjustments (which typically include the installation of conduit structures and/or cable to reroute existing communication lines during construction) are a frequent source of contention between TxDOT and utility companies because of the difficulty of inspecting and measuring those items. In general, considering temporary adjustments to be subsidiary to the installation of the permanent installations is not appropriate because the magnitude and cost of the temporary adjustments could distort the cost of the permanent installations. In some instances, TxDOT has found it effective to pay for temporary adjustments per linear foot of temporary adjustment. This strategy is not always feasible, particularly in complex localized construction situations. Nonetheless, this strategy is preferable to the simpler alternative of paying for the temporary adjustment as a lump sum. Disaggregating temporary adjustments to account for different conduit sizes and/or number of conduits is certainly a possibility, but whether the practice could be beneficial in the long run (i.e., whether the added bid item disaggregation could result in monetary savings to TxDOT) remains unanswered at this point. To facilitate inspection, measurement, and payment, it may be advisable to consider temporary adjustments as plans quantity measurement items—and to explicitly state it as such in the specification—in which the quantity to pay is the quantity shown on the proposal. Note: Article

9.2 in Item 9, “Measurement and Payment,” includes provisions for potential modifications to plans quantity measurements.

- There were several cases of specifications that assumed certain relatively large items to be subsidiary, potentially skewing the unit cost associated with the associated pay item. For example, Special Specification 6014, “Fiber Optic Cable,” included a requirement for a “building” to house connector panel module housings and splice housings. This “building” was quite likely a relatively large structure, probably comparable to a manhole in size.

  Similarly, Special Specification 6515, “Multi-Duct Conduit System,” indicated that trenchless construction procedures, when needed, would not be considered for measurement and payment. Special Specification 6452, “Multi-Duct Conduit System,” indicated that copper cable would be subsidiary to the installation of the conduit system.

- Special Specification 6402 had confusing language regarding the wiring, harnesses, and cable assemblies required for equipment to be housed in a communication cabinet. Although the specification mentioned the equipment in general terms, it would be hard to prepare a bid for the item without more detailed information.

  Likewise, Special Specification 6559 indicated that telecommunication cable would be measured by the foot along the cable. At the same time, it specified that existing terminated or spliced cable would be measured as each telecommunication cable terminated or spliced. This differentiation was confusing because earlier in the specification, the requirement for termination and splicing was only for new—not existing—cable. In addition, the payment article assumed terminating and splicing to be subsidiary to the installation of the (new) communication cable, yet it included separate bid items for terminating and splicing.

- Several special specifications (e.g., 6076, 6144, 6202, 6285, 6292, 6393, and 6421) required that the outer conduit in a multi-duct conduit system not exceed an ovality of five percent. However, the specifications did not define the term “ovality,” which could cause confusion during inspection, depending on the reference used to compare the difference between the major and minor axis lengths (major axis length, minor axis length, or average of major and minor axis lengths). In addition, some specifications included language such as “do not exceed the ovality of the conduit system by 5%” or “do not exceed 5% ovality of the conduit system,” which presumably could be interpreted as meaning that any ovality would be acceptable as long it did not exceed a reference (not pre-established) ovality by more than five percent. Interestingly, the special specifications also required that inner ducts not exceed an ovality of five percent, which would be extremely difficult to inspect and verify with the typical measuring tools available to inspectors in the field.

Feedback provided by utility company representatives indicates that ovality is a concept they rarely (if ever) use, which raises the question about the effectiveness of specifying ovality requirements. The industry is more familiar with mandrel tests (typically done on conduit structures after backfilling), which enable the detection of variations with respect to circular cross sections and situations where sharp bends in the conduit might make cable installation more difficult.

  - Special Specification 6382 included requirements for the preparation of existing conduit, including installation of new junction boxes, repair of damaged ground boxes and manholes, and preparation or replacement of existing conduit. The specification also indicated that measurement of cleared existing conduit or newly installed conduit would be done by the foot of conduit. However, the payment article indicated that payment would be made at the unit price of conduit or multi-duct conduit system, without clarifying if it would be for cleared existing conduit or newly installed conduit.

  - Special Specification 6235 included a requirement that the contractor furnish all materials needed for repairing breaks in conduit and cable, including but not limited to, all gravel fill and backfill. At the same, the specification indicated that TxDOT would furnish all other materials, which raises the question of how a prospective bidder would be able to determine which materials to include in the bid.

  - Special Specification 6222 included a requirement not to exceed the maximum pulling tension and bending radii specified by the optical fiber cable manufacturer. The same specification also included a requirement not to exceed a pulling tension of 2700 N (600 lbf), which was unnecessary given the requirement previously stated.

- Several specifications included incomplete references to other specifications. Typically, the reference included the specification title, e.g., "Underground Cable Vault," "Communication Hub Enclosure, or "Multi-Duct Conduit System," but not the corresponding specification number.

- Several specifications included references to Item 465, "Manholes and Inlets," in ways that could cause confusion. For example, Special Specification 5732 required that all manholes conform to the requirements of Item 465 (making it a binding requirement to the contractor). At the same time, it clarified that the telephone provider would supply all pre-cast manholes at no cost to the contractor, raising the question of whether the pre-cast manholes would conform to the requirements of Item 465 and what liability the contractor would be willing to accept in that regard. The issue of conformance also raises the question whether it would be necessary to modify Item 465 to address communication infrastructure requirements, e.g., to clarify differences between manholes and vaults.

TXDOT STANDARD SPECIFICATIONS

TxDOT does not have standard communication-related construction specifications. As Figure 1 shows, a number of TxDOT standard specifications pertain to lighting and signals, some of which may be relevant to the analysis. For consistency with the specification framework used during the first phase of the research, the framework in Figure 1 includes five groups of specifications: Earth Work, Lines, Appurtenances, Other, and General (left-most column). The General group includes standard specifications such as mobilization and traffic control, which highway construction contracts typically include but at the same time are relevant to the utility adjustment process. A summary of some of the lighting and signal-related specifications follows.

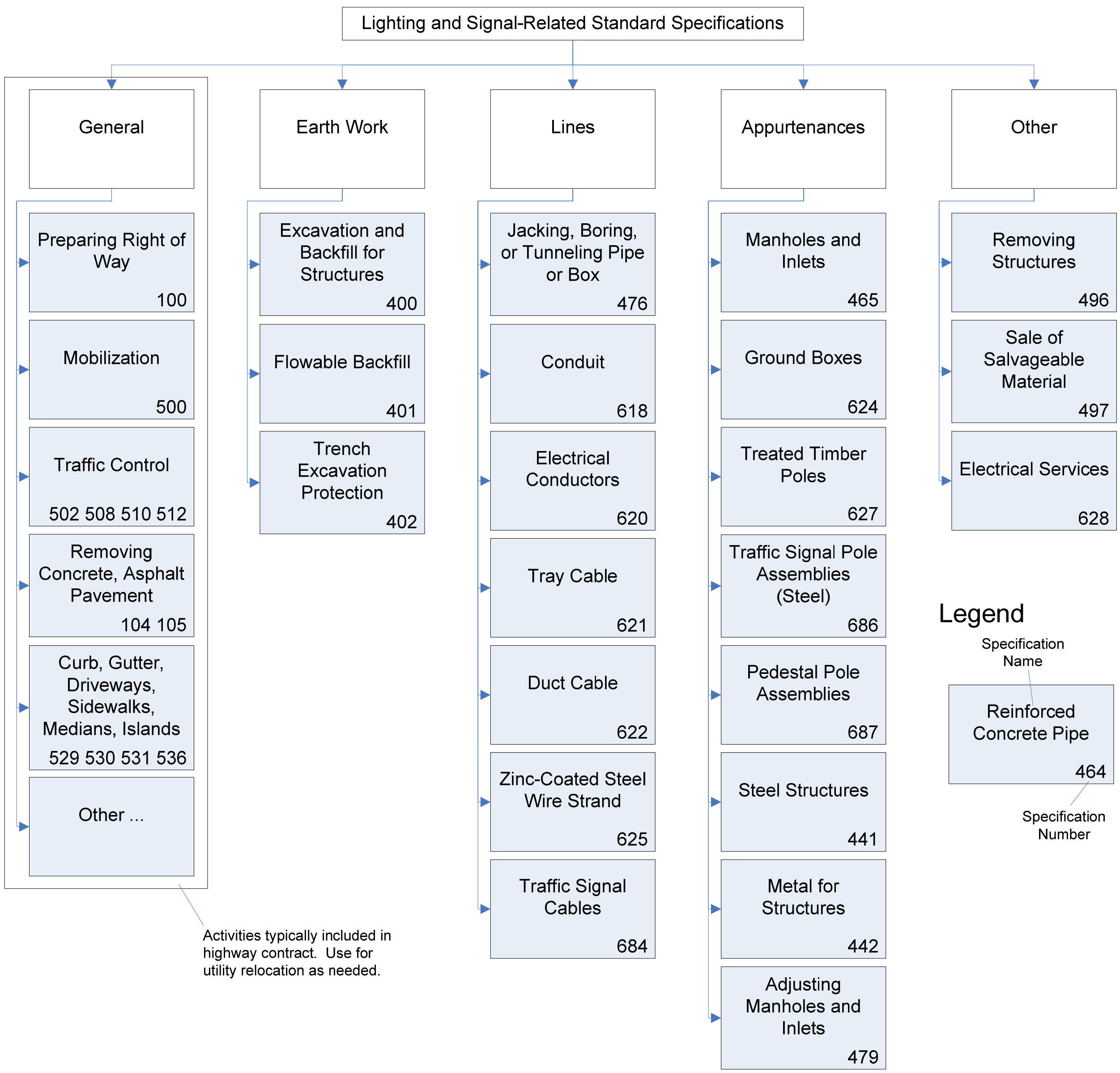


Figure 1. Lighting and Signal-Related Standard Specifications—Year 2004 Specifications.

- **Item 618, "Conduit."** This specification covers metal or plastic conduit. The unit bid price for "Conduit" includes activities such as furnishing and installing conduit; hanging; strapping, jacking, boring, tunneling, excavating, and furnishing and placing backfill; replacing pavement structure, sod, riprap, or other surface; marking location of conduit; furnishing and installing fittings, junction boxes, and expansion joints; and equipment, labor, tools, and incidentals.

- **Item 620, "Electrical Conductors."** This specification covers most electrical conductors that are rated for 600 volts and approved for wet locations. The unit bid price for "Electrical Conductors" includes activities such as furnishing, installing, and testing electrical conductors, as well as equipment, labor, tools, and incidentals.

- **Item 621, "Tray Cable."** This specification covers a variety of bare and insulated conductors that are suitable for outdoor use, under exposure to ultraviolet light, and in wet locations. The unit bid price for "Tray Cable" includes furnishing and installing materials, as well as equipment, labor, tools, and incidentals.

- **Item 622, "Duct Cable."** This specification covers complete assemblies of conductors enclosed in a high-density polyethylene (HDPE) duct. The conductors must meet the requirements of Item 620, "Electrical Conductors." The unit bid price for "Duct Cable" includes activities such as furnishing and installing all duct cable; pulling through conduit; excavating and backfilling the trenches; replacing riprap, pavement structure, topsoil, sod, or other structure; testing insulation resistance; and equipment, labor, tools, and incidentals. The specification requires the use of open-trench methods in accordance with the National Electric Code (NEC), except at locations where installing duct cable in conduit (which takes into account cases where construction requires hanging, strapping, jacking, boring, or tunneling).

- **Item 624, "Ground Boxes."** This specification covers cast-in-place and pre-cast ground boxes and aprons. The unit bid price for "Ground Boxes" includes excavating and backfilling; constructing, furnishing and installing the ground boxes and concrete aprons when required; and equipment, labor, materials, tools, and incidentals.

- **Item 625, "Zinc-Coated Steel Wire Strand."** This specification covers zinc-coated steel wire strand. This item is subsidiary to pertinent items.

- **Item 627, "Treated Timber Poles."** This specification covers treated timber poles. This item is subsidiary to pertinent items.

- **Item 628, "Electrical Services."** This specification covers the installation or removal of complete and independent points of electrical service. The unit bid price for "Electrical Services" includes fees, permits, and other costs; making arrangements with the utility company for work and materials the utility company provides; furnishing, installing, and connecting all components such as poles, service supports, foundations, anchor bolts, enclosures, switches, breakers, conduit and conductors (from the service equipment including the elbow below ground), fittings, brackets, bolts, hangers, and hardware; and equipment, labor, tools, and incidentals. The unit bid price for "Remove Electrical Services" includes coordinating with the utility company to disconnect and isolate the electrical service; removing the service supports; backfilling holes; and equipment, labor, tools, and incidentals. The specification indicates that TxDOT will reimburse the contractor for costs related to utility-owned power line extensions, connection charges, meter charges, and other charges in accordance with Article 9.5, "Force Account."

PROPOSED SPECIFICATION FRAMEWORK

During the first phase of the project, the researchers developed a prototype framework for water and sanitary sewer utility installations (Figure 2 and Figure 3), as well as a prototype updated specification framework for drainage structures (Figure 4) (*6, 7*). Using the basic specification framework in Figure 2, Figure 3, and Figure 4, in conjunction with elements from the lighting and signal specification framework in Figure 1, the researchers developed a similar framework for communication utilities (Figure 5). In general terms, the framework includes four groups of specifications: Earth Work, Lines, Appurtenances, and Other.

The framework in Figure 5 also includes a fifth group (left-most column) that includes standard specifications such as mobilization and traffic control, which highway construction contracts typically include but at the same time are relevant to the utility adjustment process. Because the highway contract already includes those items, it would constitute duplicate payment to include any activities related to those items in other work items. This is the case for Item 100, "Preparing Right of Way," which involves clearing the ROW of all obstructions in preparation for the construction, and 2004 Item 502, "Barricades, Signs, and Traffic Handling," which involves providing traffic control devices and maintaining adequate traffic control during construction.

In practice, it is frequently desirable and most efficient to relocate utilities before letting the highway contract in order to prevent interference with highway contractor activities. As a result, some activities that would normally be part of the highway contract end up becoming the responsibility of utility companies and/or their contractors, impacting utility adjustment work items and costs. In general, if the utility agreement needs to include activities such as traffic control, mobilization, and ROW clearing, it would be advisable to account for those activities separately, e.g., by using separate bid items, instead of including those activities as subsidiary items to other work items.

- The integrity of the utility adjustment unit cost data would be retained and facilitated, particularly in cases where the impact of items such as mobilization and traffic control on total utility adjustment cost is significant, therefore facilitating the comparison of unit cost data across projects. As the impact on total utility adjustment cost decreases, keeping those items separate becomes less critical. However, as a matter of general policy, it should be possible to require utility companies always to submit the corresponding cost data using separate bid items.

- Current standard specifications (e.g., 100, 500, 502, 508, and so on) could be used with little or no modifications, making it possible to request utility companies to use those standard specifications and prepare the corresponding unit costs. If modifications to the standard specifications are necessary, special provisions could be used to modify specific sections or articles, following a practice that is already standard in regular highway construction projects.

- Although the impact on highway contract quantities and/or unit costs would be relatively minor, maintaining a separate tally of activities that are now part of the utility relocation process (but that would be part of the highway contract under normal circumstances) would facilitate overall project management and monitoring.

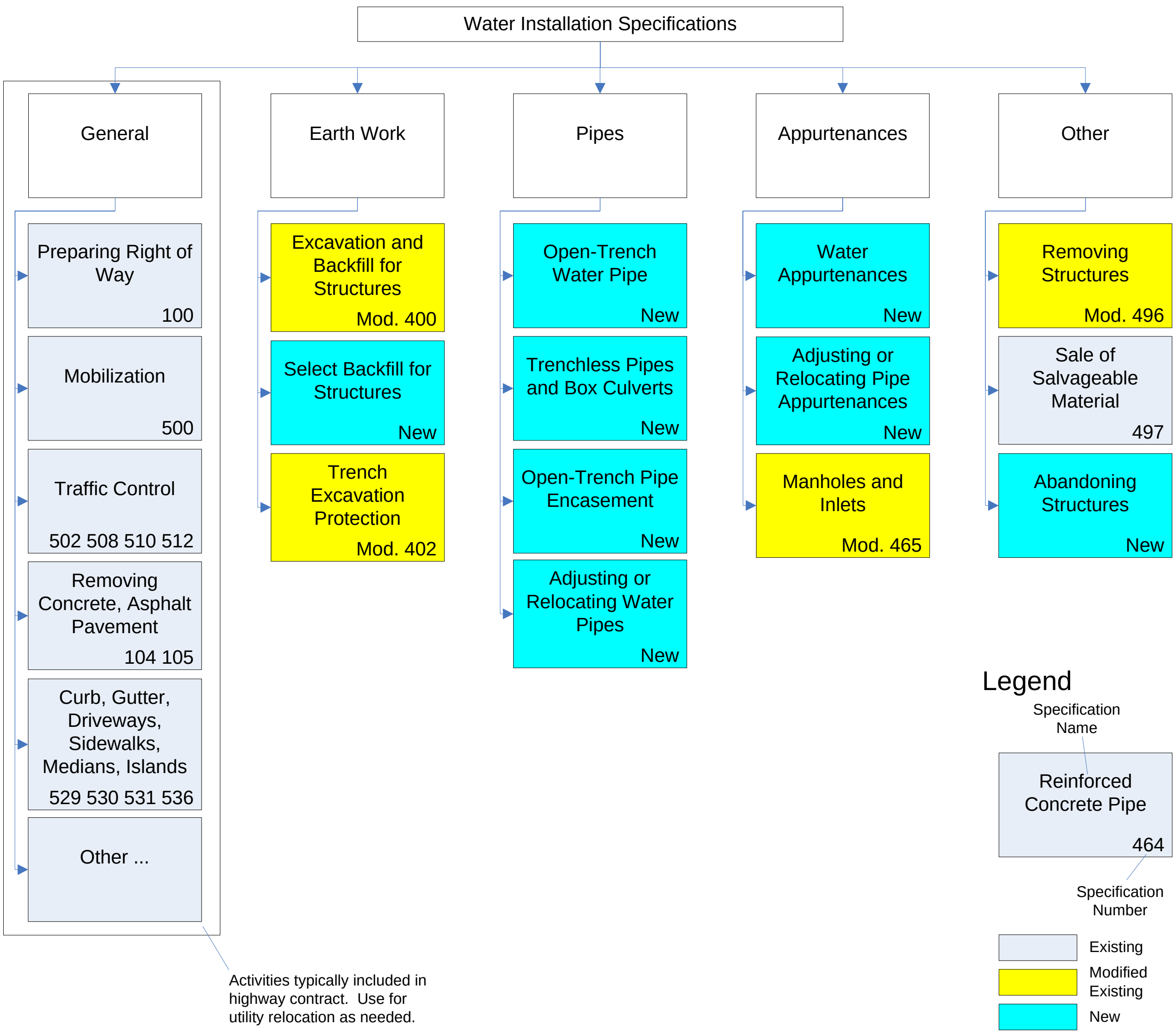


Figure 2. Proposed Water Installation Specification Framework (6, 7).

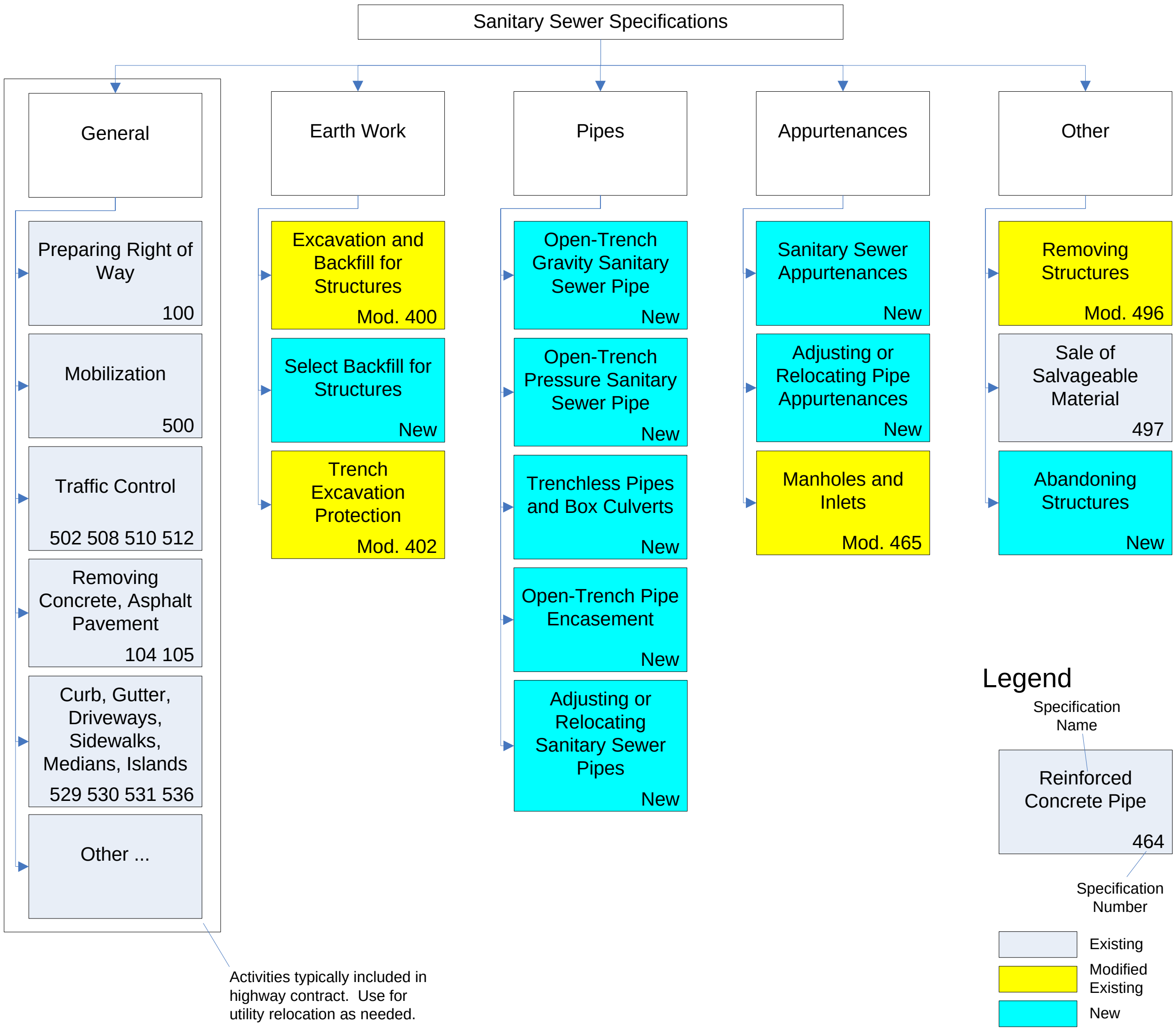


Figure 3. Proposed Sanitary Sewer Specification Framework (6, 7).

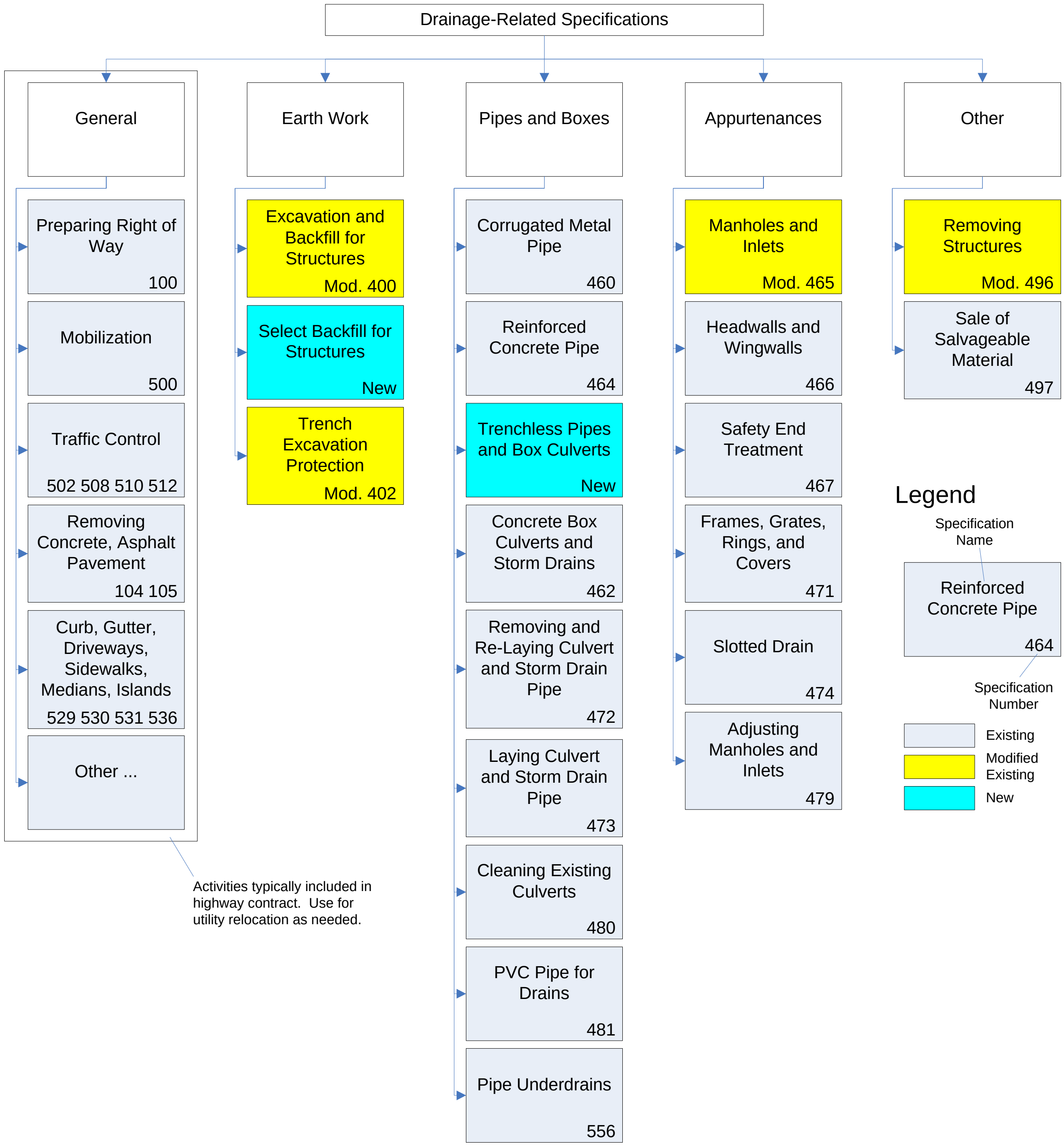


Figure 4. Proposed Drainage-Related Specification Framework (6, 7).

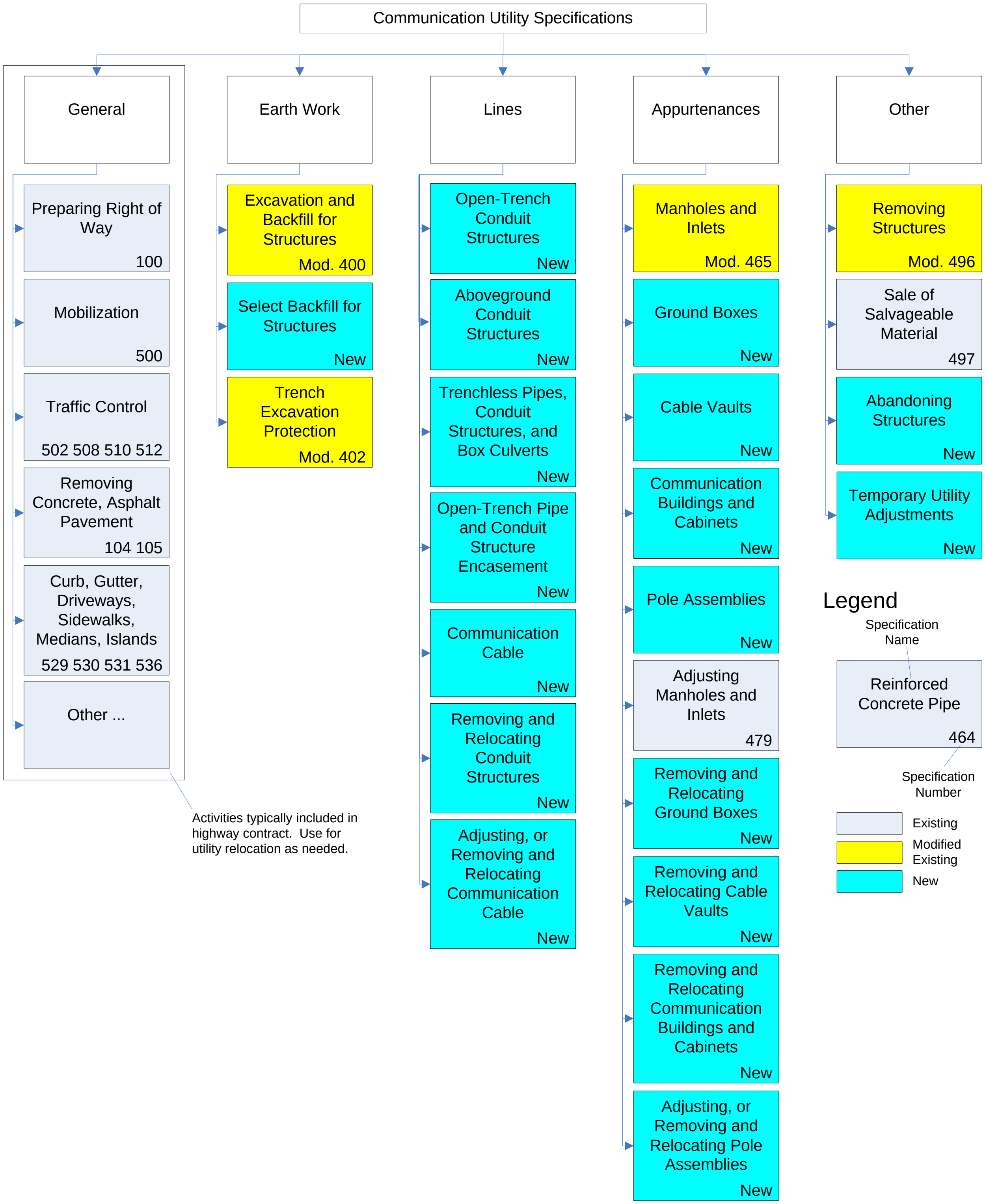


Figure 5. Prototype Communication Utility Specification Framework.

To facilitate the understanding of the specification framework and the corresponding specification requirements (next section), Table 3 provides definitions of commonly-used communication-related items. The purpose of Table 3 is to provide examples of common terms, not to serve as a final, authoritative source of definitions (although the table does intend to group terms following the specification and construction item structure described in this chapter). The reason is that terminology in the telecommunication industry varies widely. Further, terminology for similar items across industries, primarily the communication and electric industries, also varies widely. As an illustration of this situation, cable vaults typically refer to underground chambers that enable the installation of cables and other devices, and for making connections and tests. Boxes such as handholes, pull boxes, and ground boxes serve a similar purpose. However, while cable vaults tend to be relatively large structures (large enough for a person to enter) and boxes tend to be small structures where a person cannot usually enter, it is somewhat common to refer to boxes as "vaults." It is also somewhat common to hear the term "pedestal vault" when referring to an aboveground pedestal. For simplicity, this chapter uses the term "ground box" when referring to relatively small boxes such as handholes, pull boxes, junction boxes, and pedestals.

A related case is the overlap between vaults and manholes. Nowadays, manholes come in a variety of shapes, sizes, and materials. It is common to find references to rectangular underground structures as manholes as well as cases where, depending on the specific individual or agency, the same or similar structure might be called vault or manhole. It is also common to find definitions for cable vaults as manholes containing cables or as underground chambers that allow entry through manhole openings. The latter definition highlights further confusion with the term "manhole" because, strictly speaking, a "manhole" is just an opening that is large enough to allow access to an underground structure. However, it is common to refer to the complete underground structure, including any access barrel(s), as a "manhole." For simplicity, this chapter uses the term "cable vault" to denote a subsurface chamber, typically flat at the top, without access barrels, and typically large enough for a person to enter. This chapter also uses the term "manhole" to denote a subsurface chamber equipped with access barrels.

The terms duct, conduit structure, single-duct conduit system, multi-duct conduit system, and duct bank are also sources of confusion because the terms are commonly used interchangeably to denote the same type of structure. For simplicity, this report uses the term "conduit" to denote a single pipe or tube that houses cables and/or inner ducts. The report also uses the term "conduit structure" to denote a structural arrangement of one or more conduits bound together using devices such as bands, templates, or spacers.

Table 3. Commonly-Used Terms and Definitions.

Definition	Example
Cabinet. A cabinet is an enclosure, typically aboveground, that houses electrical and communication equipment and enables cable connections and tests. This definition covers a wide range of communication structures and devices that normally have electrical power and/or do not fall under the categories of vaults, manholes, or ground boxes. Examples include the following: communication building, communication cabinet, communication hub, communication hut, concrete universal enclosure (CUE), controlled environment cabinet (CEC), serving area interface (SAI), and loop carrier box. Depending on the case, the structures could include all the electrical and communication equipment inside the enclosure or just the enclosure, electrical connections, and cable terminals. Cabinets do not include central offices under the assumption that central offices are large buildings for which considerable bid item disaggregation may be necessary to properly estimate and control construction costs.	Communication cabinets    

Table 3. Commonly-Used Terms and Definitions (Continued).

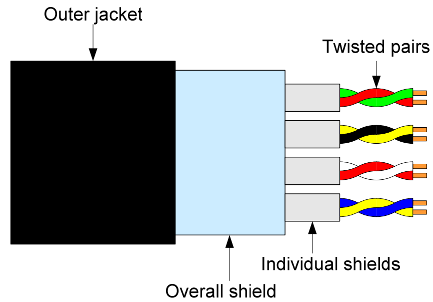
Cable. A cable is a longitudinal assembly of conductors such as wires, conducting sheaths, or optical fibers, surrounded by insulating layers. Common communication cable types include twisted pair cable, coaxial cable, and optical fiber cable (also known as fiber optic cable).

A *twisted pair cable* (typically) includes copper wires that follow a twisted pair configuration to cancel out electromagnetic interference. Twisted pair cable subtypes include unshielded twisted pair (UTP) cables and shielded twisted pair (STP) cables (which include insulation around each individual pair of wires to protect the cable from external electromagnetic interference).

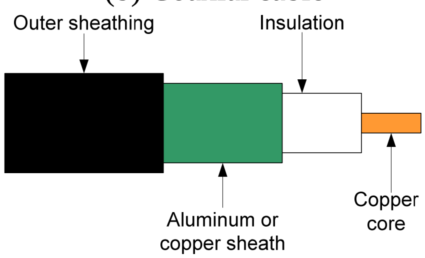
A *coaxial cable* includes a core wire surrounded by an insulating spacer layer, a metallic conducting sheath or shield, and an outer insulating jacket. Coaxial cables normally carry high-frequency or broadband signals. Coaxial cable subtypes include rigid coaxial cables and flexible coaxial cables (in which the metallic conducting sheath is usually thin braided copper wire).

An *optical fiber cable* includes sets of optical fiber strands (each including a core surrounded by a cladding layer –of lower refractive index than the core—and a color-coded protective cover) inside buffer layers, which are surrounded by one or more protective layers. Some cables include a metallic armored sheath to increase protection against rodents. Cable placed in underground conduit is normally filled with a waterproof gel compound. Optical fiber cable subtypes include multimode optical fiber cable (fiber diameter ~>10μm), which allows multiple light paths and is suitable for short distances, and single mode optical fiber cable (fiber diameter ~<10μm), which causes light to travel through a single path and is suitable for longer distances.

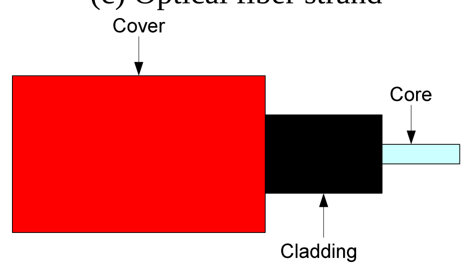
(a) Twisted pair cable



(b) Coaxial cable



(c) Optical fiber strand



(d) Optical fiber cable

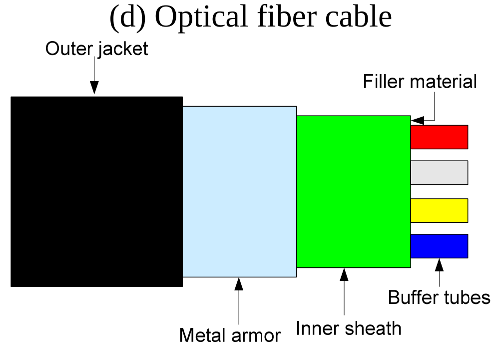


Table 3. Commonly-Used Terms and Definitions (Continued).

Cable Splice. A cable splice is an interconnection method for joining the ends of two cables in a permanent or semi permanent fashion. Splice enclosures provide protection against the elements through the use of boxes, tubes, or coatings.	Splice enclosure 
Cable Termination. Cable termination is the hardware and process that enables the connection of cables to devices such as equipment, panels, or other cables. Termination hardware may include cable connectors as well as patch panels, punch blocks, jacks, equipment racks, and shelves.	n/a
Cable Vault. A cable vault (also sometimes called a utility vault) is a subsurface chamber, typically flat at the top, *without* access barrel(s), and large enough for a person to enter, for the purpose of installing cables and other devices, and for making connections and tests. In this report, the main difference between vaults and manholes is that vaults do not have access barrel(s) whereas manholes do have access barrel(s). An *environmentally controlled cable vault* (also called controlled environment vault [CEV]) is a vault equipped to control environmental conditions inside the vault, primarily temperature and moisture.	n/a

Table 3. Commonly-Used Terms and Definitions (Continued).

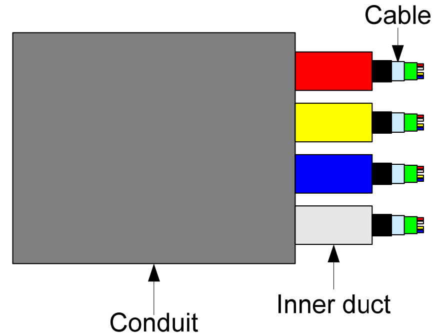
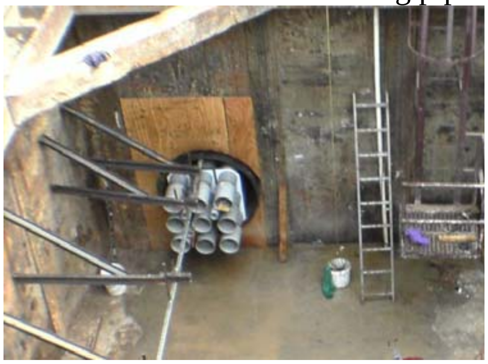
Conduit. A conduit (or duct) is a single pipe or tube that houses cables and/or inner ducts. This report treats conduits as components of conduit structures.	Conduit with innerducts and cable 
Conduit Structure. A conduit structure is a structural arrangement of one or more conduits bound together using devices such as bands, templates, or spacers. Conduit structures include single-duct conduit systems and multi-duct conduit systems (also known as duct banks). Conduit structures are classified according to the number and diameter of conduits that form the structure. For example, a 1x4 conduit structure contains one four-inch diameter conduit. A 12x4 conduit structure contains 12 four-inch diameter conduits. Similarly, a 12x4, 6x2 conduit structure contains 18 conduits: 12 4-inch diameter conduits and six two-inch diameter conduits.	Conduit structure with spacers and encasement 
Encasement. Encasement is a structural protection for pipes and conduit structures that uses a rigid enclosure. Typical subtypes include cast-in-place (CIP) concrete encasement and casing pipe. *Casing pipe* is a type of structural protection for pipes and conduit structures that uses a prefabricated pipe.	Conduit structure inside casing pipe 

Table 3. Commonly-Used Terms and Definitions (Continued).

Ground Box. A ground box is a relatively small cable enclosure that is usually mounted flush with the ground. Alternative names for ground boxes include handholes, junction boxes, and pull boxes.	Ground boxes  
Guy Wire. A guy wire is a cable that provides stability to tall, narrow structures such as poles. A guy wire assembly typically includes the tensioned cable, cable terminations, a bracket or other device to connect the guy wire to the structure, and a buried anchor.	Guy wire assembly  

Table 3. Commonly-Used Terms and Definitions (Continued).

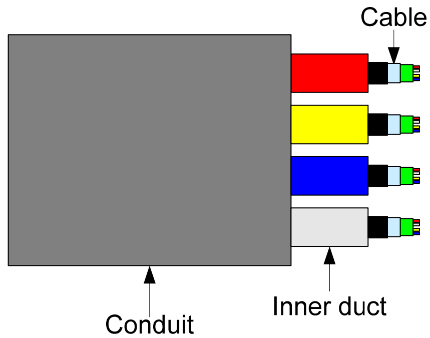
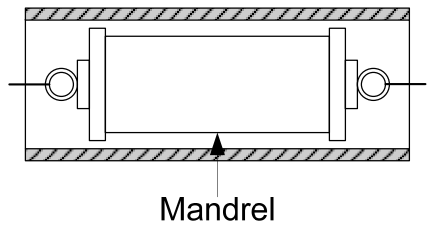
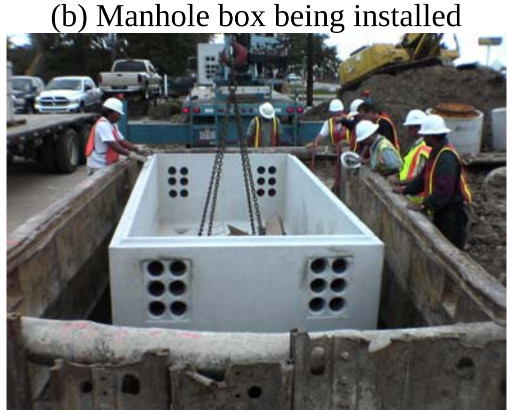
Inner Duct. An inner duct is a duct placed inside a larger conduit or duct that houses one or more cables.	Conduit with inner ducts and cable 
Mandrel. A mandrel is a device to test for "out-of-round" shape and joint integrity of conduit structures.	(a) Mandrel test 
Manhole. A manhole is a subsurface chamber *with* access barrel(s) and is large enough for a person to enter for the purpose of installing cables and other devices and for making connections and tests. In this report, the main difference between cable vaults and manholes is that cable vaults do not have access barrel(s) whereas manholes do have access barrel(s).	(a) Manhole access barrel  (b) Manhole box being installed 

Table 3. Commonly-Used Terms and Definitions (Continued).

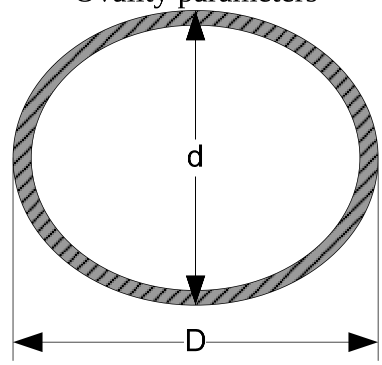
Ovality. Ovality is a measure of the "roundness" of a pipe or conduit. It is typically expressed as the difference between the maximum (D) and minimum (d) outer diameters divided by the average between the maximum and minimum diameters.	Ovality parameters 
Pedestal. A pedestal is a box that typically protrudes from the ground and contains terminals for wiring connections.	Telephone Pedestal 
Pole assembly. A pole assembly is an assembly that includes a pole and all additional hardware necessary to support cables and other equipment.	Pole assembly 

Table 3. Commonly-Used Terms and Definitions (Continued).

Riser Assembly. A riser assembly is a conduit structure that protects a cable transitioning from an underground installation to an aerial installation.	Riser assembly 
Trench Plate. A trench plate is a square or rectangular plate (typically steel) and the associated anchoring mechanism placed over an open trench to facilitate vehicular traffic. Trench plates may include non-skid surface treatments to minimize the risk of surface slippery conditions, particularly in rainy weather.	Trench plate 

SPECIFICATION REQUIREMENTS

This section includes specification requirements for each specification labeled "New" or "Modified Existing" in Figure 5. Each specification requirement uses the following structure:

- **Summary Table**. Each summary table (Table 4 through Table 25) describes the main characteristics of the proposed new or modified specification. The table structure should facilitate the use of and/or complement TxDOT's Form 1814 (*10*) to prepare and submit the corresponding specification approval request. A critical component of the summary table is a list of bid items, corresponding measurement units, and subsidiary items.

- **Specification Requirements**. Following each summary table is a compilation of requirements that are consistent with the current TxDOT specification style (*8*). Readers should be aware that the purpose of developing the specification requirements was not to write the specifications (which was outside the scope of the research), but to provide a foundation upon which a specification writer could prepare the specification. To assist in this process, the specification requirements provide references to industry standards, specifications, codes, regulations, and guidelines, including the following:

    - American National Standards Institute (ANSI) (*11*)
    - American Society for Testing and Materials (ASTM) (*12*)
    - City of Houston (*13*)
    - Electronic Industries Alliance (EIA) (*14*)
    - Federal Highway Administration (FHWA) (*15*)
    - Insulated Cable Engineers Association (ICEA) (*16*)
    - Institute of Electrical and Electronics Engineers (IEEE) (*17*)
    - National Electrical Manufacturers Association (NEMA) (*18*)
    - National Fire Protection Association (NFPA) (*19*)
    - National Institute of Building Sciences (NIBS) (*20*)
    - North Central Texas Council of Governments (NCTCOG) (*21*)
    - Rural Utilities Service (RUS) (*22*)
    - Telcordia (*23*)
    - Telecommunications Industry Association (TIA) (*24*)
    - Underwriters Laboratory (UL) (*25*)
    - Utility Accommodation Rules (*1*)

While individual specification requirements provide references to specific standards and specifications, for the most part the requirements do not repeat content the specification writer can find directly in the documents cited. To the extent possible, the specification requirements include content such as description, measurement, and payment (which are standard in TxDOT specifications), as well as content that is not necessarily evident or found in industry standard and specifications (e.g., related to survey control and positional accuracy). It is important to note that standards listed for a particular material or construction method may not be applicable in all situations.

For proposed modified specifications, both summary tables and specification requirements use the corresponding three-digit Item number (e.g., Item 400, “Excavation and Backfill for Structures”). For new specifications, the summary table and specification requirements use “XXXX” to identify the specification. Some specification requirements (more specifically Excavation and Backfill for Structures; Select Backfill for Structures; Trench Excavation Protection; Trenchless Pipes, Conduit Structures, and Box Culverts; Manholes and Inlets; Removing Structures; and Abandoning Structures) are also found in the reports from the first phase of the research (*6*, *7*). Those specification requirements include modifications to address the needs of communication installations and, consequently, should be used during implementation instead of the earlier versions.

The specification requirements cover typical topics in construction specifications at TxDOT, such as description, materials, construction methods, measurement, and payment (*9*). For each topic, the specification requirements include a list of appropriate industry standards and additional requirements a specification writer would need to consider when developing the specification. Many of the additional requirements were in response to issues transportation officials highlighted as critical for managing the state ROW effectively, such as compliance with the UAR, as well as ground control and positional accuracy.

For example, a frequent complaint by transportation officials is that utility companies and/or their contractors do not follow basic UAR requirements such as minimum depths of cover, encasement requirements, and minimum spacing between adjacent utility facilities (*1*). The utility industry is responsible for knowing the UAR. However, the researchers found that the level of UAR knowledge among utility company designers and technicians (i.e., at the level where UAR proficiency is most critical) was scant at best. To address this issue, in addition to recommending the implementation of dissemination and outreach programs, the specification requirements provide ample references to the UAR.

Ground control and positional accuracy issues are another point of contention between transportation officials and utility companies. The UAR requires all utility installation design plans and as-built plans to include vertical elevations and horizontal alignments based on the department's survey datum (*1*). To improve compliance, the specification requirements include horizontal and vertical positional accuracy requirements in line with existing survey standards in Texas (*26*), the requirement to measure and recording as-built alignments at specific intervals, and the requirement to submit as-built plans in accordance with the UAR. For trenchless construction or renewal, the specification requirements include the requirement to furnish a plan that includes the proposed line profile (in the case of horizontal directional drilling) and horizontal and vertical control method and expected accuracies.

Excavation and Backfill for Structures

Table 4. Proposed Specification: Excavation and Backfill for Structures.

Specification Number	400
Specification Title	Excavation and Backfill for Structures
Description	Excavate for placement and construction of structures and backfill for structures. Cut and restore pavement.
Previous Specifications	2004 Item 400, “Excavation and Backfill for Structures.”
Proposed Changes	Delete references to select backfill, e.g., cement stabilized backfill and flowable backfill. A new special specification (Special Specification XXXX “Select Backfill for Structures,” would cover all non-regular types of backfill). Expand description of excavation and bedding specifications to account for pipes other than drainage pipes, such as water and sewer installations, as well as communication and electric conduit structures and cable. ***Note to Specification Writer***: Examples of additional bedding specifications include Year 1993 Special Specification 5737 (p. 11-21), NCTCOG construction specifications (Section 203, Site Preparation and 504.5, Embedment), and City of Houston Standard Specifications (02317, Excavation and Backfill for Utilities).
Comment	Unless specified as a pay item, structural excavation is subsidiary to pertinent items (installation of bridges, boxes, pipes, conduit structures, and direct-buried cable).

Bid Item	**Measurement Unit**
Structural Excavation (Bridge) (if specified)	Cubic yard
Structural Excavation (Box) (if specified)	Cubic yard
Structural Excavation (Pipes) (if specified)	Cubic yard
Cutting and Restoring Pavement	Square yard
Removing Unstable or Incompressible Material	Cubic yard
Overexcavation (according to overexcavation table)	Cubic yard
Note to Specification Writer: Add other pay items as indicated on the plans or other design documents.	Varies

Subsidiary Item (if specified)	**Referenced Item**	**Subsidiary to**
Structural Excavation (Bridge)	400	Bridge construction
Structural Excavation (Box)		Box installation
Structural Excavation (Pipes)		Pipe, conduit structure, or cable installation
Bedding		Corresponding item installation
Conventional Backfill		Corresponding item installation
Note to Specification Writer: Add other subsidiary items as indicated on the plans or as required by this specification.		

Specification Requirements

400.2. Materials.

- Remove references to flowable fill, hydraulic cement concrete, and hydraulic cement. These materials are select backfill materials, which will become part of Special Specification XXXX, "Select Backfill for Structures."
- Insert the following text: "Remove unsuitable, unstable, or incompressible material as shown on the plans or as directed by the Engineer." ***Note to Specification Writer***: Include testing requirements such as gradation and plasticity index to assist in the assessment of material suitability.
- Insert the following text: "Provide bedding material as shown on the plans, as directed by the Engineer, or as recommended by the pipe manufacturer." ***Note to Specification Writer***: Refer to bedding material using the naming convention in ASTM D2487, "Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)." Likewise, include requirements for select bedding material such as crushed stone, gravel, and sand, taking into consideration appropriate testing requirements according to gradation, liquid limit, plasticity index, and bar linear shrinkage.

400.3. Construction.

- **400.3.A.1.c. Utilities.**
  - Add the following text at the end of the second paragraph: "Use an appropriate pole bracing system to ensure the structure stability of all poles and lines found. Protect all utility pits in accordance with National Cooperative Highway Research Project Report 350 and the provisions in the Utility Accommodation Rules (TAC Title 43, Part 1, Chapter 21, Subchapter C)."
  - Add paragraph and insert the following text: "When installing new or relocated utilities, ensure excavation lines and grades provide finished depths of cover to the top of the pipe, conduit structure, casing, or direct-bury cable that are in accordance with the Utility Accommodation Rules (TAC Title 43, Part 1, Chapter 21, Subchapter C)."
- **400.3.A.4. Culverts and Storm Drains.** Change the title of this section to "Culverts, Pipes, and Conduit Structures" and add text to describe excavation requirements for water, sewer, communication, and electric installations. ***Note to Specification Writer***: A number of specifications, standards, and guidelines provide information regarding excavation requirements for utility installations. Examples include NCTCOG construction specifications (Section 504.5, Embedment), City of Houston Standard Specifications (02317, Excavation and Backfill for Utilities), and NEMA TCB 2, "NEMA Guidelines for the Selection and Installation of Underground Nonmetallic Duct."
- **400.3.A.4.a. Unstable Material.** Replace "unless the Engineer authorizes additional depth" with "unless the Engineer authorizes a different or additional depth."

- **400.3.A.5. Poles.** Add section and include the following text: "Locate poles as shown on the plans or as approved by the Engineer. Drill holes for setting poles a minimum diameter of 1.5 times the diameter of the pole butt. Unless otherwise shown on the plans, set the pole a minimum depth in accordance with Table XXXX." ***Note to Specification Writer***: Table XXXX refers to current Table 3 in Item 627, "Treated Timber Poles."
- **400.3.B. Shaping and Bedding.**
  - Replace "Where cement-stabilized backfill is indicated on the plans, undercut the excavation at least 4 in. and backfill with stabilized material to support the pipe or box at the required grade" with "Where select backfill is indicated on the plans, undercut the excavation at least 4 in. and backfill with stabilized material to support the pipe or box at the required grade."
  - ***Note to Specification Writer***: For clarity, it is advisable to divide this section into separate subsections for box sections, storm sewer pipe, water pipe, sanitary sewer pipe, conduit structures, and other structures such as cabinets. For water pipe and sanitary sewer pipe, provide bedding diagrams similar to those shown in Item 400 (Figure 1, Bedding diagrams). Examples of additional bedding specifications include Year 1993 Special Specification 5737, "Water Mains and Sanitary Sewers," NCTCOG construction specifications (Section 504.5, Embedment), and City of Houston Standard Specifications (02317, Excavation and Backfill for Utilities).
- **400.3.C.1. General.** Replace "Obtain backfill from excavation or from other sources" with "Backfill using material from the excavation or from other sources as shown on the plans or directed by the Engineer."
- **400.3.C.3. Pipe.** Replace "at most 8 in. deep (loose measurement)" with "at most 8 in. deep, or as shown on the plans or directed by the Engineer (loose measurement)." Add backfill requirements for water pipes and sanitary sewer pipes.
- **400.3.C.4. Cement-Stabilized Backfill.** Remove this section. Special Specification XXXX, "Select Backfill for Structures," covers it. ***Note to Specification Writer***: As currently written, this section includes specifications both for materials and construction. When developing Special Specification XXXX, "Select Backfill for Structures," it would be advisable to move material-related text to Article XXXX.2, Materials.
- **400.3.C.5. Flowable Backfill.** Remove this section. Special Specification XXXX, "Select Backfill for Structures," covers it.
- **400.3.C.6. Conduit Structures.** Add this section and include backfill requirements for conduit structures. ***Note to Specification Writer***: A number of specifications, standards, and guidelines provide information regarding backfill requirements for conduit structures, e.g., NEMA TCB 2, "NEMA Guidelines for the Selection and Installation of Underground Nonmetallic Duct."
- **400.3.C.7. Poles.** Add this section and add the following text: "Unless otherwise shown on the plans, set the poles plumb. Backfill the poles thoroughly by tamping in 6-in. lifts. After tamping to grade, place additional backfill material in a 6 in.-high cone around the pole to allow for settling. Use material equal in composition and density to the

surrounding area, unless otherwise shown on the plans. Repair surface where existing surfacing material is removed, such as asphalt pavement or concrete riprap, with like material to equivalent condition."

400.4. Measurement.

- **400.4.C. Cement-Stabilized Backfill.** Remove this section. Special Specification XXXX, "Select Backfill for Structures," covers it.

400.5. Payment.

- **400.5.C. Cutting and Restoring Pavement.** Delete reference to flowable backfill.

Select Backfill for Structures

Table 5. Proposed Specification: Select Backfill for Structures.

<table>
<tr><td>Specification Number</td><td colspan="2">XXXX</td></tr>
<tr><td>Specification Title</td><td colspan="2">Select Backfill for Structures</td></tr>
<tr><td>Description</td><td colspan="2">Furnish and place select backfill for trench, hole, or other void.</td></tr>
<tr><td>Previous Specifications</td><td colspan="2">2004 Item 400, “Excavation and Backfill for Structures.”
2004 Item 401, “Flowable Backfill.”</td></tr>
<tr><td>Proposed Changes</td><td colspan="2">Create new specification to handle various select backfill types (such as cement stabilized backfill, flowable backfill, and lime stabilized backfill).
Specify payment to include the incremental price above conventional backfill (because according to Item 400, “Excavation and Backfill for Structures,” conventional backfill is considered subsidiary to the installation of the pipe).</td></tr>
<tr><td>Comment</td><td colspan="2">Including cost above regular backfill eliminates redundancy and facilitates unit cost comparisons.</td></tr>
<tr><td colspan="2">Bid Item</td><td>Measurement Unit</td></tr>
<tr><td colspan="2">Cement Stabilized Backfill</td><td>Cubic yard</td></tr>
<tr><td colspan="2">Flowable Backfill</td><td>Cubic yard</td></tr>
<tr><td colspan="2">Lime Stabilized Backfill</td><td>Cubic yard</td></tr>
<tr><td colspan="2">Note to Specification Writer: Add other pay items as indicated on the plans or as required by this specification.</td><td></td></tr>
<tr><td>Subsidiary Item (if specified)</td><td>Referenced Item</td><td>Subsidiary to</td></tr>
<tr><td>Loading and Hauling Select Material</td><td></td><td>Select backfill installation</td></tr>
<tr><td>Loading and Hauling Waste Material</td><td></td><td>Select backfill installation</td></tr>
<tr><td>Disposal of Waste Material</td><td></td><td>Select backfill installation</td></tr>
<tr><td>Note to Specification Writer: Add other subsidiary items as indicated on the plans or as required by this specification.</td><td></td><td>Select backfill installation</td></tr>
</table>

Specification Requirements

XXXX.1. Description. Furnish and place select backfill for trench, hole, or other void.

XXXX.2. Materials.

- Insert Sections 401.2.A, 401.2.B, 401.2.C, 401.2.D, and 401.2.E from Item 401, “Flowable Backfill.”
- Insert a new section for lime and add the following text: Furnish lime conforming to ASTM C977, “Specification for Quicklime and Hydrated Lime for Soil Stabilization.”

XXXX.3. Construction.

