Illinois Demonstration Project:

Knox County Highway 4 Reconstruction Project

Final Technical Brief

August 2015

HIGHWAYS FOR LIFE

Accelerating Innovation for the American Driving Experience.

U.S.Department of Transportation

Federal Highway Administration

FOREWORD

The purpose of the **Highways for LIFE (HfL)** pilot program is to accelerate the use of innovations that improve highway safety and quality while reducing congestion caused by construction. **LIFE** is an acronym for **L**onger-lasting highway infrastructure using **I**nnovations to accomplish the **F**ast construction of **E**fficient and safe highways and bridges.

Specifically, HfL focuses on speeding up *the widespread adoption* of proven innovations in the highway community. Such "innovations" encompass technologies, materials, tools, equipment, procedures, specifications, methodologies, processes, and practices used to finance, design, or construct highways. HfL is based on the recognition that innovations are available that, if widely and rapidly implemented, would result in significant benefits to road users and highway agencies.

Although innovations themselves are important, HfL is as much about changing the highway community's culture from one that considers innovation something that only adds to the workload, delays projects, raises costs, or increases risk to one that sees it as an opportunity to provide better highway transportation service. HfL is also an effort to change the way highway community decision makers and participants perceive their jobs and the service they provide.

The HfL pilot program, described in Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) Section 1502, includes funding for demonstration construction projects. By providing incentives for projects, HfL promotes improvements in safety, construction-related congestion, and quality that can be achieved through the use of performance goals and innovations. This report documents one such HfL demonstration project.

Additional information on the HfL program is at www.fhwa.dot.gov/hfl.

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16. Abstract

The Knox County Highway 4 reconstruction project is located in west central Illinois, approximately 14 miles northeast of Galesburg. The construction was carried out on County Highway 4, which ran in the east/west direction and connected U.S. Route 34 to Illinois Route 17. The primary purpose of the reconstruction project was to enhance motorist safety on County Highway 4 by improving both the horizontal and vertical alignments, as well as to address deterioration problems on the existing pavement.

The Knox County Highway Department, with assistance from the Illinois Department of Transportation, submitted a grant application to the Federal Highway Administration in January 2013. As a part of the Highways for LIFE program, Knox County was awarded $880,000 for utilizing 3D modeling technology. This project was first of its kind wherein the 3D modeling was used on an Illinois Department of Transportation let project. For this project, the 3D model data were made available to the contractor prior to bidding at no expense to the contractor.

There were no worker injuries or work zone related crashes on this project, and the project met the Highways for LIFE goal of no more than a 10 percent increase in trip time compared to the average preconstruction conditions.

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ABBREVIATIONS AND SYMBOLS

FHWA	Federal Highway Administration
GPS	Global Positioning System
HfL	Highways for LIFE
IDOT	Illinois Department of Transportation
IRI	International Roughness Index
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users

INTRODUCTION

HIGHWAYS FOR LIFE DEMONSTRATION PROJECTS

Highways for LIFE (HfL) is the Federal Highway Administration's (FHWA) initiative to advance longer-lasting and promote efficient and safe construction of highways and bridges using innovative technologies and practices. The HfL program provides incentive funding to highway agencies to try proven but little-used innovations on eligible Federal-aid construction projects. The HfL team prioritizes projects that use innovative technologies, manufacturing processes, financing, contracting practices, and performance measures that demonstrate substantial improvements in safety, congestion, quality, and cost-effectiveness. An innovation must be one the applicant State has never or rarely used, even if it is standard practice in other States. Recognizing the challenges associated with deployment of innovations, the HfL program provides incentive funding for up to 15 demonstration construction projects a year. The funding amount typically totals up to 20 percent of the project cost, but not more than $5 million.

The HfL program promotes project performance goals that focus on the expressed needs and wants of highway users. They are set at a level that represents the best of what the highway community can do, not just the average of what has been done. The goals are categorized into the following categories:

1. **Safety**
   a. Work zone safety during construction—Work zone crash rate equal to or less than the preconstruction rate at the project location.
   b. Worker safety during construction—Incident rate for worker injuries of less than 4.0, based on incidents reported on Occupational Safety and Health Administration (OSHA) Form 300.
   c. Facility safety after construction—Twenty percent reduction in fatalities and injuries in 3-year average crash rates, using preconstruction rates as the baseline.
2. **Construction Congestion**
   a. Faster construction —Fifty percent reduction in the time highway users are impacted, compared to traditional methods.
   b. Trip time during construction — Less than 10 percent increase in trip time compared to the average preconstruction speed, using 100 percent sampling.
   c. Queue length during construction—A moving queue length of less than 0.5 miles in a rural area or less than 1.5 miles in an urban area (in both cases at a travel speed 20 percent less than the posted speed).
3. **Quality**
   a. Smoothness—International Roughness Index (IRI) measurement of less than 48 in/mi.
   b. Noise—Tire-pavement noise measurement of less than 96.0 A-weighted decibels (dB(A)), using the onboard sound intensity (OBSI) test method.

4. **User Satisfaction**
    a. An assessment of how satisfied users are with the new facility compared to its previous condition and with the approach used to minimize disruption during construction. The goal is a measurement of 4 or more on a 7-point Likert scale.

