Develop an Improved Selection Methodology for Safety Improvements at Public Highway-Railroad Grade Crossings Project

Final Report, September 2018

IHRB Project Number TR-732

Prepared by HDR Engineering, Inc.

Sponsored by the Iowa Highway Research Board

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16. Abstract

The Iowa Department of Transportation (Iowa DOT) currently prioritizes highway-rail grade crossing safety improvement projects and funding through a benefit-cost analysis (BCA) methodology developed by department staff in 2006. The current evaluation methodology using the benefit-cost ratio includes highway and grade crossing characteristics, highway and train traffic, accident history, societal costs, and anticipated cost of improvements. The purpose of this research was for the Iowa DOT Office of Rail Transportation to identify other variables and approaches in use by other states that the current methodology does not include, and investigate if appropriate data and methods of analysis are utilized to identify grade crossings in Iowa that are most in need of future improvements and would receive the most benefits from the limited Section 130 funding. Interviews of Iowa DOT and other state DOT staff, stakeholder survey, a Class I railroad presentation, coordination with a Technical Advisory Committee, and evaluation of the current Iowa DOT methodology and a literature review of select resources were used to develop findings, conclusions, and recommendations. From these recommendations, Iowa DOT selected a final project workplan for implementation, which included an analysis of hazard ranking practices and models used by other states to determine the best-fit and approach for Iowa (the current Texas Model was selected by Iowa DOT), development of a database / hazard ranking spreadsheet tool that is supported by the most recent FRA crash and Iowa grade crossing inventory data available to Iowa DOT and a companion project prioritization spreadsheet tool, and identification of additional datasets for identifying and prioritizing grade crossing investments in the future and potential actionable strategic program and policy changes that could improve the facilitation of the Iowa Section 130 program in Iowa in the future.

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Executive Summary

Research Problem

The Iowa Department of Transportation (Iowa DOT) had been prioritizing highway-rail grade crossing safety improvement projects and funding statewide through a benefit-cost analysis (BCA) methodology developed by department staff in 2006. That evaluation methodology used criteria such as a benefit-cost ratio informed by highway and grade crossing characteristics, highway and train traffic, accident history, societal costs, and anticipated cost of improvements. The Iowa DOT Office of Rail Transportation realized that that there are other variables and approaches available, which the current methodology does not account for, and wanted to investigate if better data and methods of analysis are available that can be utilized to identify and prioritize grade crossings within the state that are: 1) most in need of future safety improvements, and 2) would generate the most public benefit from investment in the State's limited Federal Highway-Railroad Grade Crossings (Section 130) Program grant funding (about $5.5 million annually that the State of Iowa receives from the U.S. Department of Transportation, or U.S. DOT).

Research Background

The purpose of this Develop an Improved Selection Methodology for Safety Improvements at Public Highway-Railroad Grade Crossings project by Iowa DOT and its consultant HDR Engineering, Inc. (HDR), is to conduct research and develop findings that will help to inform Iowa DOT of the most current approaches to identify and prioritize public highway-railroad grade crossing improvements, which will aid in developing recommendations and actionable steps for implementing changes into Iowa's current prioritization methodology.

The research results and the tools developed throughout the project are expected to provide Iowa's highway authorities, railroads, and other stakeholders with an enhanced means of identifying needs and opportunities for potential improvements to the public highway-railroad grade crossings under their jurisdiction, and for streamlining the process to pursue Section 130 program grant funds through Iowa DOT in order to develop these improvements. Iowa DOT can apply the research results and tools to drive internal processes and maximize the positive impact generated by Iowa's highway-railroad grade crossings safety program and its partnerships with the state's highway authorities and railroads.

The following potential benefits are expected from the research and tools developed throughout the project:

- Improved identification of public highway-railroad grade crossing investment priorities in Iowa to drive increased value for the state's highway-railroad grade crossing safety program.
- Increased public safety at Iowa's public highway-railroad grade crossings, which is expected to reduce rates of fatalities, injuries, and property damage.
- Enhanced process efficiencies and leveraging of existing data from variable sources for Iowa's highway-railroad grade crossing safety program.

- Enriched program coordination and cooperation between Iowa DOT and the state's roadway authorities and railroads, which would enhance meaningful and lasting communication between all parties with regard to the relative risks of public highway-railroad grade crossings and to encourage funding applications for the state's highway-railroad grade crossing safety program that would target the grade crossings that are potentially the greatest safety risk.