- Divide section into three subsections: Cement Stabilized Backfill, Flowable Backfill, and Lime Stabilized Backfill.
- Insert Sections 401.3.A and 401.3.B from Item 401, "Flowable Backfill" into the flowable backfill section.
- Insert text related to cement stabilized backfill from Item 400, "Excavation and Backfill for Structures."
- Add the following references to standards and specifications:
  - Cement Stabilized Backfill:
    - ASTM WK2799, "Standard Practice for Making and Curing Soil-Cement Compression and Flexure Test Specimens in the Laboratory"
    - ASTM D806, "Standard Test Method for Cement Content of Hardened Soil-Cement Mixtures"
    - ASTM D2901, "Standard Test Method for Cement Content of Freshly Mixed Soil-Cement"
  - Flowable Backfill:
    - ASTM D5971, "Standard Practice for Sampling Freshly Mixed Controlled Low-Strength Material"
    - ASTM D6103, "Standard Test Method for Flow Consistency of Controlled Low Strength Material (CLSM)"
    - ASTM D6023, "Standard Test Method for Unit Weight, Yield, Cement Content, and Air Content (Gravimetric) of Controlled Low Strength Material (CLSM)"
  - Lime Stabilized Backfill:
    - ASTM D6236, "Standard Guide for Coring and Logging Cement- or Lime-Stabilized Soil"
    - ASTM D3551-02, "Standard Practice for Laboratory Preparation of Soil-Lime Mixtures Using a Mechanical Mixer"

XXXX.4. Measurement. This Item will be measured by the cubic yard of material placed. Measurement will not include additional volume caused by slips, slides, or cave-ins resulting from the Contractor's operations.

XXXX.5. Payment. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Cement Stabilized Backfill," "Flowable Backfill," or "Lime Stabilized Backfill." This price is the incremental price above the price for conventional backfill, which, according to Item 400, "Excavation and Backfill for Structures," is considered subsidiary to the installation of the structure in question.

Table 6. Proposed Specification: Trench Excavation Protection.

Specification Number	402	
Specification Title	Trench Excavation Protection	
Description	Furnish and place excavation protection for trenches deeper than 5 ft.	
Previous Specifications	2004 Item 402, "Trench Excavation Protection."	
Proposed Changes	Modify current standard specification to clarify that protection will be needed not just to satisfy Occupational Safety and Health Administration (OSHA) requirements but also, in general, whenever there is a technical reason (e.g., presence of other utilities, excavation next to the ROW line).	
Comment		
Bid Item		**Measurement Unit**
Trench Excavation Protection		Foot

Specification Requirements

402.2. Construction. Replace paragraph with the following: "Provide vertical or sloped cuts, benches, shields, support systems, or other systems providing the necessary protection in accordance with OSHA regulations, 29 C.F.R. 1926, Subpart P – Excavations. Protect the stability of adjoining buildings, walls, sidewalks, pavements, other structures, or when excavating close to the right of way line."

Open-Trench Conduit Structures

Table 7. Proposed Specification: Open-Trench Conduit Structures.

Specification Number	XXXX
Specification Title	Open-Trench Conduit Structures
Description	Furnish and install open-trench conduit structures
Previous Specifications	Several, including: 2004 Special Specification 6076, "Multi-Duct Conduit System." 2004 Special Specification 6100, "Multi-Duct Conduit System." 2004 Special Specification 6214, "Multi-Duct Conduit System." 2004 Special Specification 6139, "Duct Bank for Surveillance, Communication, and Control (SC&C)." 2004 Special Specification 6563, "Duct Bank for Surveillance, Communication, and Control (SC&C)." 1993 Special Specification 5970, "Southwestern Bell Telephone Underground Telephone." 1993 Special Specification 5732, "Underground Telephone Systems." 2004 Item 618, "Conduit."
Proposed Changes	Create new specification for open-trench conduit structures.
Comment	

Bid Item	Measurement Unit
Open-Trench Conduit Structure (PVC) (several combinations of number of conduits and conduit diameter)	Foot
Open-Trench Conduit Structure (PE) (several combinations of number of conduits and conduit diameter)	Foot
Open-Trench Conduit Structure (HDPE) (several combinations of number of conduits and conduit diameter)	Foot
Open-Trench Conduit Structure (Steel) (several combinations of number of conduits and conduit diameter)	Foot
Open-Trench Conduit Structure (Aluminum) (several combinations of number of conduits and conduit diameter)	Foot
Inner Duct (several materials) (several diameters)	Foot
Note to Specification Writer: Add other pay items as indicated on the plans or other design documents.	
Note to Specification Writer: Denote conduit structures according to the number and diameter of conduits that form the structure. For example, a 1x4 conduit structure contains one four-inch diameter conduit. A 12x4 conduit structure contains 12 four-inch diameter conduits. Similarly, a 12x4, 6x2 conduit structure contains 18 conduits: 12 four-inch diameter conduits and six two-inch diameter conduits.	
Note to Specification Writer: Measure and pay for each inner duct separately according to the material, diameter, and length of the inner duct.	

Table 7. Proposed Specification: Open-Trench Conduit Structures (Continued).

Subsidiary Item	Referenced Item	Subsidiary to
Structural Excavation (Pipes)	400, 401	Conduit structure installation
Bedding	400	Conduit structure installation
Spacers		Conduit structure installation
Fittings		Conduit structure installation
Non-Metallic Detection System		Conduit structure installation
Backfill	400	Conduit structure installation
Manhole or Vault Modification		Conduit structure installation
Conduit Testing		Conduit structure installation
CIP Trench Cap (Concrete)	XXXX	Open-Trench Pipe Encasement
CIP Encasement (Concrete)	XXXX	Open-Trench Pipe Encasement
Note to Specification Writer: Manhole or vault modifications are assumed to be relatively minor. Major modifications would likely require removing the old structure and installing a new one.		
Note to Specification Writer: Add other subsidiary items as indicated on the plans or as required by this specification.		

Specification Requirements

XXXX.1. Description. Furnish and install open-trench conduit structures. ***Note to Specification Writer*:** Include appropriate references to definitions from Table 3 to facilitate the understanding of basic specification concepts (e.g., conduit, inner duct, conduit structure).

XXXX.2. Materials. ***Note to Specification Writer*:** The material standards listed here may not be applicable for every installation.

A. General Standards and Rules. Applicable standards and rules include the following:

1. Standards. Applicable standards and guidelines include the following:

- NEMA TCB 2, "Guidelines for the Selection and Installation of Underground Nonmetallic Duct"
- NEMA TC 13, "Electrical Nonmetallic Tubing"
- TAC Title 43, Part 1, Chapter 21, Subchapter C
- Telcordia GR-356, "Generic Requirements for Optical Cable Innerduct and Accessories"
- UL 514B, "Conduit, Tubing, and Cable Fittings"

- RUS 1751F-642, “Construction Route Planning of Buried Plant”
- RUS 1751F-643, “Underground Plant Design”

B. Conduit (PVC).

1. Standards. Applicable standards include the following:

- ASTM D1785, “Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120”
- ASTM D2239, “Standard Specification for Polyethylene (PE) Plastic Pipe (SIDR-PR) Based on Controlled Inside Diameter”
- ASTM D2447, “Standard Specification for Polyethylene (PE) Plastic Pipe, Schedules 40 and 80, Based on Outside Diameter”
- ASTM D3035, “Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter”
- ASTM D2657, “Standard Practice for Heat Fusion Joining of Polyolefin Pipe and Fittings”
- ASTM D2683, “Standard Specification for Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing”
- ASTM D3350, “Standard Specification for Polyethylene Plastics Pipe and Fittings Materials”
- ASTM F2176, “Standard Specification for Mechanical Couplings Used on Polyethylene Conduit, Duct and Innerduct”
- NEMA TCB 2, “Guidelines for the Selection of Underground Nonmetallic Duct”
- NEMA TC 2, “Electrical Polyvinyl Chloride (PVC) Tubing and Conduit”
- NEMA TC 3, “Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing”
- NEMA TC6&8, “Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installations”
- NEMA TC 9, “Fittings for Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installations”
- NEMA TC 18, “Packaging of Master Bundles for EPC-40 Polyvinyl Chloride (PVC) Conduit”
- UL 651, “Standard for Schedule 40 and 80 Rigid PVC Conduit and Fittings”

C. Conduit (PE)

1. Standards. Applicable standards include the following:

- ASTM D2737, “Standard Specification for Polyethylene (PE) Plastic Tubing”
- ASTM D3485, “Standard Specification for Smooth-Wall Coilable Polyethylene (PE) Conduit (Duct) for Preassembled Wire and Cable”

- NEMA TC 7, “Smooth Wall Coilable Polyethylene Electrical Plastic Duct”

D. Conduit (HDPE)

1. **Standards.** Applicable standards include the following:
   - ASTM F2160, “Standard Specification for Solid Wall High Density Polyethylene (HDPE) Conduit Based on Controlled Outside Diameter (OD)”
   - UL651A, “Type EB and A Rigid PVC Conduit and HDPE Conduit”
   - UL 651B, “Continuous Length HDPE Conduit”

E. Conduit (Steel)

1. **Standards.** Applicable standards include the following:
   - ANSI/NEMA FB 1, “Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable”
   - ANSI C80.1, “American National Standard for Electric Rigid Steel Conduit (ERSC)”
   - ANSI C80.3, “American National Standard for Steel Electrical Metallic Tubing (EMT)”
   - ANSI C80.6, “American National Standard for Intermediate Metal Conduit (EIMC)”
   - ASTM A90/A90M, “Standard Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings”
   - NEMA FB 2.20, “Selection and Installation Guidelines for Fittings for Use with Flexible Electrical Conduit and Cable”
   - NEMA RN 2, “Packaging of Master Bundles for Steel Rigid Conduit, Intermediate Metal Conduit (IMC), and Electrical Conduit”
   - UL 1, “Flexible Metal Conduit”
   - UL 6, “Electrical Rigid Metal Conduit – Steel”
   - UL 797, “Electrical Metallic Tubing – Steel”
   - UL 1242, “Electrical Intermediate Metal Conduit – Steel”

F. Conduit (Aluminum)

1. **Standards.** Applicable standards include the following:
   - ANSI C80.5, “American National Standard for Electrical Rigid Aluminum Conduit (ERAC)
   - UL 1, “Flexible Metal Conduit”
   - UL 6A, “Electrical Rigid Metal Conduit – Aluminum, Red Brass, and Stainless Steel”
   - UL 797A, “Electrical Metallic Tubing – Aluminum”

G. Nonmetallic Conduit Detection System. Provide a nonmetallic conduit detection method as shown on the plans.

H. Inspections. Provide facilities and access to allow for inspection. Provide access for inspection of conduit and inner ducts at the project site before and during installation.

I. Rejections.

1. List causes for rejection of individual sections of conduit or inner ducts including fractures, cracks, and damaged ends where such damage would prevent making a satisfactory joint.
2. Allow access for the marking of rejected conduit. The Engineer will plainly mark rejected conduit or inner ducts by painting colored spots. Remove the rejected conduit or inner ducts from the project and replace with conduit or inner ducts meeting the requirements of this item.

J. Anchorage. Use conduit structure anchorage as specified on the plans.

K. Bedding Material. Furnish bedding in accordance with Item 400, "Excavation and Backfill for Structures."

L. Backfill Material. Furnish conventional backfill material in accordance with Item 400, "Excavation and Backfill for Structures," or select backfill in accordance with Special Specification XXXX, "Select Backfill for Structures," as specified on the plans.

XXXX.3. Construction.

A. Excavation, Shaping, Bedding, and Backfill. Excavate, shape, bed, and backfill in accordance with Item 400, "Excavation and Backfill for Structures," and Special Specification XXXX, "Select Backfill for Structures," except as described below:

1. Do not excavate more than the maximum length ahead of backfilling operations, as shown on the plans or as approved by the Engineer.
2. Protect adjacent property and infrastructure in accordance with Item 402, "Trench Excavation Protection," if excavation is deeper than five feet.

B. Installing Conduit.

1. **Standards.** Applicable standards include the following:
   - ASTM D2321, "Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications"
   - ASTM D3839, "Standard Guide for Underground Installation of Fiberglass (Glass-FiberReinforced Thermosetting-Resin) Pipe"
   - ASTM F1056, "Standard Specification for Socket Fusion Tools for Use in Socket Fusion Joining Polyethylene Pipe or Tubing and Fittings"
   - ASTM F1290, "Standard Practice for Electrofusion Joining Polyolefin Pipe and Fittings"
   - IEEE 776, "Recommended Practice for Inductive Coordination of Electric Supply and Communication Lines"

- NEMA FB 2.10, "Selection and Installation Guidelines for Fittings for Use with Non-flexible Electrical Metal Conduit or Tubing (Rigid Metal Conduit, Intermediate Metal Conduit, and Electrical Metallic Tubing)"
- NEMA TCB 2, "Guidelines for the Selection and Installation of Underground Nonmetallic Duct"
- NEMA TCB 3, "User's Manual for the Installation of Underground Corrugated Coilable Plastic Utility Duct"
- RUS 1751F-644, "Underground Plant Construction"
- RUS 1753F-151, "Specification and Drawings for Construction of Underground Plant"

2. General.

- Request prior approval from the Engineer for any deviations in alignment that may be necessary due to obstructions or other design constraints not shown on the plans.
- Unless the Engineer specifies a more stringent requirement, do not exceed a maximum tolerance with respect to approved plans of 0.5 foot (horizontal) and 0.1 foot (vertical). ***Note to Specification Writer***: The TxDOT Survey Manual (*26*) and the Texas Society of Professional Surveyors (TSPS) Manual of Practice for Land Surveying in the State of Texas (*27*) provide additional information regarding construction surveying horizontal and accuracy requirements. Notice that these construction tolerances are not the same as tolerances used for design surveying. For example, for design surveying, the TxDOT Survey Manual and the TSPS Manual of Practice specify a maximum tolerance of 0.5 foot (horizontal) and 0.05 foot (vertical) for urban environments, and 1 foot (horizontal) and 0.1 foot (vertical) for rural environments.
- Measure and record "as-built" horizontal and vertical alignment at no more than every 100 feet on the on-site recorded plans, including any changes the Engineer approves. Provide as-built plans or certified as-installed construction plans in accordance with TAC Title 43, Part 1, Chapter 21, Subchapter C.
- Where plans show curves without special fittings do not exceed maximum deflection amounts recommended by the conduit manufacturer.
- Do not lay more than 50 feet of conduit in the trench ahead of backfilling operations.
- Unload conduit, fittings, and accessories at the point of delivery and haul to the site of the project. Position the material such that water or runoff does not enter or pass through the conduit. Do not skid or roll conduit handled on skidways against conduit already on the ground.
- When laying conduit is not in progress, close the open end of the conduit in the trench with a watertight plug or similar device approved by the Engineer.
- Label conduit as indicated on the plans.

C. **Installing Inner Duct.**

1. **Standards.**

- IEEE 1210, "Standard Tests for Determining Compatibility of Cable Pulling Lubricants with Wire and Cable"

2. **General.**

- Install inner duct as shown on the plans or as approved by the Engineer.
- Furnish a plan for approval describing the proposed method of inner duct construction, including equipment setup and structural support, construction schedule, and testing procedures.

D. **Testing.** Perform mandrel tests as shown on the plans or as approved by the Engineer. As required by the Engineer, repair or replace conduits at no additional cost whenever the mandrel test fails. ***Note to Specification Writer***: RUS 1751F-644, "Underground Plant Construction," includes specific requirements for mandrel tests. NEMA TCB 2, "Guidelines for the Selection and Installation of Underground Nonmetallic Duct," provides additional information.

XXXX.4. Measurement. This Item will be measured by the foot along the centerline of conduit structure or inner duct from center to center of fittings, ground boxes, manholes, or vaults. Conduit structure or inner duct will not be classified for measurement according to the depth of the trench.

XXXX.5. Payment. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Open-Trench Conduit Structure" of the type and size specified or "Inner Duct" of the type and size specified (see Table 7). All other items are considered subsidiary.

Aboveground Conduit Structures

Table 8. Proposed Specification: Aboveground Conduit Structures.

Specification Number	XXXX
Specification Title	Aboveground Conduit Structures
Description	Furnish and install aboveground conduit structures
Previous Specifications	Several, including: 2004 Special Specification 6144, "Multi-Duct Conduit System." 2004 Item 618, "Conduit."
Proposed Changes	Create new specification for aboveground conduit structures.
Comment	

Bid Item	**Measurement Unit**
Aboveground Conduit Structure (PVC) (several combinations of number of conduits and conduit diameter)	Foot
Aboveground Conduit Structure (PE) (several combinations of number of conduits and conduit diameter)	Foot
Aboveground Conduit Structure (HDPE) (several combinations of number of conduits and conduit diameter)	Foot
Aboveground Conduit Structure (Steel) (several combinations of number of conduits and conduit diameter)	Foot
Aboveground Conduit Structure (Fiberglass) (several combinations of number of conduits and conduit diameter)	Foot
Note to Specification Writer: Add other pay items as indicated on the plans or other design documents.	
Note to Specification Writer: Denote conduit structures according to the number and diameter of conduits that form the structure. For example, a 1x4 conduit structure contains one four-inch diameter conduit. A 12x4 conduit structure contains 12 four-inch diameter conduits. Similarly, a 12x4, 6x2 conduit structure contains 18 conduits: 12 four-inch diameter conduits and six two-inch diameter conduits.	
Note to Specification Writer: Measure and pay for each inner duct separately according to the material, diameter, and length of the inner duct.	

Subsidiary Item	**Referenced Item**	**Subsidiary to**
Spacers		Conduit structure installation
Hangers		Conduit structure installation
Expansion joints		Conduit structure installation
Fittings		Conduit structure installation
Conduit Testing		Conduit structure installation
Note to Specification Writer: Add other subsidiary items as indicated on the plans or as required by this specification.		

Specification Requirements

XXXX.1. Description. Furnish and install aboveground conduit structures. ***Note to Specification Writer*:** Include appropriate references to definitions from Table 3 to facilitate the understanding of basic specification concepts (e.g., conduit, inner duct, and conduit structure).

XXXX.2. Materials. ***Note to Specification Writer*:** The material standards listed here may not be applicable for every installation.

A. General Standards and Rules. Applicable standards and rules include the following:

1. **Standards.** Applicable standards include the following:
   - TAC Title 43, Part 1, Chapter 21, Subchapter C
2. **General**. Provide aboveground conduit materials that are resistant to ultraviolet (UV) damage.

B. Conduit (PVC).

1. **Standards.** Applicable standards include the following:
   - ASTM D1785, "Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120"
   - ASTM D2239, "Standard Specification for Polyethylene (PE) Plastic Pipe (SIDR-PR) Based on Controlled Inside Diameter"
   - ASTM D2447, "Standard Specification for Polyethylene (PE) Plastic Pipe, Schedules 40 and 80, Based on Outside Diameter"
   - ASTM D3035, "Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter"
   - ASTM D2657, "Standard Practice for Heat Fusion Joining of Polyolefin Pipe and Fittings"
   - ASTM D2683, "Standard Specification for Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing"
   - ASTM D3350, "Standard Specification for Polyethylene Plastics Pipe and Fittings Materials"
   - ASTM F2176, "Standard Specification for Mechanical Couplings Used on Polyethylene Conduit, Duct and Innerduct"
   - NEMA TC 2, "Electrical Polyvinyl Chloride (PVC) Tubing and Conduit"
   - NEAM TC 3, "Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing"
   - NEMA TC 18, "Packaging of Master Bundles for EPC-40 Polyvinyl Chloride (PVC) Conduit"
   - UL 651, "Standard for Schedule 40 and 80 Rigid PVC Conduit and Fittings"

C. **Conduit (PE)**

1. **Standards.** Applicable standards include the following:

- ASTM D2737, "Standard Specification for Polyethylene (PE) Plastic Tubing"
- ASTM D3485, "Standard Specification for Smooth-Wall Coilable Polyethylene (PE) Conduit (Duct) for Preassembled Wire and Cable"
- NEMA TC 7, "Smooth Wall Coilable Polyethylene Electrical Plastic Duct"

D. **Conduit (HDPE)**

1. **Standards.** Applicable standards include the following:

- ASTM F2160, "Standard Specification for Solid Wall High Density Polyethylene (HDPE) Conduit Based on Controlled Outside Diameter (OD)"
- UL651A, "Type EB and A Rigid PVC Conduit and HDPE Conduit"
- UL 651B, "Continuous Length HDPE Conduit"

E. **Conduit (Steel)**

1. **Standards.** Applicable standards include the following:

- ANSI/NEMA FB 1, "Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable"
- ANSI C80.1, "American National Standard for Electric Rigid Steel Conduit (ERSC)"
- ANSI C80.3, "American National Standard for Steel Electrical Metallic Tubing (EMT)"
- ANSI C80.6, "American National Standard for Intermediate Metal Conduit (EIMC)"
- ASTM A90/A90M, "Standard Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings"
- NEMA FB 2.20, "Selection and Installation Guidelines for Fittings for Use with Flexible Electrical Conduit and Cable"
- NEMA RN 2, "Packaging of Master Bundles for Steel Rigid Conduit, Intermediate Metal Conduit (IMC), and Electrical Tubing"
- UL 1, "Flexible Metal Conduit"
- UL 6, "Electrical Rigid Metal Conduit – Steel"
- UL 797, "Electrical Metallic Tubing – Steel"
- UL 1242, "Electrical Intermediate Metal Conduit – Steel"

F. Conduit (Fiberglass)

1. **Standards.** Applicable standards include the following:
   - ASTM D2996, "Standard Specification for Filament-Wound Fiberglass (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe"
   - ASTM D2310, "Standard Classification for Machine-Made Fiberglass (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe"
   - ASTM D2517, "Standard Specification for Reinforced Epoxy Resin Gas Pressure Pipe and Fittings"

G. Inspections. Provide facilities and access to allow for inspection. Provide access for inspection of conduit and inner ducts at the project site before and during installation.

H. Rejections.

1. List causes for rejection of individual sections of conduit or inner ducts including fractures, cracks, and damaged ends where such damage would prevent making a satisfactory joint.
2. Allow access for the marking of rejected conduit. The Engineer will plainly mark rejected conduit or inner ducts by painting colored spots. Remove the rejected conduit or inner ducts from the project and replace with conduit or inner ducts meeting the requirements of this item.

I. Anchorage. Use conduit structure anchorage as specified on the plans.

XXXX.3. Construction.

A. Installing Conduit.

1. **Standards.** Applicable standards include the following:
   - ASTM F1056, "Standard Specification for Socket Fusion Tools for Use in Socket Fusion Joining Polyethylene Pipe or Tubing and Fittings"
   - ASTM F1290, "Standard Practice for Electrofusion Joining Polyolefin Pipe and Fittings"
   - IEEE 776, "Recommended Practice for Inductive Coordination of Electric Supply and Communication Lines"
   - NEMA FB 2.10, "Selection and Installation Guidelines for Fittings for Use with Non-flexible Electrical Metal Conduit or Tubing (Rigid Metal Conduit, Intermediate Metal Conduit, and Electrical Metallic Tubing)"
   - RUS 1753F-151, "Specifications and Drawings for Construction of Underground Plant"
2. **General.**
   - Request prior approval from the Engineer for any deviations in alignment that may be necessary due to obstructions or other design constraints not shown on the plans.

- Unless the Engineer specifies a more stringent requirement, do not exceed a maximum tolerance with respect to approved plans of 0.5 foot (horizontal) and 0.1 foot (vertical). ***Note to Specification Writer***: The TxDOT Survey Manual and the TSPS Manual of Practice for Land Surveying in Texas provide additional information regarding construction surveying horizontal and accuracy requirements. Notice that these construction tolerances are not the same as tolerances used for design surveying. For example, for design surveying, the TxDOT Survey Manual and the TSPS Manual of Practice specify a maximum tolerance of 0.5 foot (horizontal) and 0.05 foot (vertical) for urban environments, and 1 foot (horizontal) and 0.1 foot (vertical) for rural environments.
- Ensure horizontal and vertical clearances are in accordance with TAC Title 43, Part 1, Chapter 21, Subchapter C.
- Measure and record "as-built" horizontal and vertical alignment at no more than every 100 feet on the on-site recorded plans, including any changes the Engineer approves. Provide as-built plans or certified as-installed construction plans in accordance with TAC Title 43, Part 1, Chapter 21, Subchapter C.
- Where plans show curves without special fittings do not exceed maximum deflection amounts recommended by the conduit manufacturer.
- Unload conduit, fittings, and accessories at the point of delivery and haul to the site of the project. Position the material such that water or runoff does not enter or pass through the conduit. Do not skid or roll conduit handled on skidways against conduit already on the ground.
- Label conduit as indicated on the plans.

B. Installing Inner Duct. Install inner duct in accordance with Item XXXX, "Open-Trench Conduit Structure."

C. Testing. Perform mandrel tests as shown on the plans or as approved by the Engineer. As required by the Engineer, repair or replace conduits at no additional cost whenever the mandrel does not pass through. ***Note to Specification Writer***: RUS 1751F-644, "Underground Plant Construction," includes specific requirements for mandrel tests. NEMA TCB 2, "Guidelines for the Selection and Installation of Underground Nonmetallic Duct," provides additional information.

XXXX.4. Measurement. This Item will be measured by the foot along the centerline of the aboveground conduit structure from center to center of fittings, boxes, manholes, or vaults.

XXXX.5. Payment. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Aboveground Conduit Structure" of the type and size specified (see Table 8). All other items are considered subsidiary. ***Note to Specification Writer:*** Inner duct installed in aboveground conduit will be paid for under the bid item "Inner Duct" of the type and size specified in Item XXXX, "Open-Trench Conduit Structure" (see Table 7).

Trenchless Pipes, Conduit Structures, and Box Culverts

Table 9. Proposed Specification: Trenchless Pipes, Conduit Structures, and Box Culverts.

Specification Number	XXXX
Specification Title	Trenchless Pipes, Conduit Structures, and Box Culverts
Description	Furnish and install pipes, conduit structures, and box culverts using trenchless construction or renewal methods.
Previous Specifications	Several, including: 2004 Item 476, "Jacking, Boring, or Tunneling Pipe or Box." 1993 Special Specification 3633, "Horizontal Directional Drilling." 1993 Special Specification 3666, "Boring 3 Inch PVC." 1993 Special Specification 4882, "Horizontal Directional Drilling." 1993 Special Specification 5885, "Water and Sanitary Sewer Systems." 1993 Special Specification 4059, "Jacking or Boring Concrete Box Culverts." 1993 Special Specification 4783, "Jacking or Boring Concrete Box Culverts." 1995 Special Specification 5368, "Boring, Jacking, and Tunneling."
Proposed Changes	Create new specification that addresses limitations of Item 476, "Jacking, Boring, or Tunneling Pipe or Box." Expand scope of Item 476 to include water, sewer, and telecommunication installations. Create specification that reflects recent trends in trenchless construction and renewal methods. Include requirements for horizontal auger boring (HAB), horizontal directional drilling (HDD), ramming (R), microtunneling (MT), jacking (J), tunneling (T), cured in place pipe (CIPP), folded pipe (FP), coating or lining (CL), sliplining (SL), plowing (PW), and pipe replacement (PR). Use "horizontal auger boring" instead of "jack and bore."
Comment	Specification describes trenchless construction and renewal methods.

Bid Item	**Measurement Unit**
Water Pipe (Ductile Iron) (MT) (several diameters)	Foot
Water Pipe (Ductile Iron) (HDD) (several diameters)	Foot
Water Pipe (Steel) (HAB) (several diameters)	Foot
Water Pipe (Steel) (HDD) (several diameters)	Foot
Water Pipe (Steel) (MT) (several diameters)	Foot
Water Pipe (Steel) (R) (several diameters)	Foot
Water Pipe (PVC) (HDD) (several diameters)	Foot
Water Pipe (PVC SDR) (HDD) (several diameters)	Foot
Water Pipe (HDPE) (HDD) (several diameters)	Foot
Gravity Sanitary Sewer Pipe (Reinforced Concrete) (HAB) (several diameters)	Foot

Table 9. Proposed Specification: Trenchless Pipes, Conduit Structures, and Box Culverts (Continued).

Bid Item	Measurement Unit
Gravity Sanitary Sewer Pipe (Reinforced Concrete) (MT) (several diameters)	Foot
Gravity Sanitary Sewer Pipe (PVC) (HDD) (several diameters)	Foot
Gravity Sanitary Sewer Pipe (PE) (HDD) (several diameters)	Foot
Gravity Sanitary Sewer Pipe (Vitrified Clay) (MT) (several diameters)	Foot
Pressure Sanitary Sewer Pipe (Ductile Iron) (MT) (several diameters)	Foot
Pressure Sanitary Sewer Pipe (Ductile Iron) (HDD) (several diameters)	Foot
Pressure Sanitary Sewer Pipe (PVC) (HDD) (several diameters)	Foot
Concrete Box Culvert (T) (several diameters)	Foot
Concrete Box Culvert (J) (several diameters)	Foot
Water Pipe Renewal (CIPP) (several diameters)	Foot
Water Pipe Renewal (FP) (several diameters)	Foot
Water Pipe Renewal (CL) (several diameters)	Foot
Water Pipe Renewal (SL) (several diameters)	Foot
Water Pipe Renewal (PR) (several diameters)	Foot
Gravity Sanitary Sewer Pipe Renewal (CIPP) (several diameters)	Foot
Gravity Sanitary Sewer Pipe Renewal (FP) (several diameters)	Foot
Gravity Sanitary Sewer Pipe Renewal (CL) (several diameters)	Foot
Gravity Sanitary Sewer Pipe Renewal (SL) (several diameters)	Foot
Gravity Sanitary Sewer Pipe Renewal (PR) (several diameters)	Foot
Pressure Sanitary Sewer Pipe Renewal (CIPP) (several diameters)	Foot
Pressure Sanitary Sewer Pipe Renewal (FP) (several diameters)	Foot
Pressure Sanitary Sewer Pipe Renewal (CL) (several diameters)	Foot
Pressure Sanitary Sewer Pipe Renewal (SL) (several diameters)	Foot
Pressure Sanitary Sewer Pipe Renewal (PR) (several diameters)	Foot

Table 9. Proposed Specification: Trenchless Pipes, Conduit Structures, and Box Culverts (Continued).

Bid Item		Measurement Unit
Conduit Structure (Steel) (HAB) (several combinations of number of conduits and conduit diameter)		Foot
Conduit Structure (Steel) (HDD) (several combinations of number of conduits and conduit diameter)		Foot
Conduit Structure (Steel) (R) (several combinations of number of conduits and conduit diameter)		Foot
Conduit Structure (PE) (HAB) (several combinations of number of conduits and conduit diameter)		Foot
Conduit Structure (PE) (HDD) (several combinations of number of conduits and conduit diameter)		Foot
Conduit Structure (PVC) (HDD) (several combinations of number of conduits and conduit diameter)		Foot
Conduit Structure (HDPE) (HAB) (several combinations of number of conduits and conduit diameter)		Foot
Conduit Structure (HDPE) (HDD) (several combinations of number of conduits and conduit diameter)		Foot
Conduit Structure (Aluminum) (HAB) (several combinations of number of conduits and conduit diameter)		Foot
Conduit Structure (Aluminum) (HDD) (several combinations of number of conduits and conduit diameter)		Foot
Conduit Structure (HDPE) (PW) (several conduit diameters)		Foot
Conduit Structure (PE) (PW) (several conduit diameters)		Foot
Note to Specification Writer: Add other pay items as indicated on the plans or as required by this specification.		
Note to Specification Writer: Denote conduit structures according to the number and diameter of conduits that form the structure. For example, a 1x4 conduit structure contains one four-inch diameter conduit. A 12x4 conduit structure contains 12 four-inch diameter conduits. Similarly, a 12x4, 6x2 conduit structure contains 18 conduits: 12 four-inch diameter conduits and six two-inch diameter conduits.		
Note to Specification Writer: Measure each inner duct separately according to material, diameter, and length.		
Subsidiary Item (if specified)	**Referenced Item**	**Subsidiary to**
Excavation and Backfill	400, 401	Pipe installation or renewal
Trench Excavation Projection	402	Pipe installation or renewal
Grout		Pipe installation or renewal
Steel Casing Pipe		Pipe installation or renewal
Reinforced Concrete Casing Pipe		Pipe installation or renewal
Ductile Iron Casing Pipe		Pipe installation or renewal

Table 9. Proposed Specification: Trenchless Pipes, Conduit Structures, and Box Culverts (Continued).

Casing Spacer System		Pipe installation or renewal
Renewal Liner System		Pipe renewal
Disinfection and Hydrostatic Test		Pipe installation or renewal
Manhole or Vault Modification		Pipe or conduit structure installation or renewal
Conduit Testing		Conduit installation or renewal
Note to Specification Writer: Manhole or vault modifications are assumed to be relatively minor. Major modifications would likely require removing the old structure and installing a new one.		
Note to Specification Writer: Add other subsidiary items as indicated on the plans or as required by this specification.		Pipe installation or renewal

Specification Requirements

XXXX.1. Description. Furnish and install pipes, conduit structures, and box culverts using trenchless construction or renewal methods. ***Note to Specification Writer*:** Include appropriate references to definitions from Table 3 to facilitate the understanding of basic specification concepts (e.g., conduit, inner duct, conduit structure).

XXXX.2. Materials. ***Note to Specification Writer*:** The list of material standards in this section is not comprehensive. See, for example, ASTM's publication *ASTM Standards Related to Trenchless Technology* (*28*) for a more comprehensive listing of standards related to trenchless technology.

A. Carrier Pipe, Conduit Structure, Inner Duct, or Box Culvert.

1. Standards. Applicable standards and specifications include the following:

- Water pipe: Special Specification XXXX, "Open-Trench Water Pipe" (*7*)
- Gravity sanitary sewer: Special Specification XXXX, "Open-Trench Gravity Sanitary Sewer Pipe" (*7*)
- Pressure sanitary sewer: Special Specification XXXX, "Open-Trench Pressure Sanitary Sewer Pipe" (*7*)
- Conduit structure: Special Specification XXXX, "Open-Trench Conduit Structure"
- Inner Duct and Accessories: Special Specification XXXX, "Open-Trench Conduit Structure"

- Concrete box culvert: Item 462, “Concrete Box Culverts and Storm Drains”
  Note to Specification Writer: Item 462 may benefit from the addition of the following standards:

  (1) ASTM C1433-04e1, “Standard Specification for Precast Reinforced Concrete Box Sections for Culverts, Storm Drains, and Sewers”

B. Steel Casing Pipe.

1. Standards. Applicable standards include the following:

- AWWA C200, “Steel Water Pipe 6 In. (150 mm) and Larger”
- AWWA C207, “Steel Pipe Flanges for Waterworks Service, Sizes 4 In. Through 144 In. (100 mm Through 3,600 mm)”
- AWWA C208, “Dimensions for Fabricated Steel Water Pipe Fittings”
- AWWA C214, “Tape Coating Systems for the Exterior of Steel Water Pipelines”
- ASTM A139, “Standard Specification for Electric-Fusion (Arc)-Welded Steel Pipe (NPS 4 and Over)”
- ASTM A36, “Standard Specification for Carbon Structural Steel”
- ASTM A572, “Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel”
- ASTM A283, “Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates”

C. Ductile Iron Casing Pipe.

1. Standards. Applicable standards include the following:

- AWWA C150, “Thickness Design of Ductile Iron Pipe”
- AWWA C151, “Ductile-Iron Pipe, Centrifugally Cast for Water or Other Liquids”
- ASTM A716, “Standard Specification for Ductile Iron Culvert Pipe”
- ASTM A746, “Standard Specification for Ductile Iron Gravity Sewer Pipe”

D. Reinforced Concrete Pipe.

1. Standards. Applicable standards and specifications include the following:

- ASCE 27-00, “Standard Practice for Direct Design of Precast Concrete Pipe for Jacking in Trenchless Construction”
- ASTM C76, “Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe”
- ASTM C1417, “Manufacture of Reinforced Concrete Sewer, Storm Drain, and Culvert Pipe for Direct Design”
- ASTM C497, “Standard Test Methods for Concrete Pipe, Manhole Sections, or Tile”
- ASTM C443, “Joints for Circular Concrete Sewer and Culvert Pipe”

- Item 464, “Reinforced Concrete Pipe”

E. Cured in Place Pipe.

1. Standards. Applicable standards include the following:

- ASTM D638, “Standard Test Method for Tensile Properties of Plastics”
- ASTM D790, “Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials”

F. Vitrified Clay Pipe.

1. Standards. Applicable standards include the following:

- ASTM C1208, “Standard Specification for Vitrified Clay Pipe and Joints for Use in Microtunneling, Sliplining, Pipe Bursting, and Tunnels”

G. Folded Pipe.

1. Standards. Applicable standards include the following:

- ASTM F1504, “Standard Specification for Folded Poly (Vinyl Chloride) (PVC) Pipe for Existing Sewer and Conduit Rehabilitation”
- ASTM F1871, “Standard Specification for Folded/Formed Poly (Vinyl Chloride) Pipe Type A for Existing Sewer and Conduit Rehabilitation”

H. Sliplining.

1. Standards. Applicable standards include the following:

- ASTM F1735, “Standard Specification for Poly (Vinyl Chloride) (PVC) Profile Strip for PVC Liners for Rehabilitation of Existing Man-Entry Sewers and Conduits”
- ASTM F1697, “Standard Specification for Poly (Vinyl Chloride) (PVC) Profile Strip for Machine Spiral-Wound Liner Pipe Rehabilitation of Existing Sewers and Conduits”

I. Casing Spacer System. Provide a casing spacer system that meets the performance requirements shown on the plans or as approved by the Engineer. At a minimum, provide a casing spacer system that protects the carrier pipe from corrosion from spacer bands and provides shock protection to the carrier pipe.

J. Joints. Provide joints as shown on the plans.

K. Non-metallic pipe detection. Provide a method approved by the Engineer or as shown on the plans for detecting nonmetallic pipes.

L. Inspections. Provide facilities and access to allow for inspection. Provide access for inspection of the finished pipe at the project site before and during installation.

M. Rejections.

1. List causes for rejection of individual sections of pipe including fractures, cracks, and damaged ends where such damage would prevent making a satisfactory joint.
2. Allow access for the marking of rejected pipe. The Engineer will plainly mark rejected pipe by painting colored spots. Remove the rejected pipe from the project and replace with pipe meeting the requirements of this item.

XXXX.3. Construction.

A. General.

1. The Engineer will make available to the Contractor a geotechnical baseline report that contains a project description, available existing information, geology description, geologic profile, groundwater conditions, and contaminant information.
2. Furnish any information required to update any data concerning the geotechnical condition of the location after installation.
3. Furnish a plan for approval describing the proposed method of trenchless construction or renewal, including location of bore pits, equipment setup and structural support, construction schedule, proposed line profile in the case of horizontal directional drilling, and horizontal and vertical control method and expected accuracies.
4. Install casing pipe within horizontal and vertical tolerances to ensure the carrier pipe will comply with required tolerances in accordance with the corresponding item specification.
5. Ensure casing pipe and carrier pipe comply with cover depth requirements in accordance with TAC Title 43, Part 1, Chapter 21, Subchapter C.
6. Measure and record "as-built" horizontal and vertical alignment at no more than every 100 feet on the on-site recorded plans, including any changes the Engineer approves. Provide as-built plans or certified as-installed construction plans in accordance with TAC Title 43, Part 1, Chapter 21, Subchapter C.

B. Excavation and Backfill.

1. Excavate and backfill shafts, bore pits, or trenches in accordance with Item 400, "Excavation and Backfill for Structures"; Special Specification XXXX, "Select Backfill for Structures"; and Item 402, "Trench Excavation Protection."

C. Horizontal Auger Boring.

1. **Standards.** Applicable standards/guidelines include the following:
   - ASCE Manuals and Reports on Engineering Practice No. 106, "Horizontal Auger Boring Projects"
2. **General.** ***Note to Specification Writer***: Use appropriate text from current Item 476, Article 476.3 (B).

D. Horizontal Directional Drilling.

1. **Standards.** Applicable standards/guidelines include the following:

- ASCE Manuals and Reports on Engineering Practice No. 108, “Pipeline Design for Installation by Horizontal Directional Drilling”
- ASTM F1962, “Standard Guide for Use of Maxi-Horizontal Directional Drilling for Placement of Polyethylene Pipe or Conduit Under Obstacles, Including River Crossings”

E. Microtunneling.

1. **Standards.** Applicable standards/guidelines include the following:
   - CI/ASCE 36-01, “Standard Construction Guidelines for Microtunneling”
   - ASTM A36, “Carbon Structural Steel (for Steel Ribs)”
   - ASTM D198, “Static Tests of Lumber in Structural Sizes (for lagging)”
   - UFGS 33 05 23.19, “Trenchless Excavation Using Microtunneling”

F. Pipe Ramming.

1. **Standards.** Applicable standards/guidelines include the following:
   - ASCE pipe ramming manual of practice (expected for publication in 2007).
   - Trenchless Technology Center (TTC) Technical Report #2001.04, “Guidelines for Pipe Ramming”

G. Jacking.

1. **Standards**. Applicable standards include the following:
   - ASCE 27-00, “Standard Practice for Direct Design of Precast Concrete Pipe for Jacking in Trenchless Construction”
2. **General.** ***Note to Specification Writer***: Use text from current Item 476, Article 476.3 (A).

H. Tunneling.

1. **General.** ***Note to Specification Writer***: Use text from current Item 476, Article 476.3 (C).

I. Cured in Place Pipe.

1. **Standards.** Applicable standards include the following:
   - ASTM F2019, “Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Pulled in Place Installation of Glass Reinforced Plastic (GRP) Cured-in-Place Thermosetting Resin Pipe”
   - ASTM D5813, “Standard Specification for Cured-in-Place Thermosetting Resin Sewer Piping Systems”
   - ASTM F1743, “Standard Practice for Rehabilitation of Existing Pipelines and Conduits by Pulled-in-Place Installation of Cured-in-Place Thermosetting Resin Pipe”

- ASTM F1216, "Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of a Resin-Impregnated Tube"
- ASCE 27-00, "Standard Practice for Direct Design of Precast Concrete Pipe for Jacking in Trenchless Construction"

J. Folded Pipe.

1. Standards. Applicable standards include the following:

- ASTM F1867, "Standard Practice for Installation of Folded/Formed Poly (Vinyl Chloride) (PVC) Pipe Type A for Existing Sewer and Conduit Rehabilitation"
- ASTM F1947, "Standard Practice for Installation of Folded Poly (Vinyl Chloride) (PVC) Pipe into Existing Sewers and Conduits"

K. Sliplining.

1. Standards. Applicable standards include the following:

- ASTM F1741, "Standard Practice for Installation of Machine Spiral Wound Poly (Vinyl Chloride) (PVC) Liner Pipe for Rehabilitation of Existing Sewers and Conduits"

L. Pipe Replacement.

1. Standards. Applicable standards/guidelines include the following:

- ASCE pipe bursting manual of practice (expected for publication in 2007).
- Trenchless Technology Center (TTC) Technical Report #2001.02, "Guidelines for Pipe Bursting"

M. Plowing.

1. Standards. Applicable standard/guidelines include the following:

- Plastic Pipe Institute, "Handbook of Polyethylene Pipe"

N. Carrier Pipe, Conduit Structure, or Box Culvert Installation.

1. General. Install carrier pipe or box culvert inside casing pipe within horizontal and vertical tolerances in accordance with the corresponding item specification:

- For water pipe, Special Specification XXXX, "Open-Trench Water Pipe"
- For gravity sanitary sewer pipe, Special Specification XXXX, "Open-Trench Gravity Sanitary Sewer Pipe"
- For pressure sanitary sewer pipe, Special Specification XXXX, "Open-Trench Pressure Sanitary Sewer Pipe"
- For box culverts, Special Specification XXXX, "Laying Culvert and Storm Sewer Pipe"
- For conduit structure, including inner ducts and accessories, Special Specification XXXX, "Open-Trench Conduit Structure

- For gravity reinforced concrete pipe, make the joints in accordance with Item 464, “Reinforced Concrete Pipe.”
- For reinforced concrete box, make the joints in accordance with Item 462, “Concrete Box Culverts and Storm Drains.”

2. **Disinfection.** For water pipes, conduct disinfection in accordance with Special Specification XXXX, “Open-Trench Water Pipe.”
3. **Testing.**
   - Water pipe. Conduct testing, including hydrostatic testing, as shown on the plans, Special Specification XXXX, “Open-Trench Water Pipes,” or as directed by the Engineer.
   - Gravity sanitary sewer pipe. Conduct testing as indicated on the plans, in accordance with Special Specification XXXX, “Open-Trench Gravity Sanitary Sewer Pipe,” or as directed by the Engineer.
   - Pressure sanitary sewer pipe. Conduct testing as indicated on the plans, in accordance with Special Specification XXXX, “Open-Trench Pressure Sanitary Sewer Pipe,” or as directed by the Engineer.
   - Conduit structure. Conduct testing as indicated on the plans, in accordance with Special Specification XXXX, “Open-Trench Conduit Structure,” or as approved by the Engineer.

XXXX.4. Measurement. This Item will be measured by the foot along the centerline of the pipe, conduit structure, or box culvert.

XXXX.5. Payment. The work performed and materials furnished in accordance with this Item and measured as provided under “Measurement” will be paid for at the unit price bid for “Water Pipe” of the type, method, and size specified; “Gravity Sanitary Sewer Pipe” of the type, method, and size specified; “Pressure Sanitary Sewer Pipe” of the type, method, and size specified; “Concrete Box Culvert” of the method and size specified; “Water Pipe Renewal” of the method and size specified; “Gravity Sanitary Sewer Pipe Renewal” of the method and size specified; “Pressure Sanitary Sewer Pipe Renewal” of the method and size specified; or “Conduit Structure” of the method and size specified (see Table 9). All other items are considered subsidiary. ***Note to Specification Writer:*** Inner duct installed in trenchless conduit will be paid for under the bid item “Inner Duct” of the type and size specified in Item XXXX, “Open-Trench Conduit Structure” (see Table 7).

Open-Trench Pipe and Conduit Structure Encasement

Table 10. Proposed Specification: Open-Trench Pipe and Conduit Structure Encasement.

Specification Number	XXXX
Specification Title	Open-Trench Pipe and Conduit Structure Encasement
Description	Furnish and install encasement protection for open-trench pipes and conduit structures.
Previous Specifications	Several, including: 1995 Special Specification 4259, "Trench Excavation, Embedment, Backfill and Encasement" 1993 Special Specification 4977, "Steel Casing" 1993 Special Specification 4811, "Steel Casing Pipe" 1993 Special Specification 5890, "Sanitary Sewers (Concrete Encasement)" 1993 Special Specification 5970, "Southwestern Bell Telephone Underground Telephone"
Proposed Changes	Create new specification for open-trench pipe and conduit structure encasement.
Comment	"Encasement" refers to the general action of protecting a carrier pipe or conduit structure using a rigid enclosure, e.g., cast-in-place concrete or a permanent steel plate, placed on or around the carrier pipe or conduit structure. "Casing" refers to the placement of a prefabricated pipe to protect the carrier pipe or conduit structure. This specification covers only the installation of encasement and excludes all activities related to carrier pipe or conduit structure installation such as excavation and backfill, select bedding, and trench excavation protection.

Bid Item	**Measurement Unit**
Casing Pipe (Steel) (several diameters)	Foot
Casing Pipe (Aluminized Steel) (several diameters)	Foot
Casing Pipe (Polyethylene) (several diameters)	Foot
Casing Pipe (PVC) (several diameters)	Foot
Casing Pipe (Reinforced Concrete) (several diameters)	Foot
CIP Trench Cap (Concrete)	Cubic yard
CIP Encasement (Concrete)	Cubic yard
Steel Plate	Pound
Note to Specification Writer: Add other pay items as indicated on the plans or as required by this specification.	

Subsidiary Item (if specified)	**Referenced Item**	**Subsidiary to**
Casing Spacer System		Casing pipe installation
Casing Pipe Joints		Casing pipe installation
Note to Specification Writer: Add other subsidiary items as indicated on the plans or as required by this specification.		

Specification Requirements

XXXX.1. Description. Furnish and install encasement protection for open-trench pipes and conduit structures. ***Note to Specification Writer*:** Include appropriate references to definitions from Table 3 to facilitate the understanding of basic specification concepts.

XXXX.2. Materials. ***Note to Specification Writer*:** The material standards listed here may not be applicable for every installation.

A. Steel Pipe.

1. Standards. Applicable standards include the following:

a. ASTM A36, "Standard Specification for Carbon Structural Steel"

B. Aluminized Steel Pipe.

1. Standards. Applicable standards include the following:

a. A760/A760M-06, "Standard Specification for Corrugated Steel Pipe, Metallic-Coated for Sewers and Drains"

C. Reinforced Concrete Pipe.

1. Standards. Applicable standards include the following:

- ASTM C76, "Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe"

D. Polyethylene Pipe.

1. Standards. Applicable standards include the following:

- ASTM A674-05, "Standard Practice for Polyethylene Encasement for Ductile Iron Pipe for Water or Other Liquids"
- AWWA C105/A21.5-05, "Polyethylene Encasement for Ductile-Iron Pipe Systems"

E. PVC Pipe.

1. Standards. Applicable standards include the following:

- ASTM D3034-04a, "Standard Specification for Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings"

F. Cast-in-Place Concrete Trench Cap.

1. Standards. Applicable standards include the following:

- Item 421, "Hydraulic Cement Concrete"
- RUS 1751F-644, "Underground Plant Construction"

G. Cast-in-Place Encasement Concrete.

1. Standards. Applicable standards include the following:

- Item 421, "Hydraulic Cement Concrete"

- RUS 1751F-644, “Underground Plant Construction”

H. Cast-in-Place Encasement Concrete.

1. **Standards.** Applicable standards include the following:
    - Item 421, “Hydraulic Cement Concrete”
    - RUS 1751F-644, “Underground Plant Construction”

I. Steel Plate. Furnish steel plate in accordance with Item 442, “Metal for Structures,” as shown on the plans or as approved by the Engineer.

J. Casing Spacer System.

1. Provide a casing spacer system that meets the performance requirements shown on the plans or as approved by the Engineer. At a minimum:
    - Protect the carrier pipe from corrosion from spacer bands.
    - Provide shock protection to the carrier pipe.

K. Joints. Provide joints for the casing pipe as shown on the plans or as approved by the Engineer. Install casing pipe end treatment as shown on the plans.

L. Inspections. Provide facilities and access to allow for inspection. Provide access for inspection of the encasement at the project site before and during installation.

M. Rejections.

1. List causes for rejection of individual sections of casing pipe including fractures, cracks, and damaged ends where such damage would prevent making a satisfactory joint.
2. Allow access for the marking of rejected pipe. The Engineer will plainly mark rejected pipe by painting colored spots. Remove the rejected pipe from the project and replace with pipe meeting the requirements of this item.

XXXX.3. Construction.

A. Cast-in-Place Concrete Trench Cap and Encasement Concrete. Furnish concrete in accordance with the details shown on plans or in accordance with Item 421, “Hydraulic Cement Concrete.”

B. Laying Casing Pipe and Steel Plate.

1. **General.**
    - Install casing pipe within horizontal and vertical tolerances to ensure the carrier pipe will comply with required tolerances in accordance with the corresponding item specification (Special Specification XXXX, “Open-Trench Water Pipe,” Special Specification XXXX, “Open-Trench Gravity Sanitary Sewer Pipe,” or Special Specification XXXX, “Open-Trench Pressure Sanitary Sewer Pipe”).
    - Ensure casing pipe and carrier pipe comply with cover depth requirements in accordance with TAC Title 43, Part 1, Chapter 21, Subchapter C.
    - Place steel plate as shown on the plans or as approved by the Engineer.

- Measure and record “as-built” horizontal and vertical alignment at no more than every 100 feet on the on-site recorded plans, including any changes the Engineer approves. Provide as-built plans or certified as-installed construction plans in accordance with TAC Title 43, Part 1, Chapter 21, Subchapter C.

XXXX.4. Measurement. This Item will be measured by the cubic yard of concrete trench cap or encasement, foot along the centerline of casing pipe, or pound of steel plate.

XXXX.5. Payment. The work performed and materials furnished in accordance with this Item and measured as provided under “Measurement” will be paid for at the unit price bid for “Casing Pipe” of the type and size specified; “Cast-in-Place Trench Cap” of the type specified; “Cast-in-Place Encasement” of the type and size specified; or “Steel Plate” (see Table 10). All other items are considered subsidiary.

Communication Cable

Table 11. Proposed Specification: Communication Cable.

Specification Number	XXXX
Specification Title	Communication Cable
Description	Furnish and install communication cable
Previous Specifications	Several, including: 2004 Special Specification 6010, "Communication Cable" 2004 Special Specification 6014, "Fiber Optic Cable" 2004 Special Specification 6430, "Fiber Optic Cable (Single Mode)" 2004 Special Specification 6490, "Fiber Optic Cable" 2004 Special Specification 6516, "Fiber Optic Cable Splicing" 2004 Special Specification 6565, "Telecommunication Cable" 2004 Standard Specification 625, "Zinc-Coated Steel Wire Strand"
Proposed Changes	Create new specification for communication cable
Comment	

Bid Item	**Measurement Unit**
Direct-Buried Twisted Pair Cable (several types) (number of pairs)	Foot
Direct-Buried Coaxial Cable (several types)	Foot
Direct-Buried Optical Fiber Cable (Single Mode) (number of fibers)	Foot
Direct-Buried Optical Fiber Cable (Multimode) (number of fibers)	Foot
In-Conduit Twisted Pair Cable (several types) (number of pairs)	Foot
In-Conduit Coaxial Cable (several types)	Foot
In-Conduit Optical Fiber Cable (Single Mode) (number of fibers)	Foot
In-Conduit Optical Fiber Cable (Multimode) (number of fibers)	Foot
Aerial Twisted Pair Cable (several types) (number of pairs)	Foot
Aerial Coaxial Cable (several types)	Foot
Aerial Optical Fiber Cable (Single Mode) (number of fibers)	Foot
Aerial Optical Fiber Cable (Multimode) (number of fibers)	Foot
Splicing (fiber)	Each fiber joined
Splicing (copper)	Each pair handled
Note to Specification Writer: Add other pay items as indicated on the plans or as required by this specification.	

Table 11. Proposed Specification: Communication Cable (Continued).

Subsidiary Item (if specified)	Referenced Item	Subsidiary to
Structural Excavation (Pipes)	400, 401	Cable installation
Bedding	400	Cable installation
Pedestals		Cable installation
Backfill	400	Cable installation
Terminations		Cable installation
Splice enclosure		Cable installation
Patch Panel		Cable installation
Manhole or Vault Modification		Cable installation
Testing		Cable installation
Warning Tape for Non-Metallic Pipes		Cable installation
Note to Specification Writer: Manhole or vault modifications are assumed to be relatively minor. Major modifications would likely require removing the old structure and installing a new one.		
Note to Specification Writer: Add other subsidiary items as indicated on the plans or as required by this specification.		

Specification Requirements

XXXX.1. Description. Furnish and install communication cable. ***Note to Specification Writer*:** Include appropriate references to definitions from Table 3 to facilitate the understanding of basic specification concepts.

XXXX.2. Materials. ***Note to Specification Writer*:** The material standards listed here may not be applicable for every installation.

A. General Standards and Codes. Applicable standards and codes include the following:

- ANSI/ICEA S77 528, "Outside Plant Communications Cables, Specifying Metric Wire Sizes"
- IEEE 776, "Recommended Practice for Inductive Coordination of Electric Supply and Communication Lines"
- FHWA-HOP-04-034, "Telecommunications Handbook for Transportation Professionals: The Basics of Telecommunications"
- NFPA 70, "National Electrical Code"
- RUS 1753F-207 (PE-87), "REA Specification for Terminating Cables"
- RUS 1753F-204 (PE-37), "Specification for Aerial Service Wires"

- RUS 1753F-205 (PE-39), “REA Specification for Filled Telephone Cables”
- RUS 1753F-206 (PE-86), “REA Specification for Filled Buried Wires”
- RUS 1753F-208 (PE-89), “REA Specification for Filled Telephone Cables with Expanded Insulation”
- ICEA P47 434, “Pressurization Characteristics of Polyethylene-Insulated and Jacketed Telephone Cables
- ICEA P61 694, “Coding Guide for Copper, Outside Plant and Riser Telecommunications Cable”
- ANSI/ICEA S56 434, “Polyolefin Insulated Communication Cables for Outdoor Use”
- ANSI/ICEA S84 608, “Telecommunications Cable, Filled Polyolefin Insulated Copper Conductor”
- ANSI/ICEA S85 625, “Aircore, Polyolefin Insulated, Copper Conductor Telecommunications Cable”
- ANSI/ICEA S86 634, “Buried Distribution and Service Wire, Filled Polyolefin Insulated, Copper Conductor”
- ANSI/ICEA S100 685, “TP Telecommunications, Station Wire, Indoor/Outdoor”
- ANSI/ICEA S106 703, “Standard for Broadband Aerial Service Wire – Aircore, Polyolefin, Copper Conductors”
- ANSI/ICEA S89 648, “Telecommunications Aerial Service Wire”

B. Twisted Pair Cable. Applicable standards include the following:

- ANSI/ICEA S80 576, “Category 1 & 2 Individually Unshielded Twisted Pair Indoor Cables for Use in Communication Wiring Systems”
- ANSI/ICEA S91 674, “Coaxial and Coaxial/Twisted Pair Composite Buried Service Wires”
- ANSI/ICEA S92 675, “Coaxial and Coaxial/Twisted Pair Composite Aerial Service Wires”
- ANSI/ICEA S98 688, “Broadband Twisted Pair, Telecommunications Cable Aircore, Polyolefin Insulated Copper Conductions
- ANSI/ICEA S99 689, “Broadband Twisted Pair Telecommunications Cable Filled, Polyolefin Insulated Copper Conductors”
- NEMA WC 63.1, “Performance Standard for Twisted Pair Premise Voice and Data Communications Cables”

C. Coaxial Cable. Applicable standards include the following:

- ANSI/NEMA WC 63.2, “Performance Standard for Coaxial Premise Data Communications Cable”

- ANSI/ICEA S91 674, “Coaxial and Coaxial/Twisted Pair Composite Buried Service Wires”
- ANSI/ICEA S92 675, “Coaxial and Coaxial/Twisted Pair Composite Aerial Service Wires”

D. Optical Fiber Cable. Applicable standards include the following:

- ANSI/ICEA S87 640, “Optical Fiber Outside Plant Communications Cable”
- FHWA OP 02 069, “Design Guide for Fiber Optic Installation on Freeway Right-of-Way”
- ICEA S104 696, “Standard for Indoor-Outdoor Optical Cable”
- ICEA S110 717, “Optical Drop Cables”
- IEEE 1138, “Standard Construction of Composite Fiber Optic Overhead Ground Wire (OPGW) for Use on Electric Utility Power Lines”
- IEEE 1222, “Standard for All-Dielectric Self-Supporting Fiber Optic Cable”
- TIA 440B, “Fiber Optic Terminology”
- TIA/EIA 568 B.3, “Optical Fiber Cabling Components Standard”
- TIA 590A, “Standard for Physical Location and Protection of Below Ground Fiber Optic Cable Plant.” ***Note to Specification Writer*:** ANSI has withdrawn approval for this standard. Implications to standard applicability are unknown.
- TIA 598 C, “Optical Fiber Color Coding”
- TIA/EIA 604, “Fiber Optic Connector Intermateability Standards (FOCIS)”
- TIA/EIA 604 6, “FOCIS 6 Fiber Optic Connector Intermateability Standards (Fiber Jack Connector)
- TIA/EIA 604 10A, “FOCIS 10 Fiber Optic Connector Intermateability Standards - Type LC
- TIA/EIA 604 12, “FOCIS 12 Fiber Optic Connector Intermateability Standards - Type MT-RJ
- TIA 4720000 A, “Generic Specification for Fiber Optic Cable”
- TIA 472F000 A, “Optical Fiber Drop Cable”
- RUS Bulletin 1753F-601 (PE-90), “REA Specification for Filled Fiber Optic Cables”

E. Nonmetallic Cable Detection Method. Provide a method approved by the Engineer or as shown on the plans for detecting nonmetallic cables.