PROJECT OVERVIEW

The Knox County Highway Department, with assistance from the Illinois Department of Transportation, submitted a grant application to the Federal Highway Administration in January 2013. As a part of the Highways for LIFE program, Knox County was awarded $880,000 for utilizing 3D modeling technology. This project was the first of its kind wherein the 3D modeling was used on an Illinois Department of Transportation let project. For this project, the 3D model data were made available to the contractor prior to bidding at no expense to the contractor.

PROJECT DETAILS

PROJECT BACKGROUND AND LOCATION

The Knox County Highway 4 reconstruction project is located in west central Illinois, approximately 14 miles northeast of Galesburg. The construction was carried out on County Highway 4, which ran in the east/west direction and connected U.S. Route 34 to Illinois Route 17. The primary purpose of the reconstruction project was to enhance motorist safety on County Highway 4 by improving both the horizontal and vertical alignments, as well as to address the deterioration problems on the existing pavement. Figure 1 presents the project limits.

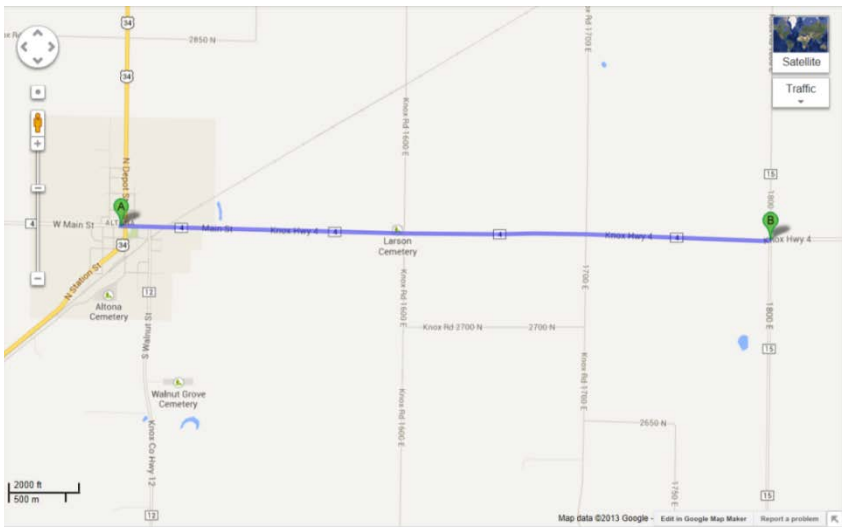


Figure 1. Map. Project limits. (courtesy: Google Maps)

PROJECT DESCRIPTION

County Highway 4 was reconstructed as a two-lane rural roadway with an overall roadway width of 30 feet from edge of shoulder to edge of shoulder. Compared to the existing 22-foot cross-section without shoulders, the new cross-section which consisted of two 11-foot-wide travel lanes and two 4-foot-wide aggregate shoulders is expected to improve roadway safety and reduce the impact of blowing and drifting snow.

The vertical profile of the project location followed the existing natural rolling terrain. A majority of the existing vertical alignment (crests and sags) only met the design standards for a design speed of 30 to 40 mph. An increase in the design speed of sag curves to a minimum of 40 mph and the crest curves to a minimum design speed of 50 mph resulted in a better vertical profile, with an improvement in the existing vertical curve deficiencies and the sight distance along County Highway 4.

The reconstruction efforts on County Highway 4 began at station 2+58.00 just east of Altona and ended at station 181+ 30.00 just east of County Highway 15/T.R. 1800 E. The reconstruction efforts involved the following:

1. Reconstruction of the entire roadway and drainage ditches.
2. Uniform placement of 8 inches of aggregate base course, type A.
3. Construction of a new 7-inch jointed concrete pavement on County Highway 4.
4. Construction of new hot mix asphalt pavement at intersections T.R. 1600, T.R. 1700, and T.R. 1800.
5. Removal of all existing drainage structures.
6. Installation of new concrete box culverts and pipe culverts, and all other appurtenant items.

A minor reverse curve located between station 165+00 and station 184+00 was eliminated. The reverse curve did not meet design standards and thus posed a safety concern. The horizontal alignment was straightened utilizing minor deflections to improve the safety and geometries of the County Highway 4 and County Highway 15 intersection.

Existing Pavement Condition

The existing pavement structure consisted of a sealcoat over an aggregate base course. While the existing horizontal alignment consisted of a few minor deflections and two reverse curves, which did not meet design standards, the existing vertical alignment followed the natural rolling terrain.

Engaging Third Parties

The Knox County Highway Department coordinated with all affected utility companies in the early stages of the project. The access for farmers was coordinated during the spring planting and fall harvest seasons. A public informational meeting was also held on January 24, 2012, in Altona.

Environmental Impact

All environmental clearances on this project were processed through the Illinois Department of Transportation. No wetlands were affected on this project and the project had a Categorical Exclusion.

Utility Relocation

For utility relocations and to coordinate with the utility companies, the contractor was required to call the number associated with State of Illinois Joint Utility Locating Information for Excavators (J.U.L.I.E.) system. The following were the utility types within the project limits:

1. Electric distribution lines.
2. Utility poles.
3. Gas main and services.
4. Fiber optic/pedestals.
5. Water and sanitary.
6. Cable.