Research Plan and Objectives

The research plan and objectives used by researchers from HDR Engineering, Inc. is identified below:

- Assessed the Iowa Department of Transportation's current methodology and related processes and policies for maintaining the Section 130 program in Iowa and the internal and external process for identifying and prioritizing investment for grade crossing improvements statewide. Assessment included interviews and ongoing coordination with various Iowa DOT offices and staff; a survey of select Iowa highway-rail grade crossing stakeholders to ascertain opportunities to improve the methodology and approach to grade crossing investment in Iowa; and engagement with a Technical Advisory Committee (TAC) consisting of Iowa highway-rail grade crossing stakeholders that was established by Iowa DOT to guide the project.
- Completed a literature review of representative current research and methodologies to identify methods, approaches, best practices, and innovative strategies used by other state DOTs and public agencies for modeling grade crossing hazard ranking and identification and prioritization of grade crossing improvements related to active warning devices and other measures.
- Coordinated with a Class I railroad serving Iowa and another state DOT to gain an understanding about their current processes and methodology for prioritizing grade crossing investment.
- Developed recommendations and actionable steps for the implementation of changes into Iowa's current prioritization methodology and develop related enhanced or new tools for prioritizing and achieving desired improvements through coordination with Iowa DOT and the project TAC.
- Developed recommendations for potential additional datasets for identifying and prioritizing grade crossing investments, communicating relative grade crossing risks to Iowa's highway authorities, determining the most advantageous projects to present to the Iowa Transportation Commission for Funding, and potential Iowa Section 130 program policy and process enhancements.

Research Conclusions

Conclusions made from key findings of the research include:

- The timeliness, reliability, and completeness of the data used to support the identification and prioritization of grade crossings in Iowa for improvement was not maintained. It was noted that the current statewide highway-rail grade crossing inventory did not include certain data categories (e.g., sight distance, skew angle, presence of sidewalks, etc.)

- The list of countermeasures for grade crossing investment does not consider the full scope of potential levels of improvement.
- Crash costs, coefficients, and constants used in the benefit-cost analysis are inconsistent with the latest practices.
- The existing methodology used to support Section 130 funding applications places an emphasis on a narrow number of grade crossings, and the threshold that identified grade crossings that have the greatest need for safety investment should be evaluated.
- According to stakeholders, the most important approval criteria for identifying and prioritizing grade crossing investment and accruing public benefits of these investments are the amount of highway traffic and intersection crash numbers.
- The current process to engage eligible applicants (e.g., highway jurisdictions, railroads, and public agencies) and supply them with the information necessary to complete a Section 130 grant application and the current application selection process may need improvement. Enhanced communication and public education with regard to the Section 130 program, the application process, and application status were identified. Grade crossing field diagnostics and related inputs and outputs are an essential component of the process to identify and prioritize grade crossing investment, yet they are not typically completed until late in the process to advance Section 130 grant applications to the Iowa Transportation Commission for funding. It was also noted that there is a backlog of Section 130 grant applications, that some applications were up to 30 years old, and that one process improvement could include shorter-term applicability and an expiration time (e.g., 5 years) on grant applications.

Summary of Recommendations and Activities Implemented

Following completion of the research, HDR developed recommendations via a list of activities that Iowa DOT could undertake through the remainder of the project. Iowa DOT selected the specific action items based on the highest priorities of Iowa DOT and determined a related final workplan for HDR. Through this approach, Iowa DOT addressed its most important needs, achieved its highest objectives, and provided the most initial value in terms of enhance safety and public benefits to Iowa. Activities implemented include the following:

- Develop a Study Report that captures all research, analysis, coordination, outreach, and work developed throughout the study.
- Hazard Raking Analysis and Development of a Database / Hazard Ranking Tool – analyze hazard ranking models used by other state DOTs to determine a best-fit for a revised Iowa DOT hazard ranking model based on available datasets; develop a tool to identify available, complete, and clean Iowa DOT datasets and links to their location; and to rank relative hazards for each grade crossing on a statewide, countywide, and railroad basis. Analysis and tool will be developed through coordination with Iowa DOT, the TAC, and HDR.