F. Inspections. Provide facilities and access to allow for inspection. Provide access for inspection of the cable at the project site before and during installation.

G. Rejections.

1. List causes for rejection of individual sections of cable including fractures, cracks, and damaged ends where such damage would prevent making a satisfactory joint.
2. Allow access for the marking of rejected cable. The Engineer will plainly mark rejected cable by painting colored spots. Remove the rejected cable from the project and replace with cable meeting the requirements of this item.

H. Backfill Material. Furnish conventional backfill material in accordance with Item 400, "Excavation and Backfill for Structures," or select backfill in accordance with Special Specification XXXX, "Select Backfill for Structures," as specified on the plans.

XXXX.3. Construction.

A. Excavation, Shaping, Bedding, and Backfill. Excavate, shape, bed, and backfill in accordance with Item 400, "Excavation and Backfill for Structures," and Special Specification XXXX, "Select Backfill for Structures," except as described below.

1. Do not excavate more than the maximum length ahead of backfilling operations, as shown on the plans or as approved by the Engineer.
2. Protect adjacent property and infrastructure in accordance with Item 402, "Trench Excavation Protection," if excavation is deeper than five feet.
3. For direct-bury cable installations without bedding material, ensure excavation is free of rocks or any other sharp materials that could damage the cable.
4. Install cable warning tape at the depth shown on the plans and specifications.

B. Splicing and Terminations

1. **Standards.** Applicable standards include the following:
   - TIA 5150000, "Generic Specification for Optical Fiber and Cable Splices"
   - TIA 515B000, "Sectional Specification for Splice Closures for Pressurized Aerial, Buried and Underground Fiber Optic Cable"
   - TIA 6090000, "Generic Specification for Optical Fiber Splices"
   - RUS 1753F-401 (PC-2), "RUS Standard for Splicing Copper and Fiber Optic Cables"

C. General.

1. Request prior approval from the Engineer for any deviations in alignment that may be necessary due to obstructions or other design constraints not shown on the plans.
2. Unless the Engineer specifies a more stringent requirement, do not exceed a maximum tolerance with respect to approved plans of 0.5 foot (horizontal) and 0.1 foot (vertical). ***Note to Specification Writer***: The TxDOT Survey Manual and the TSPS Manual of Practice for Land Surveying in Texas provide additional information regarding construction surveying horizontal and accuracy requirements. Notice that these construction tolerances are not the same as tolerances used for design surveying.

3. **3.** Ensure cable horizontal and vertical clearances are in accordance with TAC Title 43, Part 1, Chapter 21, Subchapter C.
4. **4.** Measure and record "as-built" horizontal and vertical alignment at no more than every 100 feet on the on-site recorded plans, including any changes the Engineer approves. Provide as-built plans or certified as-installed construction plans in accordance with TAC Title 43, Part 1, Chapter 21, Subchapter C.
5. **5.** Do not exceed maximum bending radius recommended by the cable manufacturer.
6. **6.** Unload cable and accessories at the point of delivery and haul to the site of the project. Position the material such that water or runoff does not enter or pass through the cable.

D. Direct-Buried Cable.

1. Standards. Applicable standards include the following:

- RUS 1753F-150, "Specifications and Drawings for Construction of Direct Buried Plant, RUS Form 515a"
- RUS 1751F 640, "Design of Buried Plant – Physical Considerations"
- RUS 1751F 641, "Construction of Buried Plant"
- RUS 1751F 642, "Construction Route Planning of Buried Plant"

E. In-Conduit or In-Duct Cable.

1. Standards. Applicable standards include the following:

- IEEE 1210, "Standard Tests for Determining Compatibility of Cable-Pulling Lubricants With Wire and Cable"
- RUS 1753F 151, "Specifications and Drawings for Construction of Underground Plant, RUS Form 515b"
- RUS 1751F 643, "Underground Plant Design"
- RUS 1751F 644, "Underground Plant Construction"

F. Aerial Cable.

1. Standards. Applicable standards include the following:

- IEEE 524, "Guide to the Installation of Overhead Transmission Line Conductors"
- RUS 1751F 626, "Staking of Aerial Plant"
- RUS 1751F 630, "Design of Aerial Plant"
- RUS 1751F 635, "Aerial Plant Construction"
- RUS 1751F 650, "Aerial Plant Guying and Anchoring"
- RUS 1753 152, "Specifications and Drawings for Construction of Aerial Plant, RUS Form 515c"
- RUS 1753F-204, "RUS Specification for Aerial Service Wires"

G. Telecommunication System Testing.

1. Standards. Applicable standards include the following:

- ANSI T1.506, "Network Performance – Switched Exchange Access Network Transmission Specifications"
- TIA 455 13, "Visual and Mechanical Inspection of Fiber Optic Components, Devices, and Assemblies"
- TIA 455 23A, "FOTP-23 Air Leakage Testing of Fiber Optic Component Seals"
- TIA 455 6B, "FOTP-6 Cable Retention Test Procedure for Fiber Optic Cable Interconnecting Devices"
- TIA 526, "Standard Test Procedures for Fiber Optic Systems"
- RUS 1753F-201, "RUS Standard for Acceptance Tests and Measurements of Telecommunications Plant"

XXXX.4. Measurement. This Item will be measured by the foot along the centerline of the cable, from center to center of manholes, handholes, and boxes. No length deductions will be made for manholes, handholes, and boxes. Direct-buried cable will not be classified for measurement according to the depth of the trench.

XXXX.5. Payment. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Direct-Buried Twisted Pair Cable" of the type and capacity specified; "Direct-Buried Coaxial Cable" of the type specified; "Direct-Buried Optical Fiber Cable" of the type and capacity specified; "Twisted Pair Cable" of the type and capacity specified; "Coaxial Cable" of the type specified; "Optical Fiber Cable" of the type and capacity specified; "Aerial Twisted Pair Cable" of the type and capacity specified; "Aerial Coaxial Cable" of the type specified; or "Aerial Optical Fiber Cable" of the type and capacity specified (see Table 11). All other items are considered subsidiary.

Removing and Relocating Conduit Structures

Table 12. Proposed Specification: Removing and Relocating Conduit Structures.

Specification Number	XXXX
Specification Title	Removing and Relocating Conduit Structures
Description	Remove and relocate conduit structure at locations shown on the plans or as approved by the Engineer. ***Note to Specification Writer***: Removing and relocating conduit structures involves moving an existing conduit structure, usually a very short distance, not abandoning (or removing) unusable conduit structures and then installing new conduit structures at a different location (for which other specifications apply).
Previous Specifications	
Proposed Changes	Create new specification for removing and relocating conduit structures.
Comment	

Bid Item	**Measurement Unit**
Remove and Relocate Underground Conduit Structure (several combinations of number of conduits and conduit diameter)	Foot
Remove and Relocate Aboveground Conduit Structure (several combinations of number of conduits and conduit diameter)	Foot
Note to Specification Writer: Add other pay items as indicated on the plans or as required by this specification.	

Subsidiary Item (if specified)	**Referenced Item**	**Subsidiary to**
Structural Excavation (Pipes)	400, 401	Conduit structure relocation
Bedding	400	Conduit structure relocation
Backfill	400	Conduit structure relocation
Move Conduit Structures		Conduit structure relocation
Testing		Conduit structure relocation
Non-Metallic Detection System		Conduit structure relocation
Manhole or Vault Modification		Conduit structure relocation
CIP Trench Cap (Concrete)	XXXX	Open-Trench Pipe Encasement
CIP Encasement (Concrete)	XXXX	Open-Trench Pipe Encasement
Note to Specification Writer: Manhole or vault modifications are assumed to be relatively minor. Major modifications would likely require replacing the old structure.		
Note to Specification Writer: Add other subsidiary items as indicated on the plans or as required by this specification.		

Specification Requirements

XXXX.1. Description. Remove and relocate conduit structure at locations shown on the plans or as approved by the Engineer. ***Note to Specification Writer***: Removing and relocating conduit structures involves moving an existing conduit structure, usually a very short distance, not abandoning (or removing) unusable conduit structures and then installing new conduit structures at a different location (for which other specifications apply). ***Note to Specification Writer*:** Include appropriate references to definitions from Table 3 to facilitate the understanding of basic specification concepts.

XXXX.2. Materials.

A. General.

1. Replace unsuitable or damaged conduit, fittings, or joints with new items in accordance with Special Specification XXXX, "Open-Trench Conduit Structure." If the Contractor damages items designated for reuse, replace them at no charge to the Department with new material or restore them to previous condition, as approved by the Engineer.

2. Remove materials not designated for reuse by the Engineer in accordance with Item 496, "Removing Structures."

B. Inspections. Provide facilities and access to allow for inspection. Provide access for inspection of the conduit structure at the project site before and during installation.

C. Bedding Material. Furnish bedding in accordance with Item 400, "Excavation and Backfill for Structures."

D. Backfill Material. Furnish conventional backfill material in accordance with Item 400, "Excavation and Backfill for Structures," or select backfill in accordance with Special Specification XXXX, "Select Backfill for Structures," as specified on the plans.

XXXX.3. Construction.

A. Excavation, Shaping, Bedding, and Backfill. Excavate, shape, bed, and backfill in accordance with Item 400, "Excavation and Backfill for Structures," and Special Specification XXXX, "Select Backfill for Structures," except as described below:

1. Do not excavate more than the maximum length ahead of backfilling operations, as shown on the plans or as approved by the Engineer.

2. Protect adjacent property and infrastructure in accordance with Item 402, "Trench Excavation Protection," if excavation is deeper than five feet.

B. Preparation.

1. Prior to removal and relocation of a conduit structure, disconnect and remove all cables from inside the conduit structure in accordance with Special Specification XXXX, "Removing and Relocating Communication Cable." Coil and store the cable in a secure manner to ensure the cable reuse. Remove inner ducts as indicated on the plans or as approved by the Engineer.

2. Remove any debris in the conduit structure prior to re-reinstalling conduit.

C. **Relocate Conduit Structure.** Install relocated conduit structure and fittings in accordance with Special Specification XXXX, “Open-Trench Conduit Structures” or Special Specification XXXX, “Aboveground Conduit Structures”

D. **Relocate Communication Cable.** Relocate communication cable in accordance with Special Specification XXXX, “Removing and Relocating Communication Cable.”

E. **Testing.** Test adjusted or relocated conduit structure and fittings in accordance with Special Specification XXXX, “Open-Trench Conduit Structure.”

XXXX.4. Measurement. This Item will be measured by the foot along the centerline of conduit structure removed and relocated, from center to center of fittings and boxes. Conduit structure removal and relocation will not be classified for measurement according to the depth of the trench.

XXXX.5. Payment. The work performed and materials furnished in accordance with this Item and measured as provided under “Measurement” will be paid for at the unit price bid for “Remove and Relocate Underground Conduit Structure” of the type and size specified or “Remove and Relocate Aboveground Conduit Structure” of the type and size specified (see Table 12). All other items are considered subsidiary.

Adjusting, or Removing and Relocating Communication Cable

Table 13. Proposed Specification: Adjusting, or Removing and Relocating Communication Cable.

Specification Number	XXXX
Specification Title	Adjusting, or removing and relocating communication cable
Description	Adjust, or remove and relocate communication cable at locations shown on the plans or as approved by the Engineer. Adjusting communication cable involves minor changes in horizontal and/or vertical alignment that do not require re-splicing. Removing and relocating communication cable involves cutting the cable at one or both ends, relocating the cable, and re-splicing connections. ***Note to Specification Writer***: Removing and relocating cable involves moving an existing cable, not abandoning (or removing) unusable cable and then installing new cable at a different location (for which other specifications apply).
Previous Specifications	Several, including: 2004 Special Specification 6489, "Removal of Existing Cables" 2004 Special Specification 6514, "Removal of Existing Cables" 2004 Special Specification 6420, "Remove and Reinstall Existing Fiber Optic Cable"
Proposed Changes	Create new specification for adjusting or removing and relocating communication cable.
Comment	

Bid Item	Measurement Unit
Adjust Direct-Buried Communication Cable	Foot
Adjust In-Conduit Communication Cable	Foot
Adjust Aerial Communication Cable	Foot
Remove and Relocate Direct-Buried Communication Cable	Foot
Remove and Relocate In-Conduit Communication Cable	Foot
Remove and Relocate Aerial Communication Cable	Foot
Note to Specification Writer: Add other pay items as indicated on the plans or as required by this specification.	

Subsidiary Item (if specified)	Referenced Item	Subsidiary to
Structural Excavation (Pipes)	400, 401	Adjusting or relocating communication cable
Bedding	400	Adjusting or relocating communication cable
Backfill	400	Adjusting or relocating communication cable
Moving Cable and Fittings		Adjusting or relocating communication cable
Testing		Adjusting or relocating communication cable

Table 13. Proposed Specification: Adjusting or Removing and Relocating Communication Cable (Continued).

Subsidiary Item (if specified)	Referenced Item	Subsidiary to
Terminations		Adjusting or relocating communication cable
Manhole or Vault Modification		Adjusting or relocating communication cable
Note to Specification Writer: Manhole or vault modifications are assumed to be relatively minor. Major modifications would likely require removing the old structure and installing a new one.		
Note to Specification Writer: Add other subsidiary items as indicated on the plans or as required by this specification.		

Specification Requirements

XXXX.1. Description. Adjust or remove and relocate communication cable at locations shown on the plans or as approved by the Engineer. Adjusting communication cable involves minor changes in horizontal and/or vertical alignment that do not require re-splicing. Removing and relocating communication cable involves cutting the cable at one or both ends, relocating the cable, and re-splicing connections. ***Note to Specification Writer***: Removing and relocating cable involves moving an existing cable, not abandoning (or removing) unusable cable and then installing new cable at a different location (for which other specifications apply). ***Note to Specification Writer*****:** Include appropriate references to definitions from Table 3 to facilitate the understanding of basic specification concepts.

XXXX.2. Materials.

A. General.

1. Replace unsuitable or damaged communication cable with new items in accordance with Special Specification XXXX, "Communication Cable." If the Contractor damages items designated for reuse, replace them at no charge to the Department with new material or restore them to previous condition, as approved by the Engineer.

2. Remove materials not designated for reuse by the Engineer in accordance with Item 496, "Removing Structures."

B. Inspections. Provide facilities and access to allow for inspection. Provide access for inspection of the communication cable at the project site before and during installation.

C. Backfill Material. Furnish conventional backfill material in accordance with Item 400, "Excavation and Backfill for Structures," or select backfill in accordance with Special Specification XXXX, "Select Backfill for Structures," as specified on the plans.

XXXX.3. Construction.

A. **Excavation, Shaping, Bedding, and Backfill.** Excavate, shape, bed, and backfill in accordance with Item 400, "Excavation and Backfill for Structures," and Special Specification XXXX, "Select Backfill for Structures," except as described below:

   1. Do not excavate more than the maximum length ahead of backfilling operations, as shown on the plans or as approved by the Engineer.

   2. Protect adjacent property and infrastructure in accordance with Item 402, "Trench Excavation Protection," if excavation is deeper than five feet.

B. **Preparation.**

   1. Pull all communication cable from inside the conduit, as shown on the plans or as approved by the Engineer, and coil the cable for future installation.

C. **Relocate Communication Cable.** Install relocated communication cable, including splicing and terminations, in accordance with Special Specification XXXX, "Communication Cable."

D. **Testing.**

   1. Conduct pre-testing and post-testing of cable performance prior to and after adjustment or relocation of the cable in accordance with Special Specification XXXX, "Communication Cable."

   2. Performance test results after adjustment or relocation should not result in signal degradation with respect to prior to the adjustment or relocation. Repair or replace components that failed testing after adjustment or relocation but passed testing prior to adjustment or relocation at the expense of the Contractor.

XXXX.4. Measurement. This Item will be measured by the foot along the centerline of communication cable adjusted or relocated. Communication cable adjustment or relocation will not be classified for measurement according to the depth of the trench.

XXXX.5. Payment. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Adjust Direct-Buried Communication Cable," "Adjust In-Conduit Communication Cable," "Adjust Aerial Communication Cable," "Remove and Relocate Direct-Buried Communication Cable," "Remove and Relocate In-Conduit Communication Cable," or "Remove and Relocate Aerial Communication Cable" (see Table 13). All other items are considered subsidiary. ***Note to Specification Writer:*** Cable splicing will be paid for under the bid item "Splicing" of the type specified in Item XXXX, "Communication Cable" (see Table 11).

Manholes and Inlets

Table 14. Proposed Specification: Manholes and Inlets.

Specification Number	465
Specification Title	Manholes and Inlets
Description	Construct manholes and inlets, complete in place or to the stage detailed, including furnishing and installing frames, grates, rings, and covers. Drainage junction boxes are classified as manholes.
Previous Specifications	2004 Item 465, "Manholes and Inlets."
Proposed Changes	Modify specification to ensure compatibility with water, sanitary sewer, and communication manhole characteristics and requirements. Add fiberglass and connectors to the list of materials. Add testing to the construction section. Add bid items for manholes and inlets to account for different types and depths of manholes.
Comment	

Bid Item	**Measurement Unit**
Manhole (several types) (Complete) (several depths)	Each
Manhole (several types) (Stage I) (several depths)	Each
Manhole (several types) (Stage II) (several depths)	Each
Inlet (several types) (Complete) (several depths)	Each
Inlet (several types) (Stage I) (several depths)	Each
Inlet (several types) (Stage II) (several depths)	Each
Inlet Extension (several types)	Each
Note to Specification Writer: Add other pay items as indicated on the plans or as required by this specification.	

Subsidiary Item (if specified)	**Referenced Item**	**Subsidiary to**
Structural Excavation	400	Manhole or Inlet Installation
Backfill	400	Manhole or Inlet Installation
Testing		Manhole or Inlet Installation
Seals		Manhole or Inlet Installation
Extensions		Manhole or Inlet Installation
Covers	471	Manhole or Inlet Installation
Rings	471	Manhole or Inlet Installation
Grates	471	Manhole or Inlet Installation
Frames	471	Manhole or Inlet Installation
Note to Specification Writer: Add other subsidiary items as indicated on the plans or as required by this specification.		

Specification Requirements

465.2. Materials.

- Insert section **465.2.G. Fiberglass** to list of materials and add the following text: "Furnish fiberglass manholes in accordance with ASTM D3753, "Standard Specification for Glass-Fiber-Reinforced Polyester Manholes and Wetwells.""
- Insert section **465.2.H. Joints** to list of materials and add the following text: "Unless otherwise shown on the plans or as directed by the Engineer, furnish joints between concrete manholes and pipes in accordance with ASTM C478, "Precast Reinforced Concrete Manhole Sections.""
- Insert section **465.2.I. Connectors** to list of materials and add the following text: "Unless otherwise shown on the plans or as directed by the Engineer, furnish connectors between manholes and laterals in accordance with ASTM C923, "Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes and Laterals," or ASTM C1478, "Standard Specification for Storm Drain Resilient Connectors Between Reinforced Concrete Storm Sewer Structures, Pipes, and Laterals.""

465.3. Construction.

- Insert section **465.3.J. Testing** and add the following text: "Test manhole by hydrostatic exfiltration, vacuum testing, other method approved by TCEQ, or as shown on the plans or directed by the Engineer. For vacuum testing, use ASTM C1244, "Standard Test Method for Concrete Sewer Manholes by the Negative Air Pressure (Vacuum) Test Prior to Backfill.""

465.5. Payment.

- Replace "type" with "type and depth" in sections **465.5.A**, **465.5.B**, **465.5.D**, **465.5.E**, **465.5.F**, and **465.5.G**.

Ground Boxes

Table 15. Proposed Specification: Ground Boxes.

Specification Number	XXXX
Specification Title	Ground boxes
Description	Furnish and install ground boxes (such as handholes, junction boxes, pull boxes, splice enclosures, pedestals, or other similar boxes) used for communication or electric installations.
Previous Specifications	2004 Special Specification 6155, "Communications Ground Box" 2004 Special Specification 6513, "Concrete Ground Boxes" 2004 Special Specification 6539, "Communications Ground Box" 1993 Special Specification 1383, "Communications Ground Box" 1993 Special Specification 6566, "Ground Box for Surveillance, Communication, and Control (SC&C)" 2004 Item 624, "Ground Boxes." DMS-11070, "Ground Boxes."
Proposed Changes	Create new specification for ground boxes.
Comment	Existing Item 624, "Ground Boxes," covers electrical ground boxes, but not communication ground boxes or pedestals. The proposed specification is broader in scope.

Bid Item	**Measurement Unit**
Ground Box (several materials) (several sizes)	Each
Pedestal (several sizes)	Each
Note to Specification Writer: Add other pay items as indicated on the plans or as required by this specification.	

Subsidiary Item (if specified)	**Referenced Item**	**Subsidiary to**
Structural Excavation	400	Ground Box Installation
Backfill	400	Ground Box Installation
Testing		Ground Box Installation
Seals		Ground Box Installation
Lid		Ground Box Installation
Note to Specification Writer: Add other subsidiary items as indicated on the plans or as required by this specification.		

Specification Requirements

XXXX.1. Description. Furnish and install ground boxes (such as handholes, junction boxes, pull boxes, splice enclosures, pedestals, or other similar boxes) used for communication or electric installations. ***Note to Specification Writer*:** Include appropriate references to definitions from Table 3 to facilitate the understanding of basic specification concepts.

XXXX.2. Materials. ***Note to Specification Writer*****:** The material standards listed here may not be applicable for every installation.

A. General Standards and Rules. Applicable standards and rules include the following:

- ANSI/NEMA FB 1, "Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable"
- ANSI/SCTE 77, "Specification for Underground Enclosure Integrity"
- ASTM C858, "Standard Specification for Underground Precast Concrete Utility Structures"
- ASTM C857, "Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures"
- National Electrical Safety Code
- RUS 345, "REA Specification for Filled Splice Closures"
- RUS 1753F-150, "Specifications and Drawings for Construction of Direct Buried Plant, RUS Form 515a"
- RUS 1753F-151, "Specifications and Drawings for Construction of Underground Plant, RUS Form 515b"
- RUS 1753F-302, "Specifications for Outside Plant Housings and Serving Area Interface Systems"

B. Precast Boxes. Provide ground boxes from manufacturers pre-qualified by the Department. The Traffic Operations Division maintains a list of pre-qualified box manufacturers.

C. Cast-in-Place Boxes. Construct cast-in-place concrete boxes and aprons in accordance with Item 420, "Concrete Structures," Item 421, "Hydraulic Cement Concrete," and Item 440, "Reinforcing Steel."

D. Labels. Label covers in accordance with DMS-11070, "Ground Boxes," as shown on the plans, or as approved by the Engineer.

E. Seals. Provide watertight seals as shown on the plans.

F. Nonmetallic Box Detection Method. Provide a method approved by the Engineer or as shown on the plans for detecting nonmetallic boxes.

G. Inspections. Provide facilities and access to allow for inspection. Provide access for inspection of ground boxes at the project site before and during installation.

H. Rejections.

1. List causes for rejection of individual boxes, including fractures, cracks, and misalignments.
2. Allow access for the marking of rejected boxes. The Engineer will plainly mark rejected boxes by painting colored spots. Remove the rejected boxes from the project and replace with boxes meeting the requirements of this item.

I. Bedding Material. Furnish bedding in accordance with Item 400, "Excavation and Backfill for Structures."

J. Backfill Material. Furnish conventional backfill material in accordance with Item 400, "Excavation and Backfill for Structures," or select backfill in accordance with Special Specification XXXX, "Select Backfill for Structures," as specified on the plans.

XXXX.3. Construction.

A. Excavation, Shaping, Bedding, and Backfill. Excavate, shape, bed, and backfill in accordance with Item 400, "Excavation and Backfill for Structures," and Special Specification XXXX, "Select Backfill for Structures," except as described below:

1. Excavate the trench to a depth of 6 inches below the bottom of the ground box.
2. Protect adjacent property and infrastructure in accordance with Item 402, "Trench Excavation Protection," if excavation is deeper than five feet.

B. Installing Box.

1. **Standards.** Applicable standards include the following:
   - ASTM C891, "Standard Practice for Installation of Underground Precast Concrete Utility Structures"
   - IEEE 776, "Recommended Practice for Inductive Coordination of Electric Supply and Communication Lines"
   - RUS 1753F-302, "Specifications for Outside Plant Housings and Serving Area Interface Systems"
2. **General.**
   - Except for pedestals, install ground box to ensure it is flush with the final grade, as indicated on the plans, or as approved by the Engineer. Ensure the horizontal and vertical alignment is in accordance with TAC Title 43, Part 1, Chapter 21, Subchapter C.
   - Request prior approval from the Engineer for any deviations in alignment that may be necessary due to obstructions or other design constraints not shown on the plans.
   - Unless the Engineer specifies a more stringent requirement, do not exceed a maximum tolerance with respect to approved plans of 0.5 foot (horizontal) and 0.1 foot (vertical). ***Note to Specification Writer***: The TxDOT Survey Manual and the TSPS Manual of Practice for Land Surveying in Texas provide additional information regarding construction surveying horizontal and accuracy requirements. Notice that these construction tolerances are not the same as tolerances used for design surveying.
   - For any box, measure and record the "as-built" horizontal and vertical location of the center point of the box cover on the on-site recorded plans. Provide as-built plans or certified as-installed construction plans in accordance with TAC Title 43, Part 1, Chapter 21, Subchapter C.

XXXX.4. Measurement. This Item will be measured by each ground box or pedestal installed and complete in place.

XXXX.5. Payment. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Ground Box" of the material and size specified or "Pedestal" of the size specified (see Table 15). All other items are considered subsidiary.

Cable Vaults

Table 16. Proposed Specification: Cable Vaults.

Specification Number	XXXX	
Specification Title	Cable Vaults	
Description	Furnish and install cable vaults	
Previous Specifications	2004 Special Specification 6343, "Environmentally Controlled Underground Vault" 2004 Special Specification 6138, "Underground Cable Vault for Surveillance, Communication, and Control (SC&C)" 2004 Special Specification 6749, "Underground Cable Vault" 1993 Special Specification 1777, "Environmentally Controlled Underground Vault" 2004 Item 465, "Manholes and Inlets."	
Proposed Changes	Create new specification for cable vaults.	
Comment		
Bid Item		**Measurement Unit**
Cable Vault (precast) (several sizes)		Each
Cable Vault (CIP) (several sizes)		Each
Environmentally Controlled Cable Vault (precast) (several sizes)		Each
Environmentally Controlled Cable Vault (CIP) (several sizes)		Each
Note to Specification Writer: Add other pay items as indicated on the plans or as required by this specification.		
Subsidiary Item (if specified)	**Referenced Item**	**Subsidiary to**
Structural Excavation	400	Cable vault installation
Backfill	400	Cable vault installation
Testing		Cable vault installation
Seals		Cable vault installation
Duct Terminators		Cable vault installation
Insulation		Cable vault installation
Weatherproofing		Cable vault installation
Equipment Racks		Cable vault installation
Cable Racks		Cable vault installation
Temperature Control and Ventilation System		Cable vault installation
Sump		Cable vault installation
Alarms		Cable vault installation
Note to Specification Writer: Add other subsidiary items as indicated on the plans or as required by this specification.		

Specification Requirements

XXXX.1. Description. Furnish and install cable vaults. ***Note to Specification Writer*:** Include appropriate references to definitions from Table 3 to facilitate the understanding of basic specification concepts.

XXXX.2. Materials. ***Note to Specification Writer*:** The material standards listed here may not be applicable for every installation.

A. General Standards and Rules. Applicable standards and rules include the following:

1. Standards. Applicable standards include the following:

- AASHTO Load and Resistance Factor Design (LRFD) Bridge Design Specifications. ***Note to Specification Writer*:** These specifications detail the H10 and H20 wheel loading requirements specified for some cable vaults.

B. Concrete.

1. Standards. Applicable standards include the following:

- ASTM C857, "Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures"
- ASTM C858, "Standard Specification for Underground Precast Concrete Utility Structures"
- Item 421, "Hydraulic Cement Concrete"
- Item 424, "Precast Concrete Structures (Fabrication)"
- Item 440, "Reinforcing Steel"
- RUS 1751F 643, "Underground Plant Design"

C. Environmental Control Systems. Furnish environmental control systems as shown on the plans or as approved by the Engineer.

D. Inspections.

1. Standards. Applicable standards include the following:

- ASTM C1037, "Standard Practice for Inspection of Underground Precast Concrete Utility Structures"

2. General.

- Provide facilities and access to allow for inspection. Provide access for inspection of cable vaults at the project site before and during installation.

E. Rejections.

1. List causes for rejection of cable vaults including fractures and cracks.

2. Allow access for the marking of rejected cable vaults. The Engineer will plainly mark rejected cable vaults by painting colored spots. Remove the rejected cable vaults from the project and replace with cable vaults meeting the requirements of this item.

F. Bedding Material. Furnish bedding in accordance with Item 400, "Excavation and Backfill for Structures."

G. Backfill Material. Furnish conventional backfill material in accordance with Item 400, "Excavation and Backfill for Structures," or select backfill in accordance with Special Specification XXXX, "Select Backfill for Structures," as specified on the plans.

XXXX.3. Construction.

A. Excavation, Shaping, Bedding, and Backfill. Excavate, shape, bed, and backfill in accordance with Item 400, "Excavation and Backfill for Structures," and Special Specification XXXX, "Select Backfill for Structures," except as described below:

1. Protect adjacent property and infrastructure in accordance with Item 402, "Trench Excavation Protection," if excavation is deeper than five feet.

B. Installing Cable Vault.

1. **Standards.** Applicable standards include the following:
   - ASTM C891, "Standard Practice for Installation of Underground Precast Concrete Utility Structures"
   - Item 420, "Concrete Structure"
   - RUS 1751F 644, "Underground Plant Construction"
2. **General.**
   - Request prior approval from the Engineer for any deviations in alignment that may be necessary due to obstructions or other design constraints not shown on the plans.
   - Unless the Engineer specifies a more stringent requirement, do not exceed a maximum tolerance with respect to approved plans of 0.5 foot (horizontal) and 0.1 foot (vertical). ***Note to Specification Writer***: The TxDOT Survey Manual and the TSPS Manual of Practice for Land Surveying in Texas provide additional information regarding construction surveying horizontal and accuracy requirements.
   - Measure and record "as-built" horizontal and vertical alignment on the on-site recorded plans, including any changes the Engineer approves. Provide as-built plans or certified as-installed construction plans in accordance with TAC Title 43, Part 1, Chapter 21, Subchapter C.
   - Label cable vaults as shown on the plans.

C. Testing.

1. **Standards.** Applicable standards include the following:
   - Item 421, "Hydraulic Cement Concrete"

XXXX.4. Measurement. This Item will be measured by each cable vault installed.

XXXX.5. Payment. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Cable

Vault" of the type and size specified or "Environmentally Controlled Cable Vault" of the type and size specified (Table 16). All other items are considered subsidiary.

Communication Buildings and Cabinets

Table 17. Proposed Specification: Communication Buildings and Cabinets.

Specification Number	XXXX
Specification Title	Communication Buildings and Cabinets
Description	Furnish and install buildings and cabinets used for communication purposes, including the foundation, housing structure, and all associated electrical, communication, and environmental control devices, wiring, harnesses, and cable assemblies. ***Note to Specification Writer:*** This specification covers a wide range of communication structures and devices that normally have electrical power and/or do not fall under the categories of vaults, manholes, or ground boxes. Communication buildings and cabinets are typically prefabricated structures that are installed aboveground and are not intended for human habitation. Examples include the following: communication building, communication cabinet, communication hub, communication hut, concrete universal enclosure, controlled environment cabinet, serving area interface, and loop carrier box. Depending on the case, the structures could include all the electrical and communication equipment inside the enclosure or just the enclosure, electrical connections, and cable terminals. For simplicity, the term "cabinet" in this specification includes buildings, cabinets, hubs, and huts. This specification does not cover central offices under the assumption that central offices are large buildings for which considerable bid item disaggregation may be necessary to properly estimate and control construction costs.
Previous Specifications	2004 Special Specification 6531, "Communication Building" 2004 Special Specification 6402, "Communication Cabinet" 2004 Special Specification 6530, "Communication Cabinet" 2004 Special Specification 6568, "Communication Hub Enclosure" 2004 Special Specification 6198, "Fiber Communications Hub" 2004 Special Specification 6260, "Fiber Communications Hub."
Proposed Changes	Create new specification for communication buildings and cabinets.
Comment	

Bid Item	**Measurement Unit**
Communication Cabinet (equipment included) (several types) (several sizes)	Each
Communication Cabinet (no equipment) (several types) (several sizes)	Each
Concrete Universal Enclosure (several sizes)	Each
Serving Area Interface (several sizes)	Each
Loop Carrier Box (several sizes)	Each
Note to Specification Writer: Add other pay items as indicated on the plans or as required by this specification.	

Table 17. Proposed Specification: Communication Buildings and Cabinets (Continued).

Subsidiary Item (if specified)	Referenced Item	Subsidiary to
Structural Excavation	400	Building or cabinet installation
Backfill	400	Building or cabinet installation
Foundation		Building or cabinet installation
Testing		Building or cabinet installation
Seals		Building or cabinet installation
Duct Terminators		Building or cabinet installation
Insulation		Building or cabinet installation
Weatherproofing		Building or cabinet installation
Equipment Racks		Building or cabinet installation
Cable Racks		Building or cabinet installation
Electrical and Communication Equipment		Building or cabinet installation
Temperature Control and Ventilation System		Building or cabinet installation
Sump		Building or cabinet installation
Alarms		Building or cabinet installation
Note to Specification Writer: Add other subsidiary items as indicated on the plans or as required by this specification.		

Specification Requirements

XXXX.1. Description. Furnish and install buildings and cabinets used for communication purposes, including the foundation, housing structure, and all associated electrical, communication, and environmental control devices, wiring, harnesses, and cable assemblies.
Note to Specification Writer: Furnish and install buildings and cabinets used for communication purposes, including the foundation, housing structure, and all associated electrical, communication, and environmental control devices, wiring, harnesses, and cable assemblies.
Note to Specification Writer: This specification covers a wide range of communication structures and devices that normally have electrical power and/or do not fall under the categories of vaults, manholes, or ground boxes. Communication buildings and cabinets are typically prefabricated structures that are installed aboveground and are not intended for human habitation. Examples include the following: communication building, communication cabinet, communication hub, communication hut, concrete universal enclosure, controlled environment cabinet, serving area interface, and loop carrier box. Depending on the case, the structures could include all the electrical and communication equipment inside the enclosure or just the enclosure, electrical connections, and cable terminals. For simplicity, the term “cabinet” in this specification includes buildings, cabinets, hubs, and huts. This specification does not cover central offices under the assumption that central offices are large buildings for which considerable bid item disaggregation may be necessary to properly estimate and control

construction costs. ***Note to Specification Writer*:** Include appropriate references to definitions from Table 3 to facilitate the understanding of basic specification concepts.

XXXX.2. Materials. ***Note to Specification Writer*:** The material standards listed here may not be applicable for every installation.

A. General.

1. Standards. Applicable standards include the following:

- RUS 1753F-302, "RUS Specification for Outside Plant Housings and Serving Area Interface Systems"

B. Aluminum.

1. Standards. Applicable standards include the following:

- ASTM B209, "Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate"
- MIL-A-8625, "Anodic Coatings for Aluminum and Aluminum Alloys"

C. Concrete Masonry Units.

1. Standards. Applicable standards include the following:

- ASTM C90, "Standard Specification for Loadbearing Concrete Masonry Units"
- ASTM C270, "Standard Specification for Mortor for Unit Masonry"

D. Concrete.

1. Standards. Applicable standards include the following:

- Item 421, "Hydraulic Cement Concrete"
- Item 440, "Reinforcing Steel"

E. Electrical Materials.

1. General. ***Note to Specification Writer*:** A number of material standards might apply depending on the type of equipment, configuration, and materials required for the communication building or cabinet. See, for example, 2004 Special Specification 6531, "Communication Building," 2004 Special Specification 6402, "Communication Cabinet," or 2004 Special Specification 6198, "Fiber Communications Hub."

XXXX.3. Construction.

A. Excavation, Shaping, Bedding, and Backfill. Excavate, shape, bed, and backfill in accordance with Item 400, "Excavation and Backfill for Structures," and Special Specification XXXX, "Select Backfill for Structures," except as described below:

1. Protect adjacent property and infrastructure in accordance with Item 402, "Trench Excavation Protection," if excavation is deeper than five feet.

B. Foundation. Construct foundation in accordance with Item 656, "Foundations for Traffic Control Devices," as shown on the plans, or as approved by the Engineer.

C. Installing Building or Cabinet.

1. **Standards.** Applicable standards include the following:
   - RUS 1753F-302, "Specifications for Outside Plant Housings and Serving Area Interface Systems"
   - AWS C5.6, "Recommended Practices for Gas Metal Arc Welding"
   - AWS A5.10, "Specification for Bare Aluminum and Aluminum-Alloy Welding Electrodes and Rods"
2. **General.**
   - Request prior approval from the Engineer for any deviations in alignment that may be necessary due to obstructions or other design constraints not shown on the plans.
   - Unless the Engineer specifies a more stringent requirement, do not exceed a maximum tolerance with respect to approved plans of 0.5 foot (horizontal) and 0.1 foot (vertical). ***Note to Specification Writer***: The TxDOT Survey Manual and the TSPS Manual of Practice for Land Surveying in Texas provide additional information regarding construction surveying horizontal and accuracy requirements.
   - Measure and record "as-built" horizontal and vertical alignment on the on-site recorded plans, including any changes the Engineer approves. Provide as-built plans or certified as-installed construction plans in accordance with TAC Title 43, Part 1, Chapter 21, Subchapter C.
   - Label building or cabinet as shown on the plans.

D. Testing. ***Note to Specification Writer*:** A number of testing requirements might apply depending on the type of equipment, configuration, and materials required for the communication building or cabinet. Examples of tests include temperature, condensation, and relative humidity tests; primary power variation tests; high-frequency tests; vibration tests; factory demonstration tests; continuity tests; operational tests; stand-alone tests; and system integration tests. See, for example, 2004 Special Specification 6531, "Communication Building," 2004 Special Specification 6402, "Communication Cabinet," or 2004 Special Specification 6198, "Fiber Communications Hub."

E. Documentation.

1. Provide two copies of the following documentation for each communication building or cabinet:
   - Building or cabinet wiring diagrams.
   - Warranties. Furnish a copy of all available building and/or equipment manufacturer's warranties for future potential dealing with the guarantor.
2. Place one set of the documentation in an approved heavy duty plastic envelope. Deliver the other set to the Engineer.

XXXX.4. Measurement. This Item will be measured by each communication cabinet (equipment included), communication cabinet (no equipment), concrete universal enclosure, serving area interface, or loop carrier box installed.

XXXX.5. Payment. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Communication Cabinet (equipment included)" of the type and size specified, "Communication Cabinet (no equipment)" or the type and size specified, "Concrete Universal Enclosure" of the size specified, "Serving Area Interface" of the size specified, or "Loop Carrier Box" of the size specified (Table 17). All other items are considered subsidiary.

Pole Assemblies

Table 18. Proposed Specification: Pole Assemblies.

Specification Number	XXXX
Specification Title	Pole Assemblies
Description	Furnish and install pole assemblies
Previous Specifications	2004 Special Specification 6252, "TXU Electric Delivery – Electrical Transmission & Distribution System." 2004 Item 627, "Treated Timber Poles."
Proposed Changes	Create new specification for pole assemblies.
Comment	This specification does not include requirements for pole safety devices. See Item 545, "Crash Cushion Attenuators."

Bid Item	**Measurement Unit**
Treated Timber Pole (several heights) (several diameters)	Each
Laminated Wood Pole (several heights) (several diameters)	Each
Concrete Pole (several heights) (several diameters)	Each
Composite Pole (several materials) (several heights) (several diameters)	Each
Steel Pole (several heights) (several diameters)	Each
Aluminum Pole (several heights) (several diameters)	Each
Crossarm Assembly (several types)	Each
Riser Assembly (several types)	Each
Guy Wire Assembly (several types)	Each
Note to Specification Writer: Add other pay items as indicated on the plans or as required by this specification.	

Subsidiary Item (if specified)	**Referenced Item**	**Subsidiary to**
Structural Excavation (Poles)	400	Pole installation
Backfill	400	Pole installation
Preservative Treatment		Pole installation
Woodpecker Protection		Pole installation
Note to Specification Writer: Add other subsidiary items as indicated on the plans or as required by this specification.		

Specification Requirements

XXXX.1. Description. Furnish and install pole assemblies. ***Note to Specification Writer*:** Include appropriate references to definitions from Table 3 to facilitate the understanding of basic specification concepts.

XXXX.2. Materials. ***Note to Specification Writer*:** The material standards listed here may not be applicable for every installation.

A. General Standards and Rules. Applicable standards and rules include the following:

- ASCE Standard No 48, “Design of Steel Transmission Pole Structures”
- ASTM Manuals and Reports on Engineering Practice No. 111, “Reliability-Based Design of Utility Pole Structures”
- IEEE 751, “Trial-Use Design Guide for Wood Transmission Structures”
- National Electrical Safety Code
- RUS 1724E 150, “Unguyed Distribution Poles – Strength Requirements”

B. Treated Timber Pole.

1. Standards. Applicable standards include the following:

- ANSI 05.1, “Specifications and Dimensions for Wood Poles”
- ANSI O5.TR.01, “Photographic Manual of Wood Pole Characteristics”
- ASTM D1036, “Standard Test Methods of Static Tests of Wood Poles”
- RUS 1728F 700, “REA Specification for Wood Poles, Stubs, and Anchor Logs”

C. Laminated Wood Pole.

1. Standards. Applicable standards include the following:

- ANSI O5.2, “Structural Glued Laminated Timber for Utility Structures”

D. Concrete Pole.

1. Standards. Applicable standards include the following:

- ASTM C1098, “Standard Specification for Spun Cast Prestressed Concrete Poles”
- ASTM C935, “Standard Specification for Prestressed Concrete Poles Statically Cast”
- RUS 1724E 206, “Guide Specification for Spun, Prestressed Concrete Poles and Concrete Pole Structures”
- RUS 1724E-216, “Guide Specification for Standard Class Spun, Prestressed Concrete Transmission Poles”

E. Steel Pole.

1. Standards. Applicable standards include the following:

- RUS 1724E 204, “Guide Specification for Steel Single Pole and H-Frame Structures”
- RUS 1724E 214, “Guide Specification for Standard Class Steel Transmission Poles”

F. Composite Pole.

1. Standards. Applicable standards include the following:

- ASCE 104, “Recommended Practice for Fiber-Reinforced Polymer Products for Overhead Utility Line Structures”

- ASTM D4923, “Standard Specification for Reinforced Thermosetting Plastic Poles”

G. Preservative Treatment.

1. **Standards**. Applicable standards include the following:
    - AWPA C1, “All Timber Products – Preservative Treatment by Pressure Processes”
    - AWPA C4, “Poles – Preservative Treatment by Pressure Processes”
    - AWPA P1/P13, “Standard for Creosote Preservative”
    - AWPA P5, “Standard for Waterborne Preservative”
    - AWPA P8, “Standard for Oil-Borne Preservatives”
    - AWPA P9, “Standards for Solvents and Formulations for Organic Preservative Sytems”
    - IEEE 1217, “Guide for Preservative Treatment of Wood Distribution and Transmission Line Structures”

H. Guy Wire Assembly.

1. **Standards.** Applicable standards include the following:
    - ASTM A368, “Standard Specification for Stainless Steel Wire Strand”
    - ASTM A460, “Standard Specification for Copper-Clad Wire Strand”
    - ASTM A474, “Standard Specification for Aluminum-Coated Steel Wire Strand”
    - ASTM A475, “Standard Specification for Zinc-Coated Steel Wire Strand”
    - ASTM A855, “Standard Specification for Zinc-5% Aluminum-Mischmetal Alloy-Coated Steel Wire Strand”
    - RUS 1724E 153, “Electric Distribution Line Guys and Anchors”

I. Riser Assembly.

1. **Standards.** Applicable standards include the following:
    - National Electrical Safety Code

J. Crossarm Assembly.

1. **Standards.** Applicable standards include the following:
    - ANSI O5.3, “Solid Sawn-Wood Crossarms and Braces – Specifications and Dimensions”
    - IEEE C135.33, “Galvanized Ferrous Crossarm Gains for Overhead Line Construction”
    - IEEE C135.6, “Zinc-Coated Ferrous Crossarm Braces for Overhead Line Construction”

- RUS 1724E 151, “Mechanical Loading on Distribution Crossarms”
- RUS 1728F 800, “Assembly Unit Numbers and Standard Format”
- RUS 1728H 701, “REA Specification for Wood Crossarms (Solid and Laminated), Transmission Timbers and Pole Keys”

K. Anchors.

1. **Standards**. Applicable standards include the following:
    - ASTM A153, “Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware”
    - ASTM F1554, “Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength”

L. Fasteners.

1. **Standards.** Applicable standards include the following:
    - ASTM A194, “Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both”
    - ASTM A307, “Standard Specification for Carbon Steel Bolts and Studs, 60 000 psi Tensile Strength”
    - ASTM A325, “Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength”
    - ASTM A354, “Standard Specification for Quenched and Tempered Alloy Steel Bolts, Studs, and Other Externally Threaded Fasteners”
    - ASTM A394, “Standard Specification for Steel Transmission Tower Bolts, Zinc-Coated and Bare”
    - ASTM A449, “Specification for Hex Cap Screws, Bolts, and Studs, Steel, Heat Treated, 120/105/90 ksi Minimum Tensile Strength, General Use”
    - ASTM A490, “Standard Specification for Structural Bolts, Alloy Steel, Heat Treated, 150 ksi Minimum Tensile Strength”
    - ASTM A563, “Standard Specification for Carbon and Alloy Steel Nuts”
    - ASTM B695, “Standard Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel”
    - ASTM F436, “Standard Specification for Hardened Steel Washers”
    - ASTM F959, “Standard Specification for Compressible-Washer-Type Direct Tension Indicators for Use with Structural Fasteners”
    - ASTM F2437, “Standard Specification for Carbon and Alloy Steel Compressible-Washer-Type Direct Tension Indicators for Use with Cap Screws, Bolts, Anchors, and Studs”

M. Insulators.

1. **Standards.** Applicable standards include the following:

    - ANSI C29.12, “Insulators – Composite – Suspension Type”
    - ANSI C29.13, “Insulators – Composite Distribution Deadend Type”
    - ANSI C29.17, “Insulators – Composite-Line Post Type”
    - ANSI C29.18, “Insulators Composite – Distribution Line Post Type”
    - ANSI C29.2, “Insulators – Wet-Process Porcelain and Toughened Glass – Suspension Type”
    - ANSI C29.3, “Wet-Process Porcelain Insulators (Spool Type)”
    - ANSI C29.4, “Wet-Process Porcelain Insulators – Strain Type”
    - ANSI C29.5, “Wet-Process Porcelain Insulators, Low- and Medium-Voltage Pin Type”
    - ANSI C29.6, “Wet-Process Porcelain Insulators – High-Voltage Pin Type”
    - ANSI C29.7, “Wet-Process – Porcelain Insulators – High Voltage Line-Post Type”
    - ANSI C29.8, “Wet-Process Porcelain Insulators (Apparatus, Cap and Pin Type)”
    - ANSI C29.9, “Wet-Process Porcelain Insulators (Apparatus, Post Type)”
    - IEC 60120, “Dimensions of Ball and Socket Couplings of String Insulator Units”
    - IEC 60273, “Characteristics of Indoor and Outdoor Post Insulators for Systems with Nominal Voltages Greater Than 1000 V”
    - IEC 60305, “Insulators for Overhead Lines with a Nominal Voltage Above 1000 V - Ceramic or Glass Insulator Units for A.C. Systems - Characteristics of Insulator Units of the Cap and Pin Type”
    - IEC 60372, “Locking Devices for Ball and Socket Couplings of String Insulator Units: Dimensions and Tests”
    - IEC 60383 1, “Insulators for Overhead Lines with a Nominal Voltage Above 1000 V Part 1: Ceramic or Glass Insulator Units for A.C. Systems - Definitions, Test Methods and Acceptance Criteria”
    - IEC 60383 2, “Insulators for Overhead Lines with a Nominal Voltage Above 1000 V Part 2: Insulator Strings and Insulator Sets for A.C. Systems - Definitions, Test Methods and Acceptance Criteria”
    - IEC 60433, “Insulators for Overhead Lines with a Nominal Voltage Above 1000 V - Ceramic Insulators for A.C. Systems - Characteristics of Insulator Units of the Long Rod Type”
    - IEC 60720, “Characteristics of Line Post Insulators”

- IEC 61109, “Composite Insulators for A.C. Overhead Lines with a Nominal Voltage Greater Than 1000 V - Definitions, Test Methods and Acceptance Criteria”
- IEC 61325, “Insulators for Overhead Lines with a Nominal Voltage Above 1000 V - Ceramic or Glass Insulator Units for D.C. Systems - Definitions, Test Methods and Acceptance Criteria”
- IEC 61952, “Insulators for Overhead Lines - Composite Line Post Insulators for Alternative Current with a Normal Voltage Greater Than 1000 V”
- IEC 60383 1, “Insulators for Overhead Lines with a Nominal Voltage Above 1000 V Part 1: Ceramic or Glass Insulator Units for A.C. Systems - Definitions, Test Methods and Acceptance Criteria”
- IEEE 987, “Guide for Applications of Composite Insulators”

N. Markings. Mark the following information by branding on all poles: supplier’s code or trademark, plant location and year of treatment, species and preservative code, and class length. ***Note to Specification Writer***: Table 2 in Item 627, “Treated Timber Poles” includes a more detailed list of pole markings.

O. Inspections. Provide facilities and access to allow for inspection. Provide access for inspection of pole assemblies at the project site before and during installation.

1. **Standards.** Applicable standards include the following:
   - AWPA M2, “Standard for Inspection of Treated Wood Products”
   - IEEE 1441, “IEEE Guide for Inspection of Overhead Transmission Line Construction”

P. Rejections.

1. List causes for rejection of individual poles and crossarm assemblies, including fractures, cracks, and misalignments.
2. Allow access for the marking of rejected poles and crossarm assemblies. The Engineer will plainly mark rejected poles and crossarm assemblies by painting colored spots. Remove the rejected poles and crossarm assemblies from the project and replace with poles and crossarm assemblies meeting the requirements of this item.

Q. Backfill Material. Furnish conventional backfill material in accordance with Item 400, “Excavation and Backfill for Structures,” or select backfill in accordance with Special Specification XXXX, “Select Backfill for Structures,” as specified on the plans.

XXXX.3. Construction.

A. Excavation, Shaping, Bedding, and Backfill. Drill and backfill holes for poles in accordance with Item 400, “Excavation and Backfill for Structures”

B. Installing Pole Assembly.

1. **Standards.** Applicable standards include the following:

- IEEE 142, “Recommended Practice for Grounding of Industrial and Commercial Power Systems”
- IEEE 1025, “Guide to the Assembly and Erection of Concrete Pole Structures”
- IEEE 1048, “Guide for Protective Grounding of Power Lines”
- IEEE 1299, “Guide for the Connection of Surge Arresters to Protect Insulated, Shielded Electric Power Cable Systems”
- IEEE C62.22.1, “Guide for the Connection of Surge Arresters to Protect Insulated, Shielded Electric Power Cable Systems”
- National Electrical Safety Code
- RUS 1724E 205, “Design Guide: Embedment Depths for Concrete and Steel Poles”
- RUS 1751F 650, “Aerial Plant Guying and Anchoring”
- RUS 1753F 152, “Specifications and Drawings for Construction of Aerial Plant, RUS Form 515c”

2. General.

- Place poles as shown on the plans, as approved by the Engineer, or in accordance with TAC Title 43, Part 1, Chapter 21, Subchapter C. Place poles supporting longitudinal utility lines within three feet of the right of way line. Do not place poles with bases greater than 36 inches in diameter within the right of way.
- Request prior approval from the Engineer for any deviations in alignment that may be necessary due to obstructions or other design constraints not shown on the plans.
- Unless the Engineer specifies a more stringent requirement, do not exceed a maximum horizontal tolerance of 0.5 foot at the base of the pole with respect to approved plans.
- For any pole, measure and record the “as-built” horizontal location of the pole on the on-site recorded plans. Provide as-built plans or certified as-installed construction plans in accordance with TAC Title 43, Part 1, Chapter 21, Subchapter C.
- Install systems to protect wood poles from woodpecker damage as shown on the plans.
- Install pole safety system as shown on the plans or as approved by the Engineer, in accordance with Item 545, “Crash Cushion Attenuators.”
- Place guy wire assembly as shown on the plans, as approved by the Engineer, or in accordance with TAC Title 43, Part 1, Chapter 21, Subchapter C. Keep the number of guy wires within the right of way to a minimum. Place guy wires in line with the pole line, unless the Engineer approves other locations.

XXXX.4. Measurement. This Item will be measured by each pole, crossarm assembly, riser assembly, or guy wire assembly installed.

XXXX.5. Payment. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Treated Timber Pole" of the size specified, "Laminated Wood Pole" of the size specified, "Concrete Pole" of the size specified, "Composite Pole" of the size specified, "Steel Pole" of the size specified, "Aluminum Pole" of the size specified, "Crossarm Assembly" of the type specified, "Riser Assembly" of the type specified, or "Guy Wire Assembly" of the type specified (see Table 18). All other items are considered subsidiary.

Removing and Relocating Ground Boxes

Table 19. Proposed Specification: Removing and Relocating Ground Boxes.

<table>
<tr><td>Specification Number</td><td colspan="3">XXXX</td></tr>
<tr><td>Specification Title</td><td colspan="3">Removing and Relocating Ground Boxes</td></tr>
<tr><td>Description</td><td colspan="3">Remove and relocate ground boxes (such as handholes, junction boxes, pull boxes, splice enclosures, pedestals, or other similar boxes) at locations shown on the plans or as approved by the Engineer. Note to Specification Writer: Removing and relocating ground boxes involves moving existing ground boxes, not abandoning (or removing) unusable ground boxes and then installing new ground boxes at a different location (for which other specifications apply).</td></tr>
<tr><td>Previous Specifications</td><td colspan="3"></td></tr>
<tr><td>Proposed Changes</td><td colspan="3">Create new specification for removing and relocating ground boxes.</td></tr>
<tr><td>Comment</td><td colspan="3"></td></tr>
<tr><td colspan="3">Bid Item</td><td>Measurement Unit</td></tr>
<tr><td colspan="3">Remove and Relocate Ground Box</td><td>Each</td></tr>
<tr><td colspan="3">Note to Specification Writer: Add other pay items as indicated on the plans or as required by this specification.</td><td></td></tr>
<tr><td colspan="2">Subsidiary Item (if specified)</td><td>Referenced Item</td><td>Subsidiary to</td></tr>
<tr><td colspan="2">Structural Excavation (Pipes)</td><td>400, 401</td><td>Ground box relocation</td></tr>
<tr><td colspan="2">Bedding</td><td>400</td><td>Ground box relocation</td></tr>
<tr><td colspan="2">Backfill</td><td>400</td><td>Ground box relocation</td></tr>
<tr><td colspan="2">Moving Ground Box</td><td></td><td>Ground box relocation</td></tr>
<tr><td colspan="2">Testing</td><td></td><td>Ground box relocation</td></tr>
<tr><td colspan="2">Note to Specification Writer: Add other subsidiary items as indicated on the plans or as required by this specification.</td><td></td><td></td></tr>
</table>

Specification Requirements

XXXX.1. Description. Remove and relocate ground boxes (such as handholes, junction boxes, pull boxes, splice enclosures, pedestals, or other similar boxes) at locations shown on the plans or as approved by the Engineer. ***Note to Specification Writer***: Removing and relocating ground boxes involves moving existing ground boxes, not abandoning (or removing) unusable ground boxes and then installing new ground boxes at a different location (for which other specifications apply). ***Note to Specification Writer*:** Include appropriate references to definitions from Table 3 to facilitate the understanding of basic specification concepts.

XXXX.2. Materials.

A. General.

1. Replace unsuitable or damaged ground boxes with new items in accordance with Special Specification XXXX, "Ground Boxes." If the Contractor damages items designated for reuse, replace them at no charge to the Department with new material or restore them to previous condition, as approved by the Engineer.

2. Remove materials not designated for reuse by the Engineer in accordance with Item 496, "Removing Structures."

B. Inspections. Provide facilities and access to allow for inspection. Provide access for inspection of the ground boxes at the project site before and during installation.