7. Telephone.

Bidding Information

The contractors were required to use 3D modeling for the construction of this project. Five bids were received for this project, and the winning bid was from Brandt Construction Co. at $4,893,000.00. The contractor was responsible for reconstructing County Highway 4 on a new aggregate subbase, portland cement concrete pavement, box culverts, pipe culverts, storm sewer, and sidewalks, from the BNSF tracks at the East Corporate limits of Altona for 3.4 miles to County Highway 15. Table 1 presents a bid comparison summary.

Table 1. Bid comparison summary.

Bidder	Bid Amount
Brandt Construction Co.	$ 4,893,000.00
R. W. Dunteman Company	$ 5,746,358.26
Gunther Construction, a Division of United Contractors Midwest, Inc.	$ 5,634,319.83
Laverdiere Construction, Inc.	$ 6,298,976.07
McCarthy Improvement Company	$ 5,131,111.40

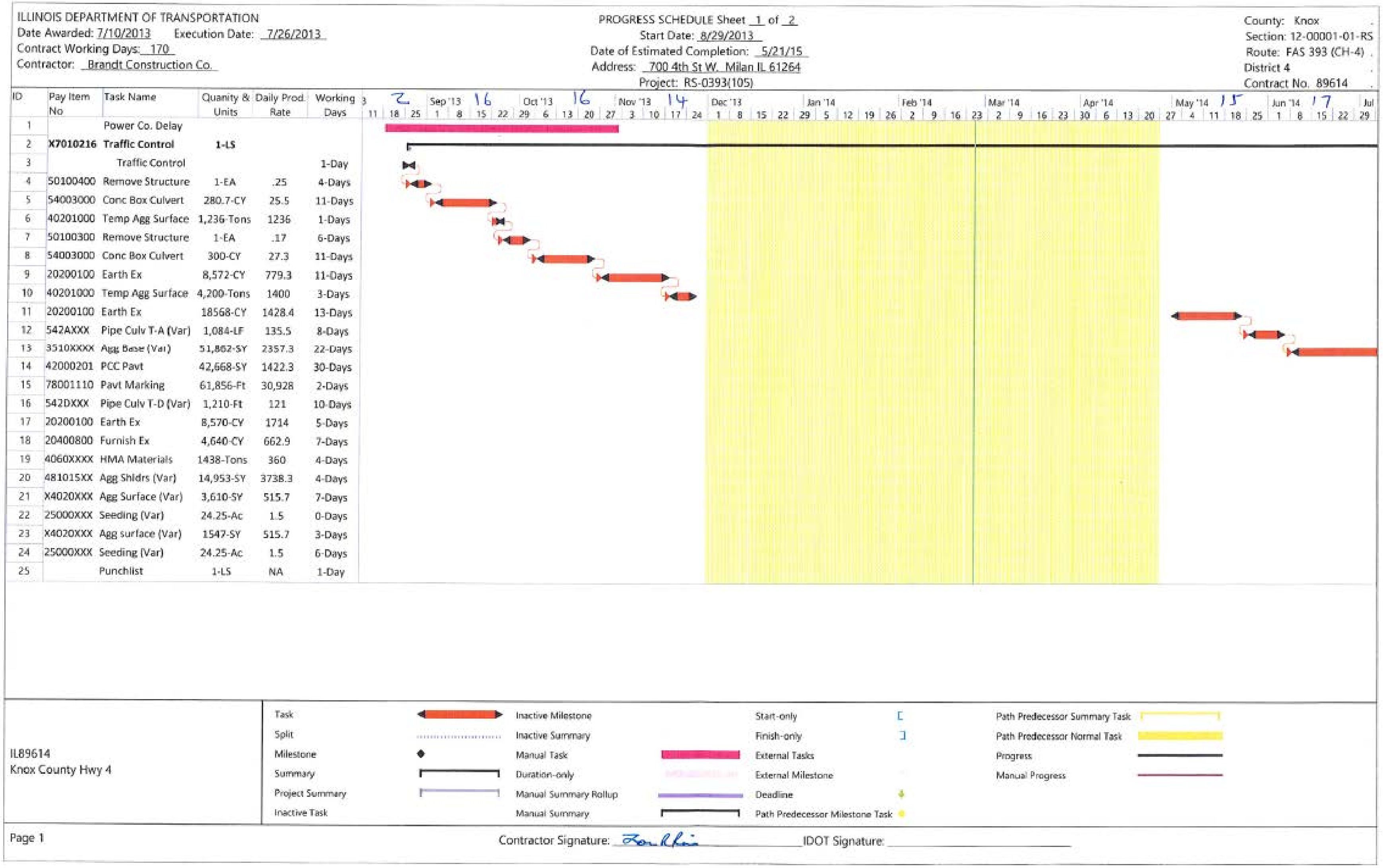
Project Schedule Information

The Knox County Highway 4 reconstruction project was let on June 14, 2013, awarded on July 10, 2013, and the construction work began on August 26, 2013. The project limits extended 3.4 miles east of the BNSF crossing in Altona to the intersection at County Highway 15. The project was completed on May 22, 2015. The detailed project schedule is provided in Figure 2.