- Economic Analysis and Development of a Revised Project Prioritization Tool – analysis of benefit-cost and cost-effectiveness factors (including thresholds, values, and benefit categories) and development of a tool with interface to the separate database / hazard ranking tool that identifies and prioritizes the highway-rail grade crossings that are most in need of future improvements and would receive the most benefits from limited Section 130 funding.
- Identify recommendations for potential additional datasets for identifying and prioritizing grade crossing investments, communicating relative grade crossing risks to Iowa's highway authorities, determining the most advantageous projects to present to the Iowa Transportation Commission for Funding, and potential Iowa Section 130 program policy and process enhancements.

See the Develop an Improved Selection Methodology for Safety Improvements at Public Highway-Railroad Grade Crossings Report in the following sections for additional details related to the research plan and objectives, findings, conclusions, recommendations, and overall implementation of the project.

1.0 Research Introduction and Problem

The Federal Highway-Railroad Grade Crossings (Section 130) Program provides funding for the elimination of hazards at U.S. highway-railroad crossings. Since the program's introduction in 1987[1], there has been a significant decrease in fatalities at public highway-railroad grade crossings nationwide despite an increase in vehicle miles traveled (VMT) on roadways and an increase in passengers and freight moved over railroad corridors. Funding from this program helped to eliminate many safety hazards in Iowa and other states, notably through the installation and upgrade of protective devices at public highway-railroad grade crossings. In Iowa, this has been demonstrated by an annual 4.2 percent trend line decrease in collisions at the state's public highway-railroad grade crossings from 1980 through 2009[2].

A collision between a motor vehicle and a train is generally considered 20 times more likely to result in a fatality than other highway collisions[3]. Grade crossing safety is therefore one of the primary missions of the Iowa Department of Transportation (Iowa DOT) Office of Rail Transportation, and the agency works to reduce the number of occurrences and severity of crashes at highway-railroad grade crossings in the state. Improvements in grade crossing safety for motorists, pedestrians, railroad employees, and others is a key initiative for Iowa DOT, as well as railroads and other highway jurisdictions that operate within the state. In 2012, Iowa DOT developed a *State of Iowa Highway-Rail Grade Crossing Safety Action Plan*, with the purpose of identifying an "action plan through analysis, discussion, and partnership, to lay a framework for continued reductions in collisions at Iowa's highway-rail grade crossings[4]." The state also has an active Operation Lifesaver chapter, which is a nonprofit program that educates and provides awareness in order to minimize tragic collisions, fatalities, and injuries at highway-railroad grade crossings in the State of Iowa[5].

The Iowa rail network is currently comprised of approximately 3,851 railroad route miles and is served by 18 railroads, including Class I (large) railroads, Class II (regional) railroads, and Class III (short line) railroads[6]. Amtrak also operates intercity and long-distance passenger trains over two routes in Iowa. These railroads intersect with the state's 114,000-mile public roadway network via grade separated crossings and at-grade highway-railroad crossings. According to Iowa DOT, about 43 percent of Iowa's highway-railroad grade crossings are equipped with active warning devices (such as flashing light signals, gates, or both) but that leaves almost 2,500 that are passively protected (meaning they only have traffic control signs and/or crossbucks to warn the public of the crossing).

[1] https://safety.fhwa.dot.gov/hsip/xings

[2] *State of Iowa Highway-Rail Grade Crossing Safety Action Plan* (Program for Implementation in Calendar Years 2012-2016), Iowa Department of Transportation Office of Rail Transportation, August 31, 2012

[3] Note that some federal and state agencies and past research have referred to accidents between trains and motor vehicles at highway-rail grade crossings as collisions or crashes. Both terms are therefore used interchangeably throughout this report, based on varying usage of terminology by these parties.

[4] Ibid.

[5] http://www.iowaoperationlifesaver.org/

[6] Iowa State Rail Plan, *Appendix A: Profile of Iowa's Railroad Network*, Iowa Department of Transportation, 2017

Per U.S. Federal Code (23 USC 130), each state is required to conduct and maintain a survey of all public-highway railroad grade crossings, establish and implement a schedule of projects, update public highway-railroad grade crossing inventories, and submit annual reports of their programs. The federal funding share for this program is 90 percent, and the State of Iowa receives and administers approximately $5.5 million annually through this program which is managed by Iowa DOT. The state's cities, counties, highway jurisdictions, and railroads are eligible to apply for Section 130 funds, and need to provide a non-federal funding match to fully fund projects that improve grade crossing safety. However, available Section 130 funding can only a limited number of safety improvements requested each year on the state's rail network.