C. Bedding Material. Furnish bedding in accordance with Item 400, "Excavation and Backfill for Structures."

D. Backfill Material. Furnish conventional backfill material in accordance with Item 400, "Excavation and Backfill for Structures," or select backfill in accordance with Special Specification XXXX, "Select Backfill for Structures," as specified on the plans.

XXXX.3. Construction.

A. Excavation, Shaping, Bedding, and Backfill. Excavate, shape, bed, and backfill in accordance with Item 400, "Excavation and Backfill for Structures," and Special Specification XXXX, "Select Backfill for Structures."

B. Preparation. Prior to removal of a ground box, cut or disconnect all cables and conduit that connect to the ground box. Coil and store the cable in a secure manner to ensure the cable reuse. Remove any debris in the ground box prior to cable installation.

C. Remove and Relocate Ground Box. Remove and relocate existing ground box at the location shown on the plans or as approved by the Engineer in accordance with Special Specification XXXX, "Ground Boxes."

D. Remove and Relocate Conduit Structures. Remove and relocate conduit structures in accordance with Special Specification XXXX, "Removing and Relocating Conduit Structures."

E. Remove and Relocate Communication Cable. Remove and relocate communication cable, including splicing and terminations, in accordance with Special Specification XXXX, "Removing and Relocating Communication Cable."

XXXX.4. Measurement. This Item will be measured by each ground box removed and relocated. Ground box removal and relocation will not be classified for measurement according to the depth of the trench.

XXXX.5. Payment. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Remove and Relocate Ground Box" (see Table 19). All other items are considered subsidiary. ***Note to Specification Writer:*** Cable splicing will be paid for under the bid item "Splicing" of the type specified in Item XXXX, "Communication Cable" (see Table 11).

Removing and Relocating Cable Vaults

Table 20. Proposed Specification: Removing and Relocating Cable Vaults.

Specification Number	XXXX
Specification Title	Removing and Relocating Cable Vaults
Description	Remove and relocate cable vaults at locations shown on the plans or as approved by the Engineer. ***Note to Specification Writer***: Removing and relocating cable vaults involves moving existing cable vaults, not abandoning or removing unusable cable vaults and installing new ones at a different location (for which different specifications apply).
Previous Specifications	
Proposed Changes	Create new specification for removing and relocating cable vaults.
Comment	

Bid Item	**Measurement Unit**
Remove and Relocate Cable Vault (several sizes)	Each
Remove and Relocate Environmentally Controlled Cable Vault (several sizes)	Each
Note to Specification Writer: Add other pay items as indicated on the plans or as required by this specification.	

Subsidiary Item (if specified)	**Referenced Item**	**Subsidiary to**
Structural Excavation (Pipes)	400, 401	Cable vault relocation
Bedding	400	Cable vault relocation
Backfill	400	Cable vault relocation
Moving Cable Vault		Cable vault relocation
Testing		Cable vault relocation
Note to Specification Writer: Add other subsidiary items as indicated on the plans or as required by this specification.		

Specification Requirements

XXXX.1. Description. Remove and relocate cable vaults at locations shown on the plans or as approved by the Engineer. ***Note to Specification Writer***: Removing and relocating cable vaults involves moving existing cable vaults, not abandoning or removing unusable cable vaults and installing new ones at a different location (for which different specifications apply). ***Note to Specification Writer*****:** Include appropriate references to definitions from Table 3 to facilitate the understanding of basic specification concepts.

XXXX.2. Materials.

A. General.

1. Replace unsuitable or damaged cable vaults with new items in accordance with Special Specification XXXX, "Cable Vaults." If the Contractor damages items

designated for reuse, replace them at no charge to the Department with new material or restore them to previous condition, as approved by the Engineer.

2. Remove materials not designated for reuse by the Engineer in accordance with Item 496, “Removing Structures.”

B. Inspections. Provide facilities and access to allow for inspection. Provide access for inspection of the cable vaults at the project site before and during installation.

C. Bedding Material. Furnish bedding in accordance with Item 400, “Excavation and Backfill for Structures.”

D. Backfill Material. Furnish conventional backfill material in accordance with Item 400, “Excavation and Backfill for Structures,” or select backfill in accordance with Special Specification XXXX, “Select Backfill for Structures,” as specified on the plans.

XXXX.3. Construction.

A. Excavation, Shaping, Bedding, and Backfill. Excavate, shape, bed, and backfill in accordance with Item 400, “Excavation and Backfill for Structures,” and Special Specification XXXX, “Select Backfill for Structures.”

B. Preparation.

1. Prior to removal of a cable vault, cut or disconnect all cables and conduit that connect to the cable vault. Coil and store the cable in a secure manner to ensure the cable reuse.

2. Remove any debris in the cable vault prior to cable installation.

C. Remove and Relocate Environmental Control Features. Remove and relocate environmental control features (e.g., air conditioners, dehumidifiers) as shown on the plans or as approved by the Engineer in accordance with Special Specification XXXX, “Cable Vaults.”

D. Remove and Relocate Cable Vault. Remove and relocate existing cable vault at the location shown on the plans or as approved by the Engineer in accordance with Special Specification XXXX, “Cable Vaults.”

E. Remove and Relocate Conduit Structures. Remove and relocate conduit structures in accordance with Special Specification XXXX, “Removing and Relocating Conduit Structures.”

F. Remove and Relocate Communication Cable. Remove and relocate communication cable, including splicing and terminations, in accordance with Special Specification XXXX, “Removing and Relocating Communication Cable.”

XXXX.4. Measurement. This Item will be measured by each cable vault removed and relocated. Cable vault removal and relocation will not be classified for measurement according to the depth of the trench.

XXXX.5. Payment. The work performed and materials furnished in accordance with this Item and measured as provided under “Measurement” will be paid for at the unit price bid for “Remove and Relocate Cable Vault” of the size specified or “Remove and Relocate Environmentally Controlled Cable Vault” of the size specified (see Table 20). All other items are considered subsidiary. ***Note to Specification Writer:*** Cable splicing will be paid for under the bid item “Splicing” of the type specified in Item XXXX, “Communication Cable” (see Table 11).

Removing and Relocating Communication Buildings and Cabinets

Table 21. Proposed Specification: Removing and Relocating Communication Buildings and Cabinets.

Specification Number	XXXX
Specification Title	Removing and Relocating Communication Buildings and Cabinets
Description	Remove and relocate communication buildings and cabinets at locations shown on the plans or as approved by the Engineer.
Previous Specifications	2004 Special Specification 6487, "Remove and Relocate Existing Communication Hub Building"
Proposed Changes	Create new specification for removing and relocating communication buildings and cabinets.
Comment	

Bid Item	**Measurement Unit**
Remove and Relocate Communication Cabinet (equipment included) (several types) (several sizes)	Each
Remove and Relocate Communication Cabinet (no equipment) (several types) (several sizes)	Each
Remove and Relocate Concrete Universal Enclosure	Each
Remove and Relocate Serving Area Interface	Each
Remove and Relocate Loop Carrier Box	Each
Note to Specification Writer: Add other pay items as indicated on the plans or as required by this specification.	

Subsidiary Item (if specified)	**Referenced Item**	**Subsidiary to**
Structural Excavation (Pipes)	400, 401	Building or cabinet relocation
Bedding	400	Building or cabinet relocation
Backfill	400	Building or cabinet relocation
Foundation		Building or cabinet relocation
Moving Enclosure and Equipment		Building or cabinet relocation
Testing		Building or cabinet relocation
Note to Specification Writer: Add other subsidiary items as indicated on the plans or as required by this specification.		

Specification Requirements

XXXX.1. Description. Remove and relocate communication buildings and cabinets at locations shown on the plans or as approved by the Engineer. ***Note to Specification Writer*:** Include appropriate references to definitions from Table 3 to facilitate the understanding of basic specification concepts.

XXXX.2. Materials.

A. General.

1. Replace unsuitable or damaged cabinets with new items in accordance with Special Specification XXXX, "Communication Buildings and Cabinets." If the Contractor damages items designated for reuse, replace them at no charge to the Department with new material or restore them to previous condition, as approved by the Engineer.
2. Remove materials not designated for reuse by the Engineer in accordance with Item 496, "Removing Structures."

B. Inspections. Provide facilities and access to allow for inspection. Provide access for inspection of the ground boxes at the project site before and during installation.

C. Bedding Material. Furnish bedding in accordance with Item 400, "Excavation and Backfill for Structures."

D. Backfill Material. Furnish conventional backfill material in accordance with Item 400, "Excavation and Backfill for Structures," or select backfill in accordance with Special Specification XXXX, "Select Backfill for Structures," as specified on the plans.

XXXX.3. Construction.

A. Excavation, Shaping, Bedding, and Backfill. Excavate, shape, bed, and backfill in accordance with Item 400, "Excavation and Backfill for Structures," and Special Specification XXXX, "Select Backfill for Structures."

B. Preparation.

1. Prior to removal of a building or cabinet, cut or disconnect all cables and conduit that connect to the building or cabinet. Pull cable to a nearby ground box, as shown on the plans, and coil and store the cable in a secure manner to ensure the cable reuse.
2. Remove any debris in the building or cabinet prior to cable installation.
3. Remove existing foundation to 2 ft. below existing grade and backfill and repair with material to match existing area surrounding removed foundation or as approved by the Engineer.
4. Provide foundation for relocated building or cabinet at the location shown on the plans or as approved by the Engineer in accordance with Special Specification XXXX, "Communication Buildings and Cabinets."

C. Remove and Relocate Building or Cabinet. Remove and relocate existing building or cabinet at the location shown on the plans or as approved by the Engineer in accordance with Special Specification XXXX, "Communication Buildings and Cabinets."

D. Remove and Relocate Conduit Structures. Remove and relocate conduit structures in accordance with Special Specification XXXX, "Removing and Relocating Conduit Structures."

E. Remove and Relocate Communication Cable. Remove and relocate communication cable, including splicing and terminations, in accordance with Special Specification XXXX, "Removing and Relocating Communication Cable."

F. Testing.

1. Conduct communication building or cabinet testing in accordance with Special Specification XXXX, “Communication Buildings and Cabinets.”
2. Conduct pre-testing and post-testing of cable performance prior to and after adjustment or relocation of the cable in accordance with Special Specification XXXX, “Communication Cable.”
3. Performance test results after adjustment or relocation should not result in signal degradation with respect to prior to the adjustment or relocation. Repair or replace components that failed testing after adjustment or relocation but passed testing prior to adjustment or relocation at the expense of the Contractor.

XXXX.4. Measurement. This Item will be measured by each communication cabinet (equipment included), communication cabinet (no equipment), concrete universal enclosure, serving area interface, or loop carrier box removed and relocated.

XXXX.5. Payment. The work performed and materials furnished in accordance with this Item and measured as provided under “Measurement” will be paid for at the unit price bid for “Remove and Relocate Communication Cabinet (equipment included)” of the type and size specified, “Remove and Relocate Communication Cabinet (no equipment)” of the type and size specified, “Remove and Relocate Concrete Universal Enclosure,” “Remove and Relocate Serving Area Interface,” or “Remove and Relocate Loop Carrier Box” (see Table 21). All other items are considered subsidiary. ***Note to Specification Writer:*** Cable splicing will be paid for under the bid item “Splicing” of the type specified in Item XXXX, “Communication Cable” (see Table 11).

Adjusting, or Removing and Relocating Pole Assemblies

Table 22. Proposed Specification: Adjusting, or Removing and Relocating Pole Assemblies.

Specification Number	XXXX
Specification Title	Adjusting, or Removing and Relocating Pole Assemblies
Description	Adjust, or remove and relocate pole assemblies (such as poles, crossarm assemblies, riser assemblies, and guy wire assemblies) at locations shown on the plans or as approved by the Engineer. Adjusting a pole assembly involves raising or lowering assembly components (e.g., raising or lowering a crossarm assembly) or adjusting guy wire assembly anchor points. Removing and relocating a pole assembly involves moving existing assembly components (e.g., when it is necessary to move poles to new locations). ***Note to Specification Writer***: Item 545, "Crash Cushion Attenuators," includes requirements and bid items for relocating pole safety devices.
Previous Specifications	2004 Special Specification 6119, "Relocate or Remove Pedestal Pole Assemblies" 2004 Special Specification 6184, "Remove and Relocate Camera Pole Structure" 1993 Special Specification 6078, "Remove and Relocate High Mast Illumination Poles" Item 610, "Roadway Illumination Assemblies" Item 627, "Treated Timber Poles" Item 545, "Crash Cushion Attenuators"
Proposed Changes	Create new specification for adjusting or removing and relocating pole assemblies.
Comment	

Bid Item	**Measurement Unit**
Adjust Crossarm Assembly	Each
Adjust Riser Assembly	Each
Adjust Guy Wire Assembly	Each
Remove and Relocate Pole (several heights)	Each
Remove and Relocate Crossarm Assembly	Each
Remove and Relocate Riser Assembly	Each
Remove and Relocate Guy Wire Assembly	Each
Note to Specification Writer: Add other pay items as indicated on the plans or as required by this specification.	

Subsidiary Item (if specified)	**Referenced Item**	**Subsidiary to**
Structural Excavation (Poles)	400	Adjust or relocate pole assembly
Backfill	400	Adjust or relocate pole assembly

Table 22. Proposed Specification: Adjusting or Removing and Relocating Pole Assemblies (Continued).

Subsidiary Item (if specified)	Referenced Item	Subsidiary to
Woodpecker Protection		Adjust or relocate pole assembly
Moving Pole Assembly		Adjust or relocate pole assembly
Note to Specification Writer: Add other subsidiary items as indicated on the plans or as required by this specification.		

Specification Requirements

XXXX.1. Description. Adjust, or remove and relocate pole assemblies (such as poles, crossarm assemblies, riser assemblies, and guy wire assemblies) at locations shown on the plans or as approved by the Engineer. Adjusting a pole assembly involves raising or lowering assembly components (e.g., raising or lowering a crossarm assembly) or adjusting guy wire assembly anchor points. Removing and relocating a pole assembly involves moving existing assembly components (e.g., when it is necessary to move poles to new locations). ***Note to Specification Writer***: Item 545, "Crash Cushion Attenuators," includes requirements and bid items for relocating pole safety devices. ***Note to Specification Writer*****:** Include appropriate references to definitions from Table 3 to facilitate the understanding of basic specification concepts.

XXXX.2. Materials.

A. General.

1. Replace unsuitable or damaged poles, crossarm assemblies, or related hardware with new items in accordance with Special Specification XXXX, "Pole Assembly." If the Contractor damages items designated for reuse, replace them at no charge to the Department with new material or restore them to previous condition, as approved by the Engineer. ***Note to Specification Writer:*** RUS 1730B-121, "Pole Inspection and Maintenance," describes methods for determining the serviceability of used timber poles.

2. Remove materials not designated for reuse by the Engineer in accordance with Item 496, "Removing Structures."

B. Inspections. Provide facilities and access to allow for inspection. Provide access for inspection of the pole assemblies at the project site before and during installation. ***Note to Specification Writer:*** RUS 1730B-121, "Pole Inspection and Maintenance" describes methods for inspecting timber poles.

C. Backfill Material. Furnish conventional backfill material in accordance with Item 400, "Excavation and Backfill for Structures," or select backfill in accordance with Special Specification XXXX, "Select Backfill for Structures," as specified on the plans.

XXXX.3. Construction.

A. **Excavation, Shaping, Bedding, and Backfill.** Excavate, shape, bed, and backfill in accordance with Item 400, "Excavation and Backfill for Structures," and Special Specification XXXX, "Select Backfill for Structures."

B. **Preparation.**

   1. For any pole that contains electric or communication cable that is in service, coordinate the adjustment or relocation with the utility owners in a manner that minimizes utility service disruption.

   2. Prior to removal and relocation of a pole or crossarm assembly, remove all electric or communication cables attached to the pole. Prior to removal and relocation of a guy wire assembly, remove all electric or communication cables that the guy wire assembly supports, or anchor the pole assembly as shown on the plans or as approved by the Engineer. Coil and store the cable in a secure manner to ensure the cable can be reused.

   3. Remove abandoned foundations, including steel, to 2 ft. below the finished grade. Backfill with material equal in composition and density to the surrounding area.

   4. Store pole assemblies in a manner that prevents damage or deterioration.

C. **Adjust Crossarm Assembly, Riser Assembly, and Guy Wire Assembly.** Adjust crossarm assemblies, riser assemblies, and guy wire assemblies as shown on the plans or as approved by the Engineer.

D. **Remove and Relocate Pole, Crossarm Assembly, Riser Assembly, and Guy Wire Assembly.** Install relocated poles, crossarm assemblies, riser assemblies, and guy wire assemblies in accordance with Special Specification XXXX, "Pole Assemblies."

E. **Remove and Relocate Communication Cable.** Remove and relocate communication cable, including splicing and terminations, in accordance with Special Specification XXXX, "Adjusting or Removing and Relocating Communication Cable."

XXXX.4. Measurement. This Item will be measured by each pole, crossarm assembly, riser assembly, or guy wire assembly adjusted or removed and relocated.

XXXX.5. Payment. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Adjust Crossarm Assembly," "Adjust Riser Assembly," "Adjust Guy Wire Assembly," "Remove and Relocate Pole" of the size specified, "Remove and Relocate Crossarm Assembly," "Remove and Relocate Riser Assembly," or "Remove and Relocate Guy Wire Assembly" (see Table 22). All other items are considered subsidiary. ***Note to Specification Writer:*** Cable splicing will be paid for under the bid item "Splicing" of the type specified in Item XXXX, "Communication Cable" (see Table 11).

Removing Structures

Table 23. Proposed Specification: Removing Structures.

Specification Number	496
Specification Title	Removing Structures
Description	Remove and either dispose of or salvage structures.
Previous Specifications	2004 Standard Specification 496, "Removing Structures" 1993 Special Specification 5062, "Salvaging Water Lines, Sanitary Sewer Lines, Fire Hydrants, Valves and Fittings" 1993 Special Specification 5000, "Transporting Salvaged Items" 1993 Special Specification 8634, "Remove Rigid Metal Conduit" 2004 Special Specification 6489, "Removal of Existing Cables"
Proposed Changes	Modify specification to include the removal of utility appurtenances, conduit structures, and cable.
Comment	Removing water appurtenances includes removing valves, meters, meter boxes, and hydrants. Removing sanitary sewer appurtenances includes removing valves, cleanouts, and pumps. All other fittings are subsidiary to pipe removal. Removing communication appurtenances includes removing items such as ground boxes and cabinets. All other fittings are subsidiary to conduit structure removal, or cable removal. ***Note to Specification Writer***: The proposed modifications do not include a provision for asbestos cement pipe because TxDOT is revising Items 1 through 9 to more explicitly account for the presence of asbestos at the job site.

Bid Item	**Measurement Unit**
Removing Structures (Pipe)	Foot
Removing Structures (Concrete, Brick, or Stone)	Each
Removing Structures (Steel)	Each
Removing Structures (Timber)	Each
Removing Structures (Conduit Structures)	Foot
Removing Structures (Communication Cable)	Foot
Removing Structures (Utility Appurtenances)	Each
Note to Specification Writer: Add other pay items as indicated on the plans or as required by this specification.	

Subsidiary Item (if specified)	**Referenced Item**	**Subsidiary to**
Structural Excavation (Pipes)	400	Item removal
Backfill	400	Item removal
Remove Pipe or Conduit Structure Fittings		Item removal
Note to Specification Writer: Add other subsidiary items as indicated on the plans or as required by this specification.		

496.2. Construction.

- **496.2.A.5. Conduit Structures.** Add this section and include requirements for removing conduit structures.
- **496.2.A.6. Communication Cable.** Add this section and include requirements for removing communication cable.
- **496.2.A.7. Utility Appurtenances.** Add this section and include requirements for removing utility appurtenances. ***Note to Specification Writer***: Removing water appurtenances includes removing valves, meters, meter boxes, and hydrants. Removing sanitary sewer appurtenances includes removing valves, cleanouts, and pumps. All other fittings are subsidiary to pipe removal. Removing communication appurtenances includes removing ground boxes (such as handholes, junction boxes, pull boxes, pedestals, and splice enclosures). All other fittings are subsidiary to conduit structure removal, or cable removal.

Abandoning Structures

Table 24. Proposed Specification: Abandoning Structures.

Specification Number	XXXX
Specification Title	Abandoning Structures
Description	Permanently decommission structures such as pipes, manholes, underground fuel storage tank systems, conduit structures, and cable in place.
Previous Specifications	1993 Special Specification 7321 – Abandonment and Permanent Removal from Service of Underground Fuel Storage Tank Systems. 1993 Special Specification 7328 – Abandonment and Permanent Removal from Service of Underground Fuel Storage Tank Systems. 1993 Special Specification 5740 – Water Mains and Service Lines.
Proposed Changes	Create new specification for abandoning (i.e., permanently decommissioning) structures in place.
Comment	

Bid Item	Measurement Unit
Abandon Structure (Cut and Plug End) (several diameters)	Each
Abandon Structure (Grout Fill)	Cubic yard
Abandon Cable (Cut)	Each
Abandon Underground Fuel Storage Tank System	Lump sum
Note to Specification Writer: Add other pay items as indicated on the plans or as required by this specification.	

Subsidiary Item (if specified)	Referenced Item	Subsidiary to
Note to Specification Writer: Add subsidiary items as indicated on the plans or as required by this specification.		

Specification Requirements

XXXX.1. Description. Permanently decommission structures such as pipes, manholes, underground fuel storage tank systems, conduit structures, and cable in place.

XXXX.2. Materials.

A. Grout and Plug. Provide grout and plug material of the type and composition shown on the plans or as approved by the Engineer.

XXXX.3. Construction.

A. Standards and Codes. Applicable standards and codes include the following:

1. Texas Administrative Code Title 43, Part 1, Chapter 21, Subchapter C, “Utility Accommodation”

B. General.

1. **1.** Abandoning a facility in place does not constitute a transfer of ownership of the abandoned facility from the utility to the department, unless utility adjustment is the financial responsibility of the department.
2. **2.** At the request of the Engineer, submit a certification to the department that abandonment has complied with the appropriate federal, state, and local laws and regulations.

C. Abandon Structure (Complete Structure or Partial Demolition). As shown on the plans or as approved by the Engineer, portions of structures that will not interfere with the proposed construction may remain in place 2 ft. or more below the permanent ground line. Square off remaining structures and cut reinforcement flush with the surface of the concrete. Remove the material that will not remain in the ground.

D. Abandon Structure (Cut and Plug End).

1. Disconnect pipe or shut off service to conduit structure.

2. Cut existing pipe or conduit structure at the locations indicated on the plans or as approved by the Engineer.

3. Remove all cable from the conduit structure in accordance with Special Specification XXXX, "Removing Structures."

4. Fill the abandoned pipe or conduit with water and plug each end as shown on the plans or as approved by the Engineer.

E. Abandon Structure (Grout Fill).

1. Submit for the Engineer's review the method to grout fill the abandoned structure.

2. Grout fill abandoned valve boxes and extensions to within eight inches of the finished surface. Fill the remaining eight inches with Class "D" concrete in accordance with Item 421, "Hydraulic Cement Concrete," or as shown on the plans or approved by the Engineer.

3. Salvage valve covers as directed by the Engineer.

F. Abandon Cable.

1. Shut off service to the cable.

2. Cut existing cable at the locations indicated on the plans or as approved by the Engineer.

G. Abandon Underground Fuel Storage Tank System.

1. Standards and Codes. Applicable standards and codes include the following:

- American Petroleum Institute Recommended Practice 1604, "Closure of Underground Storage Tanks"
- Code of Federal Regulations Title 40, Part 280, Subpart G, "Out of Service UST Systems and Closure"

- Texas Administrative Code Title 30, Chapter 334, “Underground and Aboveground Storage Tanks”

2. **General. Note to Specification Writer:** Include in the specification requirements for the following:

   - Qualifications and experience of the contractor
   - Underground fuel storage tank removal plan
   - Waste disposal documentation
   - Permits and notifications
   - Safety plan, including trench safety, vapor and other flammable materials
   - Contingencies
   - Excavation and backfill procedures
   - Tank purging
   - Testing

XXXX.4. Measurement. This Item will be measured by each cut and plugged structure, by each cubic yard of grout fill, by each cable cut, or by each underground fuel tank system abandoned in place.

XXXX.5. Payment. The work performed and materials furnished in accordance with this Item and measured as provided under “Measurement” will be paid for at the unit price bid for “Abandon Structure” of type and size specified, “Abandon Cable,” or “Abandon Underground Fuel Storage Tank System” (see Table 24). All other items are considered subsidiary.

Temporary Utility Adjustments

Table 25. Proposed Specification: Temporary Utility Adjustments.

Specification Number	XXXX	
Specification Title	Temporary Utility Adjustments	
Description	Construct, maintain, and remove temporary utility adjustments.	
Previous Specifications	Several, including: 1993 Special Specification 5970, "Southwestern Bell Telephone Underground Telephone" 2004 Special Specification 5500, "NBU Utility Adjustments" 2004 Item 508, "Constructing Detours."	
Proposed Changes	Create new specification for temporary utility adjustments.	
Comment		
Bid Item		**Measurement Unit**
Temporary Utility Adjustment		Foot
Temporary Utility Adjustment		Lump Sum
Note to Specification Writer: Add other pay items as indicated on the plans or other design documents.		
Subsidiary Item	**Referenced Item**	**Subsidiary to**
Temporary Adjustment Maintenance		Temporary utility adjustment
Structural Excavation (Pipes)	400, 401	Temporary utility adjustment
Bedding	400	Temporary utility adjustment
Spacers		Temporary utility adjustment
Fittings		Temporary utility adjustment
Non-Metallic Detection System		Temporary utility adjustment
Backfill	400	Temporary utility adjustment
Manhole or Vault Modification		Temporary utility adjustment
Trench Plate		Temporary utility adjustment
Conduit Testing		Temporary utility adjustment
CIP Trench Cap (Concrete)	XXXX	Temporary utility adjustment
CIP Encasement (Concrete)	XXXX	Temporary utility adjustment
Note to Specification Writer: Add other subsidiary items as indicated on the plans or as required by this specification.		

Specification Requirements

XXXX.1. Description. Construct, maintain, and remove temporary utility adjustments. ***Note to Specification Writer***: Include appropriate references to definitions from Table 3 to facilitate the understanding of basic specification concepts (e.g., conduit, inner duct, conduit structure, and temporary utility adjustment).

XXXX.2. Materials.

A. **General.** Furnish materials for temporary utility adjustments as shown on the plans or as approved by the Engineer.

B. **Steel Plate.** Furnish steel plate for trench plates in accordance with Item 442, "Metal for Structures," as shown on the plans, or as approved by the Engineer. ***Note to Specification Writer*****:** To minimize the risk of slippery surface conditions, particularly under rainy weather, include requirements for trench plate non-skid surface treatments as well as requirements for maximum lengths vehicles are allowed to traverse on trench plates.

C. **Recovered Materials.** Provide facilities and access to allow for inspection of materials used for the temporary adjustment. Identify and clearly mark materials recovered from the temporary use that the utility accepts for re-use as well as recovered materials that are unsuitable and the utility does not accept for re-use, grouped according to their sale value. ***Note to Specification Writer*****:** The TxDOT Utility Manual includes provisions regarding the acceptance of materials suitable for re-use and the corresponding procedure to credit the project.

XXXX.3. Construction.

A. **General.**

1. Construct the temporary utility adjustment at the locations and to the lines, grades, and typical sections shown on the plans or as approved by the Engineer, in accordance with pertinent Items.
2. Provide trench plates where traffic must cross open trenches, as shown on the plans, or as approved by the Engineer. Prior to the installation of trench plates and opening the trench plates to traffic, provide traffic control plan for the Engineer's review and approval, including measures to control traffic under rainy weather. ***Note to Specification Writer*****:** Include requirements for trench plate thickness, width, and mechanism to anchor trench plate to ground surface. Include requirements for maximum number of days trench is allowed to be covered by trench plates.
3. Remove all materials used for the temporary utility adjustment after they are no longer needed to maintain service to utility customers. If shown on the plans, abandon temporary facilities in accordance with Special Specification XXXX, "Abandoning Structures." Dispose of the materials off the right of way, unless otherwise directed, in accordance with federal, state, and local requirements.

XXXX.4. Measurement. This Item will be measured by the foot along the centerline of temporary utility adjustment or by each temporary utility adjustment constructed. Temporary utility adjustment will not be classified for measurement according to the depth of the adjustment. If the temporary utility adjustment has been disaggregated into discrete construction units, measurement and payment will be made in accordance with the corresponding Items.

XXXX.5. Payment. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Temporary Utility Adjustment" (see Table 25). All other items are considered subsidiary.

CHAPTER 3. IMPACT OF UTILITY ADJUSTMENT COSTS ON HIGHWAY CONSTRUCTION COST ESTIMATION

INTRODUCTION

The implementation of the methodology described in the previous chapter, as well as that developed in previous reports (*6, 7*), should result over time in a sizable, detailed unit cost database that TxDOT officials could use to help track utility adjustment costs. This historical unit cost database could be particularly useful during negotiations with utility companies, e.g., as a mechanism to validate unit cost data utility companies submit as part of the utility agreement documentation during the design phase.

However, during the planning or preliminary design phases of the project development process, when horizontal alignments are still under development and detailed information about existing utility installations and utility adjustment needs is preliminary if not absent, there is frequently very little information to help "forecast" utility adjustment costs. Nonetheless, developing this capability is important for a number of reasons, including the following:

- District utility agents frequently have the task of estimating utility adjustment costs during the preliminary design phase (Figure 6) as one of the inputs for the preliminary design construction cost estimate. This activity is also necessary in order to prepare Alternate Procedure documentation that TxDOT submits to FHWA to secure federal funding.

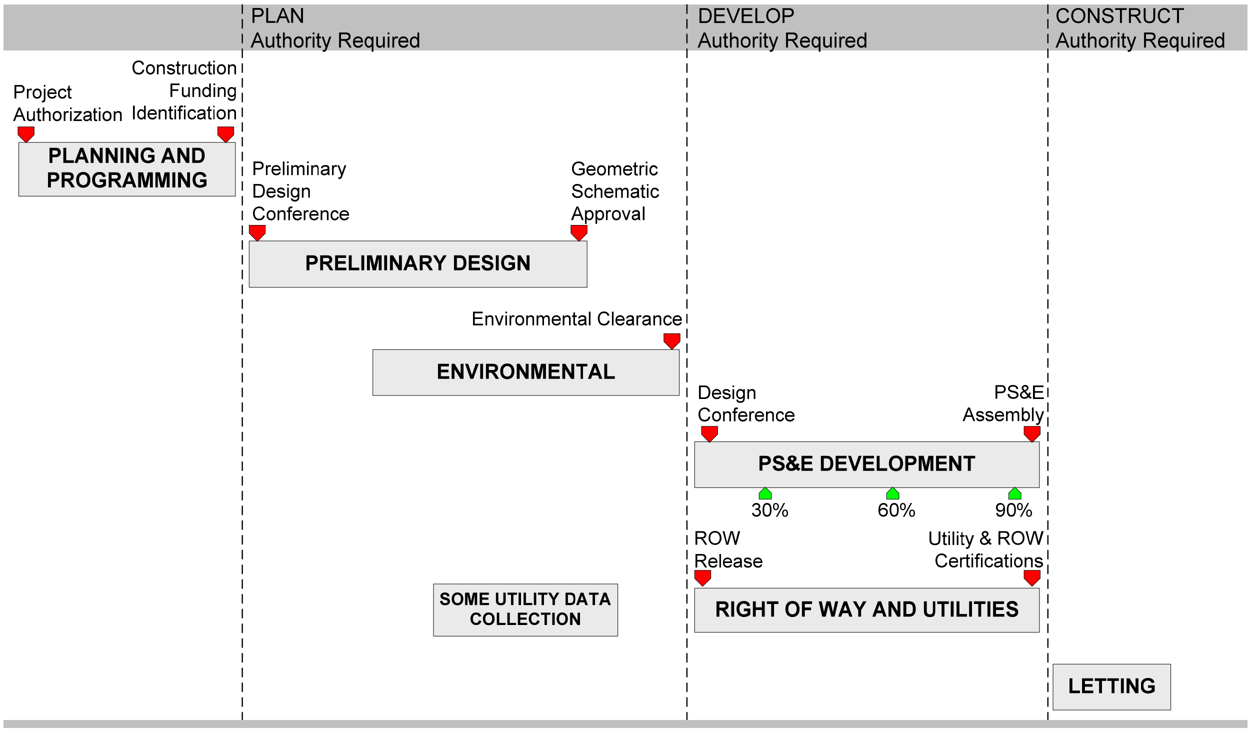


Figure 6. Current Project Development Process at TxDOT (adapted from [29]).

- Particularly in the case of large-scale projects, there is considerable evidence that costs tend to be underestimated, highlighting the need to develop better preliminary estimates. For example, a recent study evaluated 258 large projects over the last seven decades and compared final project costs and the estimates at the time the decision to proceed was made (*30*). The study found that costs were underestimated in 90 percent of the projects, actual costs were on average 28 percent above the estimate, and costs that were underestimated were wrong by a much larger margin than those that were overestimated.

- The Safe, Accountable, Flexible, Efficient Transportation Equity Act – A Legacy for Users (SAFETEA-LU) introduced a series of additional requirements for states to provide adequate project financial integrity, delivery, and oversight (*31*). For example, projects with a total estimated cost of at least $100 million must provide an annual financial plan that includes detailed estimates of the total cost to complete the project and annual updates based on reasonable assumptions of future increase of project costs. Major projects (i.e., projects with a total estimated cost of least $500 million, which SAFETEA-LU lowered from the previous threshold of $1 billion) must also provide project management plans that document procedures and processes to manage the scope, costs, quality, and applicable federal requirements. As a result of these requirements, TxDOT is implementing a total project cost initiative, where districts are becoming responsible for all the cost components of a project, which in turn is resulting in additional pressure to develop accurate cost estimates throughout the entire project development process, including utility adjustments. It may be worth noting the TxDOT Design and Construction Information System (DCIS) recently underwent modifications to calculate and display total project cost estimates on user interfaces.

- Utility adjustment costs are among the most difficult costs to estimate and carry a high potential for risk and change. FHWA's Cost Estimating Guidance (*32*) acknowledges this reality and recommends including appropriate contingencies for utility adjustments, as well as the implementation of mitigating strategies such as locating and avoiding utility adjustments whenever possible and including subsurface utility engineering (SUE) in the project development budget.

This chapter describes the work completed to estimate utility adjustment costs during the early stages of the project development process.

LITERATURE REVIEW

Despite the potential impact that utility adjustment costs could have on total highway project costs, it is quite common to estimate utility adjustment costs at a much higher level of aggregation than highway construction costs. Common practices include estimating utility adjustment cost as a fixed percentage of the highway construction cost, as a lump sum, or (if some information about existing utility installations is available) as an aggregate dollar amount per mile of installation. For example, the Florida Department of Transportation (FDOT) State Estimates Office provides information regarding highway construction cost estimates and reimbursements, including a Basis of Estimates Handbook, construction cost history, average item unit costs, and estimator software links (*33*). For estimating and monitoring highway construction projects, FDOT uses tools such as the District Contract Protocol, the Florida Long Range Estimating System, and several American Association of State Highway and Transportation Officials (AASHTO) Trns*port modules, including the Cost Estimation System (CES) and the Proposal and Estimates System (PES) (*34*).

FDOT tracks some utility adjustment costs, but not at the same level as road work. Although the Basis of Estimates Handbook describes FDOT's standard method for documenting construction pay item quantities and units, including utility pipes, boxes, structures, and communication cable, different districts for the most part use project-specific utility work specifications, provisions, and pay items, resulting in very little reuse of these cost elements from project to project. As a result, although the State Estimates Office maintains a listing of typical "per-mile" costs, the listing does not include utility work elements. It may be worth noting that for each item, the Basis of Estimates Handbook provides a description of the measurement unit, whether the item is a plans quantity item, the corresponding accuracy, design and construction documentation requirements, and item disaggregation levels (e.g., by operation, materials, and sizes).

The Virginia Department of Transportation (VDOT) Project Cost Estimating System (PCES) enables the production of scoping or screening cost estimates early during the project development process (*35*). VDOT developed PCES after a 2001 legislative study documented frequent cases of final project costs exceeding initial estimates and recommended VDOT to examine ways to improve cost estimates. PCES includes a cost estimation tool, a scoping process, and a website for project development. Project scoping includes a repository of project data, from initial conception to final documentation.

PCES takes into account requirements such as land acquisition, utility adjustments, preliminary engineering, site preparation, construction, environmental mitigation, landscaping, lighting, retaining walls, turn lanes, traffic signals, and cultural site preservation. PCES also includes inflationary and regional effects. The inclusion of features unique to specific projects such as crossovers and turn lanes was due to the realization that omission of unique features often led to poor estimates because unique feature costs were typically added late in the design phase.

The ROW acquisition and utility adjustment functions in PCES include the option to enter "best judgment" data because the data repository for those items was not as extensive as that for general construction and, as a result, the system developers could not properly calibrate the corresponding estimation parameters. The final sheet also shows total utility adjustment cost estimates and total project cost estimates, making it possible to provide context to the utility adjustment cost calculations.

The use of simple methodologies to estimate utility adjustment costs is the norm rather than the exception. A few additional examples from the literature include the following:

- **2020 Peninsula Gateway Corridor Study (*36*)**. The focus of this study was to identify and evaluate potential projects to improve traffic along Route 101 in San Mateo, California. For developing cost estimates, the consultant assumed lump sum utility adjustment cost values based on "experience with similar recent construction projects."

Relative to the estimated construction costs, the assumed utility adjustment cost ranged from 4 – 23 percent, for an overall average of 7.6 percent.

- **California High-Speed Train Program San Francisco Bay Crossing (*37*)**. For developing cost estimates, the consultant assumed utility adjustment costs were a function of land use density (urban, suburban, or undeveloped) based on the number of interchanges associated with each highway segment. The equivalent average cost values per mile were $1.2 million (urban), $654,000 (suburban), and $19,000 (undeveloped).

- **Contra Costa Transportation Authority (*38*)**. The Contra Costa Transportation Authority in California uses a lump sum approach for utility adjustment estimates.

- **Pennsylvania Maglev Project (*39*)**. The project team assumed ROW, environmental, and utility adjustment costs to be 7 percent of the project construction cost. The estimate used work and findings from other organizations and projects as well as Pennsylvania Department of Transportation's construction cost catalog.

- **North South Transportation Initiative (*40*)**. The focus of this initiative in the Ohio, Kentucky, and Indiana areas is to improve the safety, efficiency, and reliability of the transportation system around the I 75 corridor. For developing cost estimates, the study team assumed utility adjustment costs to be 8 percent of the construction costs, with some variability for individual alternatives.

- **Seattle Monorail Project (*41*)**. For developing cost estimates, the study team assumed utility adjustment costs to be $60 million (or 6 percent of a construction cost estimate of $1.1 billion).

- **TTC-35 High Priority Trans-Texas Corridor (*42*)**. For developing cost estimates, the consortium that prepared the TTI-35 master plan used information utility companies provided and as-built data available from other projects of similar scope and magnitude. The analysis assumed utility adjustment costs were $943,000 per mile (which correspond to $313.6 million for a total project length of 332.6 miles, or 4.2 percent on a total primary road facility construction cost estimate of $7.5 billion).

These examples are useful as general reference. However, their suitability for more detailed analysis is somewhat limited because references frequently do not provide enough information regarding:

- whether the costs include all the necessary utility adjustment work or only the work included in some of several possible utility adjustment contracting mechanisms (e.g., including utility items in the highway contract, utility agreements with utility companies, agreements with municipalities);

- whether the reference construction costs (i.e., the values in the denominator) are highway construction-only costs (i.e., excluding any utility adjustment work) or whether the reference construction costs include all or part of the utility adjustment costs; and

- whether the costs include separate contingency allowances for utility adjustments.

Accounting for all contracting mechanisms and calculation details when evaluating utility adjustment costs is important for several reasons, including that different contracting mechanisms may require different approaches for handling uncertainties and that utility adjustments (even if included in the highway contract) may be susceptible to additional requirements and procedures that could affect the total cost of the project.

In general, contingency allowances are funds above the estimate that are designed to reduce the risk of project overruns by covering for situations resulting from insufficient project definition during the project development process (*43*). It is customary to calculate contingency as a percentage of the construction cost estimate and to add the contingency to the project budget. Contingencies typically decrease as a project moves through the project development process. For example, the Contra Costa Transportation Authority in California uses the following contingency levels as percentages of the construction cost (*38*): initial estimate (25 percent), conceptual estimate (20 percent), preliminary estimate (15 percent), 30 – 75 percent design (10 percent), and engineer's estimate (5 percent).

Including contingencies in the project budgeting process is critical. However, using contingencies indiscriminately, e.g., to cover significant changes in scope of work or as a mechanism to absorb artificially low construction cost estimates, ignores that the main purpose of contingencies is to absorb the lack of design definition during the project development process (*44*). To address this issue, several agencies are now recommending the implementation of risk-based strategies for the quantification of contingency funds. For example, for major projects, FHWA recommends dividing contingencies into four major categories (*45*):

- design contingency (varies throughout the project development process),
- construction contingency (to cover cost growth during construction),
- overall management contingency (for third-party and other unanticipated changes), and
- other contingencies (for high-risk areas such as environmental mitigation, ROW, utilities, and highly specialized designs).

For each contingency category, FHWA recommends evaluating factors such as probability of occurrence, severity, and expected financial impact, and estimating the contingency level so that it reflects the remaining risk associated with the corresponding project cost component (*45*).

Recognizing the need to ensure consistency in the production of cost estimates, the TxDOT Houston District recently implemented a web-based system called Projected Total Cost (ProtoCost) to develop highway construction estimates (*46*). To generate cost estimates, ProtoCost includes a variety of cost elements, inflation factors that take into consideration the time lag between the date of the estimate and the time the estimated cost might take place, and contingency allowances that depend on the level of detail of the cost estimates. The system also provides reports with summary cost estimate data that users can apply to populate DCIS fields. ProtoCost runs on a Microsoft structured query language (SQL) Server platform with custom-built web pages that are accessible to authorized TxDOT users through a link on the Houston District Intranet page.

ProtoCost uses six modules to develop cost estimates throughout the project development process: Planning/Major Investment Study (MIS), preliminary design, 30 percent design, 60 percent design, 90 percent design, and 100 percent design. The level of detail for each module varies as a function of the cost data that are typically available for the corresponding phase in the project development process. The system also includes a tool to develop basic construction cost estimates that could rely on average cost-per-mile data for typical cross sections (*47*), cost-per-mile data plus add-ons, or quantities and unit costs depending on the level of design details at the time of preparation of the estimate.

For every estimate, the user determines a basic construction cost estimate and provides the estimate date as well as the projected start and end dates of construction. From these dates, ProtoCost calculates the period of escalation (difference in dates between the estimate date and the midpoint between the projected start and end construction dates), which the system uses to obtain the escalated value of the basic construction cost estimate. The analyst must also enter an annual inflation rate estimate. The TxDOT Design Division provides estimates of inflation rates for construction cost estimates. However, ProtoCost enables users to enter different values and provide a justification for their use in a comment field (*46*).

ProtoCost distinguishes between pre-contract contingencies (which account for unknown costs that might be identified prior to letting) and post-contract contingencies (which account for unknown costs that might happen after awarding the contract). ProtoCost enables users to enter different contingency values according to where the project is along the project development process. For example, for preliminary design, the ProtoCost manual suggests 30-45 percent for pre-contract contingency and 5-10 percent for post-contract contingency (which could increase by up to 5 percent if the contract has incentives). For 30 percent design, the manual suggests 25-35 percent for pre-contract contingency and 5-15 percent for post-contract contingency.

As Table 26 shows, ProtoCost uses 17 major cost elements, which were adapted from a generic list included in the FHWA Cost Estimating Guidance (*32*). Of interest here is the methodology in ProtoCost to estimate the utility adjustment cost component. For Planning/MIS and preliminary design, the system estimates the utility adjustment cost as a percentage of the highway construction cost. That percentage could vary according to the basic construction estimate (<$10 million, $10-30 million, $30-60 million, $60-120 million, >$120 million), location (rural, metro, urban), roadway type (Interstate, US/State Highway, FM), and project type (new location, reconstruction). The system also enables users to enter three different percentage values (low, most likely, and high) for every combination of project size, location, roadway type, and project type.

There may be up to 90 possible combinations of project size, location, roadway type, and project type. For each combination, users enter the desired set of low, most likely, and high utility adjustment cost percentages. In practice, the system displays a set of default values the user can accept or modify to suit the project needs. Although the default value table has entries for all 90 possible combinations, many entries are the same (because of the limited amount of data available for the calibration), and as a result, there are only three different sets of low, most likely, and high utility adjustment percentages in the default value table. Table 27 shows the corresponding values, which in effect assume the utility adjustment cost percentage to be a function of project location and project size, but not roadway type or project type.

Table 26. Cost Elements in ProtoCost (adapted from [*46*]).

Cost Element	Description
Construction	Cost of construction contracts, excluding aesthetic treatments, environmental and drainage mitigation, historic preservations, and intelligent transportation systems (ITS).
Right of Way	Cost of parcel acquisition plus other costs such as cost of legal and administrative services, hazardous material handling, relocations, and expert witnesses.
Utilities	Cost of utility adjustment including costs such as SUE, design, engineering, constructions, and elective betterments.
Preliminary Engineering (Schematic)	Cost of preliminary engineering tasks including development and preparation of schematic plans.
Environmental Documentation	Cost of preparing documents such as Finding of No Significant Impact (FONSI), Categorical Exclusion (CE), and Environmental Impact Statement (EIS).
Detailed Design	Cost of plans, specifications, and estimate (PS&E) preparation from schematic to 100% PS&E bid package.
Design Support	Cost of engineering services the designer provides during construction in support of the Area Engineer (e.g., shop drawing review, request for information (RFI) responses, plan sheet changes).
Environmental Mitigation	Cost of environmental mitigation measures such as noise walls, reforestation, and protection of wetlands and endangered species.
Drainage Mitigation	Cost of drainage mitigation measures such as detention ponds and underground detention in box culverts.
Historic Preservations	Costs related to the preservation of entities that are designated historic.
Aesthetic Treatments	Costs such as pavers, sidewalks, star-embossed retaining wall panels, column flares, and landscaping (trees and shrubs).
Intelligent Transportation Systems	Cost of construction and installation of ITS facilities such as communication trunk line, closed circuit television (CCTV) cameras, and dynamic message signs (DMS).
Public Involvement	Cost of public outreach activities.
TxDOT Construction Management	Costs related to area office or district construction section personnel, equipment, and other resources required to manage the construction project.
Project Management (Consultant)	Costs of project management services a consultant provides.
Project Management (TxDOT)	Costs that TxDOT's in-house personnel (design, ROW, inspection, other) incur, which can be traced directly to a CSJ or a project.
TxDOT Indirect Costs	TxDOT's general and administrative costs, including legal, accounting, and executive administration, which can be attributed to the project.

Table 27. Utility Adjustment Cost Percentages in ProtoCost.

Utility Adjustment Cost Percentage			Cost Factor			
Low	**Most likely**	**High**	**Project Size**	**Location**	**Roadway Type**	**Project Type**
1%	2%	5%	Any	Rural	Any	Any
10%	10%	15%	Any	Urban	Any	Any
			$10–30 M	Metro	Any	Any
10%	20%	25%	>$30 M	Metro	Any	Any

For 30, 60, 90, and 100 percent design, users enter a utility adjustment cost estimate. Beginning at 60 percent, users can divide the estimate into an awarded cost (or sum of costs that are locked in by contract and, therefore, are only susceptible to post-contract contingency allowances) and outstanding adjustment estimate. The system suggests users to develop the estimate using plan quantities and appropriate unit prices or, in their absence, using a range of pre-determined factors. The manual highlights that utility adjustment costs could vary from 5–50 percent of the highway construction cost, depending on the magnitude, density, and type of utilities in need of adjustment. In addition to the utility adjustment construction cost estimate, users need to enter cost percentages for SUE, design and engineering, and elective betterments (which are not eligible for TxDOT or federal participation). Users also need to enter an appropriate inflation rate as well as the estimate date and projected start and end dates of the utility adjustment. From these data, ProtoCost calculates the period of escalation and the escalated value of the utility adjustment estimate. For utility adjustment contingencies, the system asks users to enter percentages for scope definition contingencies (to account for unknown costs that might need to be added to the basic utility adjustment estimate) and post-contract contingencies. The manual indicates that scope definition contingencies could range from 25–35 percent and post-contract contingencies could range from 5–15 percent.

SAMPLE DATA ASSEMBLY

As mentioned previously, Houston District's ProtoCost tool assumes the utility adjustment cost percentage to be a function of project size, location, roadway type, and project type (although the entries in the default factor table in ProtoCost currently assume the percentage is only a function of project size and location [Table 27]). This modeling approach assumes utility adjustment costs could be modeled properly as a percentage of the highway construction cost. Many professionals tend to disregard any assumption of "causality" between utility adjustment costs and highway construction costs, noting that many factors—which have nothing to do with the highway project—could influence the cost of adjusting utilities. Nonetheless, it is reasonable to assume that, under certain conditions, at least an assumption of "correlation" between highway construction costs and utility adjustment costs may be valid. If so, the question would be whether it is possible to identify those conditions and determine how to apply them in practice.

To assess the feasibility of a procedure to estimate utility adjustment costs at an early stage in the project development process, the researchers analyzed sample data from the following sources:

- Unit cost data from the Trns*port Bid Analysis Management System/Decision Support System (BAMS/DSS) module *(34)*, which the TxDOT Construction Division uses to track highway construction projects and data. The BAMS/DSS database contains detailed historical unit bid data for highway construction projects at TxDOT.

- 1993 and 2004 TxDOT special specifications, with a focus on utility-related special specifications *(9)*. This source was necessary to identify utility-related construction items.
- Utility adjustment data from the TxDOT ROW Division's utility agreement database.
- Route and control section geodatabase from the TxDOT Transportation Planning and Programming (TPP) Division, which contains information about the on-system transportation network.
- RHiNo highway inventory file from TPP, which contains information about individual segments on the state-maintained highway network.

The BAMS/DSS database included five tables of interest to the analysis:

- **Dproject**. This table contains information about highway projects (72,886 records).
- **Dbidders**. This table contains highway contractor bid data (141,167 records).
- **Dbidtabs**. This table contains bid data for every highway project (3,892,018 records).
- **Dproposl**. This table contains additional information about the project, including letting date (34,081 records).
- **Itemlist**. This table contains a listing of all the highway construction items at TxDOT (150,323 records).

The Appendix describes the procedure followed to extract and assemble data from the data sources above, along with a listing of projects selected. The assembled dataset included 476 highway projects where there were utility adjustment dollar amounts, either through bid items in the highway contract or through utility agreements. Table 28 shows the number of projects in the sample, grouped by DCIS project type.

Table 28. Number of Projects in Sample by DCIS Project Project Type.

DCIS Project Type Code	Project Type Description	Number of Projects in Sample
WNF	Widen non-freeway	132
MSC	Miscellaneous construction	62
RER	Rehabilitate existing road	60
WF	Widen freeway	60
BR	Bridge replacement	36
INC	Interchange	28
NNF	New location non-freeway	28
CNF	Convert non-freeway to freeway	20
UPG	Upgrade to standards freeway	12
HES	Hazard elimination and safety	7
UGN	Upgrade to standards non-freeway	6
OV	Overlay	5
RES	Restoration	4
NLF	New location freeway	4
SFT	Safety	3
BCF	Border crossing facility	2
SKP	Skip (exempt from sealing) trans enhancement	2
BWR	Bridge widening or rehab	1
FBO	Ferry boat	1
LSE	Landscape and scenic enhancement	1
ROW	Right of way	1
SRA	Safety rest area	1
	Total	**476**

Each of the projects listed in the appendix includes the following cost data (expressed in 2006 dollars):

- total winning bid;
- total utility adjustment amount in the highway contract winning bid;
- total utility adjustment estimate in the utility agreement database;
- non-utility highway cost (NUHC), which is the total winning bid minus the total utility adjustment amount in the highway contract winning bid; and
- total utility cost (TUC), which is the sum of the total utility adjustment amount in the highway contract winning bid and the total utility adjustment estimate in the utility agreement database.

The reasoning behind using TUC and NUHC as the basis for the analysis is that the dollar amounts associated with individual utility adjustment contracting mechanisms (e.g., utility agreements and adding bid items to the highway contract) could be significant and should therefore be considered explicitly. In addition, as mentioned previously, accounting for all the contracting mechanisms when evaluating utility adjustment costs is important because different contracting mechanisms may require different approaches for handling uncertainties and, furthermore, utility adjustments may be susceptible to additional accounting requirements and procedures than regular highway construction items.

ANALYSIS OF THE SAMPLE DATA

General Observations

An analysis of the sample data described in the appendix yields the following observations:

- Most highway projects did not include utility adjustment items. Of the 8856 highway construction projects for which the total bid was larger than zero and there were contract award amounts, the project was listed as "Construction," and the specifications used were year 1993 or 2004, only 476 projects included utility adjustment work. Readers should note that the dataset included all utility agreement data associated with a construction CSJ (if recorded in the TxDOT ROW Division's utility agreement database), which presumably included agreements that were necessary after the highway project letting. The dataset did not include highway project change orders. It is possible, therefore, that the dataset did not include cases where change orders covered utility adjustment work but there was not a utility agreement associated with that activity.

- Of the 2,737 records in the ROW Division's utility agreements table, only 579 records included construction CSJ numbers. Of this total, 183 records did not have a matching construction CSJ number in the BAMS/DSS Dproposl table. An analysis of the corresponding data in the utility agreements database revealed 44 percent of records missed critical date stamps (e.g., received date, reviewed date, or approved date), 9 percent corresponded to utility agreements between 1994 and 2000, 30 percent corresponded to utility agreements between 2001 and 2003, and 16 percent corresponded to utility agreements between 2004 and 2006. Although the percentage of mismatched records has decreased in recent years, that percentage is still high. Likewise, 334 records did not have a matching construction CSJ number in the total highway cost query (see appendix), which represents total bid amounts and letting dates for highway contract CSJs. The BAMS/DSS database relies on direct imports from DCIS, whereas the ROW Division's utility agreement database is a standalone database that requires entering all data manually, included construction CSJ numbers. To decrease the chances of mismatched construction CSJ numbers in the utility agreement database, it would be advisable to implement a procedure to automatically link to DCIS and enable users to select construction CSJ numbers from a drop down menu and check the current status of highway contracts.

- After joining the queries that contained total highway cost data, total utility cost in highway contract data, and total utility agreement cost data, the result was a dataset that contained 476 records. This number represents a sample of construction CSJs for which there were utility adjustments in the highway contract and, if available, separate agreements with utility companies. As such, the sample did not provide a comprehensive view of highway projects with utility adjustments. However, it was large enough to include records for a wide range of project types.

It is important to highlight the ROW Division's utility agreement database only provides a measure of the financial impact of utility adjustments at TxDOT. As such, the database does not track actual utility adjustment costs but rather cost estimates utility companies submit (normally seeking reimbursement from TxDOT) as well as a history of partial and final payments. To capture actual utility adjustment costs, both reimbursable and non-reimbursable, it would be necessary to make several modifications to the ROW Division's utility agreement database. Introducing those changes has now become critical as a result of Senate Bill 1209, which the Texas Legislature passed recently, authorizing the establishment of prepayment funding agreements between TxDOT and utility companies for situations where the utility would not be otherwise eligible for reimbursement under Section 203.092 of the Texas Transportation Code (*48*). The prepayment funding agreements will require utility companies to initially prepay TxDOT an annual amount equal to 75 percent of the annual average of the direct and related indirect costs the utility has incurred over the preceding three-year period (after the initial three-year period, the annual amount will equal 75 percent of the annual average of the direct and related indirect costs TxDOT has reimbursed the utility). In turn, TxDOT will reimburse the utilities appropriate reimbursable costs under the agreement. One of the effects of Senate Bill 1209 will likely be an increase in the number of utility agreements and an increase in the total amount TxDOT reimburses utility companies—it is reasonable to assume TxDOT would be responsible for approximately 25 percent of previously ineligible utility adjustment amounts.

- As mentioned previously, during the process to select utility-related specifications from the list of special specifications, the researchers highlighted 443 special specifications that were utility-related, most of which pertained to water and sanitary sewer utilities. The original selection included many special specifications related to telecommunications. However, after a closer analysis, it turned out that practically all of these specifications referred to TxDOT-owned telecommunication infrastructure (e.g., traffic signals or ITS). From the list of specifications alone, it is not necessarily obvious whether the specifications and corresponding bid items in the highway contract are associated with TxDOT-owned installations or installations other agencies own. One potential strategy to address this issue is to account for all utility adjustment expenses regardless of contracting mechanism—highway contract or through separate utility agreements—separately (e.g., using the "ROW" or "UTL" DCIS project type).

- Of the 476 highway contracts selected in the final query, 330 projects had utility items in the highway contract (worth $339 million in 2006 dollars) and 201 projects handled utility adjustment through utility agreements (worth $424 million in 2006 dollars). Only 55 projects had utility work in both highway contracts and utility agreements. In these cases, for simplicity, the researchers assumed the utility agreements and the highway contracts did not overlap, i.e., they handled different utility adjustment activities. Although the dataset did not include a large number of utility agreements (see above), the frequency and dollar amount associated with utility work included in highway contracts was nonetheless significant, confirming the validity of the query building process described in the appendix, which took into account data from both utility agreements and highway contracts. Notice the research did not address the question of which contracting mechanism was more appropriate. Previous research summarized criteria elements a number of stakeholders identified for selecting the appropriate contracting mechanism (*49*). One of the criteria elements identified was cost differentials between the two contracting mechanisms. The query building process described above, along with the unit cost framework developed in the first phase of this research (*6*), could provide the foundation for a quantitative tool to systematically extract data from appropriate data repositories at TxDOT and compare costs to help make the appropriate selection.

- Of the 476 highway projects analyzed, only 32 projects corresponded to new locations (DCIS project type codes "NLF" and "NNF"). The remaining 444 projects were associated with different DCIS project types. The ProtoCost system only considers two project types: new location and reconstruction. However, a significant number of projects corresponded to other project types such as rehabilitation, restoration, and miscellaneous construction (Table 28), raising the question whether using only two project types (new location and reconstruction) is appropriate. Furthermore, from the project data sample received, it was not possible to positively identify the project category (e.g., 3R or 4R in Table 29), or the type of correlation between project categories and DCIS project types.