Project Innovation

The primary innovation on the Knox County Highway 4 reconstruction project was the use of 3D modeling and automated machine guidance. This project was the first time 3D modeling was used on an Illinois Department of Transportation let project. For this project, the 3D model data were made available to the contractor prior to bidding at no expense to the contractor. This project required the use of a global positioning system (GPS) survey rover and base station setup for land surveying purposes (see Figures 3 and 4). The GPS survey rover interacted with a GPS-enabled base station that was set up over a benchmark (near the worksite along the roadway) to convey GPS location and location within the project to the GPS survey rover. This setup was used for a number of different operations on the project, including but not limited to the following:

1. Checking subbase cut and fill levels.
2. Laying out pipes and setting pipe grades.
3. Obtaining solid rock sections.
4. Verifying and laying out grade stakes and for laying out pavement markings for the centerline and edge lines.



ILLINOIS DEPARTMENT OF TRANSPORTATION
Date Awarded: 7/10/2013 Execution Date: 7/26/2013
Contract Working Days: 170
Contractor: Brandt Construction Co.

PROGRESS SCHEDULE Sheet 1 of 2
Start Date: 8/29/2013
Date of Estimated Completion: 5/21/15
Address: 700 4th St W. Milan IL 61264
Project: RS-0393(105)

County: Knox
Section: 12-00001-01-RS
Route: FAS 393 (CH-4)
District 4
Contract No. 89614

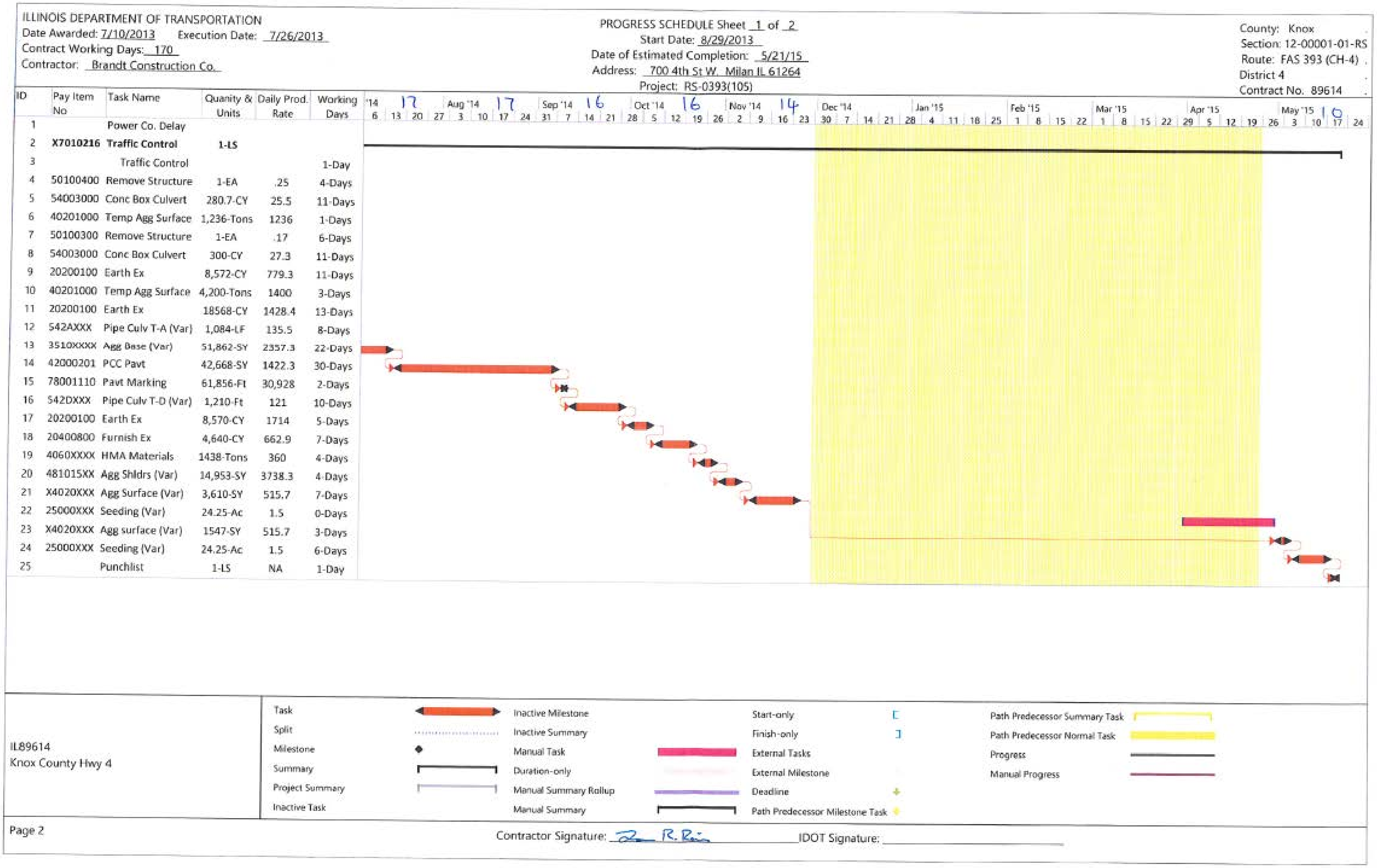
ID	Pay Item No	Task Name	Quanity & Units	Daily Prod. Rate	Working Days
1		Power Co. Delay			
2	**X7010216**	**Traffic Control**	**1-LS**		
3		Traffic Control			1-Day
4	50100400	Remove Structure	1-EA	.25	4-Days
5	54003000	Conc Box Culvert	280.7-CY	25.5	11-Days
6	40201000	Temp Agg Surface	1,236-Tons	1236	1-Days
7	50100300	Remove Structure	1-EA	.17	6-Days
8	54003000	Conc Box Culvert	300-CY	27.3	11-Days
9	20200100	Earth Ex	8,572-CY	779.3	11-Days
10	40201000	Temp Agg Surface	4,200-Tons	1400	3-Days
11	20200100	Earth Ex	18568-CY	1428.4	13-Days
12	542AXXX	Pipe Culv T-A (Var)	1,084-LF	135.5	8-Days
13	3510XXXX	Agg Base (Var)	51,862-SY	2357.3	22-Days
14	42000201	PCC Pavt	42,668-SY	1422.3	30-Days
15	78001110	Pavt Marking	61,856-Ft	30,928	2-Days
16	542DXXX	Pipe Culv T-D (Var)	1,210-Ft	121	10-Days
17	20200100	Earth Ex	8,570-CY	1714	5-Days
18	20400800	Furnish Ex	4,640-CY	662.9	7-Days
19	4060XXXX	HMA Materials	1438-Tons	360	4-Days
20	481015XX	Agg Shldrs (Var)	14,953-SY	3738.3	4-Days
21	X4020XXX	Agg Surface (Var)	3,610-SY	515.7	7-Days
22	25000XXX	Seeding (Var)	24.25-Ac	1.5	0-Days
23	X4020XXX	Agg surface (Var)	1547-SY	515.7	3-Days
24	25000XXX	Seeding (Var)	24.25-Ac	1.5	6-Days
25		Punchlist	1-LS	NA	1-Day