Iowa DOT currently prioritizes safety improvement projects and funding through a benefit-cost analysis (BCA) methodology developed by department staff in 2006 (see Appendix A) and outlined in Iowa DOT's *Federal-Aid Railroad-Highway Grade Crossing Program – Use of a Benefit-Cost Ratio to Prioritize Projects for Funding*. The current evaluation methodology using the benefit-cost ratio includes highway and grade crossing characteristics, highway and train traffic, accident history, societal costs, and anticipated cost of improvements. The Iowa DOT Office of Rail Transportation realized that that there are other variables and approaches available that the current methodology does not include, and wanted to investigate if appropriate data and methods of analysis can be utilized to identify grade crossings in the state that are most in need of future improvements and would receive the most benefits from the limited Section 130 funding.

2.0 Research Background

The purpose of this *Develop and Improved Selection Methodology for Safety Improvements at Public Highway-Railroad Grade Crossings Report* developed by Iowa DOT and its consultant HDR is to conduct research and develop findings that will help to inform Iowa DOT of the most current approaches to identify and prioritize public highway-railroad grade crossing improvements which will aid in developing recommendations and actionable steps for implementing changes into Iowa's current prioritization methodology.

The anticipated research results and the tools developed during the project are expected to provide Iowa's highway authorities, railroads, and other stakeholders with an enhanced means of identifying needs and opportunities for potential improvements to the public highway-railroad grade crossings under their jurisdiction, and for potentially streamlining the process to pursue funds through Iowa DOT to develop these improvements. Iowa DOT can apply the anticipated research results and tools to drive internal processes and maximize the positive impact of Iowa's highway-railroad grade crossings safety program and its partnerships with the state's highway authorities and railroads.

The following potential benefits are expected from the research conducted and tools developed during the project undertaken by Iowa DOT and its consultant HDR:

- Improved identification of public highway-railroad grade crossing investment priorities in Iowa to drive increased value for the state's highway-railroad grade crossing safety program.
- Increased public safety at Iowa's public highway-railroad grade crossings, which is expected to reduce rates of fatalities, injuries, and property damage.
- Highway-railroad grade crossing safety program cost savings or synergies.
- Enhanced process efficiencies and leveraging of existing data from variable sources for the Iowa highway-railroad grade crossing safety program.

Enriched program coordination and cooperation between Iowa DOT and the state's roadway authorities and railroads, which would enhance meaningful and lasting communication between all parties with regard to the relative risks of public highway-railroad grade crossings and to encourage funding applications for the state's highway-railroad grade crossing safety program that would target the grade crossings that are potentially the greatest safety risk.

3.0 Research Approach and Objectives

The general approach and objectives for this Develop an Improved Selection Methodology for Safety Improvements at Public Highway-Railroad Grade Crossings project consists of the following components, as follows:

- An assessment of Iowa DOT's current methodology and related processes and policies for maintaining the Section 130 program and the internal and external process for identifying and prioritizing investment for grade crossing improvements statewide through interviews and ongoing coordination with several Iowa DOT offices and staff; a survey of select Iowa highway-rail grade crossing stakeholders to ascertain opportunities to improve the methodology and approach to grade crossing investment in Iowa; and engagement with a Technical Advisory Committee (TAC) consisting of Iowa highway-rail grade crossing stakeholders that was established by Iowa DOT to guide the project.
- A literature review of representative current research and methodologies to identify methods, approaches, best practices, and innovative strategies used by other state DOTs and public agencies for modeling grade crossing hazard ranking and identification and prioritization of grade crossing improvements related to active warning devices and other measures.
- Coordination with one Class I railroad serving Iowa and one state DOT to gain an in-depth understanding about their processes and methodology for prioritizing grade crossing investment.
- Develop recommendations for actionable steps for implementing changes into Iowa's current prioritization methodology and developing related tools for achieving the desired improvements through coordination with Iowa DOT, the TAC, and Iowa DOT's consultant, HDR.

Additional details related to the research approach and related workplan tasks developed for this project are identified in later sections of this report.