- Table Dproject in the BAMS/DSS system includes a field to track whether the project is an urban project or a rural project. Unfortunately, data for that field were not reliable. First, the rural versus urban field was blank for 21 percent of records. Second, there were several "rural" projects for which the project description suggested an urban setting. Conversely, there were several "urban" projects for which the project description suggested a rural setting. An analysis of project locations using the TxDOT RHiNo highway inventory file, which contains information about individual segments on the state-maintained highway network, showed 8 percent of projects had a mismatch between the type of segment (urban or rural) and the urban versus rural designation in table Dproject. According to TxDOT officials, project managers frequently use the rural versus urban field to designate the type of typical cross section (e.g., curb and gutter or ditch) that applies to the project. However, it is not clear how consistently project managers follow this practice. Notice also the ProtoCost system considers three location types (rural, metro, and urban), i.e., one more type than either the BAMS/DSS system or the RHiNo highway inventory file, which could potentially result in inconsistencies in the application of the location type criteria in ProtoCost.

- The ProtoCost system assumes the utility adjustment cost percentage to be a function of roadway type. The current version of the ProtoCost default value table accounts for three possible cases: Interstate, US/State Highway, and FM. However, there are 26 roadway system classes and 12 functional system classes on the state highway network (according to the RHiNo inventory file), and it is not necessarily evident whether a simple map from either classification to the highly aggregated roadway type structure in ProtoCost is feasible. Furthermore, the 476-project dataset only included nine (out of 26) roadway system classes, which means a statistical analysis based on the sample would not necessarily carry over well to the entire population of roadway system classes. For this reason, the researchers decided not to consider roadway type as a potential factor for utility adjustment cost estimation. It may be worth noting that, although the default value table structure in ProtoCost takes into consideration three roadway types, the actual values in the table do not vary by roadway type (Table 27).

- Figure 7 shows a scatter plot of total utility cost versus non-utility highway cost both in arithmetic and logarithmic scales for all 476 projects. Figure 8 through Figure 15 show the corresponding scatter plots (in logarithmic scale) for project types with the largest number of data points (Table 28). Although the correlation between utility costs and non-utility highway construction costs does not prove causal relationships, these figures suggest the cost of utility adjustment tends to increase as the non-utility highway construction costs increase and that project type tends to play a role. If this is true, and the underlying drivers of these two costs do not change, the correlation can be used to estimate utility costs based on non-utility costs. To reveal the significance of these observations and the potential effect of other related factors, the researchers conducted a statistical analysis.

Table 29. Highway Project Categories (*50*).

Project Category	Description
5R	Mobility corridor projects consist of transportation projects to provide a new roadway or upgrade/reconstruct an existing roadway to meet geometric design criteria for a new high-speed facility. TxDOT intends mobility corridors for long distance travel that may include multiple modes such as rail, utilities, freight, and passenger transportation. A 5R project includes all work described under 4R for mobility corridor projects, but different design standards apply because of the roadway's higher design speed and multiple participating transportation modes.
4R	Reconstruction projects consist of transportation projects to provide a new roadway or upgrade an existing roadway to meet geometric design criteria for a new facility. In addition to work described under resurfacing, restoration and rehabilitation, reconstruction work generally includes substantial changes in the geometric character of the highway, such as widening to provide additional through lanes and horizontal or vertical realignment, and major improvements to the pavement structure to provide long term service. Reconstruction work includes bridge replacement work.
3R	Rehabilitation projects consist of non-freeway transportation projects that extend the service life and enhance the safety of a roadway. In addition to the work described under resurfacing and restoration, the activities include upgrading the geometric design and safety of the facility. Work does not include the addition of through travel lanes. Work may include the upgrading of geometric features such as roadway widening, minor horizontal realignment, and improving bridges to meet current standards for structural loading and to accommodate the approach roadway width.
2R	Restoration projects consist of non-freeway work on facilities with an ADT of less than 3000 that propose to restore the pavement to its original condition. Upgrading roadway components as needed to maintain the roadway in an acceptable condition may be included in restoration work. The addition of through travel lanes is not permitted under 2R. Analyses should be performed to identify high accident locations so that corrective measures can be taken.
PM	Preventive Maintenance projects consist of work proposed to preserve, rather than improve, the structural integrity of the pavement and/or structure. Examples of preventive maintenance activities include ACP overlays (maximum 2" thick); seal coats; cleaning and sealing joints and cracks; patching concrete pavement; shoulder repair; scour countermeasures; cleaning and painting steel members to include application of other coatings; restore drainage systems; cleaning and sealing bridge joints; microsurfacing; bridge deck protection; milling or bituminous level-up; clean, lubricate and reset beatings; and clean rebar/strand and patch structural concrete and seal cracks.

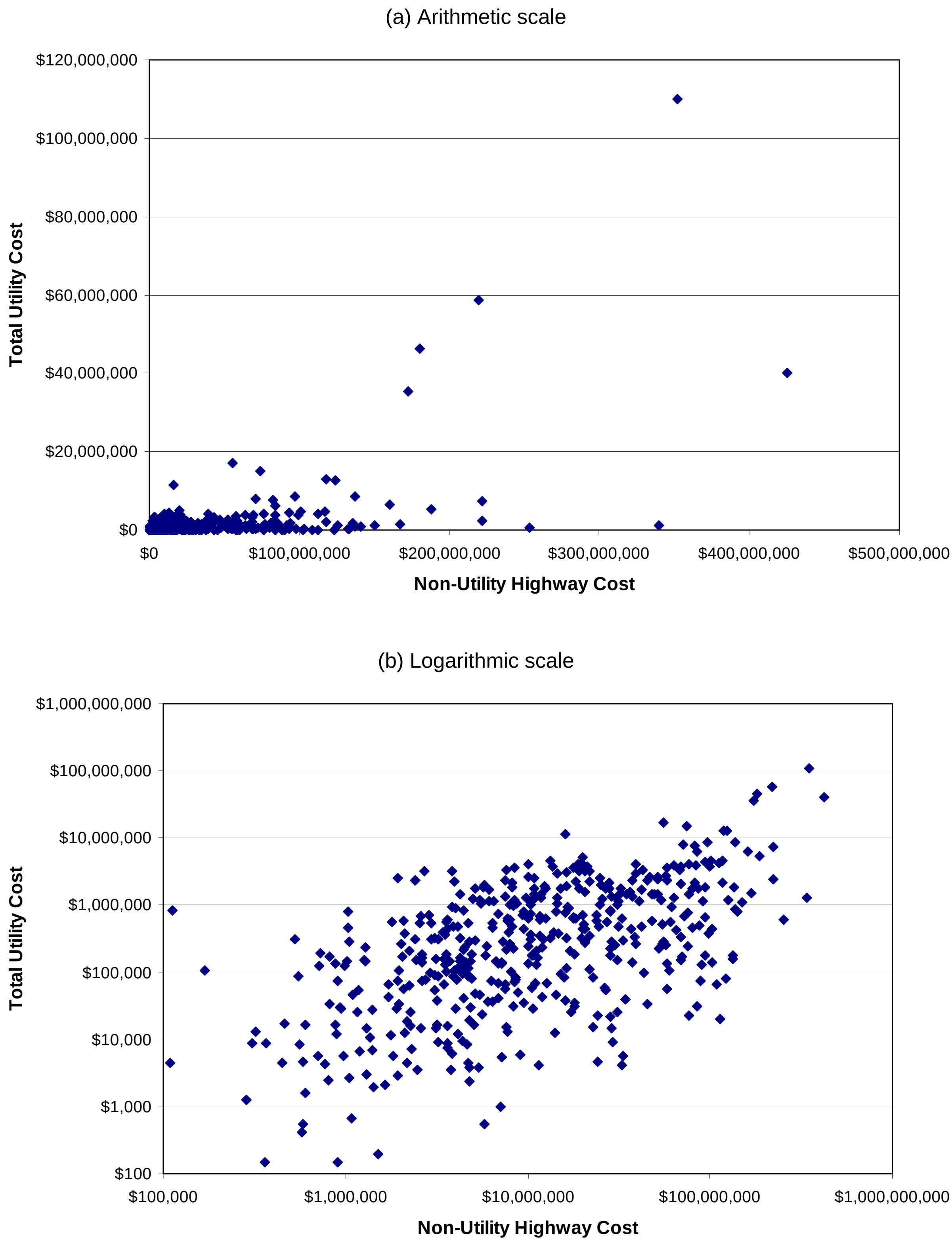


Figure 7. Total Utility Cost versus Non-Utility Highway Cost – 476 Records.

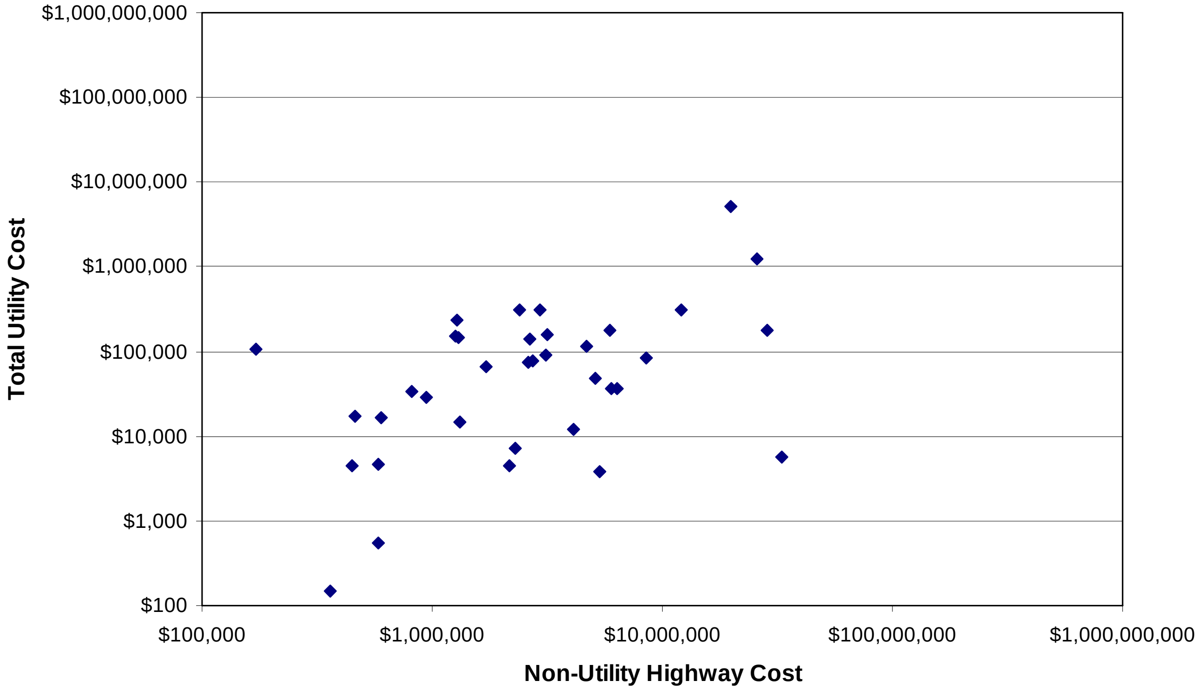


Figure 8. Total Utility Cost versus Non-Utility Highway Cost for Project Type "BR" (Bridge Replacement) – 36 Records.

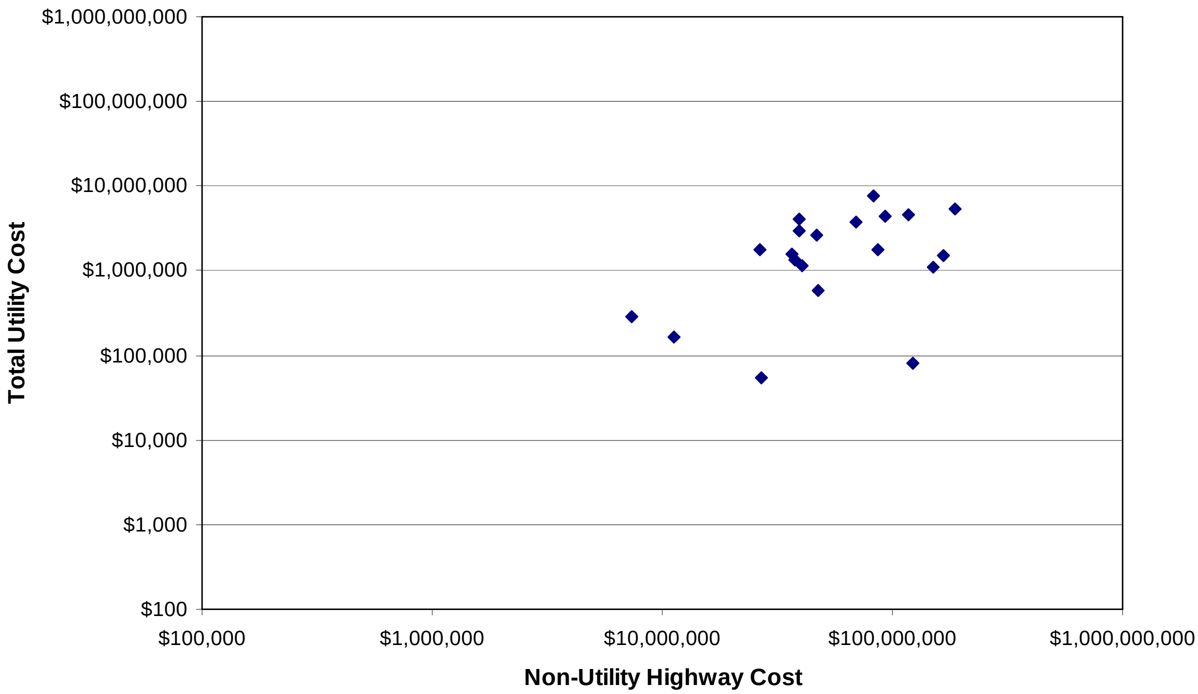


Figure 9. Total Utility Cost versus Non-Utility Highway Cost for Project Type "CNF" (Convert Non-Freeway to Freeway) – 20 Records.

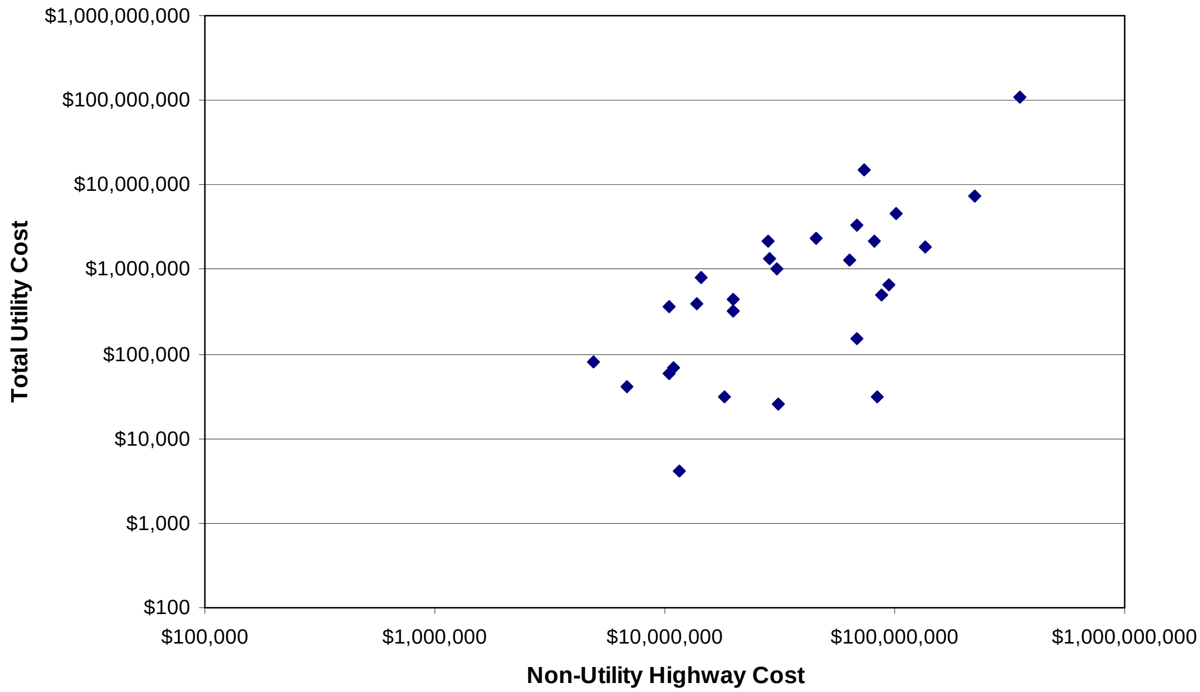


Figure 10. Total Utility Cost versus Non-Utility Highway Cost for Project Type "INC" (Interchange) – 28 Records.

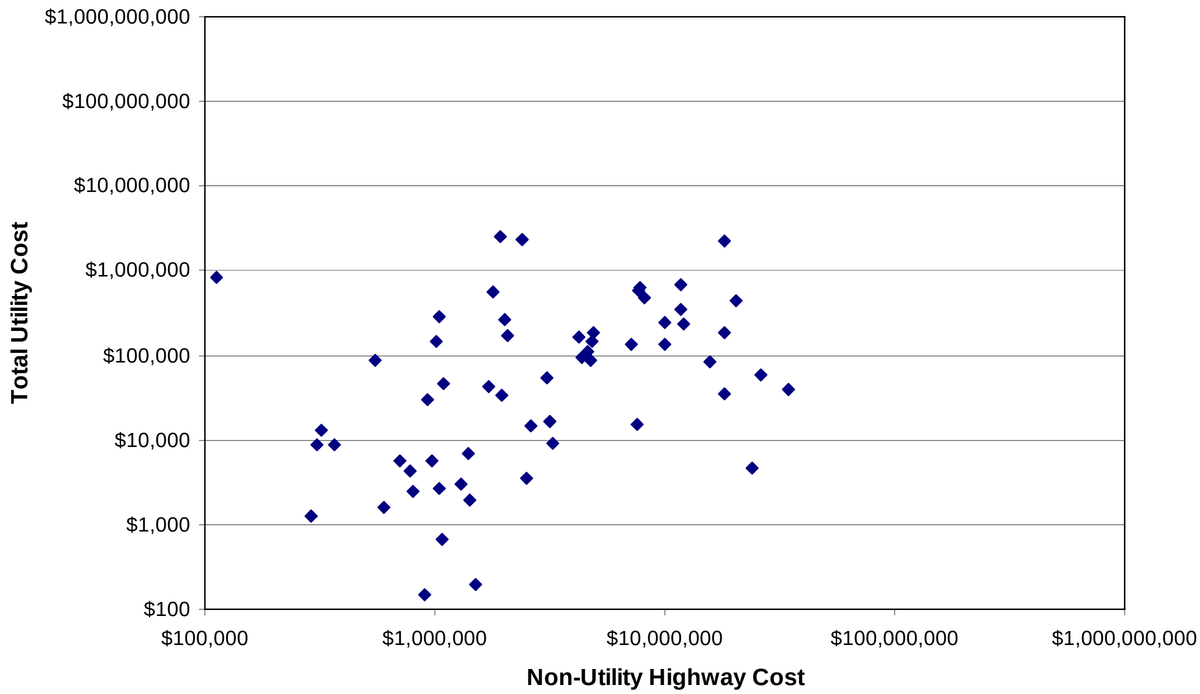


Figure 11. Total Utility Cost versus Non-Utility Highway Cost for Project Type "MSC" (Miscellaneous Construction) – 62 Records.

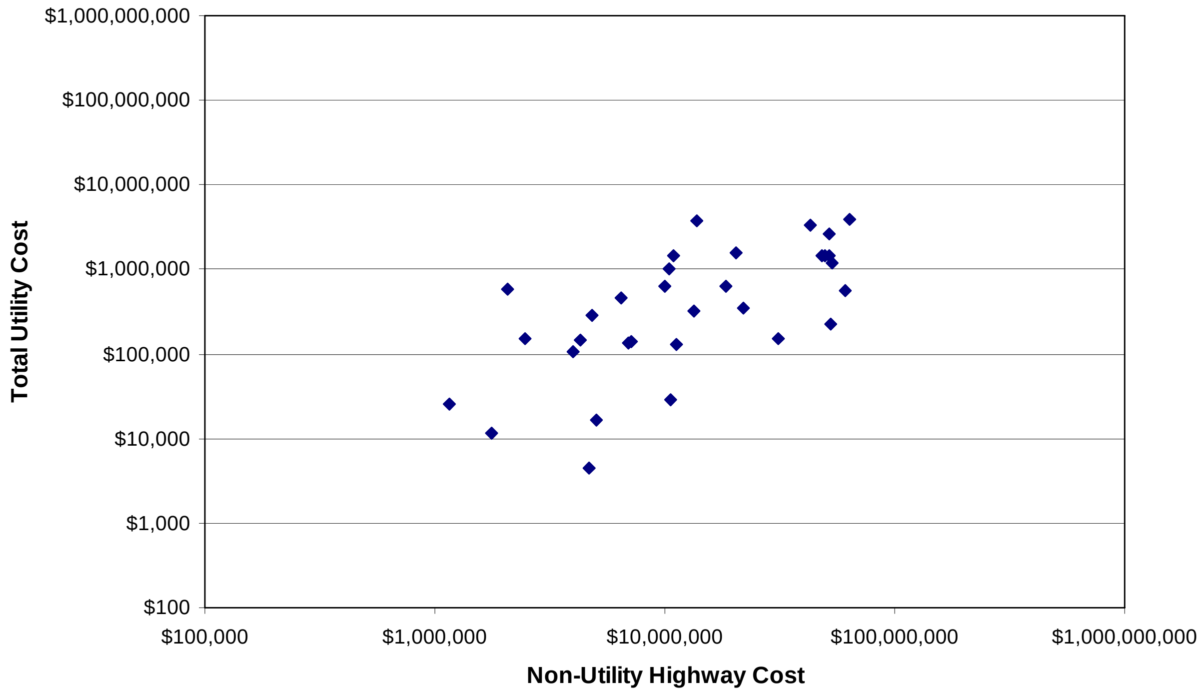


Figure 12. Total Utility Cost versus Non-Utility Highway Cost for Project Types "NNF" (New Location Non-Freeway) and "NLF" (New Location Freeway) – 32 Records.

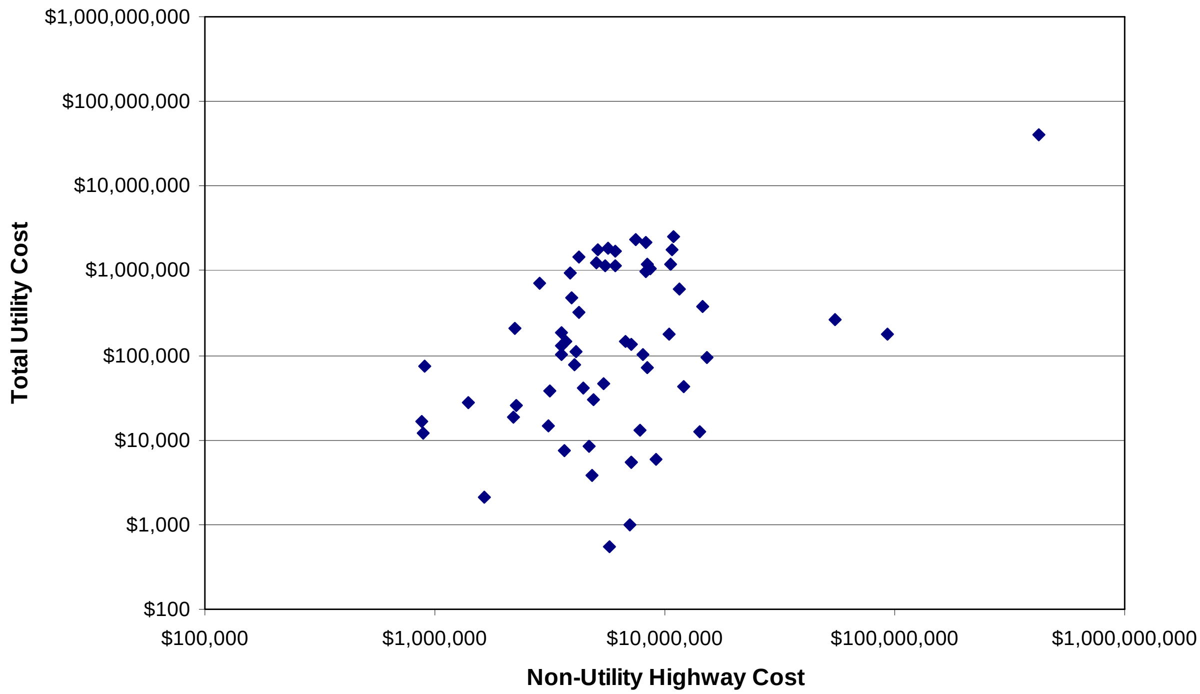


Figure 13. Total Utility Cost versus Non-Utility Highway Cost for Project Type "RER" (Rehabilitate Existing Road) – 60 Records.

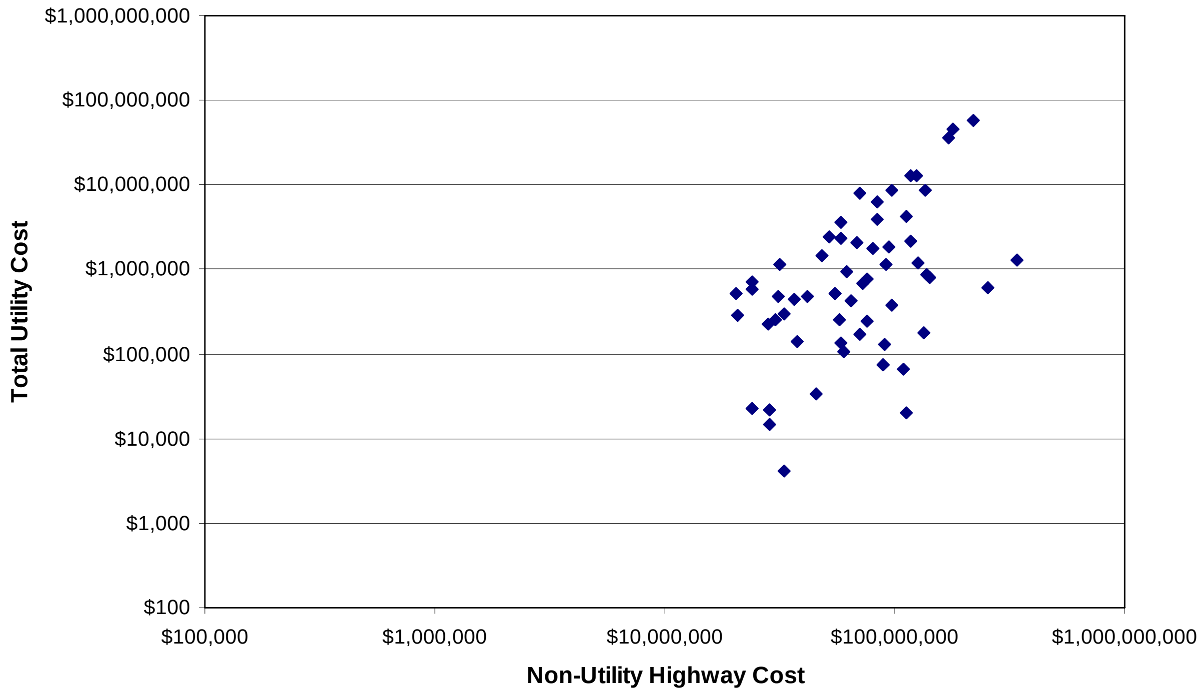


Figure 14. Total Utility Cost versus Non-Utility Highway Cost for Project Type "WF" (Widen Freeway) – 60 Records.

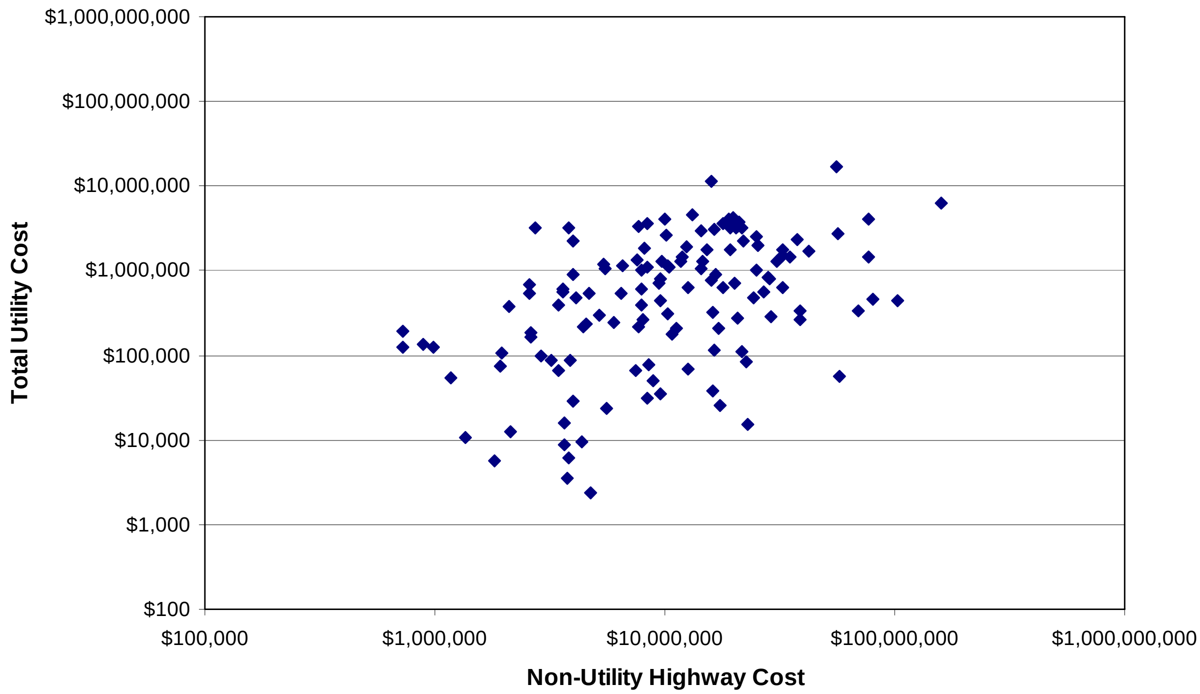


Figure 15. Total Utility Cost versus Non-Utility Highway Cost for Project Type "WNF" (Widen Non-Freeway) – 132 Records.

Statistical Analysis

The statistical analysis included the use of two types of models (generalized linear models and binomial proportion models) to predict total utility cost using explanatory variables such as non-utility highway cost, project type, and length.

Generalized Linear Models

These models treat total utility cost as the dependent variable and other variables as independent variables or factors. The first model was a simple linear regression line fitted on the bivariate total utility cost (TUC) versus non-utility highway cost (NUHC) data:

$$TUC = -6.99x10^5 + 0.0801\ NUHC \quad (R^2 = 0.32)$$

where R^2 is the coefficient of determination. The corresponding residual plot exhibited an increasing pattern as the non-utility highway cost increased, violating one of the underlying assumptions for applying linear regression models, which is a constant variance assumption.

The second model was a linear regression line fitted on the logarithmic transformation of the bivariate data:

$$Log_{10}\ TUC = -0.519 + 0.837\ Log_{10}\ NUHC \qquad (R^2 = 0.33)$$

The corresponding residual plot did not exhibit any particular pattern, indicating no serious violation of regression assumptions. However, $R^2 = 0.33$ was very low, indicating high uncertainty levels in prediction. The wide range in TUC values (three to five orders of magnitude) for individual NUHC values supports this assessment (Figure 7b). For example, for a non-utility highway cost of $1,000,000, the range in the sample suggests that total utility costs could range from $100–$1,000,000.

The third model was a regression line on the logarithmic transformation of the bivariate data for each project type separately. As an illustration, the results for project types with at least 20 data points were as follows:

"BR" (Bridge Replacement):

$$Log_{10}\ TUC = -0.185 + 0.753\ Log_{10}\ NUHC \qquad (R^2 = 0.22)$$

"CNF" (Convert Non-Freeway to Freeway):

$$Log_{10}\ TUC = 0.639 + 0.708\ Log_{10}\ NUHC \qquad (R^2 = 0.19)$$

"INC" (Interchange):

$$Log_{10}\ TUC = -4.85 + 1.40\ Log_{10}\ NUHC \qquad (R^2 = 0.46)$$

“MSC” (Miscellaneous Construction):

$$\text{Log}_{10}\ \text{TUC} = 0.0555 + 0.725\ \text{Log}_{10}\ \text{NUHC} \qquad (R^2 = 0.18)$$

“NNF” (New Location Non-Freeway) and “NLF” (New Location Freeway) combined:

$$\text{Log}_{10}\ \text{TUC} = -1.50 + 0.989\ \text{Log}_{10}\ \text{NUHC} \qquad (R^2 = 0.44)$$

“RER” (Rehabilitate Existing Road):

$$\text{Log}_{10}\ \text{TUC} = -0.964 + 0.892\ \text{Log}_{10}\ \text{NUHC} \qquad (R^2 = 0.15)$$

“WF” (Widen Freeway):

$$\text{Log}_{10}\ \text{TUC} = -5.85 + 1.49\ \text{Log}_{10}\ \text{NUHC} \qquad (R^2 = 0.24)$$

“WNF” (Widen Non-Freeway):

$$\text{Log}_{10}\ \text{TUC} = -0.209 + 0.774\ \text{Log}_{10}\ \text{NUHC} \qquad (R^2 = 0.21)$$

With the exception of “CNF” (Convert Non-Freeway to Freeway), which had outliers that could alter the regression equation significantly, the residual plots for the remaining regression equations did not exhibit any particular pattern, indicating no serious violation of regression assumptions. In general, however, R^2 values were low and there was considerable variability in R^2 values, indicating a lack of consistency in the relationship between the dependent variable (Log_{10} TUC) and the independent variable (Log_{10} NUHC) over different project types.

The fourth model was a regression line on the logarithmic transformation of the bivariate data for each project type separately after normalizing the data by project length, i.e., by using TUC/mi and NUHC/mi. For most project types, normalizing the data by project length produced higher R^2 values, but these values were still relatively low. R^2 values were higher for the following project types:

“CNF” (Convert Non-Freeway to Freeway):

$$\text{Log}_{10}\ (\text{TUC/mi}) = -2.34 + 1.10\ \text{Log}_{10}\ (\text{NUHC/mi}) \qquad (R^2 = 0.71)$$

“INC” (Interchange):

$$\text{Log}_{10}\ (\text{TUC/mi}) = -3.90 + 1.27\ \text{Log}_{10}\ (\text{NUHC/mi}) \qquad (R^2 = 0.60)$$

“MSC” (Miscellaneous Construction):

$$\text{Log}_{10}\ (\text{TUC/mi}) = -1.90 + 1.01\ \text{Log}_{10}\ (\text{NUHC/mi}) \qquad (R^2 = 0.61)$$

“RER” (Rehabilitate Existing Road):

$$\text{Log}_{10}\,(\text{TUC/mi}) = -6.69 + 1.77\ \text{Log}_{10}\,(\text{NUHC/mi}) \quad (R^2 = 0.58)$$

“WF” (Widen Freeway):

$$\text{Log}_{10}\,(\text{TUC/mi}) = -7.53 + 1.74\ \text{Log}_{10}\,(\text{NUHC/mi}) \quad (R^2 = 0.38)$$

“WNF” (Widen Non-Freeway):

$$\text{Log}_{10}\,(\text{TUC/mi}) = -2.47 + 1.16\ \text{Log}_{10}\,(\text{NUHC/mi}) \quad (R^2 = 0.25)$$

In the case of project type “CNF” (Convert Non-Freeway to Freeway), there was one influential point that had an unusually large value for the independent variable. There were also two outliers. After removing these points, R^2 decreased to 0.34. In the case of project type “INC” (Interchange), there was one influential point that had an unusually large value for the independent variable. After removing the influential point, R^2 decreased to 0.48.

Binomial Proportion Models

Low accuracy is a recurring problem of regression-based techniques, due in part to their inability to properly account for the complex relationship among potentially large numbers of variables *(51)*. To address the limitations of this type of model, the researchers used a different modeling technique that involved calculating the ratio of utility cost to non-utility highway cost for each project, sorting the ratios in descending order, and plotting the ordered series to provide a measure of the likelihood of exceedance of individual ratio values (Figure 16). This technique offers a number of advantages, including the following:

- not having to rely on a regression line or equation that could be very easily misinterpreted—and therefore misused—by analysts who do not fully understand the limitations of the linear regression approach;
- explicit representation of the likelihood that a specific utility cost adjustment estimate could be exceeded based on the previous history of cost data in the database; and
- avoiding a sense of false accuracy, which, particularly in the case of early estimates, can result in significant problems later *(52)*.

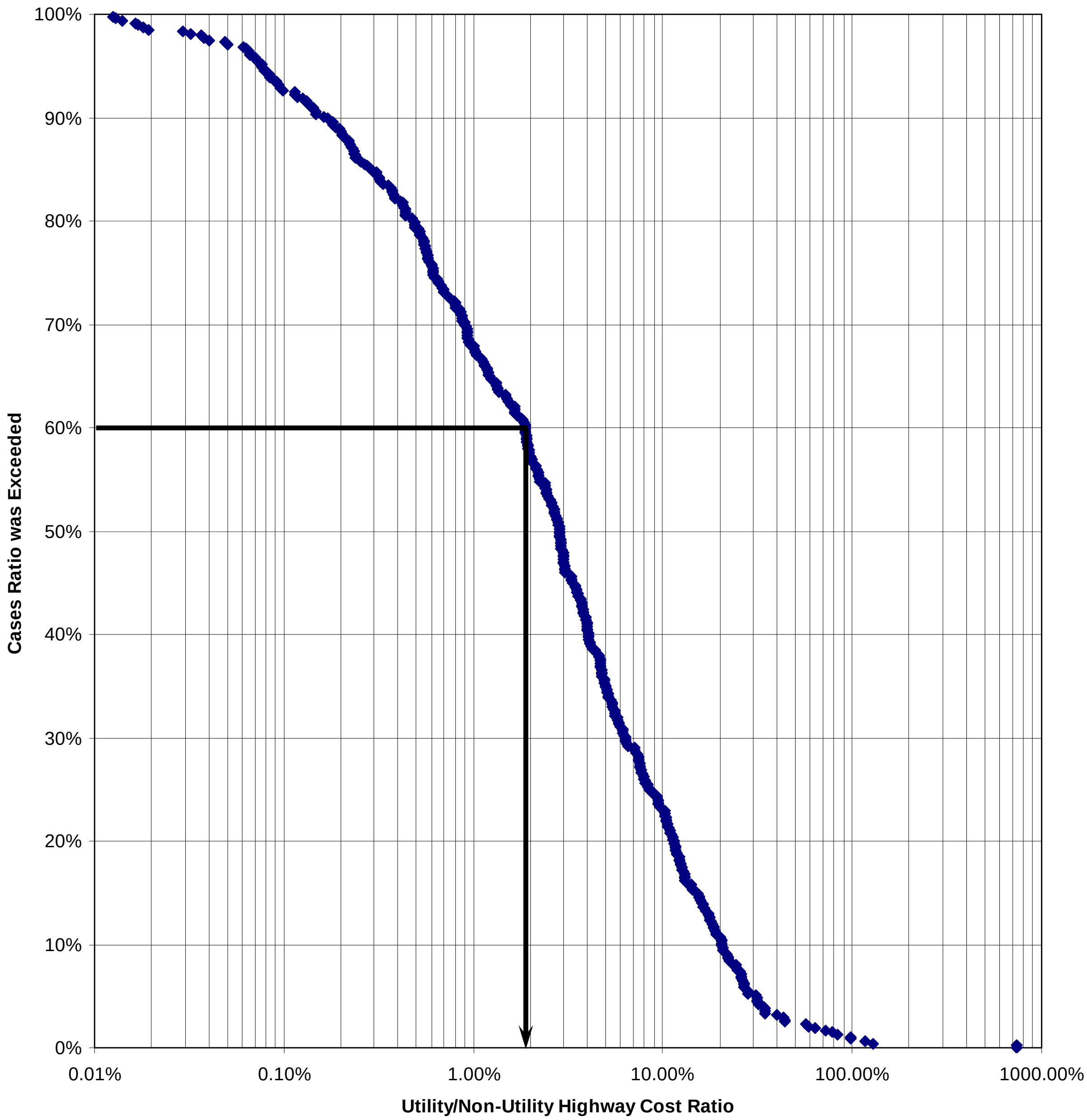


Figure 16. Total Utility Cost to Non-Utility Highway Cost Ratio – 476 Records.

Figure 16 illustrates the technique by using the utility cost to non-utility highway cost ratio plot for all 476 projects (**Note**: It is possible to develop similar plots for individual project types, as discussed later in this section). Assume a utility agent needs to provide an early estimate of the utility adjustment cost for a highway project. At this stage in the project, the project manager estimates the highway construction cost to be around $10,000,000 (without utilities). Using Figure 16, the utility agent could provide information such as the following:

- Based on historical data, there is a 60 percent chance the utility adjustment cost will exceed 1.9 percent (or $190,000) of the non-utility highway cost. Or,

- The early utility adjustment cost estimate is $190,000, which has a 60 percent chance of being exceeded based on historical data.

Strictly speaking, the utility agent would first conduct a preliminary assessment using available information to determine whether utility adjustments are necessary at all. After all, as mentioned previously, most projects do not involve utility adjustments. If there is any reason to believe the project could include utility adjustments, the utility agent would use the methodology outlined above to provide a preliminary assessment of utility adjustment impacts. It may be worth noting that, as the design phase progresses (e.g., 30, 60, 90, and 100 percent design) and information about existing utility installations improves, the analyst could (and should) use more accurate methods to provide utility adjustment estimates (preferably based on quantities and unit prices).

Implicit in the application of the methodology is the assumption the utility cost to non-utility highway cost ratio does not depend on project size (i.e., the non-utility highway cost). Otherwise, it would be necessary to explicitly account for project size in the analysis. To test that hypothesis, the researchers prepared scatter plots of utility cost to non-utility highway cost ratio versus non-utility highway cost in arithmetic, semilogarithmic, and logarithmic scales and tested whether any non-zero trends were statistically significant. In all cases, R^2 was practically zero, indicating the lack of correlation between the utility cost to non-utility highway cost ratio and project size.

The cumulative distribution plot in Figure 16 is based on a sample, which means different samples from the same population could produce different plots. To address the issue of plot uncertainty, the researchers added confidence intervals to the plot. Mathematically, the problem is to determine the proportion of projects for which the ratio of utility cost to non-utility highway cost exceeds a certain percentage c. Let C be the ratio and π_c be the true (or population) proportion of projects for which $C > c$. It is possible to estimate π_c by using the sample proportion p_c associated with a random sample of size n as follows:

$$p_c = \frac{y_c}{n}$$

where

y_c = number of projects for which $C > c$.

Under these circumstances, y_c follows a binomial distribution with parameters n and π_c, i.e.,

$$y_c \sim \text{Bin}(n, \pi_c)$$

and it is possible to use the binomial confidence intervals to provide uncertainty estimates for π_c.

Several free online statistical software packages enable this calculation (see for example [*53*]). Figure 17 through Figure 25 show the results for all projects and for those project types for which the number of data points was at least 20, assuming a 95 percent confidence level (i.e., the error rate of the method used to construct this confidence interval was 5 percent), which is a confidence level used in practice for statistical analysis. For example, Figure 17 shows the plot with 95 percent confidence intervals for the 476-project series. The sample proportion of projects for which a utility cost to non-utility highway cost ratio exceeds 1 percent is about 68 percent. With 95 percent confidence, it is then possible to conclude that the true proportion of projects for which the utility cost to non-utility highway cost ratio exceeds 1 percent lies between 63 and 72 percent. Similarly, the sample proportion of projects for which a utility cost to non-utility highway cost ratio exceeds 10 percent is about 23 percent. With 95 percent confidence, it is also possible to conclude that the true proportion of projects for which the utility cost to non-utility highway cost ratio exceeds 10 percent lies between 19 and 27 percent.

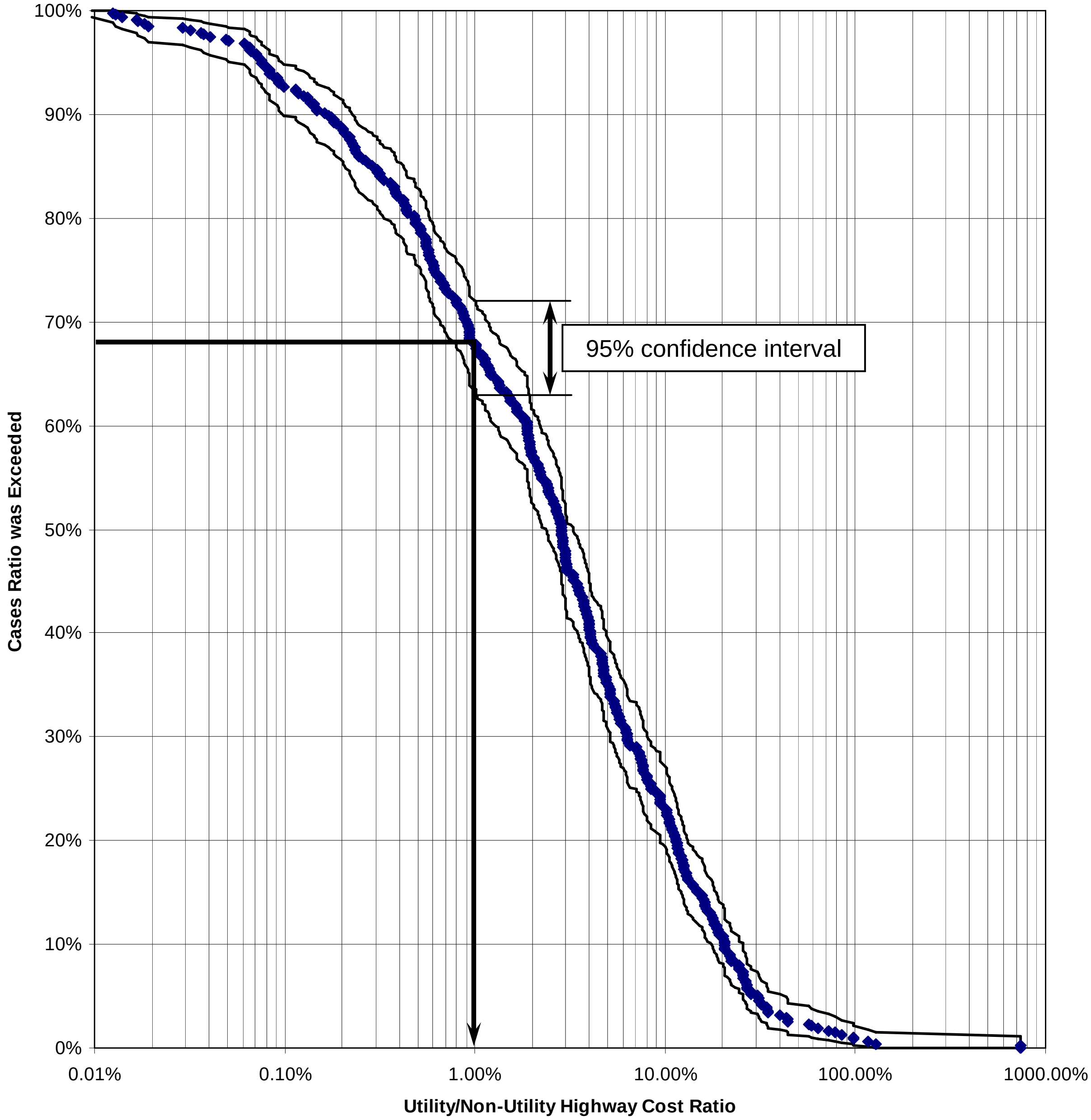
A closer look at the results in Figure 17 through Figure 25 revealed some interesting trends:

- As mentioned previously, Figure 17 corresponds to the 476-project series. While useful for general-purpose analysis at the highest aggregation level, the figure lumps the data for all project types, neglecting significant differences that become evident in the plots for individual project types (Figure 18 through Figure 25). Those differences reinforce the conclusion from the previous section that project type plays a significant role in the estimation of utility adjustment costs.

- Different graphs had different 95-percent confidence interval widths, which were inversely proportional to the corresponding sample sizes. This situation explains why the confidence interval for project type "BR" (bridge replacement), which had 36 records, was much wider than the confidence interval for project type "WNF" (widen non-freeway), which had 132 records.

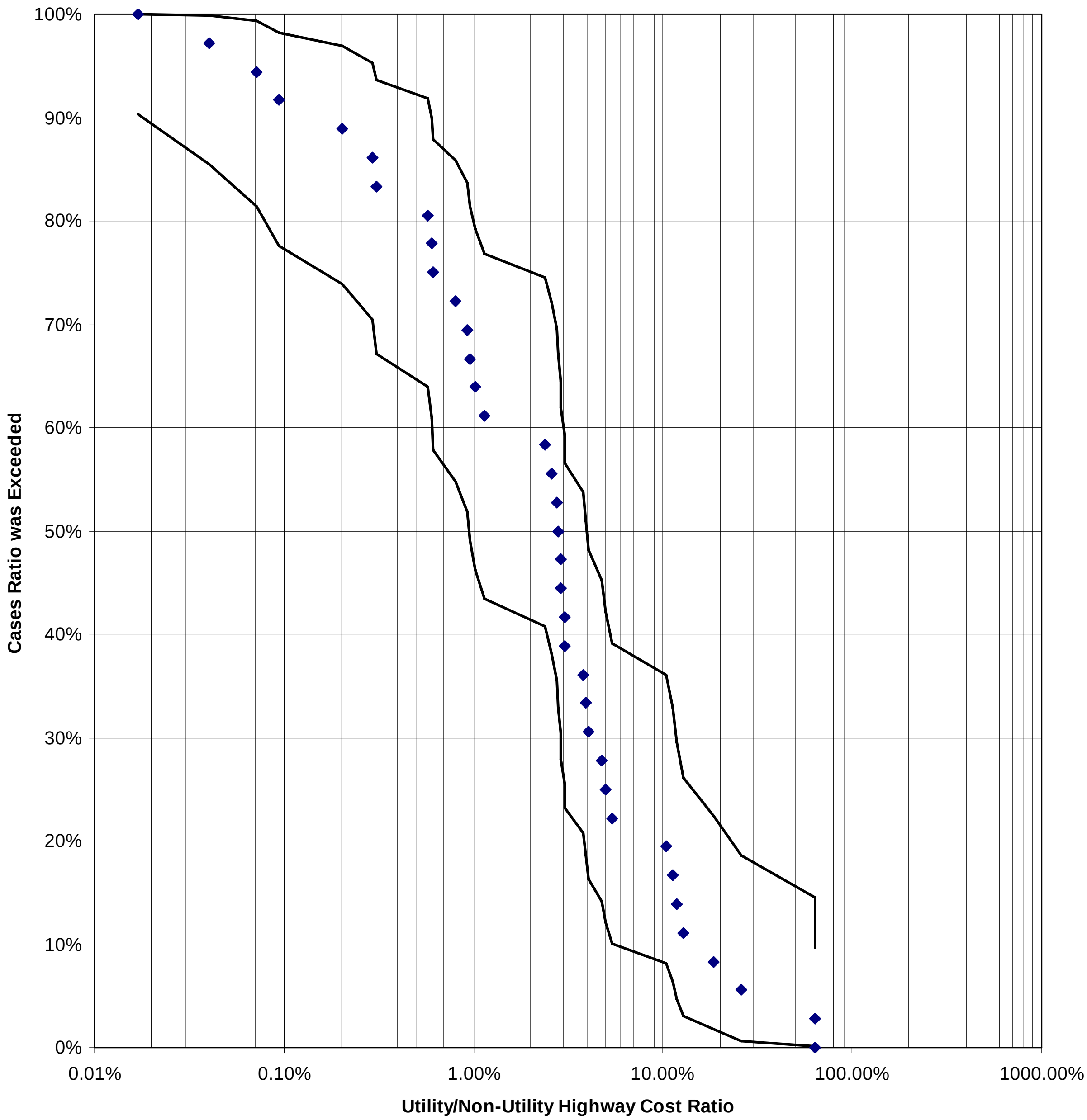
- Some graphs (e.g., "CNF" [Convert Non-Freeway to Freeway], "INC" [Interchange] as well as "NNF" [New Location Non-Freeway] and "NLF" [New Location Freeway]) were considerable steeper than other graphs, suggesting a smaller variation in the utility cost to non-utility highway cost ratio for those project types. By comparison, graphs such as those for "MSC" [Miscellaneous Construction] and "RER" [Rehabilitate Existing Road] had a gentler slope than other graphs, suggesting a wider variation in the utility cost to non-utility highway cost ratio for those project types. In general, these results are consistent with those in the previous section regarding the variability of R^2 values across project types.

- Some graphs exhibited a noticeable shift to the right compared to other graphs. This trend was particularly evident for project type "WNF" (Widen Non-Freeway), which exhibited quite a significant shift to the right compared to "WF" (Widen Freeway), indicating much larger utility cost to non-utility highway cost ratios. This result is consistent with feedback provided by some TxDOT officials, who have noticed that projects that involve ROW acquisition (perhaps more common for widening non-freeway projects than for widening freeway projects) also tend to have relatively higher utility adjustment costs.



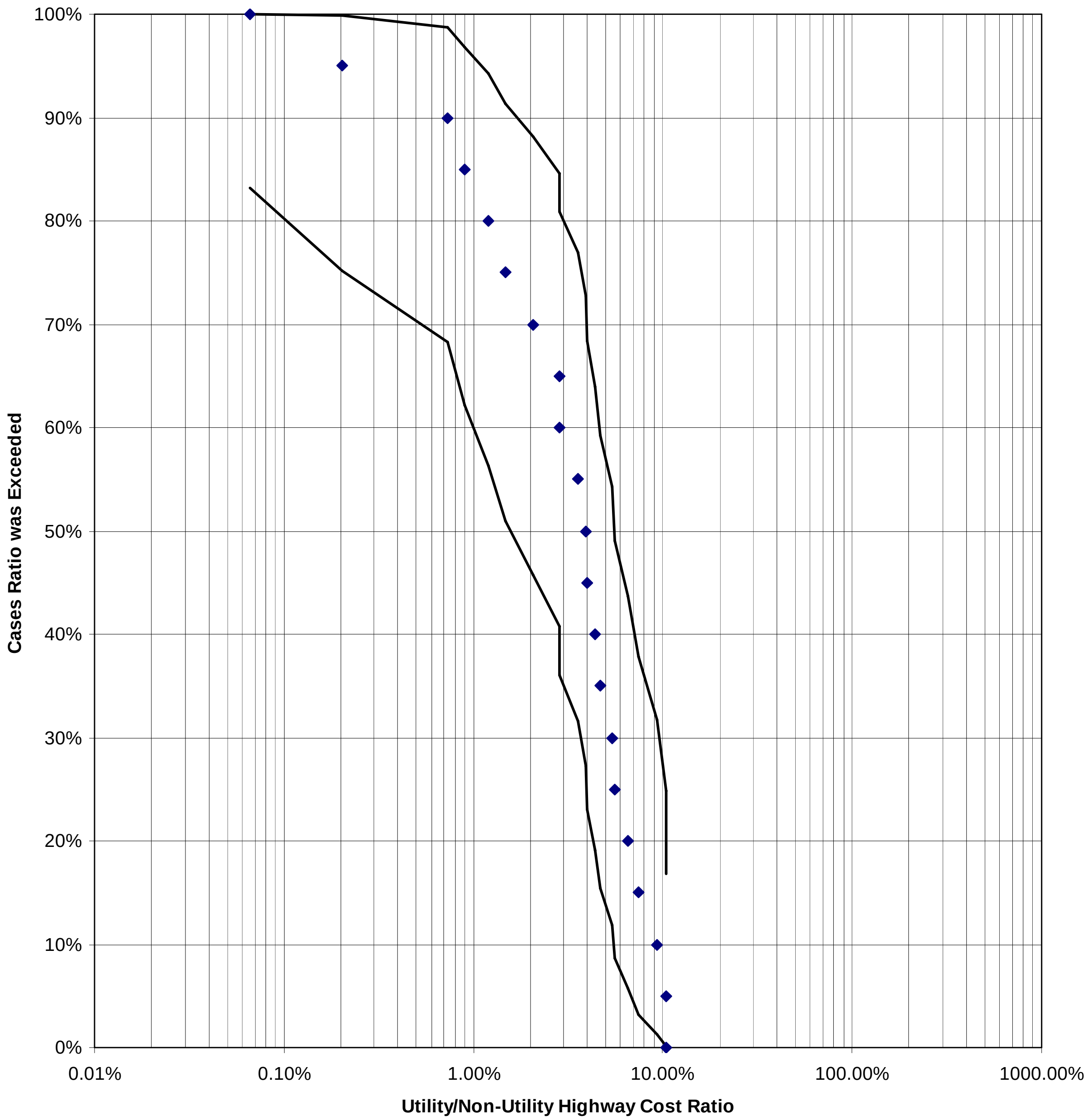
Note: The 95% confidence interval represents the range (at the 95% confidence level) associated with the true proportion of projects for which the utility cost to non-utility highway cost ratio exceeds the ratio.

Figure 17. Proportion of Projects Exceeding Utility Cost to Non-Utility Highway Cost Ratio – 476 Records.