IL89614
Knox County Hwy 4

Page 1

Contractor Signature: IDOT Signature:

Figure 2. Screenshot. Knox County Highway 4 reconstruction project schedule.



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24	25000XXX	Seeding (Var)	24.25-Ac	1.5	6-Days
25		Punchlist	1-LS	NA	1-Day

Figure 2. Screenshot. Knox County Highway 4 reconstruction project schedule, continued.

Figure 3. Photo. An operator using the GPS survey rover.

Figure 4. Photo. GPS survey rover screen indicating surface elevation and fill.

In addition, the bulldozer used on this project was equipped with a GPS rover that made the cutting blade fully automated (see figures 5 through 9) and allowed the operator to let the blade make cuts and fills automatically without requiring any human inputs. The bulldozer had two GPS antennae on masts above each corner of the bulldozer blade, as a part of the Trimble navigation system. The on-board computer on the machine calculated the actual position of the corner of the cutting edge of the blade based on the offset from the antenna to the cutting edge. This process facilitated the fine grading operation and allowed the operator to monitor roadway elevations during the grading process.

Figure 5. Photo. Operator using the on-board computer on the bulldozer.

Figure 6. Photo. Screen showing the alignment of the bulldozer.

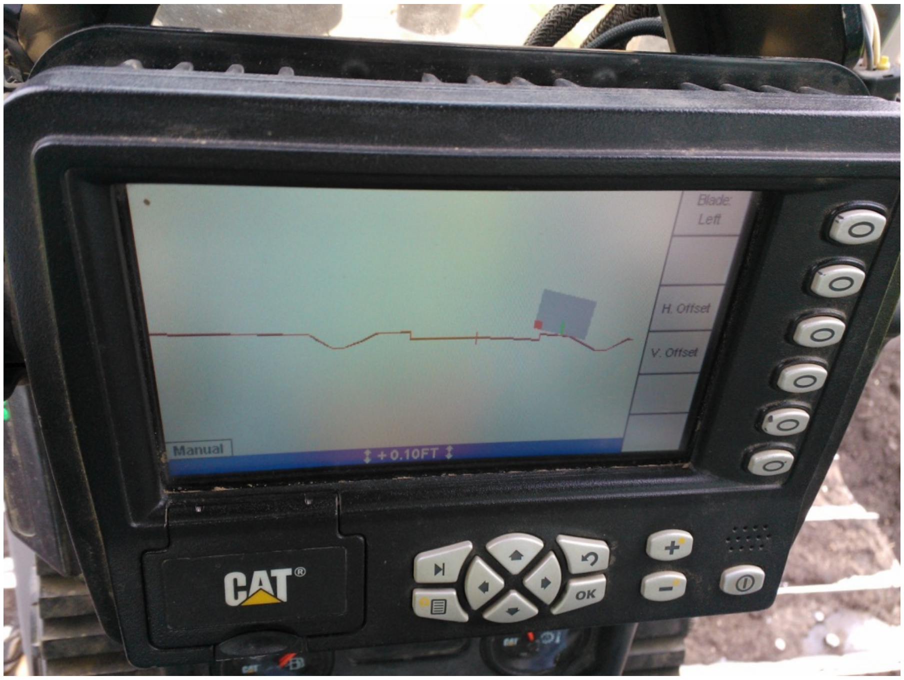

Figure 7. Photo. Screen showing the vertical profile of the area being graded.