4.0 Summary of Iowa's Federal Highway-Railroad Grade Crossings (Section 130) Program

As background, Table 1 below provides general details about the Federal Highway-Railroad Grade Crossings (Section 130) Program currently administered by the State of Iowa and managed by Iowa DOT.

Table 1: General Summary of Iowa's Federal Highway-Railroad Grade Crossings (Section 130) Program

Program Intent and General Background	Summary below: ▪ This federally funded program improves safety of public highway-railroad grade crossings. The federal funds are authorized in Title 23 United States Code (23 USC Section 130) and most recently reauthorized in Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU). ▪ The Federal Highway Administration (FHWA) distributes Section 130 funds, and the Iowa DOT Office of Rail Transportation administers those funds. ▪ Typical upgrades include enhancements to existing grade crossing active warning infrastructure (i.e. adding gates to a crossing with flashing light signals) or improvements that upgrade a passive grade crossing with active warning devices (i.e. installing flashing light signals). ***Section 130 funding is not currently used to fund grade crossing separations.***
Funding Eligibility	The program is application-based and railroad companies and public road jurisdictions statewide (including cities, counties, or the state) can participate. Because both parties have a vested interest, both the highway authority and the railroad must agree on any improvement, including the type of improvement and the cost that will be borne by each party.
Funding Qualifications	Summary below: ▪ 10 percent non-federal match required (from the railroad company and/or public road jurisdictions); note that the Section 130 funds provide 90 percent funding for each improvement project. ▪ Inclusion of crossing location on a prioritized list of projects. Priorities are determined through a benefit-cost analysis that takes into consideration the extent of vehicle and train traffic at the crossing, speed of trains, certain characteristics of the crossing, effectiveness of the proposed improvement, estimated cost of improvement, and other factors. Generally, those crossings with a high probability for a serious crash with a proposed improvement anticipated to be effective and cost efficient will receive the highest priority.
Type of Submittal Required	Form provided by Iowa DOT.
Application Deadline	July 1 of each year
Type of Approval Required	Iowa DOT staff recommendation with Iowa Transportation Commission (ITC) approval.
Average Length of Time for Acceptance Decision	Nine months

Program's Annual Funding Level	Approximately $5.5 million
For More Information / Applications	Iowa Department of Transportation Office of Rail Transportation 800 Lincoln Way Ames, IA 50010 (515) 239-1549 www.iowarail.com

Sources: Iowa DOT Guide to Transportation Funding Programs of Interest to Local Governments and Others; January 2017; Iowa DOT Office of Rail Transportation web site, accessed November 3, 2017; https://iowadot.gov/iowarail/highway-railroad-crossings/about-crossings

5.0 Summary and Evaluation of Current Iowa DOT Methodology to Identify and Prioritize Grade Crossing Investment

This section summarizes and evaluates the current Iowa DOT methodology to identify and prioritize grade crossing investment in the state via the Section 130 program.

5.1 Summary

Iowa DOT currently prioritizes safety improvement projects and funding through a benefit-cost analysis (BCA) methodology developed by department personnel in 2006 and outlined in Iowa DOT's *Federal-Aid Railroad-Highway Grade Crossing Program – Use of a Benefit-Cost Ratio to Prioritize Projects for Funding*.

Funding for highway-railroad grade crossing improvements is application-based and eligible applicants include railroad and highway jurisdictions. In order to best maximize public funds, Iowa DOT uses a benefit-cost approach developed in 2006 to prioritize investments at public highway-railroad grade crossings. Top priority projects must exceed a determined predicted accident threshold of 0.075 accidents per year in order to be considered for further benefit-cost evaluation. Once funding is allocated to the top priority projects, crossings with a predicted accident rate less than 0.075 are considered for potential improvements.

The benefit-cost approach takes into account collision severity and overall effectiveness over a project lifecycle to determine net societal benefits. The calculation of benefits and costs involves various highway and railroad characteristics including vehicle and train traffic, number of highway lanes and railroad tracks, accident history and costs, and the anticipated cost of improvements. Project benefits are realized through effectiveness, which is defined as the reduction in the accident rate. Iowa DOT determined the accident effectiveness factors, by proposed improvement type, that are used in calculating benefits. Benefits are then compared against total social costs to determine a benefit-cost ratio. Total social costs include the anticipated cost of improvements, specifically capital and yearly maintenance costs of new grade crossing warning devices, and accident costs by severity type. A benefit-cost ratio greater than one (1.0) signals that a project is feasible and produces positive net societal benefits.