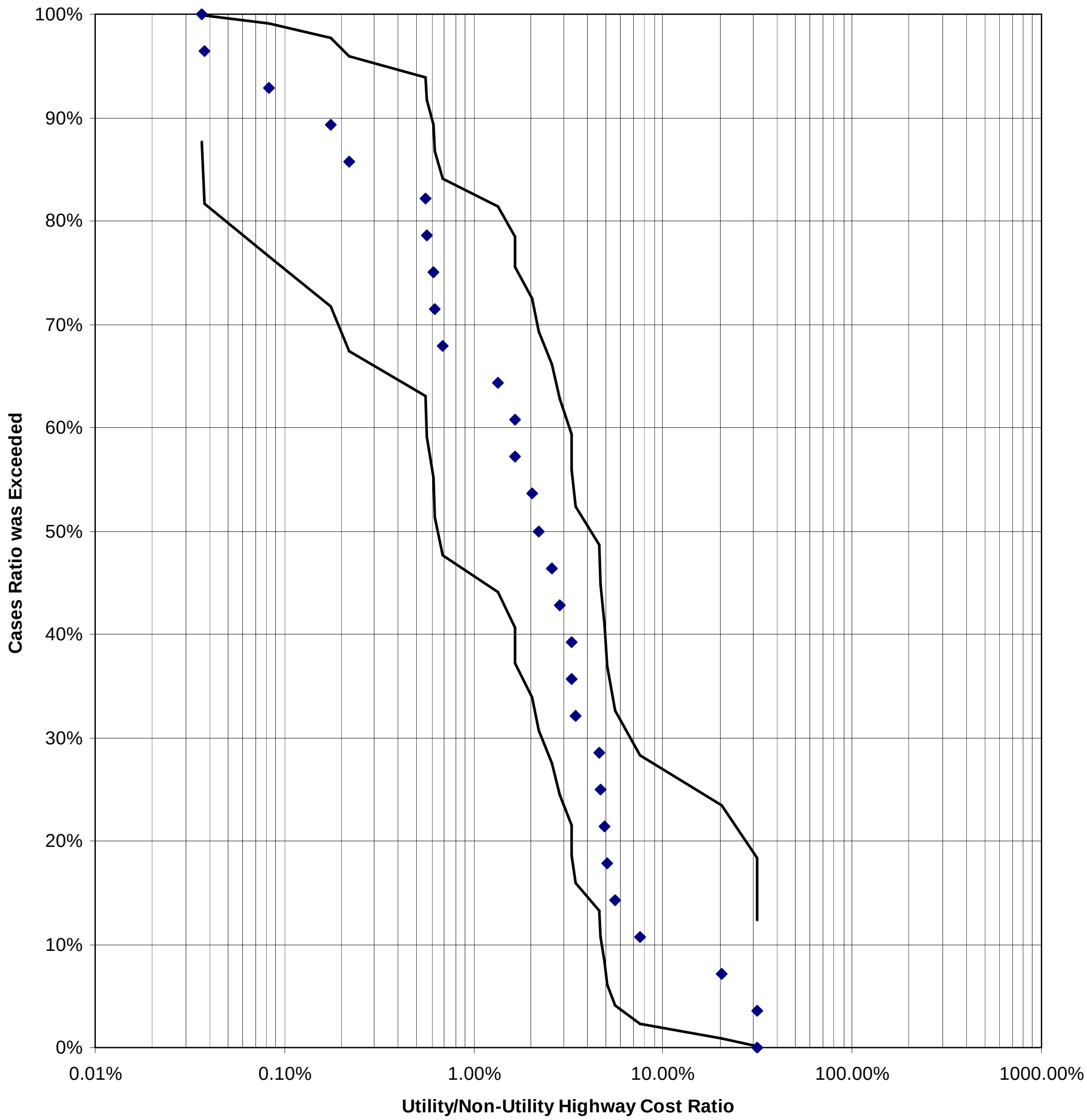
Note: The 95% confidence interval represents the range (at the 95% confidence level) associated with the true proportion of projects for which the utility cost to non-utility highway cost ratio exceeds the ratio.

Figure 18. Proportion of Projects Exceeding Utility Cost to Non-Utility Highway Cost Ratio for Project Type "BR" (Bridge Replacement) – 36 Records.



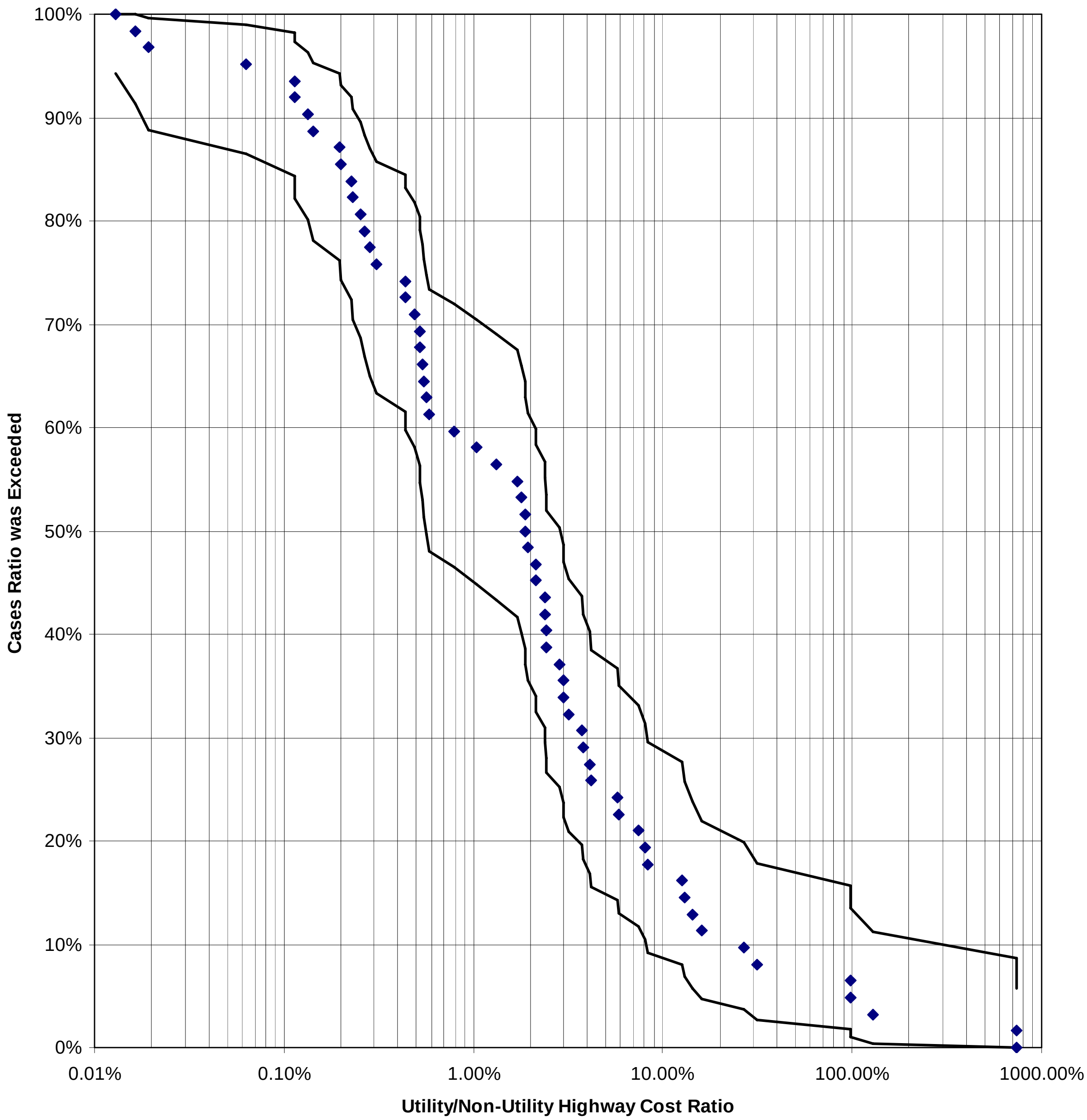
Note: The 95% confidence interval represents the range (at the 95% confidence level) associated with the true proportion of projects for which the utility cost to non-utility highway cost ratio exceeds the ratio.

Figure 19. Proportion of Projects Exceeding Utility Cost to Non-Utility Highway Cost Ratio for Project Type "CNF" (Convert Non-Freeway to Freeway) – 20 Records.



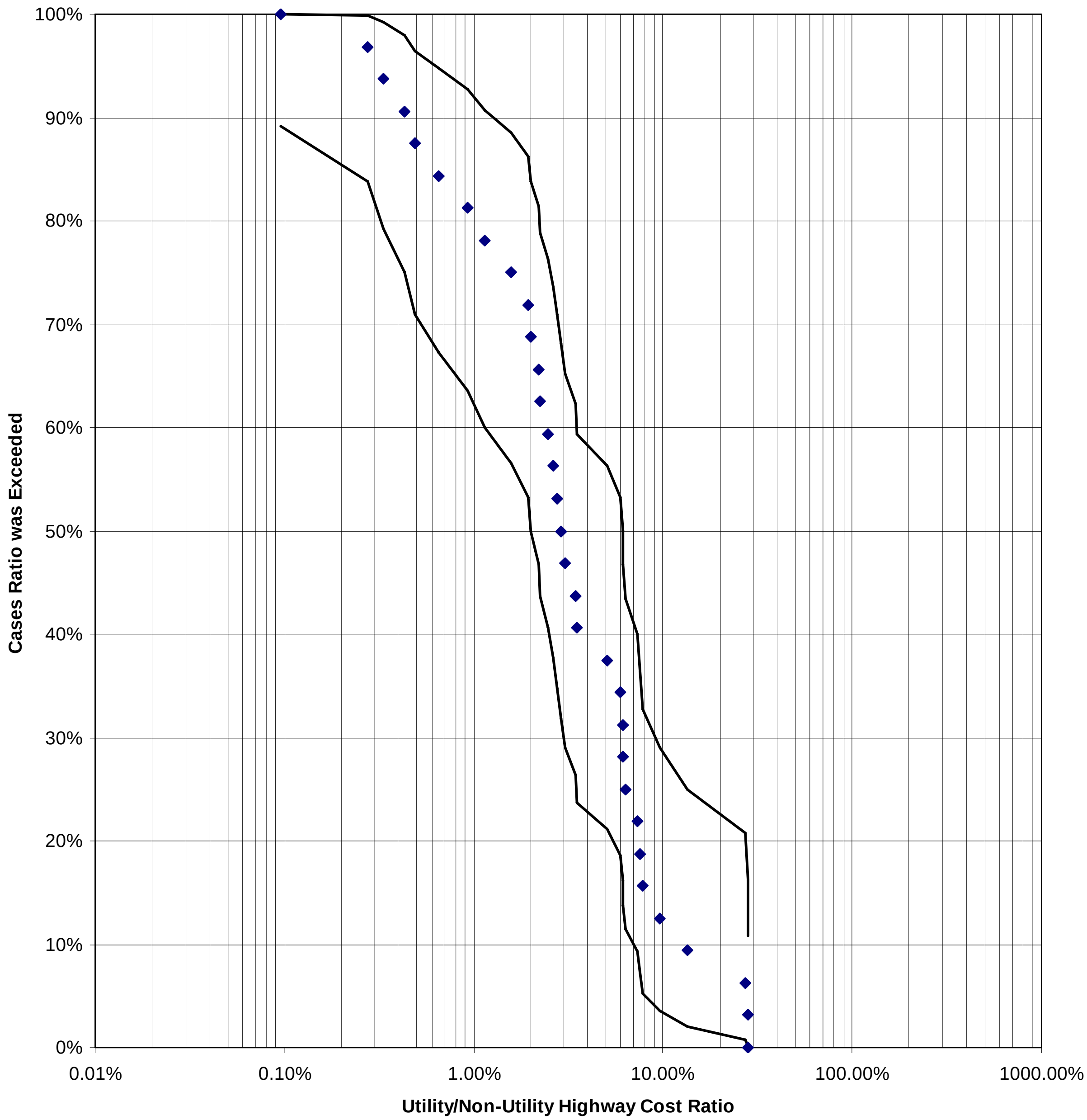
Note: The 95% confidence interval represents the range (at the 95% confidence level) associated with the true proportion of projects for which the utility cost to non-utility highway cost ratio exceeds the ratio.

Figure 20. Proportion of Projects Exceeding Utility Cost to Non-Utility Highway Cost Ratio for Project Type "INC" (Interchange) – 28 Records.



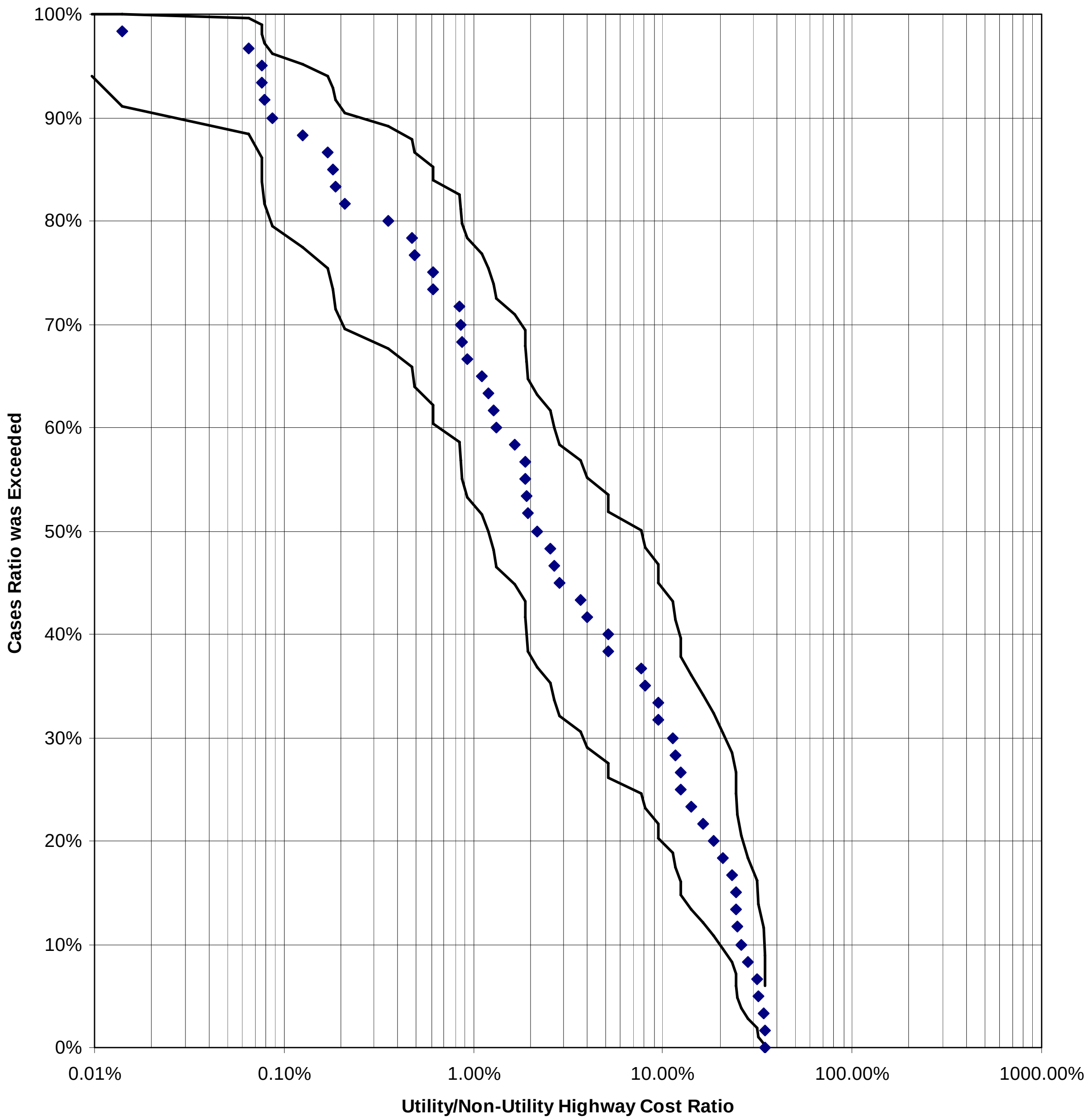
Note: The 95% confidence interval represents the range (at the 95% confidence level) associated with the true proportion of projects for which the utility cost to non-utility highway cost ratio exceeds the ratio.

Figure 21. Proportion of Projects Exceeding Utility Cost to Non-Utility Highway Cost Ratio for Project Type "MSC" (Miscellaneous Construction) – 62 Records.



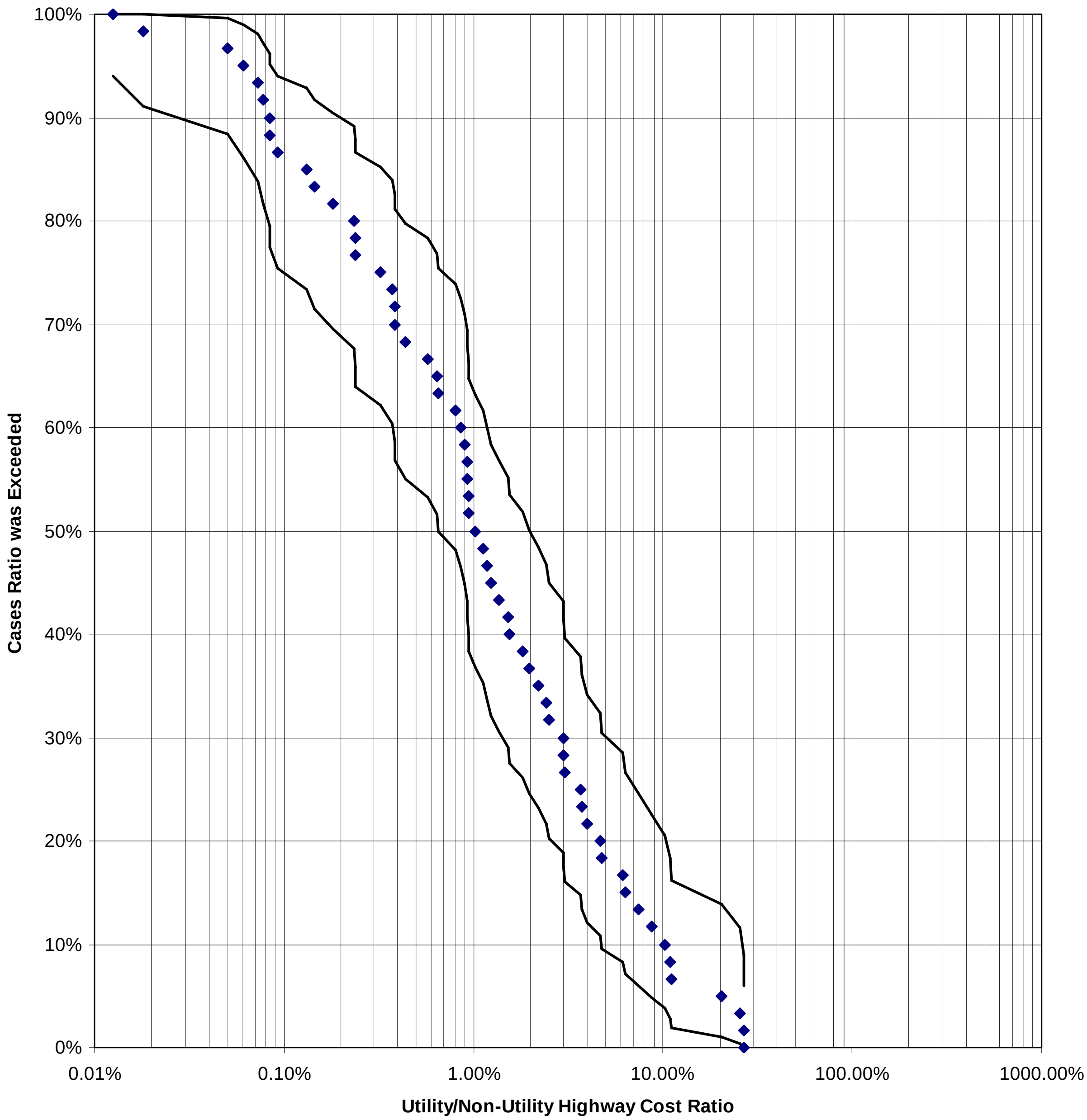
Note: The 95% confidence interval represents the range (at the 95% confidence level) associated with the true proportion of projects for which the utility cost to non-utility highway cost ratio exceeds the ratio.

Figure 22. Proportion of Projects Exceeding Utility Cost to Non-Utility Highway Cost Ratio for Project Types "NNF" (New Location Non-Freeway) and "NLF" (New Location Freeway) – 32 Records.



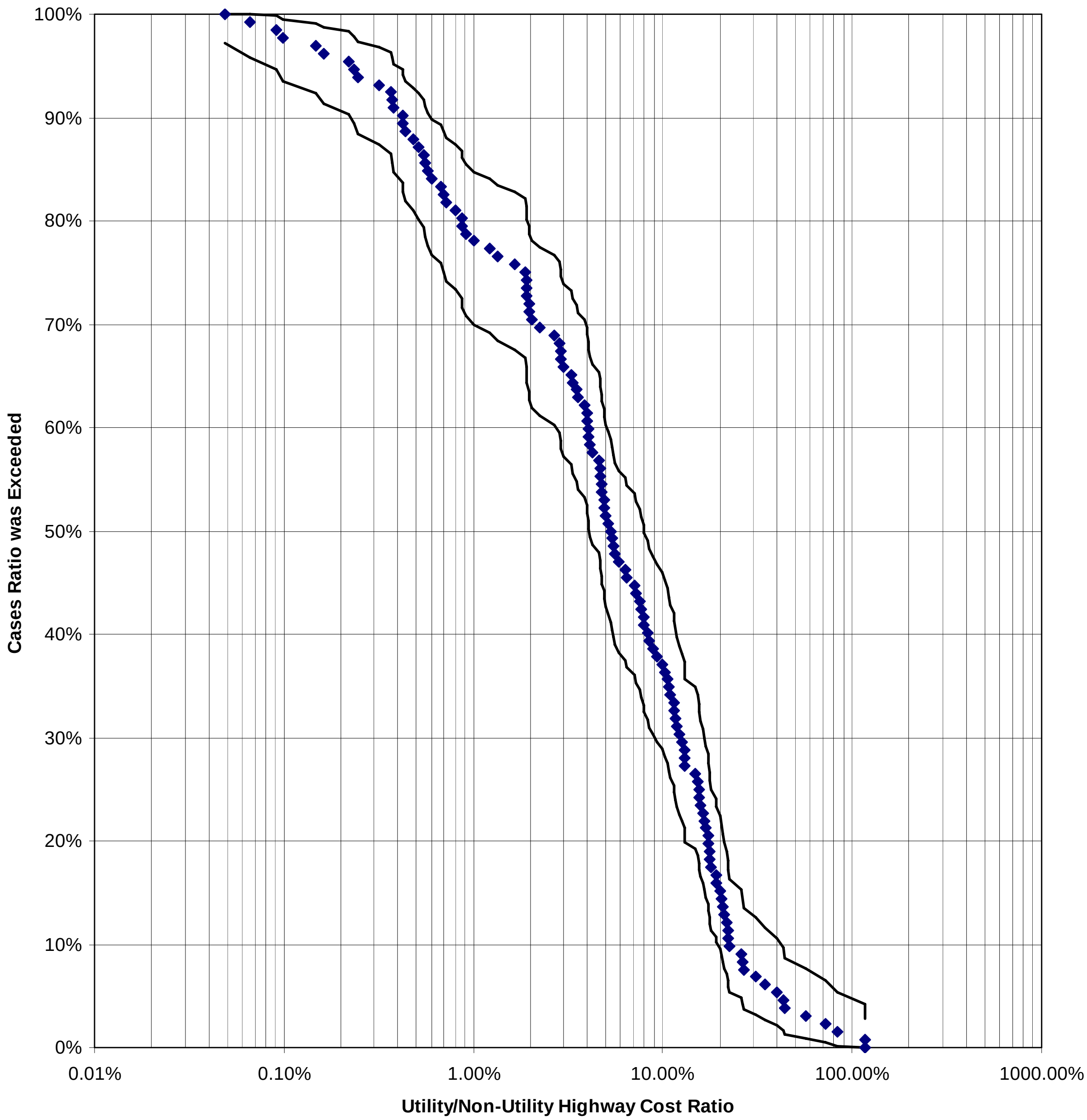
Note: The 95% confidence interval represents the range (at the 95% confidence level) associated with the true proportion of projects for which the utility cost to non-utility highway cost ratio exceeds the ratio.

Figure 23. Proportion of Projects Exceeding Utility Cost to Non-Utility Highway Cost Ratio for Project Type "RER" (Rehabilitate Existing Road) – 60 Records.



Note: The 95% confidence interval represents the range (at the 95% confidence level) associated with the true proportion of projects for which the utility cost to non-utility highway cost ratio exceeds the ratio.

Figure 24. Proportion of Projects Exceeding Utility Cost to Non-Utility Highway Cost Ratio for Project Type "WF" (Widen Freeway) – 60 Records.



Note: The 95% confidence interval represents the range (at the 95% confidence level) associated with the true proportion of projects for which the utility cost to non-utility highway cost ratio exceeds the ratio.

Figure 25. Proportion of Projects Exceeding Utility Cost to Non-Utility Highway Cost Ratio for Project Type “WNF” (Widen Non-Freeway) – 132 Records.

Application of the Binomial Proportion Model Methodology

The binomial proportion model described in the previous section highlights (and provides a tool to help deal with) one of the difficulties transportation agencies face when attempting to estimate early utility adjustment costs: how to provide a measure of uncertainty for the estimate provided. Combining this type of analysis with contingency allowances enables an explicit representation of the additional assurance contingency allowances provide.

For example, assume the non-utility highway cost for widening a non-freeway facility is $10,000,000. Assume the utility cost to non-utility highway cost ratio is 1 percent, which results in a utility adjustment cost estimate of $100,000. Based on historical data (Figure 25), there is a 78 percent chance the actual utility adjustment cost will exceed this estimate (with 95 percent confidence, the true proportion of projects for which the utility cost to non-utility highway cost ratio exceeds 1 percent lies between 70 and 85 percent). Assuming a pre-contract utility contingency of 30 percent to cover design uncertainties and a post-contract contingency of 10 percent to cover uncertainties during the utility adjustment, the combined estimate and utility contingency allowance is 1.30x1.10x$100,000 = $143,000 (which corresponds to a utility cost to non-utility highway cost ratio of 1.43 percent). Based on historical data, there would be a 76 percent chance the actual utility adjustment cost would exceed this value, i.e., a 30 percent pre-contract contingency combined with a 10 percent post-contract contingency would provide a 2 percent additional assurance that the 1 percent ratio originally assumed will not be exceeded.

If this level of additional assurance is not acceptable (e.g., based on an analysis of project urgency and the severity and financial impact on the project if the utility adjustment cost exceeds the original estimate), it might be necessary to modify the original utility adjustment cost estimate. Assuming now a utility cost to non-utility highway cost ratio of 5 percent (probability of exceedance of 52 percent, which represents 26 percentage points lower than the original 78 percent associated with the 1 percent ratio), the utility adjustment estimate cost would be $500,000. Assuming the pre-contract and post-contract contingency allowances are 30 percent and 10 percent, respectively, the combined estimate and contingency allowance would be 1.30x1.10x$500,000 = $715,000,which corresponds to a utility cost to non-utility highway cost ratio of 7.15 percent (probability of exceedance of 44 percent). In this case, the 30 percent pre-contract contingency combined with a 10 percent post-contract contingency would provide 8 percent additional assurance the 5 percent ratio originally assumed will not be exceeded. Notice that the 44 percent probability of exceedance is 32 percentage points lower than the corresponding 76 percent value associated with the utility cost to non-utility highway cost ratio of 1 percent.

The example above did not take into account inflation factors. In reality, the analysis should take into consideration both an appropriate inflation rate and critical date stamps such as estimate date and beginning and ending utility adjustment dates. Depending on project characteristics, utility adjustment and cash flow schedules, and other related considerations, a number of cost escalation methodologies might apply. As an illustration, ProtoCost uses a relatively simple methodology that relies on the estimate date and the beginning and ending utility adjustment dates to calculate a period of escalation (difference in dates between the estimate date and the midpoint between the projected beginning and ending utility adjustment dates). With this information and an annual inflation rate, the system calculates an escalated value of the basic utility adjustment estimate. Projects with long-duration and highly irregular utility adjustment characteristics and schedules might require a different cost escalation methodology to provide reliable escalated utility adjustment cost estimates.

It may be worth noting that the plots in Figure 17 through Figure 25 are based on highway construction cost data and utility adjustment cost data that correspond to highway contract bids and estimates utility companies provided to TxDOT. Under these circumstances, it is reasonable to assume the cost data used for the analysis included all or some of the pre-contract contingencies. Some optimization may be possible, e.g., by modifying both utility costs and non-utility highway costs with correction factors to ensure the utility cost to non-utility highway cost ratio represents a preliminary ratio before contingencies. Unfortunately, the magnitude of those correction factors is unknown, although if the cost data correspond to similar stages during the project development process, it is possible the correction factors would be similar in value, minimizing the impact on the estimation of the preliminary utility cost to non-utility highway cost ratio. For simplicity, this research assumes the utility cost to non-utility highway cost ratio obtained from the sample dataset also applies for the production of preliminary cost estimates.

While most analysts could use the plots in Figure 17 through Figure 25 directly to prepare early utility adjustment estimates, some analysts might prefer a more compact, tabular presentation of the results. Table 30 and Table 31 show two alternative tabular representations. Table 30 shows the proportion of projects for which the utility cost to non-utility highway cost ratio is exceeded as a function of project type and the utility cost to non-utility highway cost ratio. With this table, the analyst would first select the utility cost to non-utility highway cost ratio and then read the probability of exceedance for the corresponding project type. The example described previously that calculated the probability of exceedance for two different utility cost to non-utility highway cost ratios (1 percent and 5 percent, respectively) is a type of example for which Table 30 is well suited.

In contrast, Table 31 shows utility cost to non-utility highway cost ratios for several percentages that represent the probability of exceedance of the ratios. With this table, the analyst would first choose the probability of exceedance and then read the utility cost to non-utility highway cost ratio for the corresponding project type. For example, for miscellaneous construction, assuming a probability of exceedance of 50 percent, the corresponding utility cost to non-utility highway cost ratio would be 2 percent. Assuming a probability of exceedance of 10 percent, the utility cost to non-utility highway cost ratio for miscellaneous construction would increase to 25 percent.

As opposed to Table 30, Table 31 does not show confidence intervals. However, Table 31 explicitly shows utility cost to non-utility highway cost ratios as a function of their corresponding probability of exceedance, which might be useful at the district and/or division management level for developing initial general criteria for utility adjustment cost analyses. For example, a district might decide that as a general policy, the initial utility adjustment cost estimates should be such that the probability of exceedance of the cost estimates does not exceed 10 percent for any project type. Table 31 would provide the corresponding minimum utility cost to non-utility highway cost ratios that analysts would need to use.

Table 30. Proportion of Projects for which the Utility Cost to Non-Utility Highway Cost is Exceeded (with 95% Confidence Intervals).

Project Type		Utility Cost to Non-Utility Highway Cost Ratio					
		1%	5%	10%	20%	50%	100%
	All	63%[1] **68%**[2] 72%[1]	31% **35%** 39%	19% **23%** 27%	8% **11%** 14%	1% **2%** 4%	0.2% **0.8%** 2%
BR	Bridge replacement	46% **64%** 79%	12% **25%** 42%	8% **19%** 36%	2% **8%** 22%	0.3% **4%** 16%	**0%**
CNF	Convert non-freeway to freeway	60% **83%** 96%	14% **33%** 57%	1% **8%** 29%	**0%**	**0%**	**0%**
INC	Interchange	46% **66%** 82%	7% **19%** 38%	2% **9%** 27%	0.1% **7%** 24%	**0%**	**0%**
MSC	Miscellaneous construction	45% **58%** 70%	15% **25%** 38%	9% **17%** 29%	4% **11%** 21%	7% **2%** 17%	1% **5%** 14%
NLF NNF	New location freeway New location non-freeway	62% **80%** 92%	21% **38%** 56%	4% **12%** 29%	1% **8%** 22%	**0%**	**0%**
RER	Rehabilitate existing road	52% **66%** 78%	39% **51%** 64%	20% **31%** 45%	10% **18%** 30%	**0%**	**0%**
WF	Widen freeway	37% **50%** 63%	9% **18%** 30%	4% **10%** 21%	1% **5%** 14%	**0%**	**0%**
WNF	Widen non-freeway	70% **78%** 85%	44% **52%** 60%	29% **37%** 46%	10% **15%** 23%	1% **3%** 8%	0.1% **1%** 5%

[1] Range (at the 95% confidence level) associated with the true proportion of projects for which the utility cost to non-utility highway cost ratio exceeds the ratio shown on the column header.
[2] Sample proportion of projects for which their utility cost to non-utility highway cost ratio exceeds the ratio shown on the column header.

Table 31. Total Utility Cost to Non-Utility Highway Cost Ratio.

Project Type		Proportion of Projects for which Utility Cost to Non-Utility Highway Cost Ratio is Exceeded					
		100%	75%	50%	25%	10%	5%
	All	0.01%	0.6%	3%	8%	21%	31%
BR	Bridge replacement	0.02%	0.6%	3%	5%	14%	40%
CNF	Convert non-freeway to freeway	0.07%	1%	4%	6%	9%	10%
INC	Interchange	0.04%	0.6%	2%	5%	10%	24%
MSC	Miscellaneous construction	0.01%	0.4%	2%	5%	25%	98%
NLF NNF	New location freeway New location non-freeway	0.1%	2%	3%	6%	13%	28%
RER	Rehabilitate existing road	0.01%	0.6%	2%	12%	26%	32%
WF	Widen freeway	0.01%	0.3%	1%	4%	10%	20%
WNF	Widen non-freeway	0.05%	2%	5%	16%	22%	42%

Contingencies tend to decrease throughout the project development process. However, utility adjustments usually take place before the highway project goes to letting. As a result, there is a progression of milestones where the methodology to produce utility adjustment costs could change depending on the information available. Although each particular utility adjustment is different, Table 32 provides a summary view of different scenarios and alternatives to produce utility adjustment cost estimates depending both on utility adjustment status and highway project status. To the extent possible, the structure in Table 32 follows the progression of steps in ProtoCost. For completeness, Figure 26 provides a summary view of the utility adjustment cost sequence. However, there are some differences between Table 32 and ProtoCost:

- ProtoCost does not separately account for utility bid items included in the highway contract. For the calculation of the probability of exceedance, Table 32 assumes all utility adjustment construction costs are grouped together, regardless of whether they are handled in the highway contract or through separate utility agreements. While separating utility bid items from the highway contract was necessary for the analysis in this research, it is reasonable to assume that utility items in the highway contract are susceptible to similar pre-contract and post-contract contingencies as the rest of the highway contract. From this perspective, keeping utility items in the highway contract for overall cost estimation in ProtoCost is appropriate. Nonetheless, to the extent that reimbursement eligibility and total costs may be affected, it would advisable to develop an updated version of Table 32 as well as a separate module for utility adjustments in ProtoCost to explicitly identify which components are handled in the highway contract and which components are handled separately through utility agreements.

- ProtoCost does not support the use of utility adjustment cost percentages at 30 percent design. At the same time, it divides costs between locked-in costs and outstanding costs beginning at 60 percent design. In reality, there may be cases where at 30 percent design, there is still not enough information about the utility adjustment process to use a unit cost approach. Under these circumstances, a utility adjustment cost percentage approach would be appropriate. Likewise, while most utility adjustments take place late in the project development process, the possibility exists for some utility adjustments to undergo design and construction early. Under these circumstances, including the option to enter locked-in costs and outstanding costs at 30 percent design would be appropriate.

- Table 32 includes a recommendation to account for construction costs and all other utility adjustment-related costs separately to facilitate cost comparisons across projects. Notice that ProtoCost includes percentages for SUE, utility design and engineering, and elective betterments but not other utility adjustment-related costs such as easement acquisition, depreciation and salvaged material credits, and eligibility. It would be advisable to modify ProtoCost to include these other expenses following a similar procedure as that described in the first phase of the research (*6*). It may be worth noting that districts routinely charge SUE expenses to the DCIS "ROW" function code, although SUE is now normally considered a design task. The introduction of utility coordination contracts at several districts (which include SUE activities) will likely result in the need to account for additional utility adjustment-related expenses separately in the calculations. District design sections are responsible for managing and paying utility coordination contracts.

Table 32. General Progression of Procedures to Estimate Utility Adjustment Costs.

Highway Project Phase	Utility Adjustment Cost Estimate Method	Cost Estimate Source[1]	Probability of Exceedance[2]	Utility Pre-Contract Contingency[3]	Utility Post-Contract Contingency[4]
Planning and Programming	UC/NUHC ratio	Assume UC/NUHC ratio	Figure 17 – Figure 25	40%	10%
Preliminary design	UC/NUHC ratio	Assume UC/NUHC ratio	Figure 17 – Figure 25	30%	10%
30% design	UC/NUHC ratio	Assume UC/NUHC ratio	Figure 17 – Figure 25	0-25%	10%
	Unit costs	Quantities and locked-in unit prices		n/a[5]	10%
		Outstanding plan quantities and estimated/historical unit costs		0-25%	10%
60% design[6]	UC/NUHC ratio	Assume UC/NUHC ratio	Figure 17 – Figure 25	0-25%	10%
	Unit costs	Quantities and locked-in unit prices		n/a	10%
		Outstanding plan quantities and estimated/historical unit costs		0-25%	10%
90% design[7]	Unit costs	Quantities and locked-in unit prices	Figure 17 – Figure 25	n/a	10%
		Outstanding plan quantities and estimated/historical unit costs		0-25%	10%
100% design	Unit costs	Quantities and locked-in unit prices	Figure 17 – Figure 25	n/a	10%
		Outstanding plan quantities and estimated/historical unit costs		0-25%	10%
Construction	Unit costs	Quantities and locked-in unit prices	Figure 17 – Figure 25	n/a	10%
Post-construction	Unit costs	Final quantities and locked-in unit prices	Update appropriate figure with data point	n/a	n/a

[1] Depending on the information available, the cost estimate could rely on a selected utility cost to non-utility highway cost ratio *or* a combination of quantities and locked-in unit prices and plan quantities and estimated/historical unit costs. A unit cost approach should follow the methodology developed in the first phase of the research *(6)*, which includes accounting for and separating construction costs from other utility adjustment-related costs to facilitate cost comparisons across projects.

[2] Determining the probability of exceedance requires calculating the total utility adjustment cost estimate (from all cost estimate sources), calculating the non-utility highway construction cost estimate, and using the appropriate figure according to project type.

[3] Utility pre-contract contingency covers utility design uncertainties prior to the utility adjustment in the field. The appropriate utility pre-contract contingency depends on the utility adjustment design status (which is not necessarily the same as the highway project design status). The values shown are preliminary but could be used as a first approximation.

[4] Utility post-contract contingency covers uncertainties during the utility adjustment in the field. The utility post-contract contingency of 10% is arbitrary but could be used as a first approximation. The compounded contingency factor is (1+pre-contract contingency [see Note 3]) x (1+post-contract contingency) - 1. For appropriate cost estimation, it is necessary to include an appropriate inflation rate and critical date stamps such as the estimate date and beginning and ending utility adjustment dates.

[5] Pre-contract contingency does not apply under the assumption that quantities and locked-in unit prices correspond to 100% utility design.

[6] At 60% design, it is still possible for the utility adjustment cost estimate to rely on a selected utility cost to non-utility highway cost ratio if plan quantities and unit prices are not in place yet.

[7] At 90% design, plan quantities and unit costs for all utility adjustments should essentially be in place.

Highway Project	UC/NUHC ratio	Outstanding plan quantities and estimated/historical unit costs	Quantities and locked-in unit prices	Final quantities and locked-in unit prices
Post Construction				n/a n/a
Construction			n/a 10%	n/a n/a
100% Design		0-25% 10%	n/a 10%	n/a n/a
90% Design		0-25% 10%	n/a 10%	
60% Design	0-25% 10%	0-25% 10%	n/a 10%	
30% Design	0-25% 10%	0-25% 10%	n/a 10%	
Preliminary Design	30% 10%			
Planning & Programming	40% 10%			

Utility Adjustment Cost Estimate Source

Legend:

Utility pre-contract contingency	Utility post-contract contingency
0-25%	10%

Figure 26. General Progression of Procedures to Estimate Utility Adjustment Costs (Summary View).

CHAPTER 4. CONCLUSIONS AND RECOMMENDATIONS

SUMMARY OF FINDINGS

Communication Infrastructure Construction Specifications

This report expanded the work completed in two previous reports (*6*, *7*), which focused on water and sewer utilities, by developing a prototype framework of specification requirements and corresponding bid and subsidiary items for communication utilities. The requirements for each specification include a summary table outlining the main characteristics of the proposed specification, bid items, subsidiary items, and units of measurement, followed by a list of specification requirements that follow the TxDOT standard construction specification style (*8*).

The analysis included a review of a sample of TxDOT communication-related special specifications. The review found numerous variations with respect to the official TxDOT specification style. It also identified trends, differences, and issues with respect to specification content. For example, the review found inconsistencies in the application of bid item naming conventions, which, in the long term, could make the analysis of historical unit cost data more difficult. Perhaps recognizing the need for using standardized terminology, some special specifications included definitions of items. Providing standardized definitions is a practice that facilitates consistency in the bidding process, measurement, and payment. There were also cases where the specification was vague in the description, construction procedure, or measurement of an item. Examples included confusing application of temporary adjustment provisions and pay items; cases where the specification assumed relatively large items to be subsidiary, potentially skewing the unit cost associated with the associated pay item; cases where there was confusing language regarding the measurement and payment of cable assemblies and splicing; cases where there was no clarity regarding what party would be responsible for furnishing certain materials; and cases where the specification provided incomplete references to other specifications.

The prototype specification framework developed in this research covered most types of communication installations. The framework is generic, therefore not limited to public or private utility installations that occupy the state ROW (*1*, *3*), which means TxDOT could also use it for the design, construction, and cost management of its own communication infrastructure. One of the reasons this is possible is that the unit cost methodology developed in the first part of the research separates construction costs from reimbursement procedures and emphasizes that, to facilitate cost comparisons across projects, bid items and corresponding unit costs should follow the same structure regardless of who owns the infrastructure (*6*).

The communication specification framework included four groups of specifications: Earth Work, Lines, Appurtenances, and Other (Figure 5). The framework also included a fifth group (General) to take into account standard specifications such as mobilization and traffic control, which highway construction contracts typically include but, at the same time, are relevant to the utility adjustment process. Because the highway contract already includes those items, it would constitute duplicate payment to include the same activities in other work items. However, if needed (since utility adjustments typically take place before the highway project goes to letting), TxDOT could request utility companies to include in their cost proposals relevant bid items from the General group of specifications. If modifications to standard specifications are necessary, TxDOT could use special provisions to modify specific sections or articles, following a practice that is already standard in regular highway construction projects. In any case, in order to prevent unit cost distortions, it would not be advisable to include items from the General group of specifications as subsidiary items to other bid items in the cost proposal (unless the corresponding standard specification for the bid item already includes that provision).

The specification requirements included references to standards and specifications from a number of organizations such as ANSI, ASTM International, IEEE, NEMA, NFPA, and RUS. The framework assumed specifications resulting from the specification requirements developed in this research will reference specific relevant standards instead of reprinting text from the original standards documents (particularly in the case of materials standards), therefore enabling specifications to stay up-to-date with industry standards without requiring major revisions to the specifications. However, to facilitate the specification writer’s work when developing the specifications, the specification requirements also included references to a variety of construction specifications and guidelines from the utility industry and regulatory agencies.

The classification and level of disaggregation of bid and subsidiary items relied on a review of existing classifications in the 1993 and 2004 communication-related special specifications, 2004 TxDOT standard specification structure, and the methodology followed in the first phase of the research. In some cases, it was necessary to modify existing standard specifications and cost classifications to better facilitate “apples-to-apples” unit cost comparisons. The result was a specification and corresponding bid and subsidiary item structure that, over time, should minimize cost distortions and facilitate cost comparisons across projects.

In general, the level of bid item disaggregation was consistent with what the utility industry and regulatory agencies (e.g., RUS) use. However, readers should note that different agencies follow different cost management practices, which are reflected in the way they handle bid item disaggregation issues. Those differences make the development of a specification and cost framework that is perfectly compatible across agencies practically impossible. For this reason, the approach followed in this research was to develop a cost framework that, while being consistent with TxDOT’s highway construction cost management practices, was as neutral and encompassing as possible regarding utility industry and regulatory agency practices.

For example, RUS specifications use “assembly units” that, in general, are similar to the bid items in the framework presented here with respect to materials, labor, and construction procedure requirements. In fact, the framework in this research references many RUS specifications. However, there are several differences between the framework developed here and RUS procedures that take into account both highway construction cost management practices at TxDOT and the need to develop a unit cost structure that facilitates unbiased cost comparisons among projects. As an illustration, the RUS assembly unit for buried fiber optic cable includes ROW clearing in the cost of the cable. However, not all cable installations require the same level of ROW clearing (which could vary significantly across the state), and in addition, TxDOT already has a separate bid item, Item 100, that covers ROW preparation activities. For this reason, the framework developed in this research did not include ROW clearing in the cost of the cable. Similarly, RUS assembly units for underground conduit include the cost of encasement (concrete or sand) in the cost of the conduit structure. However, they do not include metal or plastic casing pipe as an encasement option. The RUS assembly units also include shoring in the cost of the conduit structure but do not explicitly account for differences between shallow trenches and deep trenches. To facilitate cost comparisons, the researchers developed separate bid items for concrete and casing pipe encasement and incorporated TxDOT standard specification Item 402, which explicitly includes excavation protection requirements for trenches deeper than five feet. Likewise, there are RUS assembly units for manholes. However, TxDOT already has a standard specification and bid items for manholes (Item 465). Consequently, the researchers developed proposed modifications to the existing Item 465 specification to address utility installation needs.

Although the research covered most types of communication infrastructure found on the state ROW, it left out a number of items that were not critical or for which there was not enough information to develop the specification requirements and corresponding bid and subsidiary items. Examples include utilidors, central offices, and cell towers. In the case of utilidors, their applicability is restricted to only very specific circumstances (*54*), which would perhaps warrant the development of one-time-use special specifications but not district-wide use or statewide use specifications. In the case of central offices, these facilities are frequently large buildings that require considerable bid item disaggregation to estimate and monitor construction costs properly. There is also a wide range in central office sizes and equipment, making the development of a single specification for central offices infeasible. In the case of cell towers, the industry is changing rapidly and the technology is evolving in directions that could easily render current specifications obsolete. For example, it is now common to find cell towers disguised as trees, palms, or water towers in response to requirements from municipalities. Some jurisdictions are beginning to place restrictions on cell tower heights and/or beginning to require the use of wireless facility units on structures such as poles. Rather than a specification or a specification requirement document, the researchers advise TxDOT to develop of a guideline and/or policy statement concerning the placement, characteristics, permitting provisions, and other related issues associated with cell towers.

In some other cases, it was not clear whether widespread implementation at TxDOT in the short term would be feasible and, therefore, the decision was to leave the analysis for a future phase. An example of this type of analysis was joint trenching. There is evidence that joint trenching can result in shorter installation times, cost savings for installation and maintenance, more efficient use of ROW, and streamlined inspection (*54*, *55*). An example of a well-established joint trench utility installation program is the one in Houston, which involves utilities as varied as gas, electric, and telephone (*56*). However, joint trenching requires detailed coordination throughout planning and installation among all involved utilities. Utilities involved must also come to an agreement on several aspects, including design parameters for the trench, cost sharing of the installation, a utility to lead the project, and a qualified contractor. Because of the extensive coordination requirement during planning and construction, utilities often do not make use of joint trenching. Nevertheless, considering the potential benefits that joint trenching could offer for utility adjustment work on the state ROW, the researchers advise TxDOT to evaluate its feasibility and, depending on the results, develop best practices guidelines and specifications.

Utility Adjustment Cost Estimation

The report described a methodology to produce utility adjustment cost estimates in the preliminary phases of the project development process, which complements the unit cost approach developed during the first phase of the research (*6*). The need for that methodology became apparent after realizing the limitations of traditional approaches that simply estimate utility adjustment costs as percentages of the highway construction costs without providing a measure of uncertainty for those estimates. The research highlighted several reasons for improving the capability to forecast utility adjustment costs, including that constructions costs are frequently underestimated; the new requirements in SAFETEA-LU for states to provide adequate project financial integrity, delivery, and oversight; and that utility adjustment costs are among the most difficult costs to estimate and carry a high potential for risk and change.

The analysis included a general overview of utility adjustment cost estimation practices around the country and a more detailed review of the utility components in two recently developed cost estimation tools: VDOT's Project Cost Estimating System and TxDOT's ProtoCost (recently implemented at the Houston District). As mentioned previously, existing methodologies typically assume utility adjustment to be a percentage of the highway construction cost, although lump sum approaches also exist. VDOT's PCES includes the option to enter "best judgment" utility adjustment cost data. ProtoCost differentiates between planning and preliminary design and different highway design levels. For planning and preliminary design, ProtoCost assumes utility adjustment cost to be a percentage of the highway construction cost. For design, users enter a utility adjustment cost estimate (which may be divided into a locked-in cost and an outstanding adjustment estimate). In general, ProtoCost assumes the utility adjustment cost percentage to be a function of highway project size, location, roadway type, and project type. In practice, users can select utility adjustment cost percentages from a default value table in the database. Currently, there are only three different sets of utility adjustment percentages in the default value table, assuming in effect that the utility adjustment cost percentage is a function of project location and project size but not roadway type or project type.

To assess the feasibility of a procedure to estimate utility adjustment costs in the preliminary phases of the project development process, the researchers assembled a large sample from a variety of data sources at TxDOT, including historical unit cost data, 1993 and 2004 special specifications, the ROW Division's utility agreement database, route and control section geodatabase, and the RHiNo highway inventory file. The result was a large data sample covering 476 projects, which included total highway construction cost, total utility adjustment cost, as well as additional data elements that were necessary for the analysis such as letting date, route, project description and limits, project type, urban/rural designation, and project length.

The initial hypothesis was that it would be possible to correlate utility adjustment costs with highway construction costs through simple linear models that could confirm (among other things) the use of constant utility adjustment cost percentages. The researchers experimented with several models using both arithmetic and logarithmic scales and took into consideration the potential effect of factors such as project type and project length (a previous analysis had shown the unreliability of the rural/urban and roadway type factors). In general, the results showed relatively low R^2 values and wide data scatter around the regression line, which indicated serious accuracy limitations of the linear regression modeling approach. Nonetheless, the exercise found that project type played a statistically significant role in utility adjustment cost estimation, that project length played a somewhat erratic role that varied according to project type, and that the utility adjustment cost percentage was essentially independent of project size.

Realizing the limitations of the linear regression-type models, the researchers used a different modeling technique that involved calculating the ratio of utility cost to non-utility highway cost for each project, grouping the data points by project type, and then, for each project type, sorting the ratios in descending order and plotting the ordered series to provide a measure of the likelihood that individual ratio values would be exceeded. To complete the analysis, the researchers added confidence intervals to the different plots to account for the fact that the cumulative distribution plots were based on a sample, not the entire population. In general, using this type of approach offered several advantages including (a) not having to rely on a regression line or equation that could be very easily misinterpreted and therefore misused, (b) providing an explicit representation of the likelihood that a specific utility cost adjustment estimate could be exceeded based on the previous history of cost data in the database, and (c) avoiding a false sense of security in the cost estimate provided.

A closer analysis of the cumulative distribution plots revealed several interesting trends, including that different project types resulted in markedly different plots, both in terms of slope and ratio orders of magnitude. The analysis also included the development of a procedure to combine the cumulative distribution plot concept with pre-contract and post-contract contingency allowances to provide an explicit quantitative representation of the additional assurance that contingencies offer. Using this type of procedure is consistent with FHWA recommendations regarding the evaluation of factors such as probability of occurrence, severity, and expected financial impact, as well as an estimation of the contingency level so that it reflects the remaining risk associated with the corresponding project cost component (*45*). Recognizing the expectation for contingencies to decrease throughout the project development process and realizing that utility adjustments can take place before the highway project goes to letting, the researchers developed a tabular representation of milestones where the methodology to produce utility adjustment costs could change depending on the information available (Table 32). The table provides a summary view of different scenarios and alternatives to produce utility adjustment cost estimates depending on utility adjustment status and highway project status.

RECOMMENDATIONS FOR IMPLEMENTATION

Utility Installation Construction Specifications

This section includes recommendations for implementation of communication-related specifications. These recommendations complement the framework and recommendations provided in an earlier report (*6*), which focused on water and sewer utility installations.

- **Standardize TxDOT communication utility specifications**. Develop and adopt a set of construction specifications for communication utilities based on the specification framework and requirements developed as part of this research. Developing the construction specifications should involve a series of steps including submitting the specification framework to the TxDOT Specifications Committee, circulating the specification framework to relevant stakeholders around the state for review and comment (including district personnel, local jurisdictions, and utility companies). Implementing this recommendation would provide part of the requisite foundation for consistent utility adjustment practices, the objective cost database, and the success of the other recommendations. Implementing this recommendation requires a decision and commitment of TxDOT to the framework and specification structure developed and the development of specific specifications based on the framework and structure.

- **Standardize communication utility specification format**. Adopt a policy that special specification formatting should follow that of standard specifications. Implementing this recommendation would minimize problems with interpretation and simplify the transition to standard communication utility specifications. It would also provide part of the foundation for a uniform and consistent utility cost reimbursement process and data collection. Implementing this recommendation requires the decision of and commitment by TxDOT to a standard format and the enforcement of its use in approving specifications.

- **Adopt an implementation strategy for communication utility specifications**. The implementation strategy would include selecting a pilot district in which to test the construction specifications (designated as special specifications following current procedures at TxDOT), selecting a sample of suitable projects, coordinating with project designers and affected communication companies, fine tuning the specifications as needed, following up during construction, reporting, and training. Results of the pilot implementation phase, and additional testing as required, would eventually result in the adoption of statewide standard specifications for communication utility installations. Implementing this recommendation would provide an opportunity and means to test the proposed specifications and improve them as needed.

- **Use communication asset pricing data to improve estimates of communication construction costs**. The unit cost framework and payment procedures developed in the first phase of the research (*6*) also apply to communication utility installations. Consistent with the recommendations from the first phase, the application of the proposed unit cost and payment approach to communication assets requires construction units to relate directly to the standard specification framework detailed in this report. Implementing this recommendation would help to standardize reimbursement practices and procedures, help to avoid improper payments, and establish a basis for collecting and using objective historical utility adjustment cost data. Implementing this recommendation requires the decision of and commitment by TxDOT to advance communication utility reimbursement through this recommendation, progress on the standardization of utility specifications, and implementation of a procedure for capturing detailed utility unit cost data.

- **Link historical communication construction costs to work performed**. To facilitate historical comparisons for communication utility adjustment costs and reimbursement purposes, records should include dated references to specifications and additional notations concerning any exceptions permitted or the attachment of special provisions.

TxDOT already follows this approach in the case of highway construction costs, resulting in a comprehensive database of unit costs and references to standard specifications, special specifications, and special provisions. Extending this concept to communication utility adjustments, whether included in the highway contract or through utility agreements, would lead to the development of a long-term repository of communication infrastructure cost data, which would facilitate future cost estimation and monitoring. Implementing this recommendation requires a change in TxDOT utility procedures, some training to potential users, and enforcement of the new procedures.

- **Apply communication specification and unit cost framework to TxDOT-owned communication assets**. TxDOT is increasing the deployment of communication infrastructure throughout the state. Although the number of communication-related special specifications at TxDOT is increasing, a comprehensive set of standard construction specifications and units for TxDOT communication infrastructure does not currently exist. The specification and unit cost framework developed in this research is generic and therefore not limited to utility-owned communication infrastructure. Furthermore, the unit cost methodology developed in the first part of the research (*6*) provides the mechanism to clearly separate construction costs from reimbursement eligibility and procedures. In particular, the methodology emphasizes that the treatment of construction units and corresponding unit costs should be the same regardless of who owns the infrastructure in order to facilitate cost comparisons among similar bid items on different projects.

- **Modify relevant existing standard specifications**. Development of the utility specification framework made it necessary to modify some existing standard specifications, primarily dealing with excavation, backfill, trenchless construction, manholes, and support structures such as pole assemblies. Some of the proposed modifications are improvements that would be advisable to implement in any case, even without the implementation of utility specifications. In several cases, the proposed modifications were significant enough to the point that modifying an existing standard specification was no longer feasible. In those cases, the researchers developed the requirements for a new replacement specification. Modifying relevant existing standard specifications and/or developing replacement specifications based on the prototype framework would result in a more coherent set of standard specifications at TxDOT.

- **Include utility-related definitions in the TxDOT glossary**. Using standardized definitions offers several advantages. First, it helps readers to understand specifications, which is critical to facilitate consistency in the bidding process, as well as for measurement and payment. Second, it provides clarity in the use of terminology, which is critical given the wide range of naming conventions in the telecommunication industry. Using standardized definitions is also advantageous in situations where terminology in the main body of the specification might be confusing or incorrectly used.

  The researchers developed definitions for some of the most commonly-used communication-related items. It would be advisable to develop definitions for additional communication-related items, as well as other types of utility installations (e.g., water, sanitary sewer, electric, and gas), and include those definitions in the TxDOT glossary (*59*). In the short term, it would be advisable to develop a statewide special specification devoted to definitions for utility-related items and include references to those definitions in individual utility specifications. Including definitions in individual specifications is certainly possible. However, this approach could make maintaining the integrity of the definitions more difficult because of the risk of multiplicity of definitions for similar items over time.

- **Merge the TxDOT glossary and Item 1**. Item 1, "Definition of Terms," includes 147 definitions of terms used in the TxDOT standard specifications and other contract documents. At the same time, the TxDOT glossary includes hundreds of definitions used throughout TxDOT for a wide range of applications. Many definitions in Item 1 are not found in the TxDOT glossary. Although some abbreviations and terms are common, there are numerous differences in definition scope and wording. Therefore, it would be advisable to expand the glossary with definitions from Item 1 and develop common terminology in both documents.

  Notice, however, that while developing common terminology would bring benefits to TxDOT, it is unclear why it is necessary to maintain two documents that provide essentially the same information. Therefore, it would be advisable to evaluate the feasibility of merging both documents (e.g., by eliminating Item 1 from the standard specifications book, incorporating the corresponding definitions into the TxDOT glossary, and evolving the glossary into a formal TxDOT standard that could be used as a reference in construction specifications and other contract documents). The evaluation would include an assessment of advantages and disadvantages and formulate appropriate recommendations for implementation.