Figure 8. Photo. Screen showing the cut, fill, elevation, and slope parameters.

Figure 9. Photo. Screen showing the northing, easting, station, and offset parameters.

Construction

Project construction began on August 26, 2013. The initial stages of construction involved demolition and removal of a concrete box culvert between Altona and 1600E and pouring of the floor and walls of the new box culvert. During this period, the dirt work was carried out between 1600E and 1700E. The construction work was suspended in December 2013 because of winter conditions, and the roadway was closed to all traffic between 1600E and 1650E.

The construction work was restarted on May 5, 2014. The cross-road culvert pipes were installed starting just east of the railroad tracks in Altona, and the dirt work was carried out at the east end of the project (1700E to County Highway 15). As a part of the dirt work, several hundred tons of aggregate base course was placed west of County Highway 15. Unsuitable material in the subgrade was excavated and replaced with additional aggregate. The roadway front slopes were constructed at 1V:4H, and the roadway back slopes were constructed at 1V:3H. The ditches were 2 feet wide and varied in slope.

The cross-road culverts east and west of 1700E were also replaced. This was followed by the placement of 7 inches of concrete pavement through the intersections at 1600E and 1700E.

Figures 10 and 11 are photos showing the progress of this work.

Figure 10. Photo. Aggregate base and dirt fill being carried out. (courtesy: Knox County Highway Department)

Figure 11. Photo. Placement of concrete at 1600E intersection. (courtesy: Knox County Highway Department)

During the concrete placement period, the roadway was closed to all traffic to allow for 5 to 7 days of concrete curing. The roadway was kept open to only local traffic during the reconstruction of the intersections of County Highways 4 and 15, as well as during other periods of construction. Figure 12 is a map showing the location of the closed intersection.

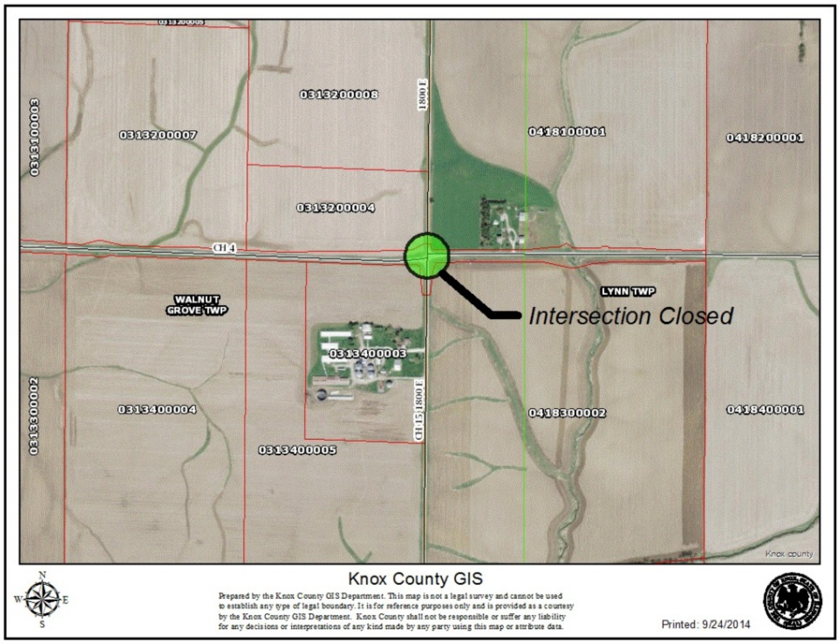

Figure 12. Map. Closure of County Highway 4 and County Highway 15 intersection. (courtesy: Knox County Highway Department)

The concrete pouring and finishing (see Figure 13) was carried out for the mainline concrete pavement along County Highway 4, and the concrete paving work was completed on November 7, 2014. This was followed by placement of aggregate shoulders along certain portions of the roadway and guardrail work at the bridge over Mud Run Creek, between 1600E and 1700E. The new hot mix asphalt pavement was then constructed at the side road intersections of 1600E North and South, 1700E North, and 1800E North. The new roadway was opened to all traffic on May 22, 2015.

Figure 13. Photo. Concrete finishing. (courtesy: Knox County Highway Department)

LESSONS LEARNED

The Knox County Highway Department is of the opinion that the 3D modeling approach allowed for faster construction, as the constant checking of grades was eliminated. Furthermore, the use of 3D modeling resulted in a much safer work environment for construction personnel, as they were not required to check grades within a close proximity to large construction equipment.

On this project, Knox County inspectors used contractor survey equipment, but it would be preferable for future projects that the owner agencies have their own survey equipment.

The 3D Modeling design approach enabled the designers to better understand the design of the project and locate possible conflicts and/or errors in the design. They were able to show key stakeholders the finished product in a three-dimensional image enabling them to understand how they will be impacted. Knox County believes that understanding the direct impacts to them, stakeholders are more likely to "buy into the project and be more cooperative in right of way and easement negotiations. 3D exhibits can be prepared for design reviews and eliminate potential errors prior to construction and also help identify potential utility conflicts.