5.2 Description of Current Methodology

The benefit-cost methodology begins with a calculation of exposure which captures the probability of a vehicle-train traffic conflict. Exposure considers vehicle and train traffic based on the time of day as well as a constant in its calculations to better reflect highway-railroad traffic conflicts. The calculated exposure factor ultimately informs a calculation of predicted accidents that takes into account additional highway and railroad crossing characteristics, type of grade crossing warning device, accident history, and a factor for the number of daily through trains that operate in the crossing. Typically, projects that receive top priority are those with a predicted accident threshold of at least 0.075 accidents per year.

Predicted accidents are then used to calculate collision severity. Specifically, predicted fatalities, injuries, and property damage only (PDO) collisions are determined. The use of collision severity considers various railroad characteristics such as the maximum timetable speed for railroad operations, number of railroad tracks, and switch (local) and through train movements that operate in the crossing. Furthermore, the calculation takes into account whether the crossing is within an urban or rural location. The collision predictions by severity type are ultimately used to determine the annual social costs of accidents. Accident costs are calculated based upon fatality and injury rates determined by historical collision data and recommended values for the cost of collisions by severity type. Annual societal costs of accidents are calculated by multiplying predicted fatal and injury collisions with respective costs. The calculation assumes that every collision involves property damage.

Benefits are realized through a reduction in the accident rate which is defined as the effectiveness factor. Iowa DOT has determined the effectiveness factors, by proposed grade crossing improvement type, that are used in calculating benefits. These effectiveness factors are drawn largely from the Federal Railroad Administration (FRA) GradeDec model, but some factors have been developed specifically for Iowa. The annual benefit is calculated by multiplying the annual societal cost with the appropriate effectiveness factor. Benefits over the project lifecycle are determined by taking the product of annual benefits and the assumed lifespan of crossing improvements, which is 25 years. Total project costs include capital and yearly maintenance costs of new grade crossing warning devices. The final step of the methodology involves the calculation of the benefit-cost ratio which is the ratio between total benefits and total costs.

In using a benefit-cost analysis approach, Iowa DOT's intent is to prioritize limited funding and maximize public benefits. The approach further allows Iowa DOT to target specific grade crossings that are most likely to experience a fatality, rather than examining total collisions.

Additional details about the methodology currently used by Iowa DOT can be found in Iowa DOT's *Federal-Aid Railroad-Highway Grade Crossing Program – Use of a Benefit-Cost Ratio to Prioritize Projects for Funding* in Appendix A.

5.3 Evaluation of Current Methodology

The following represents HDR's evaluation of the Iowa DOT's current methodology for highway-railroad grade crossing evaluation and prioritization. This evaluation is primarily based on the interview of key staff at the Iowa DOT, stakeholder survey respondents, literature review, interviews, and investigation of the existing process results. Due to the scope of this study, this evaluation is focused on the methodology and largely avoids evaluating process and policy issues, except in cases when they may directly impact the project outcome.

Data timeliness, reliability, and completeness were not maintained – Iowa DOT is undertaking a systematic field inventory and database update of public highway-railroad crossings in Iowa. This on-going effort has brought to the forefront some of the issues with the current data systems, including those of the Iowa DOT and FRA. Note that the Iowa DOT's systematic field inventory eventually becomes part of the Iowa DOT's Roadway Asset Management System (RAMS). When updating RAMS, the Iowa DOT also updates the FRA data fields in the FRA highway-railroad grade crossing database that they have access to. Keeping current field inventory information in RAMS allows the Iowa DOT to integrate the highway-railroad grade crossing inventory data with other DOT data sets (such as traffic volumes) that are routinely updated.

- **POTENTIAL ACTION:** Continue systematic field inventory of all public grade crossings and maintenance of database. Future analytical systems should be based on in-house data that the Iowa DOT controls.