- **Modify TxDOT Form 1814**. The researchers developed specification requirements that included a summary table describing the main specification characteristics, bid items, subsidiary items, and corresponding measurement units. The structure of the summary table was intended to facilitate the use of and/or complement TxDOT Form 1814. It may be possible to argue that instead of simply facilitating the use of TxDOT Form 1814, the summary table could provide the foundation for an updated version of Form 1814 that incorporates new elements that make the process to develop new specifications more effective.

Utility Adjustment Cost Estimation

- **Implement methodology to produce utility adjustment cost estimates**. The researchers developed a methodology to produce utility adjustment cost estimates in the preliminary phases of the project development process, which complements the unit cost approach developed during the first phase of the research. The methodology is particularly useful during planning and programming and preliminary design, although it could also be used during design if information about existing utilities is not available. The methodology includes cumulative distribution plots by project type (Figure 17 through Figure 25) and a summary table (Table 32) that describes a general progression of procedures to ensure consistency in the production of utility adjustment cost estimates. Implementing this recommendation could significantly improve TxDOT's ability to estimate utility adjustment costs during the project development process.

- **Develop procedure to maintain cumulative distribution plots up-to-date**. The methodology discussed in this research was based on a sample dataset. Although the sample size was significant, the researchers recognize that the long-term value of the methodology depends on TxDOT's willingness to keep the cumulative distribution plots up-to-date. It would be ideal to develop an automated process, perhaps within DCIS or within the ROW Division's utility agreement database, to automatically update the plots at the conclusion of every highway construction project that includes utility adjustments. This report documented the procedure and queries used to build the data sample. Some of the queries could be used with some modifications to develop the automated procedure described above.

  A related recommendation is to archive utility adjustment cost estimates, contingency allowance data, and other related data to enable the analysis of cost trends and the production of meaning reports. DCIS provides some functionality along these lines, but its current architecture and corresponding implementation are quite limiting. Nonetheless, a central data repository such as DCIS or the ROW Division's utility agreement database appear to be the most logical candidates for the implementation of a procedure to archive historical utility adjustment cost estimate data.

- **Develop training materials and opportunities to disseminate the utility cost estimation methodology**. A critical component in the implementation of the methodology developed in this research is developing the professional capacity necessary to understand and apply the methodology correctly and effectively. Although conceptually straightforward, the methodology requires a good understanding of statistical principles, particularly in relation to the application of concepts such as risk assessment, probability of exceedance, and the relationship between contingencies and project uncertainties. Developing and delivering appropriate training materials to TxDOT district and division officials and consultants would help to achieve those objectives and facilitate the implementation of the methods proposed here.

- **Implement changes in ProtoCost**. This report outlined several differences between the prototype utility adjustment cost estimation methodology developed in this project and the ProtoCost system that the Houston District implemented recently. Some of those differences highlight areas where ProtoCost could improve its utility adjustment cost estimation capabilities. A summary of suggested changes follows:

  - Incorporate a module to determine the probability of exceedance of utility adjustment cost percentages for each project type, and combine this calculation with pre-contract and post-contract contingencies.

  - Modify the default value table structure and user interfaces to reflect the results of the research, and include recommendations for users not to assume fixed utility adjustment cost percentages without the support of the probability of exceedance module described above.

- Implement a module to differentiate between utility adjustment costs in the highway contract and costs handled through utility agreements.

- Modify the 30 percent design module to accept both utility adjustment cost percentages and locked-in costs.

- Separate utility adjustment construction costs from other utility adjustment-related costs (e.g., those related to reimbursement eligibility requirements) following the unit cost framework developed in the first part of the research (*6*).

Other Recommendations

- **Strengthen description of temporary adjustments in regulatory documents**. This report includes the requirements for a construction specification to cover temporary utility adjustments. This specification should complement requirements in existing regulatory documents such as the Utility Accommodation Rules (*1*) and the Utility Manual (*2*). Currently, there are no references to temporary adjustments in the Utility Accommodation Rules. In the case of the Utility Manual, there are four casual references to temporary adjustments as well as one reference regarding reimbursement eligibility for materials used and recovered as part of the temporary adjustment—although the wording used in the manual is very difficult to follow and understand:

  > Materials recovered from temporary use and accepted for re-use by the utility shall be credited to the project at prices charged to the job, less a consideration for loss in service life at 10 percent.

  Notice the Utility Manual does not explicitly indicate whether labor, equipment, transportation, engineering, and other related charges used for temporary adjustments may be eligible for reimbursement. The omission of this type of information can cause confusion for utility companies.

- **Improve procedure to track construction CSJs in the utility agreement database**. The research documented a few limitations in the current version of the ROW Division's utility agreement database. One of the most severe limitations is the need to enter data manually from other systems, e.g., construction CSJs. In practice, this limitation has resulted in difficulties to match construction projects to ROW projects properly. Long term, the solution to this problem is to develop the capability to automatically link to relevant systems and either populate fields in the utility agreement database automatically or provide users with the ability to select from a list of drop down menu options. Both strategies would contribute to eliminate data integrity problems that are currently limiting the usability of the database.

- **Evaluate feasibility of joint trenching and develop implementation guidelines**. As mentioned previously, there is evidence that joint trenching can result in shorter installation times, cost savings for installation and maintenance, more efficient use of ROW, and streamlined inspection. However, there are numerous challenges related to the implementation of joint trenching practices, including detailed coordination, design parameters for the trench, and cost sharing. It would be advisable to evaluate the feasibility of joint trenching and, depending on the results, develop best practices guidelines and specifications.

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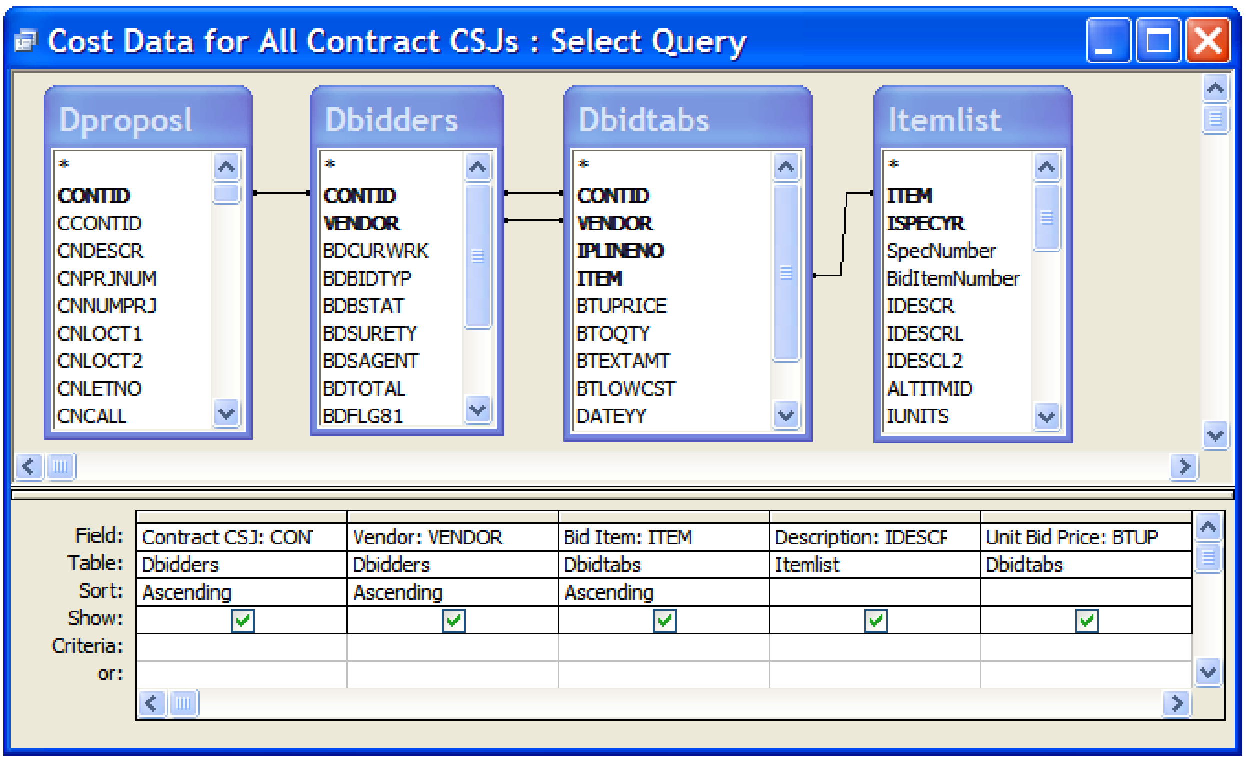
APPENDIX. PROCEDURE TO DEVELOP THE SAMPLE DATASET

The procedure to develop the dataset for the analysis using the data sources in Chapter 3 included the following steps:

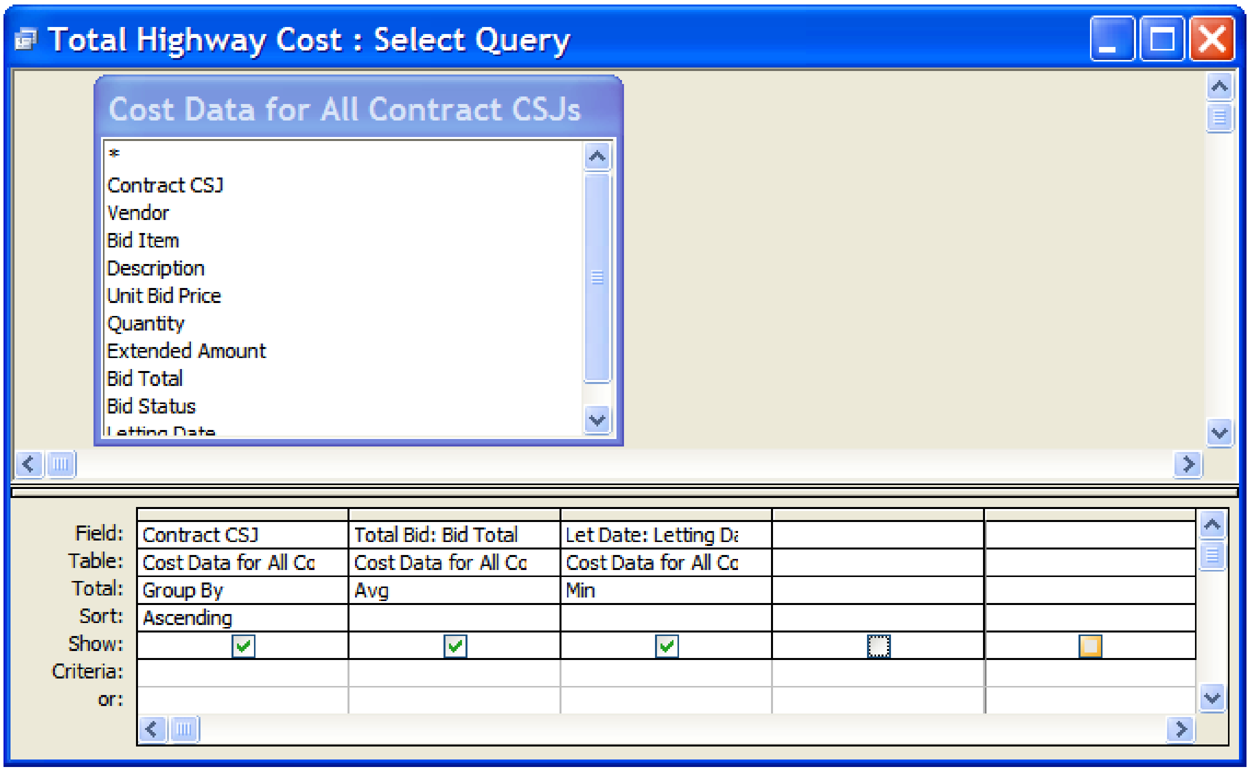
- Develop a query to join tables Dproposl, Dbidders, Dbidtabs, and Itemlist (Figure 27). The result was a dataset that contained 913,558 records containing unit cost data (from the winning bid) for all highway contract CSJs. When the query limited the search to projects that used year 1993 or 2004 specifications (because the list of special specifications analyzed only covered these two edition years), the number of records decreased to 491,519. When the query further limited the search to projects that were listed as “Construction,” the number of records retrieved was also 491,519.



SELECT Dbidders.CONTID AS [Contract CSJ], Dbidders.VENDOR AS Vendor, Dbidtabs.ITEM AS [Bid Item], Itemlist.IDESCR AS Description, Dbidtabs.BTUPRICE AS [Unit Bid Price], Dbidtabs.BTOQTY AS Quantity, Dbidtabs.BTEXTAMT AS [Extended Amount], Dbidders.BDTOTAL AS [Bid Total], Dbidders.BDBSTAT AS [Bid Status], Dproposl.CNDTLET AS [Letting Date], Itemlist.ISPECYR, Dproposl.CNCNTTYP
FROM Itemlist INNER JOIN ((Dbidders INNER JOIN Dbidtabs ON (Dbidders.CONTID = Dbidtabs.CONTID) AND (Dbidders.VENDOR = Dbidtabs.VENDOR)) INNER JOIN Dproposl ON Dbidders.CONTID = Dproposl.CONTID) ON Itemlist.ITEM = Dbidtabs.ITEM
WHERE (((Dbidders.BDTOTAL)<>0) AND ((Dbidders.BDBSTAT)="W") AND ((Itemlist.ISPECYR)="93") AND ((Dproposl.CNCNTTYP)="CONS")) OR (((Dbidders.BDTOTAL)<>0) AND ((Dbidders.BDBSTAT)="W") AND ((Itemlist.ISPECYR)="04") AND ((Dproposl.CNCNTTYP)="CONS"))
ORDER BY Dbidders.CONTID, Dbidders.VENDOR, Dbidtabs.ITEM;

Figure 27. Query to Obtain Winning Bid Unit Cost Data.

- Develop another query to obtain total bid amounts and letting dates for all highway contract CSJs (Figure 28). The result was a dataset that contained 16,872 records. When the query limited the search to projects that used year 1993 or 2004 specifications, the number of records decreased to 14,571.

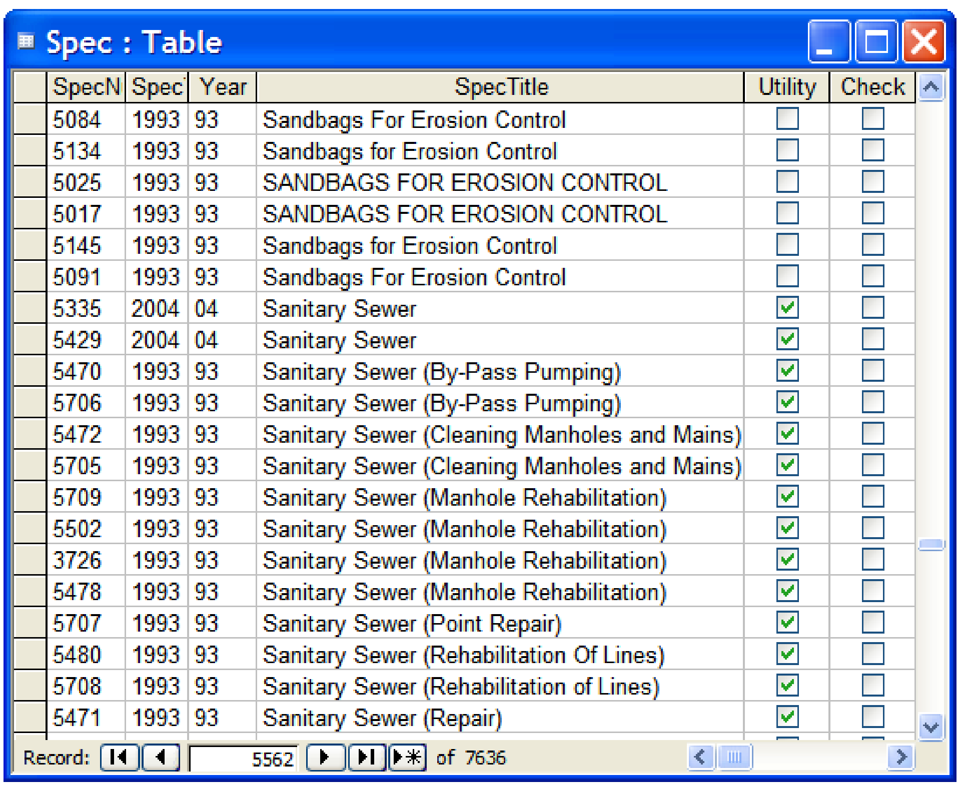


SELECT [Cost Data for All Contract CSJs].[Contract CSJ], Avg([Cost Data for All Contract CSJs].[Bid Total]) AS [Total Bid], Min([Cost Data for All Contract CSJs].[Letting Date]) AS [Let Date]
FROM [Cost Data for All Contract CSJs]
GROUP BY [Cost Data for All Contract CSJs].[Contract CSJ]
ORDER BY [Cost Data for All Contract CSJs].[Contract CSJ];

Figure 28. Query to Obtain Total Highway Construction Costs.

- Select utility-related specifications from the list of special specifications. To accomplish this task, the researchers created a table containing information about 1993 special specifications (most of which the researchers had already used during the first phase of the research [*6*])—as well as year 2004 4000-series and 5000-series special specifications from the TxDOT web site that appeared to include a significant number of utility-related specification titles. In total, out of the 7636 special specifications listed in the table, the researchers highlighted 443 special specifications that were utility-related (Figure 29). Most of these special specifications were water and sanitary sewer utilities. The original selection included many specifications related to telecommunications. However, after a closer analysis, it turned out that practically all of these specifications were in connection with TxDOT-owned telecommunication infrastructure (e.g., traffic signals or ITS).

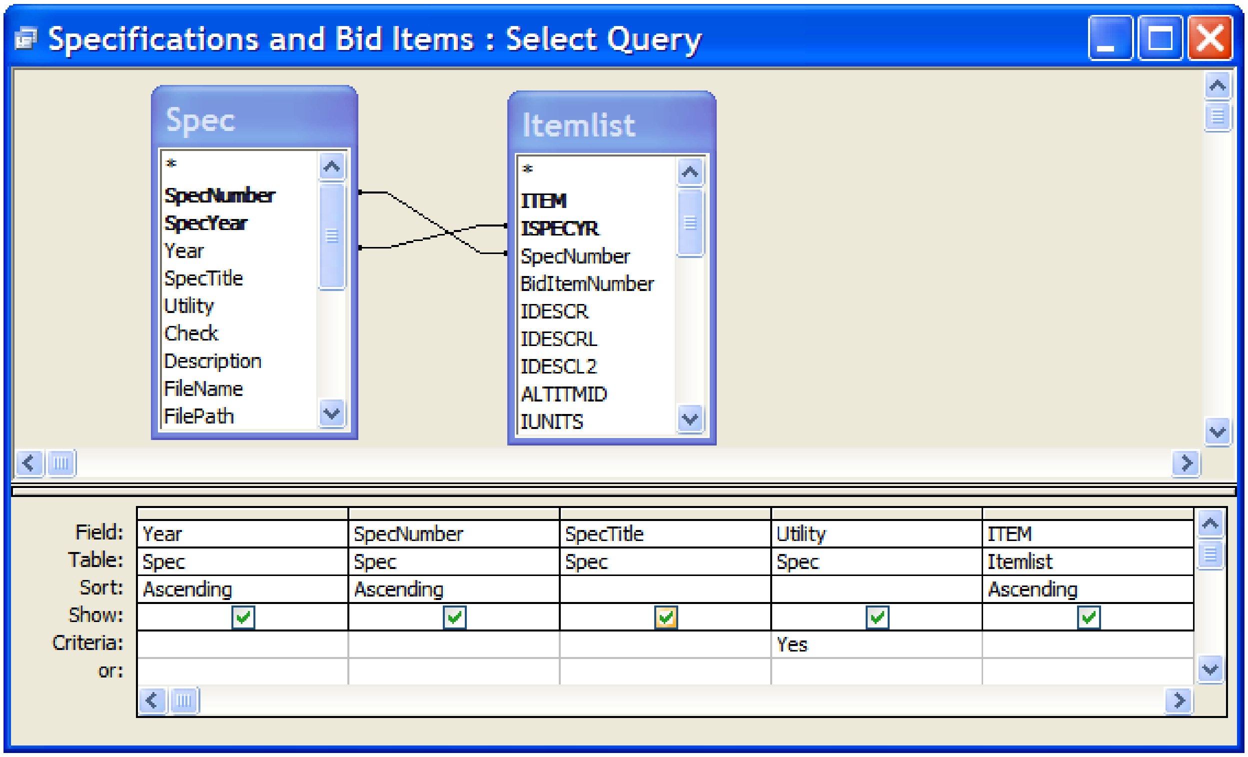
  This realization highlights a potential difficulty in isolating the cost of utility adjustment from other construction costs in highway construction projects. The reason is that from the list of specifications alone, it is not necessarily evident whether the specifications—and associated construction items—are associated with TxDOT-owned installations or with installations owned by private or public utilities (*1*, *3*). As documented below, one potential strategy to address this issue is to create one construction project for highway-related items and another construction project for utility adjustment items.



SpecN	Spec	Year	SpecTitle	Utility	Check
5084	1993	93	Sandbags For Erosion Control	☐	☐
5134	1993	93	Sandbags for Erosion Control	☐	☐
5025	1993	93	SANDBAGS FOR EROSION CONTROL	☐	☐
5017	1993	93	SANDBAGS FOR EROSION CONTROL	☐	☐
5145	1993	93	Sandbags for Erosion Control	☐	☐
5091	1993	93	Sandbags For Erosion Control	☐	☐
5335	2004	04	Sanitary Sewer	☑	☐
5429	2004	04	Sanitary Sewer	☑	☐
5470	1993	93	Sanitary Sewer (By-Pass Pumping)	☑	☐
5706	1993	93	Sanitary Sewer (By-Pass Pumping)	☑	☐
5472	1993	93	Sanitary Sewer (Cleaning Manholes and Mains)	☑	☐
5705	1993	93	Sanitary Sewer (Cleaning Manholes and Mains)	☑	☐
5709	1993	93	Sanitary Sewer (Manhole Rehabilitation)	☑	☐
5502	1993	93	Sanitary Sewer (Manhole Rehabilitation)	☑	☐
3726	1993	93	Sanitary Sewer (Manhole Rehabilitation)	☑	☐
5478	1993	93	Sanitary Sewer (Manhole Rehabilitation)	☑	☐
5707	1993	93	Sanitary Sewer (Point Repair)	☑	☐
5480	1993	93	Sanitary Sewer (Rehabilitation Of Lines)	☑	☐
5708	1993	93	Sanitary Sewer (Rehabilitation of Lines)	☑	☐
5471	1993	93	Sanitary Sewer (Repair)	☑	☐

Figure 29. Highlighting Utility-Related Special Specifications.

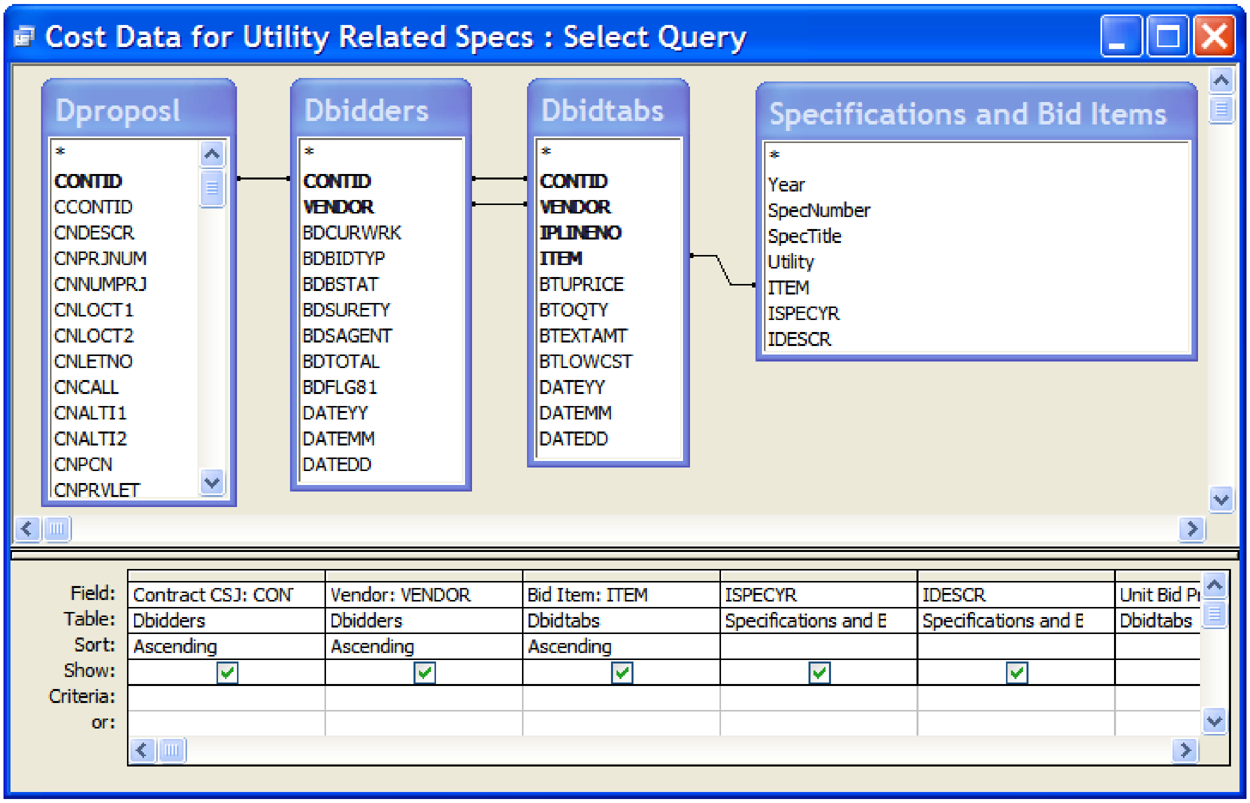
- Develop a query to obtain a listing of utility-related special specifications and their corresponding construction unit items (Figure 30). Out of the 443 utility-related special specifications, the result was a dataset that contained 7009 construction unit item records.



SELECT Spec.Year, Spec.SpecNumber, Spec.SpecTitle, Spec.Utility, Itemlist.ITEM, Itemlist.ISPECYR, Itemlist.IDESCR
FROM Itemlist INNER JOIN Spec ON (Itemlist.ISPECYR = Spec.Year) AND (Itemlist.SpecNumber = Spec.SpecNumber)
WHERE (((Spec.Utility)=Yes))
ORDER BY Spec.Year, Spec.SpecNumber, Itemlist.ITEM;

Figure 30. Query to Produce a Listing of Utility-Related Special Specifications and their Corresponding Construction Unit Items.

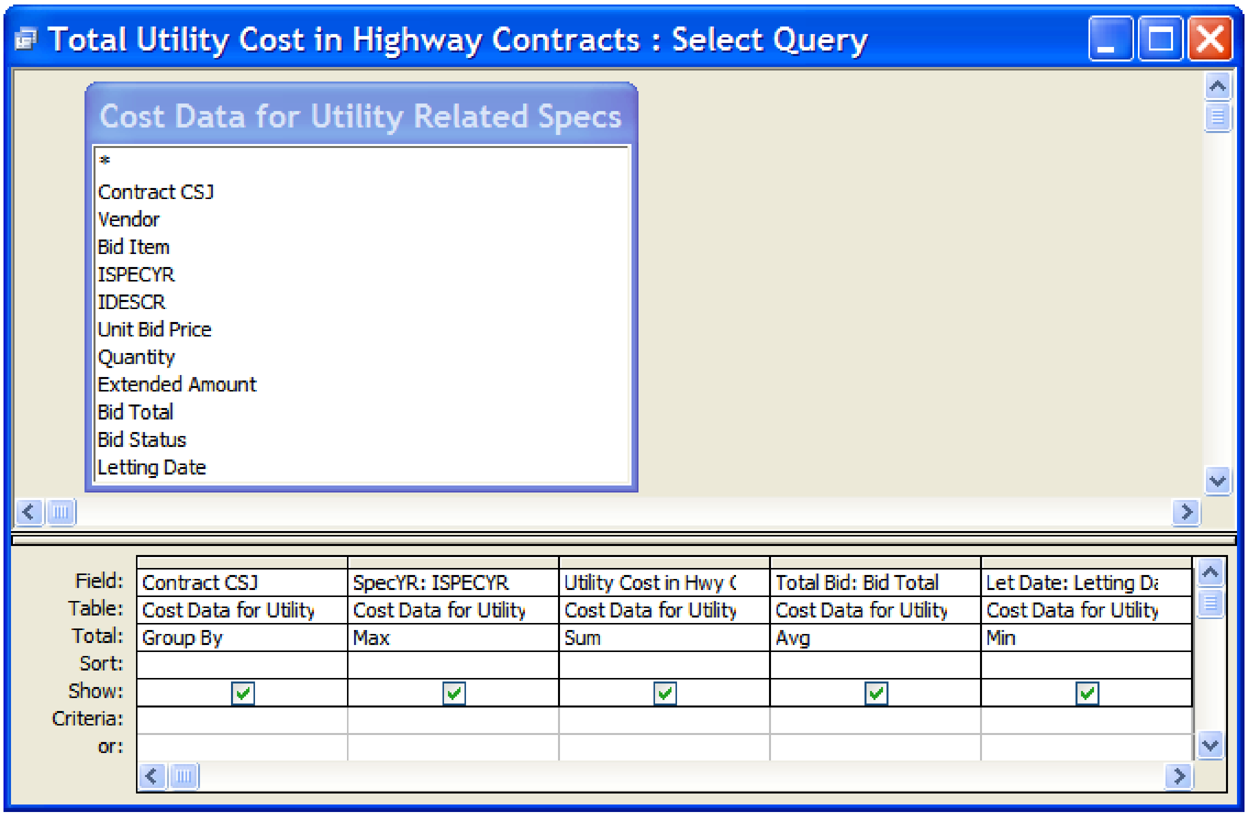
- Develop a query to obtain unit cost data for utility-related special specifications (Figure 31). The result was a dataset that contained 6773 utility-related unit cost data records. The query was essential to extract unit cost data associated with utility adjustment items included in highway contracts.



SELECT Dbidders.CONTID AS [Contract CSJ], Dbidders.VENDOR AS Vendor, Dbidtabs.ITEM AS [Bid Item], [Specifications and Bid Items].ISPECYR, [Specifications and Bid Items].IDESCR, Dbidtabs.BTUPRICE AS [Unit Bid Price], Dbidtabs.BTOQTY AS Quantity, Dbidtabs.BTEXTAMT AS [Extended Amount], Dbidders.BDTOTAL AS [Bid Total], Dbidders.BDBSTAT AS [Bid Status], Dproposl.CNDTLET AS [Letting Date]
FROM [Specifications and Bid Items] INNER JOIN ((Dbidders INNER JOIN Dbidtabs ON (Dbidders.CONTID = Dbidtabs.CONTID) AND (Dbidders.VENDOR = Dbidtabs.VENDOR)) INNER JOIN Dproposl ON Dbidders.CONTID = Dproposl.CONTID) ON [Specifications and Bid Items].ITEM = Dbidtabs.ITEM
WHERE (((Dbidders.BDTOTAL)<>0) AND ((Dbidders.BDBSTAT)="W") AND (([Specifications and Bid Items].Utility)=Yes))
ORDER BY Dbidders.CONTID, Dbidders.VENDOR, Dbidtabs.ITEM;

Figure 31. Query to Obtain Unit Cost Data for Utility-Related Special Specifications.

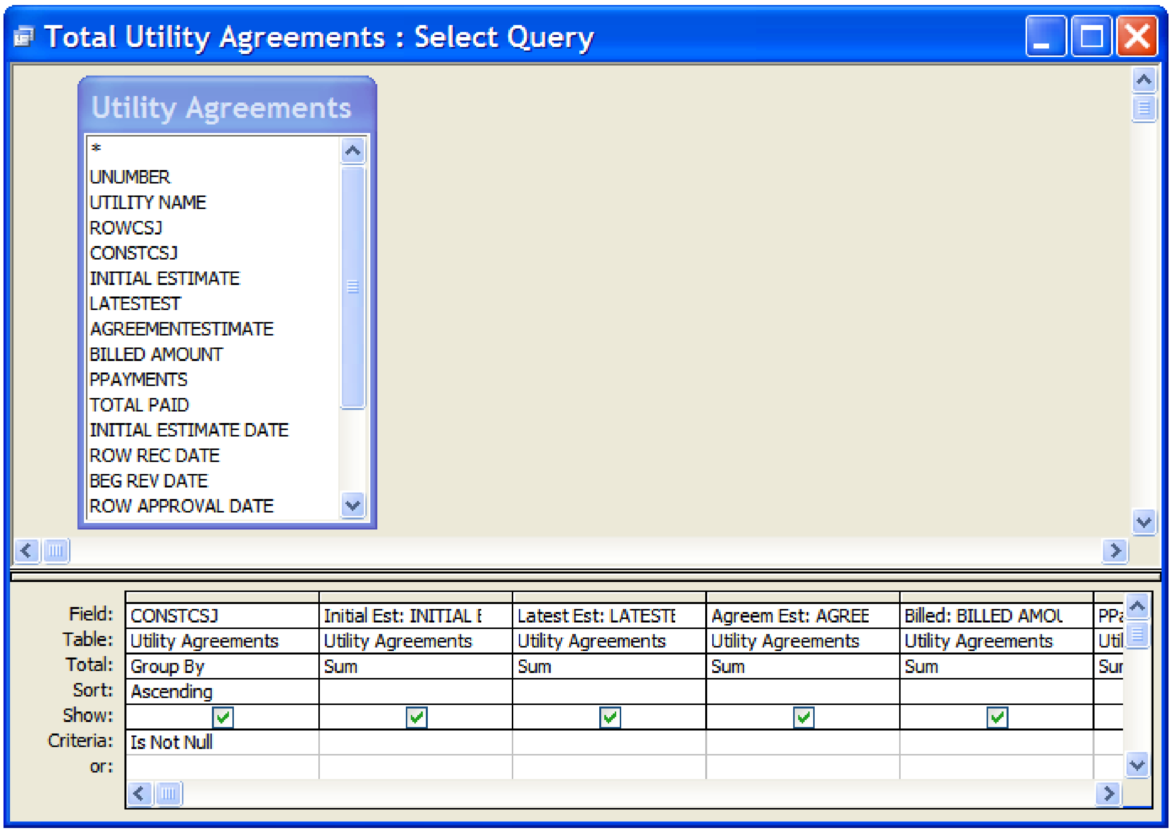
- Develop a query to obtain total utility costs in highway construction projects (Figure 32). The result was a dataset that contained 388 records that represented projects for which the total bid was larger than zero (of which, 330 records corresponded to projects with contract awards amounts), the project was listed as "Construction," and the specifications used were year 1993 or 2004.



SELECT [Cost Data for Utility Related Specs].[Contract CSJ], Max([Cost Data for Utility Related Specs].ISPECYR) AS SpecYR, Sum([Cost Data for Utility Related Specs].[Extended Amount]) AS [Utility Cost in Hwy Contract], Avg([Cost Data for Utility Related Specs].[Bid Total]) AS [Total Bid], Min([Cost Data for Utility Related Specs].[Letting Date]) AS [Let Date]
FROM [Cost Data for Utility Related Specs]
GROUP BY [Cost Data for Utility Related Specs].[Contract CSJ];

Figure 32. Query to Obtain Total Utility Costs in Highway Construction Projects.

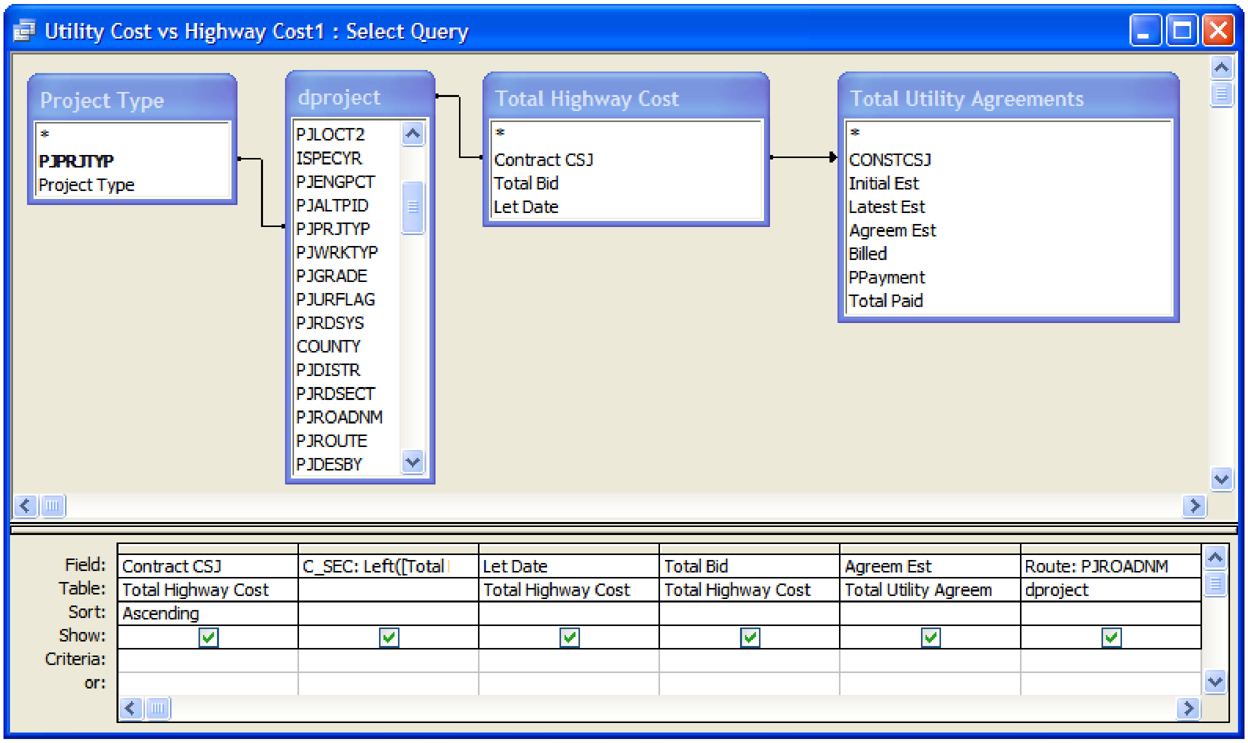
- Develop a query to obtain relevant data from the ROW Division's utility agreement database. To accomplish this task, the researchers imported table UTILITY from the ROW Division's utility agreement database and developed a query to obtain initial estimates, approved estimates, agreement estimates, as well as total amounts paid for all utility agreements for which there was information about the highway construction CSJ, i.e., the highway construction CSJ field was not null (Figure 33). Of the 2737 records in the utility agreements table, the result was a dataset that contained 579 records.



SELECT [Utility Agreements].CONSTCSJ, Sum([Utility Agreements].[INITIAL ESTIMATE]) AS [Initial Est], Sum([Utility Agreements].LATESTEST) AS [Latest Est], Sum([Utility Agreements].AGREEMENTESTIMATE) AS [Agreem Est], Sum([Utility Agreements].[BILLED AMOUNT]) AS Billed, Sum([Utility Agreements].PPAYMENTS) AS PPayment, Sum([Utility Agreements].[TOTAL PAID]) AS [Total Paid]
FROM [Utility Agreements]
GROUP BY [Utility Agreements].CONSTCSJ
HAVING ((([Utility Agreements].CONSTCSJ) Is Not Null))
ORDER BY [Utility Agreements].CONSTCSJ;

Figure 33. Query to Obtain Relevant Data from the ROW Division's Utility Agreement Database.

- Develop a query to join total highway cost data and total utility agreement cost data (Figure 34). The result was a dataset that contained 8586 records representing projects where there were highway contract award amounts and, if available, utility agreement cost data. Notice the query also included a lookup table that lists 49 project types from DCIS (Table 33).



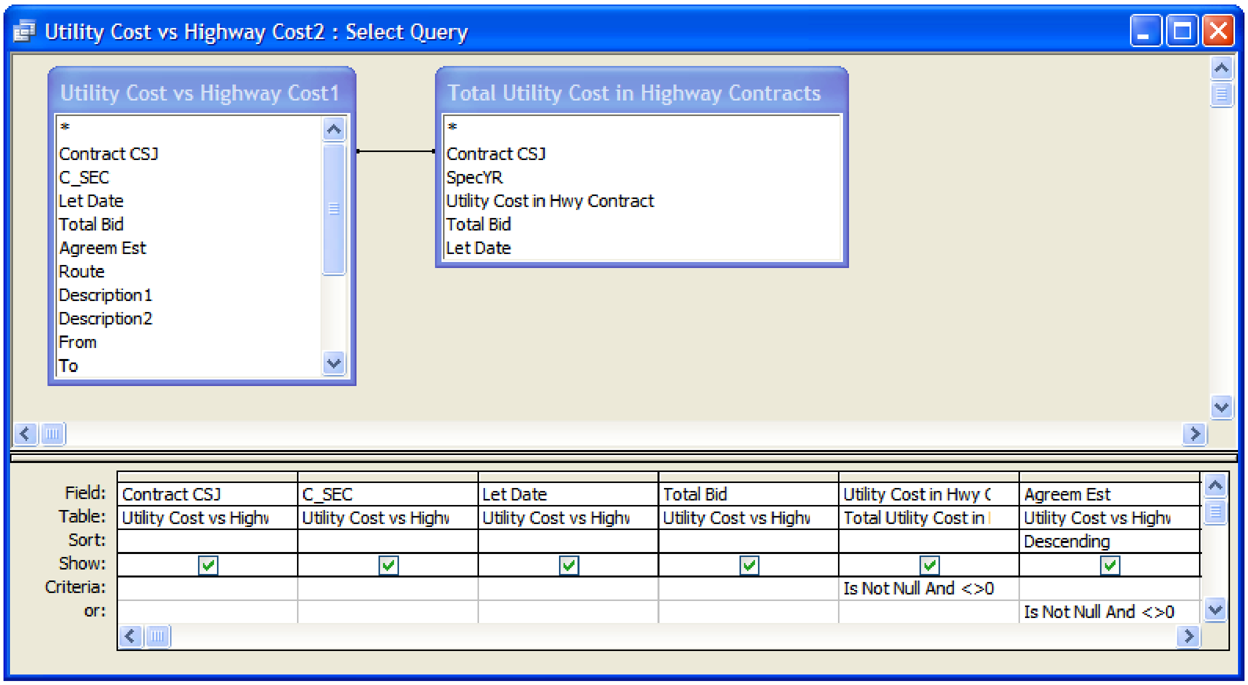
SELECT [Total Highway Cost].[Contract CSJ], Left([Total Highway Cost].[Contract CSJ],6) AS C_SEC, [Total Highway Cost].[Let Date], [Total Highway Cost].[Total Bid], [Total Utility Agreements].[Agreem Est], dproject.PJROADNM AS Route, dproject.PJDESC1 AS Description1, dproject.PJDESC2 AS Description2, dproject.PJLOCT1 AS [From], dproject.PJLOCT2 AS [To], [Project Type].[Project Type], dproject.PJURFLAG AS [R-U], dproject.PJLENGTH AS Length, dproject.PJAWDAMT AS [Awarded Amnt], dproject.PJCURAMT AS [Current Amnt], dproject.PJDTEST AS [Estimate Date]
FROM (([Total Highway Cost] LEFT JOIN [Total Utility Agreements] ON [Total Highway Cost].[Contract CSJ] = [Total Utility Agreements].CONSTCSJ) INNER JOIN dproject ON [Total Highway Cost].[Contract CSJ] = dproject.PCN) INNER JOIN [Project Type] ON dproject.PJPRJTYP = [Project Type].PJPRJTYP
ORDER BY [Total Highway Cost].[Contract CSJ];;

Figure 34. First Query to Compare Utility Adjustment Costs and Highway Costs.

Table 33. Project Types in DCIS.

Project Type Code	Project type description
BC	Building project - not sealed
BCF	Border crossing facility
BCS	Building project – sealed
BR	Bridge replacement
BWR	Bridge widening or rehab
CNF	Convert non-freeway to freeway
CTM	Corridor traffic management
EM	Emergency maintenance project – not sealed
EMS	Emergency maintenance project – sealed
FBO	Ferry boat
FS	Feasibility studies
GCP	Grade crossing protection
HES	Hazard elimination and safety
HPR	Hazardous paint removal
INC	Interchange
JC	Junkyard control
LSE	Landscape and scenic enhancement
MA	Misc maintenance agreement – not sealed
MAS	Misc maintenance agreement – sealed
MSC	Miscellaneous construction
NLF	New location freeway
NNF	New location non-freeway
OAC	Outdoor advertising control
OV	Overlay
PE	Preliminary engineering
RER	Rehabilitate existing road
RES	Restoration
RF	Routine facilities project – not sealed
RFS	Routine facilities project – sealed
RM	Routine maintenance project – not sealed
RMS	Routine maintenance project – sealed
ROW	Right of way
RR	Railroad relocation
SB	All safety bond program projects
SC	Seal coat
SFT	Safety
SKP	Skip (exempt from sealing) trans enhancement
SRA	Safety rest area
SU	State-use project – not sealed
SUS	State-use project – sealed
TC	Tunnel construction
TPD	Traffic protection devices
TS	Traffic signal
TTA	Texas turnpike authority
UGN	Upgrade to standards non-freeway
UPG	Upgrade to standards freeway
UTL	Utility adjustments
WF	Widen freeway
WNF	Widen non-freeway

- Develop a query to join highway costs, utility agreement costs, and utility costs included in the highway contract (Figure 35). The result was a dataset that contained 476 records representing highway projects where there were utility adjustment costs, either through items in the highway contract or through utility agreements.



SELECT [Utility Cost vs Highway Cost1].[Contract CSJ], [Utility Cost vs Highway Cost1].C_SEC, [Utility Cost vs Highway Cost1].[Let Date], [Utility Cost vs Highway Cost1].[Total Bid], [Total Utility Cost in Highway Contracts].[Utility Cost in Hwy Contract], [Utility Cost vs Highway Cost1].[Agreem Est], [Total Utility Cost in Highway Contracts].SpecYR, [Utility Cost vs Highway Cost1].Route, [Utility Cost vs Highway Cost1].Description1, [Utility Cost vs Highway Cost1].Description2, [Utility Cost vs Highway Cost1].From, [Utility Cost vs Highway Cost1].To, [Utility Cost vs Highway Cost1].[Project Type], [Utility Cost vs Highway Cost1].[R-U], [Utility Cost vs Highway Cost1].Length, [Utility Cost vs Highway Cost1].[Awarded Amnt], [Utility Cost vs Highway Cost1].[Current Amnt], [Utility Cost vs Highway Cost1].[Estimate Date], DatePart("yyyy",[Utility Cost vs Highway Cost1].[Let Date]) AS LetYear, DatePart("yyyy",[Estimate Date]) AS EstYear
FROM [Utility Cost vs Highway Cost1] INNER JOIN [Total Utility Cost in Highway Contracts] ON [Utility Cost vs Highway Cost1].[Contract CSJ] = [Total Utility Cost in Highway Contracts].[Contract CSJ]
WHERE ((([Total Utility Cost in Highway Contracts].[Utility Cost in Hwy Contract]) Is Not Null And ([Total Utility Cost in Highway Contracts].[Utility Cost in Hwy Contract])<>0)) OR ((([Utility Cost vs Highway Cost1].[Agreem Est]) Is Not Null And ([Utility Cost vs Highway Cost1].[Agreem Est])<>0))
ORDER BY [Utility Cost vs Highway Cost1].[Agreem Est] DESC;

Figure 35. Second Query to Compare Utility Adjustment Costs and Highway Costs.

- Develop a query to express costs in 2006 dollars (Figure 36). The query used cost index data from TxDOT's Highway Cost Index (1997 Base) (*57*), adapted with composite index data from FHWA (*58*) to cover cost data prior to 1997.

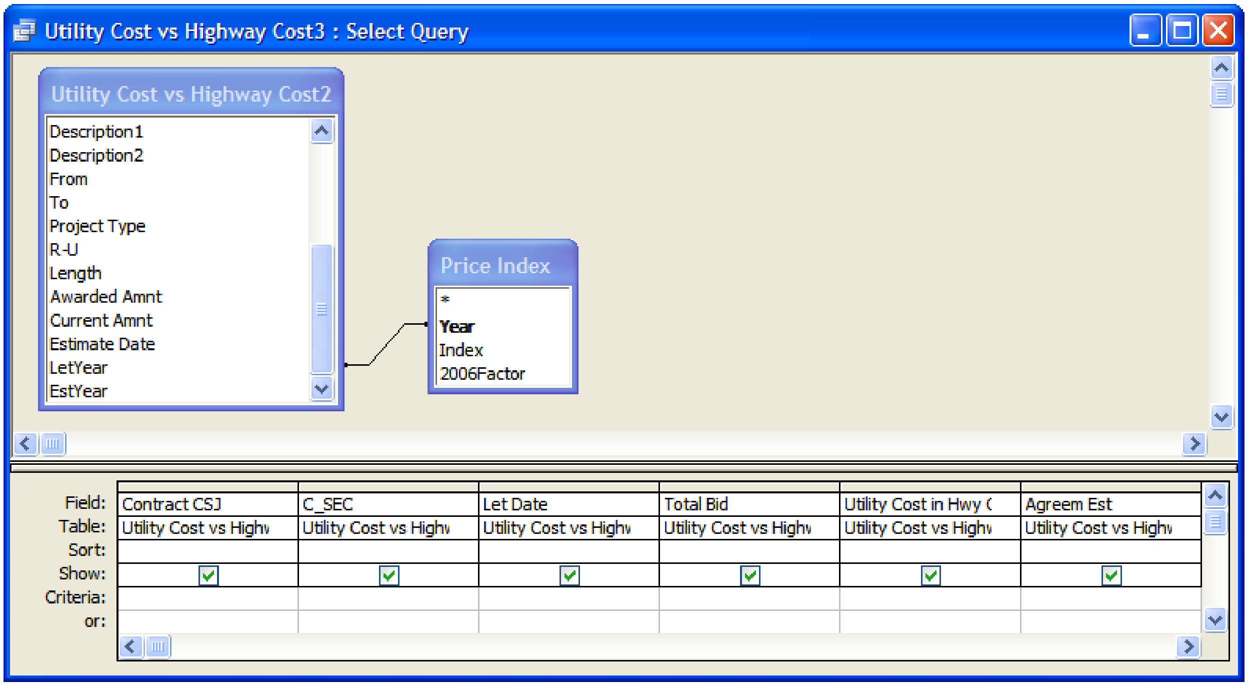


Figure 36. Query to Express Costs in 2006 Dollars.

Table 34 lists the 476 projects selected. Each of the projects listed includes the following cost data (expressed in 2006 dollars):

- total winning bid;
- total utility adjustment amount in the highway contract winning bid;
- total utility adjustment estimate in the utility agreement database;
- non-utility highway cost, which is the total winning bid minus the total utility adjustment amount in the highway contract winning bid; and
- total utility cost, which is the sum of the total utility adjustment amount in the highway contract winning bid and the total utility adjustment estimate in the utility agreement database.

Table 34. Sample Data (all dollar amounts in 2006 dollars).

Contract CSJ	Letting Date	Total Bid	Utility Cost in Highway Contract	Utility Agreement Estimate	Non-Utility Highway Cost	Total Utility Cost	Route	Project Type	R-U	Length (mi)
092400036	08/11/04	$6,984,449	$69,910		$6,914,539	$69,910		Border Crossing Facility	U	0.230
092400032	08/10/05	$18,488,933	$669,560		$17,819,373	$669,560		Border Crossing Facility	U	1.710
092106130	09/07/00	$278,468	$108,160		$170,308	$108,160		Bridge Replacement	R	0.044
091271395	08/09/95	$363,086	$147		$362,939	$147		Bridge Replacement	U	0.019
091234055	03/13/96	$453,543	$4,558		$448,985	$4,558		Bridge Replacement		0.056
058501009	03/14/95	$482,004	$17,539		$464,465	$17,539	PR 13	Bridge Replacement	R	0.105
092106095	08/03/99	$581,599	$544		$581,055	$544		Bridge Replacement	R	0.026
063503013	07/10/01	$586,468		$4,720	$586,468	$4,720	FM 228	Bridge Replacement	R	0.202
063203026	12/05/01	$601,656		$16,603	$601,656	$16,603	FM 134	Bridge Replacement	R	0.156
075001013	01/11/06	$816,603		$33,198	$816,603	$33,198	FM 144	Bridge Replacement	R	0.403
101203012	04/02/02	$948,756		$28,966	$948,756	$28,966	FM 981	Bridge Replacement		0.170
098601032	04/02/02	$1,313,869		$14,940	$1,313,869	$14,940	FM 619	Bridge Replacement	R	0.411
092106133	05/02/01	$1,420,757	$149,760		$1,270,997	$149,760		Bridge Replacement	R	0.104
091231049	09/14/94	$1,437,286	$145,423		$1,291,863	$145,423		Bridge Replacement		0.108
091231054	11/07/96	$1,518,173	$238,741		$1,279,432	$238,741		Bridge Replacement		0.083
031001036	08/10/05	$1,722,088		$67,266	$1,722,088	$67,266	SH 70	Bridge Replacement		0.313
025105040	02/09/94	$2,170,868	$4,411		$2,166,457	$4,411	US 281	Bridge Replacement		0.073
074303012	12/07/04	$2,292,601		$7,063	$2,292,601	$7,063	FM 414	Bridge Replacement	R	0.565
091271288	08/14/96	$2,693,384	$73,289		$2,620,095	$73,289		Bridge Replacement		0.090
091271287	08/08/95	$2,716,299	$308,923		$2,407,376	$308,923		Bridge Replacement		0.066
091404177	01/12/05	$2,783,255	$142,431		$2,640,824	$142,431		Bridge Replacement	U	0.871
091231106	10/10/02	$2,807,210	$78,762		$2,728,449	$78,762		Bridge Replacement	R	0.237
037101079	12/08/04	$2,942,715		$308,361	$2,942,715	$308,361	BU 77-S	Bridge Replacement	R	0.500
091271536	04/04/01	$3,199,991	$90,010		$3,109,981	$90,010		Bridge Replacement		0.195
097601026	07/09/97	$3,305,706	$157,082		$3,148,624	$157,082	FM 865	Bridge Replacement		0.295
017504067	10/14/04	$4,123,699		$12,087	$4,123,699	$12,087	US 59	Bridge Replacement	R	1.927
043703016	11/02/05	$4,718,903		$113,129	$4,718,903	$113,129	US 283	Bridge Replacement	R	0.701
101802011	08/06/02	$5,111,869		$47,632	$5,111,869	$47,632	FM 555	Bridge Replacement	R	1.292
005905034	08/07/01	$5,369,824		$3,851	$5,369,824	$3,851	SH 7	Bridge Replacement	R	1.326
091231081	04/03/01	$6,060,020	$179,584		$5,880,436	$179,584		Bridge Replacement		0.177
005905033	08/10/04	$6,063,820	$36,223	$0	$6,027,598	$36,223	SH 7	Bridge Replacement		0.322
009702024	06/09/04	$6,376,941		$36,791	$6,376,941	$36,791	SH 6	Bridge Replacement	R	1.070
032002025	08/10/05	$8,544,124		$82,387	$8,544,124	$82,387	SH 95	Bridge Replacement	R	1.902
091271532	06/08/04	$12,431,959	$314,147		$12,117,811	$314,147		Bridge Replacement		0.532
001513259	07/08/05	$21,600,749	$1,635,211	$3,520,389	$19,965,538	$5,155,600	IH 35	Bridge Replacement	R	0.758
015005037	04/04/00	$26,981,453	$1,213,974	$4,732	$25,767,479	$1,218,706	SH 29	Bridge Replacement	R	0.563
010908041	06/03/99	$28,391,011		$175,185	$28,391,011	$175,185	SH 19	Bridge Replacement	R	1.796
018402042	04/03/02	$33,173,843		$5,598	$33,173,843	$5,598	SH 36	Bridge Replacement		1.969
001709072	06/09/06	$29,090,753	$9,298		$29,081,455	$9,298	IH 35	Bridge Widening Or Rehab		0.001
050807019	05/03/00	$7,350,877		$287,503	$7,350,877	$287,503	SP 330	Convert Non-Freeway To Freeway	U	0.951
072002053	02/07/96	$11,273,133		$165,493	$11,273,133	$165,493	SH 249	Convert Non-Freeway To Freeway	U	1.629
035303052	08/04/99	$26,744,737		$54,704	$26,744,737	$54,704	SH 114	Convert Non-Freeway To Freeway	R	1.627
015604075	01/03/01	$28,091,337	$1,415,548	$320,709	$26,675,789	$1,736,257	US 82	Convert Non-Freeway To Freeway	U	1.607
017104061	08/11/04	$36,457,247		$1,598,796	$36,457,247	$1,598,796	SH 199	Convert Non-Freeway To Freeway	U	4.250
072003082	05/06/97	$37,608,079		$1,337,127	$37,608,079	$1,337,127	SH 249	Convert Non-Freeway To Freeway	U	1.931
037301037	08/07/02	$39,327,740		$4,121,296	$39,327,740	$4,121,296	US 77	Convert Non-Freeway To Freeway	U	2.877
020015008	10/09/03	$40,639,685		$1,155,014	$40,639,685	$1,155,014	US 69	Convert Non-Freeway To Freeway	R	2.781
011313072	08/13/96	$42,278,203	$2,920,797		$39,357,406	$2,920,797	US 290	Convert Non-Freeway To Freeway	U	0.001
038001049	09/10/04	$47,777,282		$574,364	$47,777,282	$574,364	US 82	Convert Non-Freeway To Freeway	U	1.977
011309048	03/12/96	$49,615,867	$2,643,524		$46,972,343	$2,643,524	US 290	Convert Non-Freeway To Freeway	U	1.715
011313069	07/09/02	$72,695,804	$3,363,365	$415,000	$69,332,439	$3,778,365	SH 71	Convert Non-Freeway To Freeway	U	2.103
015105072	08/04/99	$85,831,240		$1,771,187	$85,831,240	$1,771,187	US 183	Convert Non-Freeway To Freeway	U	3.038
015109029	12/06/02	$90,521,638	$7,735,622		$82,786,016	$7,735,622	US 183	Convert Non-Freeway To Freeway	U	2.275
025304114	09/08/05	$97,874,128	$4,396,834		$93,477,294	$4,396,834	US 281	Convert Non-Freeway To Freeway	R	3.281
005002055	12/01/05	$117,366,527		$4,653,164	$117,366,527	$4,653,164	SH 6	Convert Non-Freeway To Freeway	R	6.502
036404037	07/09/04	$123,111,473		$81,103	$123,111,473	$81,103	SH 121	Convert Non-Freeway To Freeway	U	5.049
036403066	05/11/04	$150,982,764	$931,961	$156,985	$150,050,804	$1,088,945	SH 121	Convert Non-Freeway To Freeway	U	4.931
068306015	05/07/03	$168,949,078	$1,494,790		$167,454,288	$1,494,790	SH 45	Convert Non-Freeway To Freeway	U	0.965
038001064	12/07/04	$191,404,376	$3,580,694	$1,796,201	$187,823,682	$5,376,894	US 82	Convert Non-Freeway To Freeway	U	4.277
036706054	06/08/04	$43,565,799	$96,897		$43,468,902	$96,897	SH 87	Ferry Boat		0.204
015102016	05/12/04	$821,429		$168,535	$821,429	$168,535	SH 29	Hazard Elimination & Safety	R	0.223
068301066	08/08/01	$1,912,162		$28,482	$1,912,162	$28,482	RM 620	Hazard Elimination & Safety	R	0.739
000502093	06/06/01	$1,945,515	$2,880		$1,942,635	$2,880	BI 20-E	Hazard Elimination & Safety	R	12.129
003906036	06/04/02	$2,287,773	$62,500		$2,225,274	$62,500	BU 83-S	Hazard Elimination & Safety	R	0.100
086401049	08/04/00	$6,407,335	$74,534		$6,332,801	$74,534	FM 494	Hazard Elimination & Safety	R	0.100
017702059	11/07/01	$28,734,473	$834,358	$922,043	$27,900,115	$1,756,401	US 59	Hazard Elimination & Safety	R	2.124
003917134	07/11/00	$56,027,655	$289,328	$0	$55,738,327	$289,328	US 83	Hazard Elimination & Safety		0.046
052104219	05/05/94	$4,998,740	$81,716		$4,917,024	$81,716	IH 410	Interchange	U	1.306
002407036	12/14/94	$6,890,316	$41,877		$6,848,438	$41,877	US 90	Interchange	R	0.946
025509074	03/06/01	$10,509,005	$58,067		$10,450,937	$58,067	US 281	Interchange	U	1.055
023103090	08/08/95	$10,666,653	$266,438	$95,351	$10,400,216	$361,788	US 190	Interchange	R	1.172
004212045	04/05/00	$10,969,251		$68,571	$10,969,251	$68,571	US 287	Interchange	R	1.099
003401102	03/08/00	$11,564,867		$4,200	$11,564,867	$4,200	US 83	Interchange		3.390
052104237	09/03/99	$14,194,820	$390,592		$13,804,228	$390,592	IH 410	Interchange	U	0.001

Table 34. Sample Data (all dollar amounts in 2006 dollars) (Continued).