With this particular project having numerous vertical profile deficiencies, the designers were able to check sightline visibility for intersections, no-passing zone markings, signing and decision making maneuvers. The 3D modeling approach also has the potential for lower bids since contractor can schedule activities more efficiently, as well as reduced labor for setting survey markers. It also eliminates need for contractors to convert 2D plans into 3D models since most of them use GPS machine controls.

HIGHWAYS FOR LIFE PERFORMANCE GOALS

INTRODUCTION

The primary objective of acquiring data on HfL performance goals such as safety, construction congestion, and quality is to quantify project performance and provide an objective basis from which to determine the feasibility of the project innovations and to demonstrate that the innovations can be used to do the following:

- Achieve a safer work environment for the traveling public and workers.
- Reduce construction time and minimize traffic interruptions.
- Produce a high-quality project and gain user satisfaction.

The following subsections provide additional information on some of the significant factors that influence the HfL performance goals.

TRAVEL TIME

The overall length of the project was approximately 3.4 miles. The reconstruction of County Highway 4 necessitated the use of a detour. The traffic was limited to local traffic only during the construction. The speed limits were 55 mph on the rural section and 30 mph within the city limits of Altona and Galva, through which the detour route traversed. The project limits and detour route are shown in Figure 14 and Figure 15, respectively.

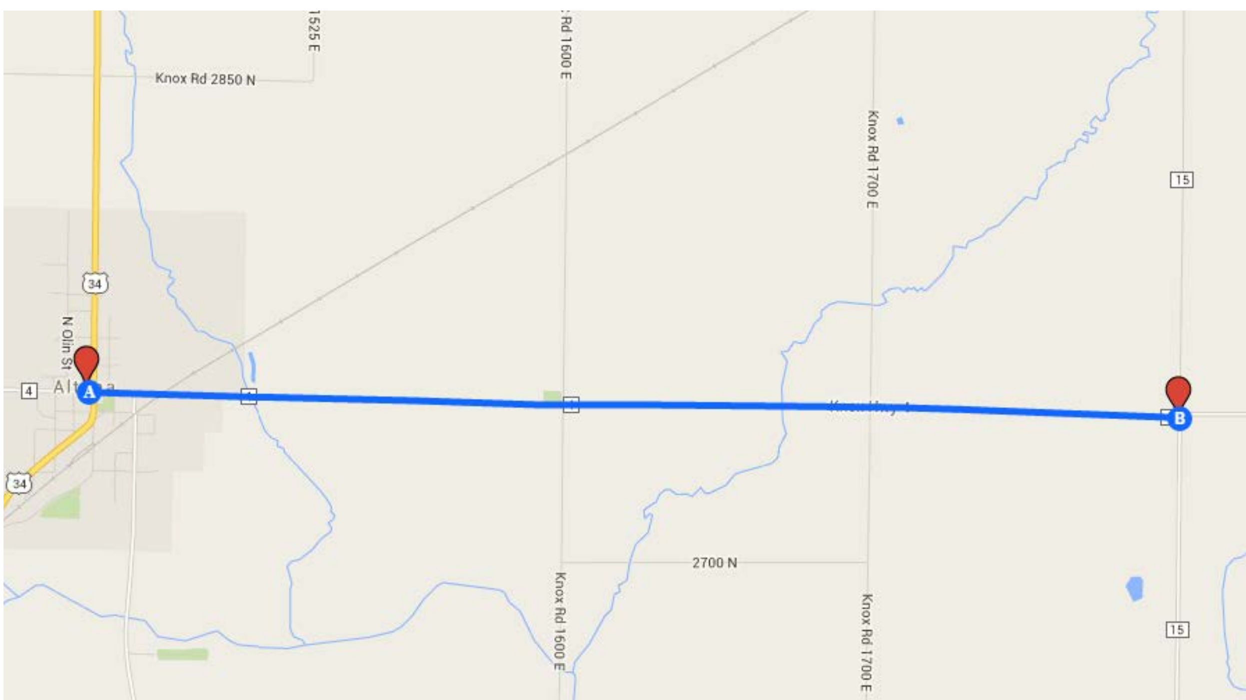

Figure 14. Map. County Highway 4 project limits.