Contract CSJ	Letting Date	Total Bid	Utility Cost in Highway Contract	Utility Agreement Estimate	Non-Utility Highway Cost	Total Utility Cost	Route	Project Type	R-U	Length (mi)
091271657	02/08/06	$15,100,116	$797,557		$14,302,559	$797,557		Interchange		0.683
003908077	06/03/99	$18,138,839	$31,620		$18,107,219	$31,620	US 77	Interchange		1.098
002408110	05/06/03	$20,029,428	$324,314		$19,705,114	$324,314	US 90	Interchange	U	1.421
007207048	04/12/06	$20,295,456	$434,946		$19,860,510	$434,946	IH 10	Interchange	U	0.570
092406258	10/06/05	$29,962,190	$1,340,414		$28,621,776	$1,340,414		Interchange	U	1.000
052104222	07/08/97	$30,135,776	$2,129,779		$28,005,997	$2,129,779	IH 410	Interchange	U	0.881
032710027	04/02/02	$31,039,018	$25,721		$31,013,297	$25,721	US 77	Interchange	R	1.532
010104077	08/11/04	$31,223,514	$383,376	$623,928	$30,840,138	$1,007,304	US 181	Interchange	R	1.780
002802044	07/06/06	$45,844,448	$279,350	$2,046,814	$45,565,098	$2,326,164	US 90	Interchange	U	0.873
050003475	09/09/05	$63,717,329	$95,004	$1,200,106	$63,622,325	$1,295,110	IH 45	Interchange	U	1.003
004809023	08/06/03	$68,308,433		$3,342,174	$68,308,433	$3,342,174	IH 35E	Interchange	U	0.991
050003427	05/06/94	$68,878,454	$150,726		$68,727,728	$150,726	IH 45	Interchange	U	0.909
001514112	12/01/05	$80,048,707	$6,064,933	$8,931,550	$73,983,773	$14,996,483	IH 35	Interchange	U	1.023
007212102	07/06/99	$84,229,289	$2,122,662		$82,106,627	$2,122,662	IH 10	Interchange	U	1.530
050003429	04/09/96	$84,321,756	$31,588		$84,290,168	$31,588	IH 45	Interchange	U	0.740
038912064	06/13/96	$87,854,368		$495,430	$87,854,368	$495,430	SH 146	Interchange	U	0.904
017711119	06/03/97	$94,498,852	$645,742		$93,853,110	$645,742	US 59	Interchange	U	0.900
001806131	07/06/99	$101,412,157	$304,297	$4,316,992	$101,107,859	$4,621,289	IH 35	Interchange	U	2.658
007212159	07/09/02	$136,514,872	$702,706	$1,115,948	$135,812,166	$1,818,655	IH 10	Interchange	U	1.530
052104223	10/14/04	$225,887,787	$3,831,579	$3,485,919	$222,056,208	$7,317,498	IH 410	Interchange	U	2.661
027107248	07/08/04	$365,601,104	$13,812,785	$96,090,041	$351,788,319	$109,902,826	IH 10	Interchange	U	1.988
091271460	11/06/97	$3,890,279	$359,948		$3,530,331	$359,948		Landscape & Scenic Enhancement	R	0.760
005008076	11/07/95	$289,054	$1,260		$287,794	$1,260	US 290	Miscellaneous Construction		0.024
005008076	11/07/95	$289,054	$1,260		$287,794	$1,260	US 290	Miscellaneous Construction		0.024
033802031	02/03/00	$314,385	$8,704		$305,681	$8,704	SH 105	Miscellaneous Construction		0.057
091419007	04/13/95	$335,943	$13,283		$322,661	$13,283		Miscellaneous Construction		0.001
068104028	07/11/01	$363,989		$8,634	$363,989	$8,634	FM 367	Miscellaneous Construction		18.900
091418048	03/07/00	$605,311	$1,600		$603,711	$1,600		Miscellaneous Construction		1.000
091512307	06/06/00	$642,862	$88,898		$553,964	$88,898		Miscellaneous Construction		1.489
011005098	09/04/96	$715,132	$5,581		$709,551	$5,581	IH 45	Miscellaneous Construction		0.260
006707078	04/05/00	$780,611	$4,225		$776,386	$4,225	IH 27	Miscellaneous Construction		0.001
005106010	10/05/94	$804,417	$2,453		$801,964	$2,453	SH 3	Miscellaneous Construction		0.340
035305099	09/07/06	$906,639	$150		$906,489	$150	SP 244	Miscellaneous Construction	U	0.095
001806150	08/09/05	$934,131		$29,667	$934,131	$29,667	IH 35	Miscellaneous Construction	U	0.212
033104037	02/05/97	$936,880	$825,160		$111,720	$825,160	PR 100	Miscellaneous Construction		0.001
003918080	03/15/95	$973,641	$5,628		$968,013	$5,628	US 83	Miscellaneous Construction	U	0.001
101902022	08/11/04	$1,046,709		$2,678	$1,046,709	$2,678	FM 557	Miscellaneous Construction	R	0.556
091271649	11/09/99	$1,079,608	$680		$1,078,928	$680		Miscellaneous Construction		29.960
091512306	08/04/00	$1,134,812	$45,441		$1,089,371	$45,441		Miscellaneous Construction		1.884
001310060	01/07/98	$1,166,738	$147,303		$1,019,434	$147,303	BU 287P	Miscellaneous Construction		0.036
027114184	08/08/95	$1,177,238	$132,042	$149,981	$1,045,196	$282,023	IH 610	Miscellaneous Construction	U	0.500
091845719	07/06/06	$1,305,410	$3,000		$1,302,410	$3,000		Miscellaneous Construction	U	0.220
025304107	11/06/97	$1,407,388	$6,815		$1,400,572	$6,815	SP 537	Miscellaneous Construction		0.250
000704085	05/07/96	$1,423,893	$1,917		$1,421,976	$1,917	SH 6	Miscellaneous Construction	U	0.278
091845187	04/09/96	$1,499,621	$194		$1,499,427	$194		Miscellaneous Construction		0.160
091512275	01/11/05	$1,767,854	$42,018		$1,725,836	$42,018		Miscellaneous Construction	U	0.850
091271502	10/07/99	$1,989,587	$33,320		$1,956,267	$33,320		Miscellaneous Construction		27.800
091418022	06/07/95	$2,232,981	$172,828		$2,060,153	$172,828		Miscellaneous Construction		0.001
091035025	06/04/03	$2,289,123	$264,750		$2,024,373	$264,750		Miscellaneous Construction	U	0.001
058101112	12/07/99	$2,352,978	$559,943		$1,793,036	$559,943	LP 12	Miscellaneous Construction	U	0.217
091404160	12/05/02	$2,501,405	$3,572		$2,497,833	$3,572		Miscellaneous Construction		0.492
091271544	02/09/07	$2,612,542	$14,798		$2,597,744	$14,798		Miscellaneous Construction		0.000
020402021	08/14/96	$3,085,560		$54,850	$3,085,560	$54,850	US 79	Miscellaneous Construction	U	1.086
092038121	03/04/03	$3,179,602	$16,400		$3,163,202	$16,400		Miscellaneous Construction		0.001
092038121	03/04/03	$3,179,602	$16,400		$3,163,202	$16,400		Miscellaneous Construction		0.000
091271434	07/07/99	$3,254,384	$9,282		$3,245,102	$9,282		Miscellaneous Construction		25.680
011004149	05/05/94	$4,413,515	$162,875		$4,250,640	$162,875	IH 45	Miscellaneous Construction		0.703
003806039	01/10/07	$4,436,627	$2,495,987		$1,940,640	$2,495,987	US 83	Miscellaneous Construction		0.000
058101095	01/11/95	$4,476,847	$93,365		$4,383,482	$93,365	LP 12	Miscellaneous Construction		0.189
027114194	09/07/00	$4,646,006		$112,465	$4,646,006	$112,465	IH 610	Miscellaneous Construction		1.981
011004158	02/06/96	$4,730,632		$88,670	$4,730,632	$88,670	IH 45	Miscellaneous Construction	U	0.322
056901043	09/10/04	$4,761,207	$2,352,116		$2,409,091	$2,352,116	SH 43	Miscellaneous Construction	U	1.989
056901043	09/10/04	$4,761,207	$2,352,116		$2,409,091	$2,352,116	SH 43	Miscellaneous Construction	U	1.989
090248403	07/01/03	$4,997,631	$144,822		$4,852,809	$144,822		Miscellaneous Construction		0.760
036704066	10/09/02	$5,104,840	$184,260		$4,920,580	$184,260	SH 87	Miscellaneous Construction		0.758
035304077	03/10/04	$7,331,976	$135,645		$7,196,331	$135,645	SP 348	Miscellaneous Construction	U	2.291
007902041	08/05/03	$7,619,882		$15,334	$7,619,882	$15,334	US 67	Miscellaneous Construction		1.620
046501051	10/08/03	$8,292,188	$576,946		$7,715,242	$576,946	SH 218	Miscellaneous Construction	U	2.687
033701029	12/07/04	$8,384,590	$622,439		$7,762,151	$622,439	SH 29	Miscellaneous Construction		0.890
091271858	11/10/04	$8,656,762	$471,984		$8,184,778	$471,984		Miscellaneous Construction		38.000
039202071	08/09/06	$10,058,860		$133,857	$10,058,860	$133,857	US 259	Miscellaneous Construction	R	1.016
004707189	09/09/04	$10,312,035	$242,493		$10,069,542	$242,493	US 75	Miscellaneous Construction	U	0.156
001602102	07/08/04	$11,679,418		$348,612	$11,679,418	$348,612	IH 35	Miscellaneous Construction	R	1.541
055002032	11/10/04	$11,709,735		$683,009	$11,709,735	$683,009	FM 8	Miscellaneous Construction	R	10.255
050003438	02/08/95	$12,313,277	$234,747		$12,078,530	$234,747	IH 45	Miscellaneous Construction	U	0.001

Table 34. Sample Data (all dollar amounts in 2006 dollars) (Continued).

Contract CSJ	Letting Date	Total Bid	Utility Cost in Highway Contract	Utility Agreement Estimate	Non-Utility Highway Cost	Total Utility Cost	Route	Project Type	R-U	Length (mi)
002713159	07/09/97	$15,901,873	$85,244		$15,816,628	$85,244	US 59	Miscellaneous Construction		0.714
050003463	07/09/96	$18,096,054	$35,257		$18,060,797	$35,257	IH 45	Miscellaneous Construction		0.544
052105123	05/12/04	$18,249,354		$2,287,376	$18,249,354	$2,287,376	IH 410	Miscellaneous Construction	U	2.272
002502164	08/09/06	$18,269,801	$186,994		$18,082,808	$186,994	IH 10	Miscellaneous Construction		1.950
017706062	09/07/95	$20,975,010	$439,072	$0	$20,535,938	$439,072	US 59	Miscellaneous Construction		0.910
001602103	12/08/04	$24,133,198		$4,619	$24,133,198	$4,619	IH 35	Miscellaneous Construction		0.301
091271441	01/06/98	$26,381,528	$59,458		$26,322,071	$59,458		Miscellaneous Construction		1.065
038912061	07/08/97	$34,491,580	$39,200		$34,452,380	$39,200	SH 146	Miscellaneous Construction	U	1.970
038912061	07/08/97	$34,491,580	$39,200		$34,452,380	$39,200	SH 146	Miscellaneous Construction	U	1.970
017809025	06/14/96	$46,022,340	$3,056,077	$295,228	$42,966,262	$3,351,305	SH 35	New Location Freeway		1.323
068306024	01/08/04	$54,910,145	$1,191,360		$53,718,785	$1,191,360	SH 45	New Location Freeway	U	1.988
072003084	06/08/05	$60,572,698		$566,819	$60,572,698	$566,819	SH 249	New Location Freeway	U	3.174
002802054	07/07/06	$67,299,167	$3,650,845	$260,523	$63,648,322	$3,911,368	US 90	New Location Freeway	U	2.246
019603210	11/10/00	$1,181,593	$25,750		$1,155,843	$25,750	IH 35E	New Location Non-Freeway	U	0.176
092106158	07/01/03	$1,783,400	$11,597		$1,771,803	$11,597		New Location Non-Freeway	U	0.752
012802013	08/09/05	$2,477,767	$23,784	$127,742	$2,453,983	$151,526	FM 3064	New Location Non-Freeway		1.292
090411023	07/12/00	$2,671,973	$589,064		$2,082,909	$589,064		New Location Non-Freeway	U	1.009
092102089	03/07/01	$4,088,082	$105,106		$3,982,976	$105,106		New Location Non-Freeway	R	2.659
040205002	08/09/06	$4,267,322		$148,349	$4,267,322	$148,349	LP 390	New Location Non-Freeway	U	0.591
001507073	01/11/05	$4,717,835	$4,493		$4,713,342	$4,493	IH 35	New Location Non-Freeway	R	3.142
025512002	07/13/94	$5,072,952	$16,814		$5,056,137	$16,814	SH 281	New Location Non-Freeway	U	0.741
092406171	11/08/02	$5,079,193	$286,778		$4,792,414	$286,778		New Location Non-Freeway	U	1.619
004520007	09/05/96	$6,424,681		$468,833	$6,424,681	$468,833	US 82	New Location Non-Freeway	R	6.358
091512223	08/03/00	$7,072,310	$134,979		$6,937,331	$134,979		New Location Non-Freeway	U	1.222
040205001	08/04/99	$7,157,653		$142,388	$7,157,653	$142,388	SH 154	New Location Non-Freeway	U	1.149
004601041	08/10/04	$10,425,291		$1,007,937	$10,425,291	$1,007,937	US 82	New Location Non-Freeway	R	2.311
014401060	04/01/03	$10,639,903	$29,079		$10,610,824	$29,079	US 87	New Location Non-Freeway	U	0.252
091512138	08/08/95	$10,664,700	$633,798		$10,030,902	$633,798		New Location Non-Freeway		0.891
052601008	11/10/04	$11,337,876	$127,729		$11,210,146	$127,729	SP 98	New Location Non-Freeway	U	1.145
029112001	10/09/03	$12,330,378	$1,466,003		$10,864,376	$1,466,003	SP 66	New Location Non-Freeway	R	1.778
004519015	07/07/98	$13,569,824	$225,000	$103,245	$13,344,824	$328,245		New Location Non-Freeway	R	2.937
092406167	01/09/02	$17,422,399	$3,710,582		$13,711,817	$3,710,582		New Location Non-Freeway		2.184
018705034	07/10/96	$18,310,793		$638,410	$18,310,793	$638,410	SP 10	New Location Non-Freeway	R	4.245
004519026	08/03/00	$21,850,790		$346,708	$21,850,790	$346,708	US 82	New Location Non-Freeway	R	8.550
068306007	10/04/00	$22,108,610	$1,549,867		$20,558,743	$1,549,867	SH 45	New Location Non-Freeway	U	2.938
013602018	09/08/00	$31,190,692		$152,874	$31,190,692	$152,874	SH 24	New Location Non-Freeway	R	2.807
068307003	03/09/04	$49,724,656	$1,455,639		$48,269,017	$1,455,639	SH 45	New Location Non-Freeway	U	1.515
015105081	11/04/03	$51,017,961	$1,427,558		$49,590,403	$1,427,558	US 183	New Location Non-Freeway	R	1.577
010108001	08/09/05	$51,910,153		$1,436,479	$51,910,153	$1,436,479	SH 89	New Location Non-Freeway	R	7.572
013801058	08/04/00	$52,005,337		$2,652,538	$52,005,337	$2,652,538	US 259	New Location Non-Freeway	R	4.476
027117138	08/07/01	$52,307,445		$224,721	$52,307,445	$224,721	IH 610	New Location Non-Freeway	U	0.393
038915013	09/05/01	$580,177	$408		$579,769	$408	BS 146D	Overlay		0.530
004905006	07/10/02	$1,485,779	$453,128		$1,032,651	$453,128	BS 6-N	Overlay		4.583
004905003	05/03/00	$3,637,905		$444,470	$3,637,905	$444,470	BS 6-N	Overlay		2.037
004905003	05/03/00	$3,637,905		$444,470	$3,637,905	$444,470	BS 6-N	Overlay		0.000
027114197	08/08/06	$76,484,640	$22,400		$76,462,240	$22,400	IH 610	Overlay	U	5.214
092102075	08/03/99	$894,235	$16,675		$877,559	$16,675		Rehabilitate Existing Road	U	0.665
092106129	03/05/02	$906,633	$11,852		$894,781	$11,852		Rehabilitate Existing Road	U	0.369
086501071	10/05/94	$976,620	$73,322		$903,298	$73,322	FM 495	Rehabilitate Existing Road	R	0.170
005406079	06/08/05	$1,408,278		$27,261	$1,408,278	$27,261	US 67	Rehabilitate Existing Road	R	0.630
068404004	09/05/02	$1,653,687	$2,075		$1,651,612	$2,075	FM 3068	Rehabilitate Existing Road	R	1.489
008701093	03/09/04	$2,210,254	$18,944		$2,191,311	$18,944	SH 44	Rehabilitate Existing Road	U	1.437
091512320	11/10/99	$2,295,297	$25,092		$2,270,205	$25,092		Rehabilitate Existing Road	U	0.588
052901019	11/09/99	$2,441,956	$210,319		$2,231,638	$210,319	FM 61	Rehabilitate Existing Road	R	2.932
086202015	05/04/00	$3,133,846	$14,833		$3,119,013	$14,833	FM 1427	Rehabilitate Existing Road	R	1.821
063002034	12/05/00	$3,204,198	$37,856		$3,166,342	$37,856	FM 106	Rehabilitate Existing Road	R	0.890
023905027	04/08/05	$3,551,819		$100,654	$3,551,819	$100,654	SH 59	Rehabilitate Existing Road	R	5.930
027501133	04/03/02	$3,566,885	$701,775		$2,865,110	$701,775	IH 40	Rehabilitate Existing Road	U	0.925
086001015	09/06/01	$3,654,085	$7,613		$3,646,472	$7,613	FM 490	Rehabilitate Existing Road	R	9.859
091512334	11/10/00	$3,670,102	$130,605		$3,539,497	$130,605		Rehabilitate Existing Road	U	0.580
082201014	05/07/03	$3,722,465		$148,306	$3,722,465	$148,306	FM 371	Rehabilitate Existing Road	R	3.015
004801057	02/08/06	$3,746,298	$183,386		$3,562,912	$183,386	SH 342	Rehabilitate Existing Road	U	1.373
091512297	06/04/02	$4,149,202	$76,448		$4,072,753	$76,448		Rehabilitate Existing Road	U	0.760
033103017	12/05/00	$4,243,303	$111,057		$4,132,246	$111,057	FM 1421	Rehabilitate Existing Road	R	6.473
001701021	05/03/00	$4,414,520	$487,756		$3,926,764	$487,756	LP 353	Rehabilitate Existing Road	U	0.534
091419010	10/06/05	$4,486,046	$41,243		$4,444,803	$41,243		Rehabilitate Existing Road	U	0.982
091271554	09/04/98	$4,577,322	$326,810		$4,250,512	$326,810		Rehabilitate Existing Road		0.980
086101049	02/02/00	$4,672,694	$8,436		$4,664,257	$8,436	FM 491	Rehabilitate Existing Road	R	3.931
003204022	01/08/02	$4,805,598		$3,812	$4,805,598	$3,812	US 83	Rehabilitate Existing Road	R	6.207
091512363	10/07/05	$4,806,843	$949,105		$3,857,738	$949,105		Rehabilitate Existing Road	U	1.002
086303025	06/06/01	$4,901,493	$29,722		$4,871,771	$29,722	FM 493	Rehabilitate Existing Road	R	8.500
072803010	09/06/01	$5,445,904		$45,848	$5,445,904	$45,848	FM 1897	Rehabilitate Existing Road	R	5.580
091271693	08/08/01	$5,712,601	$1,457,891		$4,254,710	$1,457,891		Rehabilitate Existing Road		0.835
055804017	04/08/04	$5,743,743		$560	$5,743,743	$560	FM 669	Rehabilitate Existing Road	R	14.597
091271659	05/11/05	$6,237,203	$1,225,774		$5,011,428	$1,225,774		Rehabilitate Existing Road		0.767

Table 34. Sample Data (all dollar amounts in 2006 dollars) (Continued).

Contract CSJ	Letting Date	Total Bid	Utility Cost in Highway Contract	Utility Agreement Estimate	Non-Utility Highway Cost	Total Utility Cost	Route	Project Type	R-U	Length (mi)
021603023	03/06/01	$6,683,794	$1,144,177		$5,539,616	$1,144,177	FM 466	Rehabilitate Existing Road	U	0.991
033601036	08/11/04	$6,843,842	$145,518		$6,698,324	$145,518	SH 7	Rehabilitate Existing Road	R	2.833
041301027	08/06/03	$6,932,988	$1,781,675		$5,151,313	$1,781,675	SH 164	Rehabilitate Existing Road	U	1.193
003204023	02/08/06	$7,097,279		$991	$7,097,279	$991	US 83	Rehabilitate Existing Road	R	6.259
056701017	02/07/06	$7,176,467		$134,341	$7,176,467	$134,341	FM 107	Rehabilitate Existing Road	R	5.110
094504025	11/09/04	$7,207,741	$5,475		$7,202,266	$5,475	FM 249	Rehabilitate Existing Road	U	1.833
094504025	11/09/04	$7,207,741	$5,475		$7,202,266	$5,475	FM 249	Rehabilitate Existing Road	U	0.000
091512161	05/04/00	$7,242,375	$1,133,277		$6,109,098	$1,133,277		Rehabilitate Existing Road		0.861
035602032	11/07/02	$7,490,376	$1,813,107		$5,677,269	$1,813,107	SH 207	Rehabilitate Existing Road	R	1.174
036101025	12/07/04	$7,768,060		$13,143	$7,768,060	$13,143	US 380	Rehabilitate Existing Road	R	7.304
091512360	11/04/03	$7,856,493	$1,731,002		$6,125,491	$1,731,002		Rehabilitate Existing Road	U	1.060
001708064	02/03/00	$8,079,994		$104,194	$8,079,994	$104,194	IH 35	Rehabilitate Existing Road	R	8.411
080201021	03/10/04	$8,419,075		$72,187	$8,419,075	$72,187	FM 369	Rehabilitate Existing Road	R	6.543
003804050	07/10/02	$9,118,661	$5,959		$9,112,702	$5,959	US 83	Rehabilitate Existing Road	R	2.731
091271640	05/12/04	$9,266,674	$972,849		$8,293,825	$972,849		Rehabilitate Existing Road		1.560
091271641	07/07/06	$9,607,291	$1,181,857		$8,425,434	$1,181,857		Rehabilitate Existing Road	U	1.417
091845495	11/04/03	$9,730,120	$1,078,595		$8,651,525	$1,078,595		Rehabilitate Existing Road	U	0.970
091271656	02/04/03	$9,898,815	$2,378,136		$7,520,679	$2,378,136		Rehabilitate Existing Road		1.094
024908034	10/09/02	$10,343,726	$2,124,765		$8,218,960	$2,124,765	US 281	Rehabilitate Existing Road	U	1.250
004209097	01/04/01	$10,579,034	$56,066	$118,826	$10,522,968	$174,891	US 287	Rehabilitate Existing Road	R	2.638
000103033	07/09/02	$11,853,661	$1,207,228		$10,646,432	$1,207,228	SH 20	Rehabilitate Existing Road	U	1.100
050703037	08/06/03	$12,068,972		$43,109	$12,068,972	$43,109	SH 188	Rehabilitate Existing Road	R	0.868
092406178	07/10/01	$12,199,459	$597,352		$11,602,107	$597,352		Rehabilitate Existing Road		0.179
003608044	06/09/06	$12,517,896	$1,753,146		$10,764,750	$1,753,146	US 83	Rehabilitate Existing Road	R	0.594
091512390	08/08/01	$13,440,541	$2,528,555		$10,911,986	$2,528,555		Rehabilitate Existing Road	U	0.600
049003018	12/07/99	$14,114,967		$12,304	$14,114,967	$12,304	SH 70	Rehabilitate Existing Road	R	9.390
012402027	09/09/05	$14,658,528		$375,823	$14,658,528	$375,823	US 283	Rehabilitate Existing Road	R	14.246
003203034	12/06/02	$15,266,738		$93,070	$15,266,738	$93,070	US 83	Rehabilitate Existing Road	R	13.490
027117124	06/06/01	$54,736,085		$265,890	$54,736,085	$265,890	IH 610	Rehabilitate Existing Road	U	1.372
027107210	08/08/95	$93,721,868	$175,711		$93,546,157	$175,711	IH 10	Rehabilitate Existing Road		4.552
027117127	07/01/03	$430,481,254	$5,436,537	$34,610,503	$425,044,717	$40,047,039	IH 610	Rehabilitate Existing Road	U	2.547
091512235	08/04/99	$834,819	$308,096		$526,723	$308,096		Restoration		0.653
091512328	12/05/02	$3,413,297	$320,275		$3,093,022	$320,275		Restoration	U	0.386
091271770	07/09/04	$3,504,845	$539,702		$2,965,144	$539,702		Restoration	U	0.610
091512327	01/12/05	$5,304,310	$841,846		$4,462,464	$841,846		Restoration	U	0.462
011313086	12/06/00	$571,385	$8,450		$562,935	$8,450	SH 71	Right Of Way		0.001
092102109	06/08/06	$113,256	$4,400		$108,856	$4,400		Safety		0.210
017502073	07/07/05	$2,080,644		$56,394	$2,080,644	$56,394	US 84	Safety	R	11.731
033104058	09/08/06	$4,722,796	$137,850		$4,584,946	$137,850	PR 100	Safety	R	1.140
001507062	02/08/06	$16,408,179	$66,307	$1,830,256	$16,341,871	$1,896,564	IH 35	Safety Rest Area		1.681
092038147	05/07/03	$1,208,029	$6,632		$1,201,396	$6,632		Skip (Exempt From Sealing) Trans Enhancement	U	0.438
092102101	05/11/04	$4,796,581	$19,644		$4,776,937	$19,644		Skip (Exempt From Sealing) Trans Enhancement		12.000
041003014	01/10/06	$3,471,474		$155,690	$3,471,474	$155,690	SH 160	Upgrade To Standards Freeway	R	1.421
020403039	10/15/04	$8,515,761	$222,219		$8,293,542	$222,219	US 79	Upgrade To Standards Freeway	R	2.063
007212130	06/04/03	$101,663,846	$2,067,777	$1,712,294	$99,596,069	$3,780,071	IH 10	Upgrade To Standards Freeway	U	3.100
004808037	08/05/03	$102,659,116		$139,710	$102,659,116	$139,710	IH 35E	Upgrade To Standards Freeway	U	9.848
002811182	03/04/03	$132,820,348		$155,768	$132,820,348	$155,768	IH 10	Upgrade To Standards Freeway	R	10.141
002712062	06/08/04	$222,752,580	$936,955	$1,487,134	$221,815,625	$2,424,089	US 59	Upgrade To Standards Freeway	U	2.030
029110088	12/01/05	$1,836,679	$806,959		$1,029,720	$806,959	SH 16	Upgrade To Standards Non-Freeway		0.001
091639001	07/06/95	$2,275,504	$15,708		$2,259,796	$15,708	SH 282	Upgrade To Standards Non-Freeway		0.979
014301052	10/09/03	$3,535,337	$306,234		$3,229,103	$306,234	US 87	Upgrade To Standards Non-Freeway	U	0.519
038401012	05/06/98	$4,278,606		$126,455	$4,278,606	$126,455	SH 142	Upgrade To Standards Non-Freeway	R	4.258
081508022	04/04/01	$4,791,596		$88,014	$4,791,596	$88,014	FM 663	Upgrade To Standards Non-Freeway	R	2.285
007101042	08/10/05	$5,776,258		$2,017,170	$5,776,258	$2,017,170	US 87	Upgrade To Standards Non-Freeway		1.433
097401023	09/09/05	$7,521,081		$57,104	$7,521,081	$57,104	FM 604	Upgrade To Standards Non-Freeway	R	1.616
005405010	08/05/03	$7,639,182	$727,474		$6,911,708	$727,474	SH 153	Upgrade To Standards Non-Freeway	U	0.900
091845579	12/07/04	$11,073,541	$729,704		$10,343,836	$729,704		Upgrade To Standards Non-Freeway	U	1.072
011404048	07/08/05	$12,537,738		$1,758,479	$12,537,738	$1,758,479	US 290	Upgrade To Standards Non-Freeway	R	3.820
019001019	02/05/02	$14,288,197		$45,480	$14,288,197	$45,480	SH 37	Upgrade To Standards Non-Freeway	U	2.843
001605091	04/01/03	$16,585,187	$115,471	$828,856	$16,469,716	$944,327	IH 35	Upgrade To Standards Non-Freeway	R	5.790
001605088	05/06/98	$20,445,293		$516,033	$20,445,293	$516,033	IH 35	Widen Freeway	R	1.780
052104210	06/06/01	$20,984,336	$283,951		$20,700,385	$283,951	IH 410	Widen Freeway	U	0.170
011004143	07/07/95	$23,931,454		$714,950	$23,931,454	$714,950	IH 45	Widen Freeway	U	1.344
025507101	08/06/02	$24,151,628	$22,410		$24,129,218	$22,410	US 281	Widen Freeway		2.158
001606033	12/05/95	$24,507,778	$581,122	$0	$23,926,656	$581,122	IH 35	Widen Freeway	R	1.110
001602071	07/10/01	$28,389,574		$21,999	$28,389,574	$21,999	IH 35	Widen Freeway	R	2.835
001605087	09/06/95	$28,448,144	$226,141	$0	$28,222,003	$226,141	IH 35	Widen Freeway	R	5.549
017711085	07/07/95	$28,712,620	$14,490		$28,698,130	$14,490	US 59	Widen Freeway	U	0.777
009205036	11/12/98	$30,131,436		$256,469	$30,131,436	$256,469	IH 45	Widen Freeway	R	3.581
052104216	05/04/00	$31,836,621	$482,865		$31,353,755	$482,865	IH 410	Widen Freeway	U	1.420
052104236	12/06/00	$31,864,947	$444,151	$723,440	$31,420,796	$1,167,591	IH 410	Widen Freeway	U	0.627
017705059	12/08/99	$32,833,497	$4,080		$32,829,417	$4,080	US 59	Widen Freeway	U	2.929
001501164	07/12/00	$33,119,097		$298,473	$33,119,097	$298,473	IH 35	Widen Freeway	U	2.570

Table 34. Sample Data (all dollar amounts in 2006 dollars) (Continued).

Contract CSJ	Letting Date	Total Bid	Utility Cost in Highway Contract	Utility Agreement Estimate	Non-Utility Highway Cost	Total Utility Cost	Route	Project Type	R-U	Length (mi)
052104215	05/09/95	$37,251,900	$436,549	$0	$36,815,351	$436,549	IH 410	Widen Freeway	U	0.946
001501124	02/09/94	$37,861,548	$141,605		$37,719,943	$141,605	IH 35	Widen Freeway	R	2.045
011004164	06/08/04	$41,936,315		$475,149	$41,936,315	$475,149	IH 45	Widen Freeway	U	1.326
025508094	02/10/04	$45,591,118	$33,428		$45,557,690	$33,428	US 281	Widen Freeway	U	2.235
052104209	09/10/03	$48,694,650	$629,370	$817,390	$48,065,280	$1,446,760	IH 410	Widen Freeway	U	2.617
052104189	01/09/04	$53,423,475	$1,806,918	$642,205	$51,616,557	$2,449,123	IH 410	Widen Freeway	U	0.805
002713165	05/05/99	$55,298,210	$451,826	$57,800	$54,846,384	$509,626	US 59	Widen Freeway	U	0.767
002713165	05/05/99	$55,298,210	$451,826	$57,800	$54,846,384	$509,626	US 59	Widen Freeway	U	0.000
011004122	08/04/00	$57,429,237	$45,419	$205,677	$57,383,818	$251,096	IH 45	Widen Freeway	U	1.572
002712063	08/05/97	$57,906,110		$3,584,232	$57,906,110	$3,584,232	US 59	Widen Freeway	U	1.325
003917132	01/04/01	$58,557,076	$136,938		$58,420,139	$136,938	US 83	Widen Freeway	U	5.379
009206075	07/09/04	$60,117,762		$108,256	$60,117,762	$108,256	IH 45	Widen Freeway	R	6.312
017706045	05/07/97	$60,704,887	$2,302,157	$26,172	$58,402,730	$2,328,329	US 59	Widen Freeway	U	0.896
017711105	06/08/95	$62,875,295	$941,548		$61,933,747	$941,548	US 59	Widen Freeway	U	1.017
011005063	01/10/95	$65,001,290		$425,576	$65,001,290	$425,576	IH 45	Widen Freeway	U	1.817
001805062	08/06/03	$70,620,018		$169,437	$70,620,018	$169,437	IH 35	Widen Freeway	U	2.082
007212153	07/07/95	$70,848,194	$2,088,192		$68,760,002	$2,088,192	IH 10	Widen Freeway	U	1.666
025508091	10/08/03	$72,568,809	$283,048	$397,254	$72,285,762	$680,301	US 281	Widen Freeway	U	4.095
011004123	12/05/96	$74,835,562	$3,940,425	$3,994,387	$70,895,137	$7,934,813	IH 45	Widen Freeway	U	3.488
001424049	08/10/05	$75,795,200		$774,572	$75,795,200	$774,572	IH 35	Widen Freeway	U	4.025
050802086	06/07/05	$76,026,673		$247,221	$76,026,673	$247,221	IH 10	Widen Freeway	R	6.530
011004141	07/08/98	$80,542,757		$1,778,152	$80,542,757	$1,778,152		Widen Freeway	U	4.392
017705055	09/10/04	$85,532,032	$1,564,440	$2,379,295	$83,967,592	$3,943,734	US 59	Widen Freeway	U	2.282
052104190	01/12/05	$87,855,398	$3,571,526	$2,719,557	$84,283,872	$6,291,083	IH 410	Widen Freeway	U	2.424
009202090	04/07/98	$88,700,366		$74,185	$88,700,366	$74,185	IH 45	Widen Freeway	U	0.000
009202090	04/07/98	$88,700,366		$74,185	$88,700,366	$74,185	IH 45	Widen Freeway	U	7.177
044203031	08/11/04	$89,818,564		$129,228	$89,818,564	$129,228	IH 35E	Widen Freeway	U	3.417
002809100	12/01/05	$91,571,303		$1,142,108	$91,571,303	$1,142,108	IH 10	Widen Freeway	U	1.174
017706044	05/05/98	$94,233,624	$491,164	$1,343,586	$93,742,460	$1,834,750	US 59	Widen Freeway	U	2.004
011005064	03/03/99	$97,450,624		$8,559,954	$97,450,624	$8,559,954	IH 45	Widen Freeway	U	3.536
003907185	02/06/01	$98,155,254	$377,952		$97,777,302	$377,952	US 77	Widen Freeway	U	1.911
003918086	08/10/04	$108,714,058	$66,868		$108,647,190	$66,868	US 83	Widen Freeway	U	5.242
003907186	12/05/02	$112,869,730	$20,544		$112,849,186	$20,544	US 77	Widen Freeway	U	1.980
052104187	05/09/06	$116,819,050	$4,167,233		$112,651,817	$4,167,233	IH 410	Widen Freeway	U	3.348
002713171	08/07/02	$118,041,750	$354,561	$1,795,811	$117,687,189	$2,150,372	US 59	Widen Freeway	U	1.025
027107254	12/08/04	$122,574,482	$4,503,325	$8,368,861	$118,071,158	$12,872,185	IH 10	Widen Freeway	U	1.799
017707080	12/13/94	$126,947,060	$1,183,178		$125,763,882	$1,183,178	US 59	Widen Freeway	U	3.352
044202087	12/07/99	$127,709,983	$3,411,438	$9,350,284	$124,298,545	$12,761,722	IH 35E	Widen Freeway	U	4.800
017711091	03/04/99	$133,533,006	$176,325		$133,356,680	$176,325	US 59	Widen Freeway	U	1.419
027106090	07/02/03	$136,763,320		$8,649,613	$136,763,320	$8,649,613	IH 10	Widen Freeway	U	2.935
003918085	09/05/02	$137,080,618	$280,465	$604,268	$136,800,153	$884,734	US 83	Widen Freeway	U	8.260
003919042	09/09/04	$142,087,492	$810,402		$141,277,090	$810,402	US 83	Widen Freeway	R	7.121
027107249	03/08/05	$178,466,390	$6,133,608	$29,186,887	$172,332,782	$35,320,495	IH 10	Widen Freeway	U	2.273
027107245	02/08/05	$185,140,973	$4,893,714	$41,483,991	$180,247,259	$46,377,705	IH 10	Widen Freeway	U	2.500
027107247	01/11/05	$238,993,733	$19,135,861	$39,538,602	$219,857,871	$58,674,463	IH 10	Widen Freeway	U	2.658
004707123	02/08/94	$254,195,809	$604,107		$253,591,702	$604,107	US 75	Widen Freeway	U	1.867
027106088	05/06/03	$340,784,355	$847,139	$461,366	$339,937,216	$1,308,505	IH 10	Widen Freeway	U	3.731
091512347	04/04/01	$846,138	$125,485		$720,653	$125,485		Widen Non-Freeway	U	0.349
091635068	01/05/00	$922,532	$195,601		$726,932	$195,601		Widen Non-Freeway	U	0.298
091512144	05/05/94	$1,019,821	$135,180		$884,640	$135,180		Widen Non-Freeway		0.326
091512346	05/03/00	$1,105,746	$123,509		$982,237	$123,509		Widen Non-Freeway	U	0.464
091512113	08/14/96	$1,225,349	$55,029		$1,170,320	$55,029		Widen Non-Freeway		0.359
091846144	01/12/05	$1,371,669	$10,893		$1,360,776	$10,893		Widen Non-Freeway	U	0.489
087204018	10/06/94	$1,823,413	$5,787		$1,817,627	$5,787	FM 506	Widen Non-Freeway	U	0.420
091271812	09/10/03	$2,005,038	$74,267		$1,930,770	$74,267		Widen Non-Freeway	U	0.261
091845224	06/05/02	$2,057,117	$107,007		$1,950,111	$107,007		Widen Non-Freeway		0.439
025509066	02/08/95	$2,136,361	$12,743		$2,123,618	$12,743	US 281	Widen Non-Freeway	U	0.727
091405064	08/09/95	$2,488,269	$379,186		$2,109,083	$379,186		Widen Non-Freeway		0.364
091846124	03/08/06	$2,780,995	$167,793		$2,613,202	$167,793		Widen Non-Freeway	U	0.695
091512142	08/11/94	$2,817,412	$185,670		$2,631,743	$185,670		Widen Non-Freeway		5.196
091512132	09/05/96	$3,009,418	$96,787		$2,912,631	$96,787		Widen Non-Freeway	U	0.870
091512364	06/08/05	$3,105,429	$532,328		$2,573,101	$532,328		Widen Non-Freeway	U	0.729
091512159	07/07/95	$3,272,936	$683,603		$2,589,334	$683,603		Widen Non-Freeway		0.241
091512231	06/03/03	$3,308,959	$85,872		$3,223,086	$85,872		Widen Non-Freeway	U	0.579
091512279	06/06/00	$3,528,956	$66,429		$3,462,527	$66,429		Widen Non-Freeway	U	0.551
086401043	06/07/00	$3,649,051	$15,981		$3,633,071	$15,981	FM 494	Widen Non-Freeway	U	1.086
003901056	06/06/95	$3,655,777	$8,904	$0	$3,646,873	$8,904	US 83	Widen Non-Freeway	R	1.041
003907192	03/07/00	$3,791,167	$3,467		$3,787,700	$3,467	US 77	Widen Non-Freeway	U	1.633
091512295	02/11/04	$3,831,206	$6,205		$3,825,001	$6,205		Widen Non-Freeway	U	0.756
090248542	12/07/04	$3,835,581	$399,929		$3,435,652	$399,929		Widen Non-Freeway		0.403
011003035	03/09/05	$3,970,324	$86,772		$3,883,552	$86,772	SH 75	Widen Non-Freeway	U	0.880
023116021	06/13/96	$4,040,765	$28,834		$4,011,931	$28,834	FM 436	Widen Non-Freeway	U	1.075
014205056	06/04/03	$4,157,776	$570,491		$3,587,285	$570,491	SH 27	Widen Non-Freeway	U	0.681
092038088	08/14/96	$4,211,976	$603,771		$3,608,206	$603,771		Widen Non-Freeway	U	0.892
025509067	12/06/95	$4,368,474	$9,597		$4,358,877	$9,597	US 281	Widen Non-Freeway	U	1.446

Table 34. Sample Data (all dollar amounts in 2006 dollars) (Continued).

Contract CSJ	Letting Date	Total Bid	Utility Cost in Highway Contract	Utility Agreement Estimate	Non-Utility Highway Cost	Total Utility Cost	Route	Project Type	R-U	Length (mi)
091512110	07/13/94	$4,617,622	$488,767		$4,128,855	$488,767		Widen Non-Freeway		0.558
091635077	07/12/00	$4,637,566	$217,377		$4,420,189	$217,377		Widen Non-Freeway	U	0.485
091512131	01/04/01	$4,772,942	$235,012		$4,537,930	$235,012		Widen Non-Freeway	U	1.029
091237120	07/08/04	$4,773,956	$2,336		$4,771,620	$2,336		Widen Non-Freeway		0.656
029110075	08/10/94	$4,903,187	$895,429		$4,007,758	$895,429	SP 421	Widen Non-Freeway		0.289
091635067	03/08/00	$5,232,014	$535,563		$4,696,451	$535,563		Widen Non-Freeway	U	1.044
091845472	12/04/03	$5,458,644	$302,304		$5,156,341	$302,304		Widen Non-Freeway	U	0.464
048006014	02/04/03	$5,595,346		$23,677	$5,595,346	$23,677	FM 45	Widen Non-Freeway	R	5.902
091512118	02/04/98	$5,905,188	$3,179,390		$2,725,798	$3,179,390		Widen Non-Freeway		0.635
021602028	08/04/99	$5,984,684		$246,100	$5,984,684	$246,100	SH 46	Widen Non-Freeway	U	2.220
091512117	09/04/96	$6,232,862	$2,249,647		$3,983,215	$2,249,647		Widen Non-Freeway		1.170
091512271	07/10/01	$6,579,023	$1,063,232		$5,515,791	$1,063,232		Widen Non-Freeway	U	1.421
091512204	06/14/96	$6,651,718	$1,196,011		$5,455,707	$1,196,011		Widen Non-Freeway		1.558
001601070	08/08/95	$6,973,386	$542,420		$6,430,967	$542,420	LP 275	Widen Non-Freeway	R	0.908
091512373	08/04/00	$7,043,075	$3,220,388		$3,822,687	$3,220,388		Widen Non-Freeway	U	0.635
020401050	12/07/99	$7,543,990		$1,335,466	$7,543,990	$1,335,466	US 79	Widen Non-Freeway	U	2.290
025403060	12/05/96	$7,549,036	$65,604		$7,483,432	$65,604	US 281	Widen Non-Freeway	R	2.268
035307014	01/12/05	$7,654,601		$219,718	$7,654,601	$219,718	BS 114L	Widen Non-Freeway	U	1.193
052101040	10/10/02	$7,665,970	$1,129,977		$6,535,993	$1,129,977	LP 13	Widen Non-Freeway	U	1.150
014402040	11/04/03	$7,890,566		$388,276	$7,890,566	$388,276	US 87	Widen Non-Freeway	R	3.513
010907034	09/07/95	$8,004,817		$262,892	$8,004,817	$262,892	SH 19	Widen Non-Freeway	R	0.522
021602033	06/02/98	$8,338,943		$31,766	$8,338,943	$31,766	SH 46	Widen Non-Freeway	R	2.799
028301013	09/05/02	$8,524,024		$77,937	$8,524,024	$77,937	FM 2380	Widen Non-Freeway	U	1.692
052006032	07/11/00	$8,576,644	$605,317		$7,971,327	$605,317	SH 155	Widen Non-Freeway	U	0.633
003906026	07/06/95	$8,919,004	$49,392		$8,869,612	$49,392	BU 83-S	Widen Non-Freeway	U	3.603
091512276	03/05/02	$9,009,095	$1,033,776		$7,975,319	$1,033,776		Widen Non-Freeway	U	1.700
002509058	11/07/95	$9,438,013	$1,090,132		$8,347,881	$1,090,132	FM 78	Widen Non-Freeway	U	2.358
021202017	01/11/05	$9,514,003		$448,520	$9,514,003	$448,520	SH 30	Widen Non-Freeway	R	3.459
086501056	06/08/95	$9,578,155	$35,114		$9,543,041	$35,114	FM 495	Widen Non-Freeway	U	3.963
021203026	08/04/98	$9,780,817		$1,274,776	$9,780,817	$1,274,776	FM 158	Widen Non-Freeway	U	1.785
011401045	12/05/01	$10,014,568	$1,818,128		$8,196,440	$1,818,128	SP 69	Widen Non-Freeway		1.007
078601058	11/08/96	$10,135,215		$2,614,200	$10,135,215	$2,614,200	FM 364	Widen Non-Freeway	U	1.818
091845190	02/10/99	$10,137,373	$723,657		$9,413,716	$723,657		Widen Non-Freeway		1.496
000814086	04/02/03	$10,316,542		$1,137,288	$10,316,542	$1,137,288	IH 820	Widen Non-Freeway	U	0.271
091512135	09/14/94	$10,330,957	$799,600		$9,531,357	$799,600		Widen Non-Freeway	U	2.027
017201041	06/05/01	$10,347,453		$309,064	$10,347,453	$309,064	BU 287P	Widen Non-Freeway	U	0.367
001013058	06/07/00	$10,740,580		$178,390	$10,740,580	$178,390	US 67	Widen Non-Freeway	U	1.599
020401049	10/07/05	$10,941,703	$913,454	$3,124,392	$10,028,249	$4,037,846	US 79	Widen Non-Freeway	U	1.550
091512158	07/06/95	$11,069,108	$3,389,509		$7,679,599	$3,389,509		Widen Non-Freeway		1.737
078601062	10/06/94	$11,179,125		$212,091	$11,179,125	$212,091	FM 364	Widen Non-Freeway	R	2.982
065801033	06/13/96	$11,478,448	$1,104,927		$10,373,521	$1,104,927	FM 1535	Widen Non-Freeway		1.947
101703018	01/11/05	$11,912,094		$1,465,195	$11,912,094	$1,465,195	SH 276	Widen Non-Freeway	R	5.227
084901033	01/10/06	$12,089,742	$3,666,580		$8,423,162	$3,666,580	FM 471	Widen Non-Freeway	U	1.630
069702028	09/07/06	$12,584,713		$632,922	$12,584,713	$632,922	SH 334	Widen Non-Freeway	U	1.660
003903055	03/09/94	$12,703,932	$69,400		$12,634,532	$69,400	BU 83-S	Widen Non-Freeway	U	2.643
067401032	08/06/97	$13,061,892	$1,277,867		$11,784,025	$1,277,867	FM 76	Widen Non-Freeway	U	1.088
067401048	01/10/96	$14,395,803	$1,951,491		$12,444,312	$1,951,491	FM 76	Widen Non-Freeway	U	1.415
017105055	04/02/02	$14,409,830		$2,955,308	$14,409,830	$2,955,308	SH 199	Widen Non-Freeway	U	1.183
020907031	03/09/05	$14,586,506		$1,304,636	$14,586,506	$1,304,636	FM 933	Widen Non-Freeway	U	3.865
090248196	07/07/99	$15,497,836	$1,047,918		$14,449,918	$1,047,918		Widen Non-Freeway	U	1.392
039202056	08/03/99	$15,986,911		$759,278	$15,986,911	$759,278	US 259	Widen Non-Freeway	R	3.561
004002019	07/08/05	$16,134,600		$37,943	$16,134,600	$37,943	US 87	Widen Non-Freeway	R	9.447
039202055	11/09/99	$16,204,418		$320,053	$16,204,418	$320,053	US 259	Widen Non-Freeway	R	4.033
003906031	09/10/04	$16,432,286	$21,024	$93,998	$16,411,262	$115,022	BU 83-S	Widen Non-Freeway	U	4.908
006508155	10/05/94	$16,923,798	$1,754,261		$15,169,537	$1,754,261	SP 380	Widen Non-Freeway	U	1.454
026002025	07/06/99	$17,159,788		$208,502	$17,159,788	$208,502	US 67	Widen Non-Freeway	R	3.399
006501039	07/06/06	$17,302,253		$25,424	$17,302,253	$25,424	US 96	Widen Non-Freeway	R	4.613
097801021	09/07/95	$17,615,444	$892,500		$16,722,944	$892,500	FM 517	Widen Non-Freeway	U	1.608
091845367	12/06/06	$17,789,497	$4,555,337		$13,234,160	$4,555,337		Widen Non-Freeway	U	0.000
019103009	12/02/05	$17,805,730		$624,936	$17,805,730	$624,936	FM 2493	Widen Non-Freeway	U	3.356
014403031	11/09/04	$19,222,024		$3,171,952	$19,222,024	$3,171,952	US 87	Widen Non-Freeway	R	6.935
067401036	08/11/94	$19,553,377	$3,135,150	$0	$16,418,227	$3,135,150	FM 76	Widen Non-Freeway	U	1.605
004001029	01/08/04	$20,074,374	$0	$718,438	$20,074,374	$718,438	US 87	Widen Non-Freeway	R	8.666
020405024	04/12/94	$20,662,314		$277,288	$20,662,314	$277,288	US 79	Widen Non-Freeway	R	4.661
004803049	12/04/01	$20,685,878		$3,369,459	$20,685,878	$3,369,459	US 77	Widen Non-Freeway	R	4.918
069702032	12/04/97	$20,956,997	$1,793,521		$19,163,476	$1,793,521	SH 334	Widen Non-Freeway	U	2.500
017202056	05/08/02	$21,382,642	$3,575,922		$17,806,721	$3,575,922	BU 287P	Widen Non-Freeway	U	2.854
015604094	05/12/04	$21,769,376		$111,719	$21,769,376	$111,719	US 277	Widen Non-Freeway	R	0.665
019903035	11/07/96	$22,777,764	$84,999		$22,692,765	$84,999	US 69	Widen Non-Freeway	R	6.250
036602065	09/10/04	$22,924,761	$15,257		$22,909,504	$15,257	SH 123	Widen Non-Freeway	U	1.136
091512404	02/10/04	$23,035,062	$4,147,220		$18,887,841	$4,147,220		Widen Non-Freeway	R	2.066
065801034	07/07/06	$23,665,527	$3,191,704		$20,473,823	$3,191,704	FM 1535	Widen Non-Freeway		2.445
091845234	01/04/01	$24,057,461	$4,209,795		$19,847,667	$4,209,795		Widen Non-Freeway	U	2.100
019202045	12/06/95	$24,232,759	$2,251,422	$0	$21,981,338	$2,251,422	SH 6	Widen Non-Freeway	U	2.932
015105063	05/10/95	$24,832,316	$3,730,713		$21,101,603	$3,730,713	US 183	Widen Non-Freeway	U	0.472

Table 34. Sample Data (all dollar amounts in 2006 dollars) (Continued).

Contract CSJ	Letting Date	Total Bid	Utility Cost in Highway Contract	Utility Agreement Estimate	Non-Utility Highway Cost	Total Utility Cost	Route	Project Type	R-U	Length (mi)
021804076	03/10/04	$24,856,658	$473,595	$9,430	$24,383,063	$483,025	US 59	Widen Non-Freeway	U	1.514
019706028	08/10/05	$24,956,495		$1,015,972	$24,956,495	$1,015,972	US 175	Widen Non-Freeway	U	8.018
005001060	08/10/04	$24,965,702	$3,207,362	$0	$21,758,340	$3,207,362	BS 6-R	Widen Non-Freeway	U	1.835
002708144	09/09/05	$25,601,301	$282,102	$1,737,578	$25,319,199	$2,019,680	US 90A	Widen Non-Freeway	U	0.000
002708144	09/09/05	$25,601,301	$282,102	$1,737,578	$25,319,199	$2,019,680	US 90A	Widen Non-Freeway	U	1.322
006503031	03/05/03	$27,132,177		$554,003	$27,132,177	$554,003	US 96	Widen Non-Freeway	R	4.641
002709076	05/06/98	$27,399,430	$2,489,585		$24,909,845	$2,489,585	US 90A	Widen Non-Freeway	U	1.500
019606019	10/09/97	$27,624,731	$11,614,290		$16,010,441	$11,614,290	LP 354	Widen Non-Freeway	U	1.149
016203029	09/06/01	$28,301,442		$824,349	$28,301,442	$824,349	SH 31	Widen Non-Freeway	R	8.485
008614018	08/08/01	$28,837,572		$290,701	$28,837,572	$290,701	LP 20	Widen Non-Freeway	R	4.937
007905033	06/03/98	$29,259,555	$817,608		$28,441,947	$817,608	US 67	Widen Non-Freeway	R	8.680
011602027	08/11/04	$30,673,245		$1,294,181	$30,673,245	$1,294,181	SH 21	Widen Non-Freeway	R	11.106
004902009	03/10/04	$32,356,358		$1,799,527	$32,356,358	$1,799,527	SH 6	Widen Non-Freeway	R	5.946
083602044	01/08/03	$33,073,362	$299,685	$328,283	$32,773,677	$627,968	SH 195	Widen Non-Freeway	R	7.110
098101082	02/04/97	$33,969,866	$1,414,616	$75,544	$32,555,250	$1,490,161	NAS A 1	Widen Non-Freeway	U	2.843
006502045	08/10/04	$35,025,400		$1,427,989	$35,025,400	$1,427,989	US 96	Widen Non-Freeway	R	5.523
018504033	06/09/04	$38,554,589		$336,133	$38,554,589	$336,133	SH 36	Widen Non-Freeway	R	3.404
002708143	04/11/06	$39,255,617	$263,740		$38,991,877	$263,740	US 90A	Widen Non-Freeway	U	2.341
045101032	07/07/06	$40,121,609	$2,382,426		$37,739,183	$2,382,426	SH 205	Widen Non-Freeway	U	2.810
004906061	11/09/04	$42,283,927		$1,684,165	$42,283,927	$1,684,165	SH 6	Widen Non-Freeway	R	9.536
002708108	08/10/04	$57,295,727	$410,755	$2,305,077	$56,884,972	$2,715,832	US 90A	Widen Non-Freeway	U	0.871
008803030	10/07/05	$57,812,337		$56,894	$57,812,337	$56,894	US 59	Widen Non-Freeway	R	13.234
000904039	07/07/99	$69,511,582		$334,917	$69,511,582	$334,917	SH 66	Widen Non-Freeway	U	3.450
029110079	02/08/07	$72,897,510	$17,146,941		$55,750,569	$17,146,941	SP 421	Widen Non-Freeway	U	0.000
036404022	11/08/02	$77,130,663		$1,458,801	$77,130,663	$1,458,801	SH 121	Widen Non-Freeway	U	6.287
006204035	06/09/06	$80,437,941		$459,192	$80,437,941	$459,192	US 59	Widen Non-Freeway	R	7.150
002708145	07/08/05	$80,645,232	$4,135,769		$76,509,464	$4,135,769	US 90A	Widen Non-Freeway	U	1.556
068301070	08/06/03	$103,694,149	$438,226		$103,255,924	$438,226	SH 45	Widen Non-Freeway		1.212
068301069	09/09/03	$166,586,867	$6,404,057		$160,182,810	$6,404,057	SH 45	Widen Non-Freeway	U	2.492