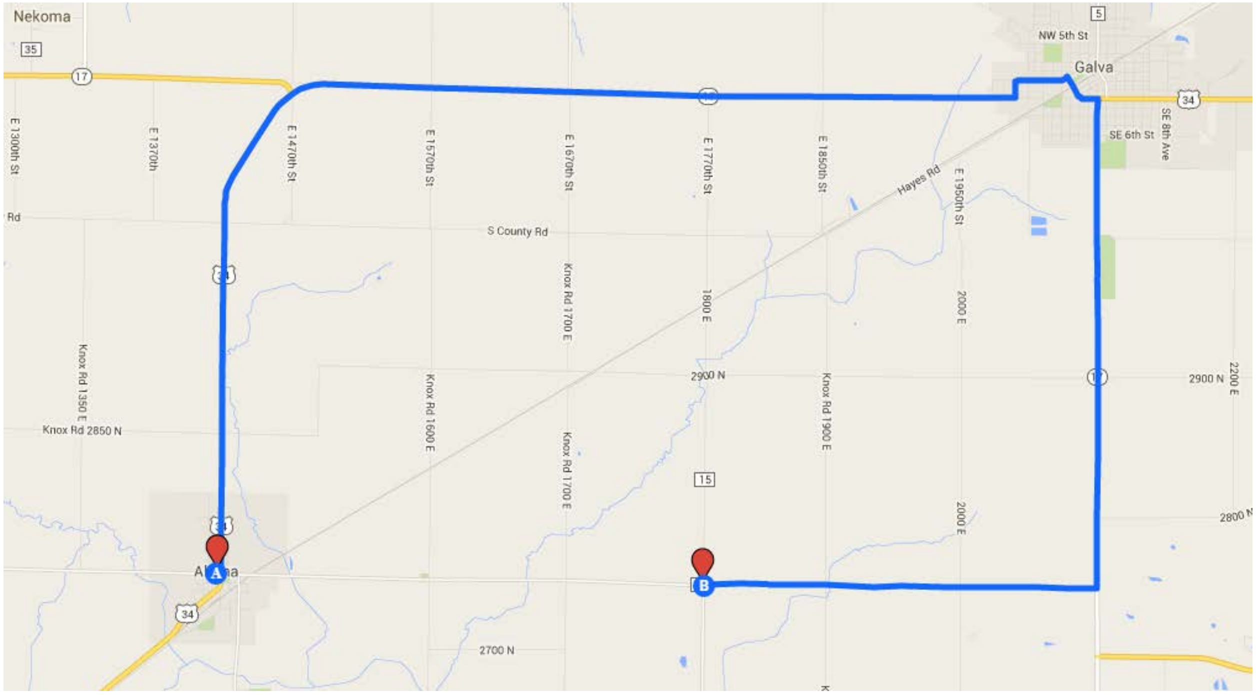

Figure 15. Map. Detour route for County Highway 4 project.

Travel time data was collected before and during construction; see Tables 2 and 3.

Table 2. Preconstruction travel time data.

Scenario	Run #	US 34/Rt 4 to Rt 4/Rt 17		Rt 4/Rt 17 to US 34/Rt 4	
		Base distance travel time (s)	Detour distance travel time (s)	Base distance travel time (s)	Detour distance travel time (s)
Before Construction	Run 1	248.80	1021.68	245.57	1036.2
	Run 2	263.34	1030.34	252.85	1001.61
	Run 3	255.24	1008.89	257.94	979.57
	Run 4	261.12	1020.87	264.35	994.46
	Run 5	271.07	1014.15	260.99	1005.88
	Run 6	257.69	1009.79	274.75	999.16
	Average	**259.54**	**1017.62**	**259.41**	**1002.81**

Table 3. During construction travel time data.

Scenario	Run #	US 34/Rt 4 to Rt 4/Rt 17	Rt 4/Rt 17 to US 34/Rt 4
		Detour distance travel time (s)	Detour distance travel time (s)
After Construction	Run 1	1000.65	1009.36
	Run 2	1010.72	1003.57
	Run 3	1007.85	989.51
	Run 4	1014.78	992.45
	Run 5	1022.58	1002.58
	Run 6	1001.75	1012.54
	Average	**1009.72**	**1001.67**

Overall, there was almost no variation in the average travel times along the designated detour route before and during construction. Thus, it can be safely assumed that there was little or no delay during the construction period. In other words, the project met the HfL goal of no more than a 10 percent increase in trip time compared to the average preconstruction conditions.

No queuing was observed on this project during the construction period.

SAFETY

The HfL performance goals for safety include meeting both worker and motorist safety goals during construction.

There were no worker safety issues during construction, and overall, the contractor exceeded the HfL goal for worker safety (incident rate of less than 4.0 based on the OSHA 300 rate).

There were no work zone related crashes or motorist injuries during construction. The lower traffic volume along the project route and use of a detour route helped to maintain a safer work zone.

CONSTRUCTION COSTS

The total construction costs on this project are estimated to be around $4,850,000. All utility relocation costs on this project were covered by the utility companies, and no money was spent on law enforcement related activities. The cost breakdown for this project is shown in Table 4.

Table 4. Project costs.

Project Phase/Activity	Amount Incurred
Preliminary engineering and design Phase I	$203,000
Preliminary engineering and design Phase II	$120,000
Mobilization	$258,224.22
Traffic control	$20,000
Right of way and/or temporary easement costs	$130,000 (Consulting fees for ROW acquisition)
	$159, 164 (Payment to landowners for various parcels)
Construction Layout	$31,500
Total Construction Cost	**$4,850,000**

ACKNOWLEDGMENTS

The project team acknowledges the invaluable insights and guidance of Highways for LIFE Team Leader Byron Lord and Program Coordinator Ewa Flom, who served as the technical panel on this demonstration project. Their vast knowledge and experience with the various aspects of construction, technology deployment, and technology transfer helped immensely in developing both the approach and the technical matter for this document. The team also is indebted to Knox County Highway Department County Engineer Duane Ratermann and Engineering Technician III Jason Petentler, IDOT Engineer Ken Park, and FHWA Engineers Heidi Liske and Brian Pfeifer, for their advice and assistance during this project.