The list of countermeasures is not comprehensive and crash costs are inconsistent with latest practices – There has been no review or updates to the list of countermeasures, their effectiveness, or cost to implement since development of the current Iowa DOT methodology in 2006. The list of countermeasures considered by the process is limited to upgrading to lights, gates, medians, and constant warning time, which means the generated projects shared with the owning road authority do not consider the full scope of potential recommendations. Furthermore, crash costs do not reflect current values and are likely inconsistent with values used by other Iowa DOT offices. For example, the value per fatality ($1 million) is significantly below current U.S. DOT guidance of $9.6 million. The injury value is estimated as double the highway value – a more precise value may be estimated. In addition, the property damage value is based on highway values. A highway-rail grade-crossing specific value (which is higher) is available from a recent National Cooperative Highway Research Program (NCHRP) report.

- **POTENTIAL ACTION:** Even if the methodology and models were to remain as they currently exist, updates to key values used in the analysis are needed and would need to be adjusted for inflation and other factors in the years after the new values have been published.

Benefit-cost ratio approach does not follow best practices – The current benefit-cost approach does not include discounting of future benefits. These benefits should be discounted to bring them into present values. The calculation of benefits does not consider the potential growth in traffic in future years. While this may not be a big factor in rural areas, it may underestimate the benefits for some highway-rail grade crossings. The benefit-cost calculation includes safety benefits. Other benefits, such as delay savings and emissions are not included, but they may not be applicable for the crossing types being considered.

- **POTENTIAL ACTION:** The benefit-cost approach should be modified to reflect best practices.

The GradeDec formula (FRA requirement for data and methods) may not be the best predictor of highway-rail grade crossing accidents and exposure – The formula emphasizes accident history as part of the calculations. It may underestimate potential accidents for crossings with no accident history, but hazards present.

- **POTENTIAL ACTION:** Iowa DOT may consider adopting an accident prediction formula consistent with the hazard index that best matches the expert panel selections.

Field reviews and diagnostic are often completed late in the process – The current process relies on the owning road authority to complete a field review to verify the recommended project before submitting a Section 130 grant application. However, 33 percent of respondents to a stakeholder survey conducted for the project (more details on that work later in the report) believe that Iowa DOT provides all the information needed for the application and only 6 percent thought they needed to complete a field visit as part of the application process. This illustrates that few applications likely included any sort of field verification; a step the Iowa DOT considers to be very important. The Iowa DOT's own field diagnostic occurs after projects are selected, so any issues that may impact the selected project (or even alternative solutions) are unknown until it is too late to change the project. Note that other process recommendations are provided in Section 4 of this report.

- **POTENTIAL ACTION:** For locations with the highest safety scores, Iowa DOT should send qualified staff to complete a field review and diagnostic prior to sending lists identifying grade crossings for potential improvements to local agencies and other highway-railroad grade crossing stakeholders.

The program places an emphasis on a narrow number of grade crossings – An evaluation of the output from the existing system and methodology identified only 28 highway-railroad grade crossings with a crash prediction at or above 0.075 crashes per year, which is the threshold for a crossing to be considered in the top tier for funding. However, the distribution of crashes reveals that most crashes were at crossings with a crash prediction at or above 0.030. Furthermore, many of these locations' potential improvement projects have benefit-cost ratios that still exceed 1.0. Note that this evaluation was based on the current methodology, including the existing crash prediction formula and benefit-cost calculations.

- **POTENTIAL ACTION:** Evaluate the threshold that identifies crossings that have the greatest need for safety investment. One alternative is to keep a single threshold, but lowering the threshold to include more locations. Another alternative would be to create a second tier of candidates by setting a second threshold.

6.0 Research Plan and Findings

HDR's research plan and analysis approach relied on key interviews and ongoing coordination with Iowa DOT staff, a stakeholder survey, a Class I railroad presentation, interview of another state DOT, and literature review of relevant research to identify the greatest needs for the Iowa DOT Office of Rail Transportation; discover cost-effective opportunities that can maximize benefits to the Public Highway-Railroad Grade Crossing Program (Section 130) in Iowa; and to create tools that the Iowa DOT Office of Rail Transportation can use in the future. This section describes the approach used for the research and related analysis undertaken for this project and identifies any findings and conclusions that resulted.

6.1 Iowa DOT Project Kick-Off Meeting, Working Session Interviews, and Subsequent Coordination

HDR interviewed Iowa DOT staff from various departments that are engaged in supporting the Section 130 program to better understand the current benefit-cost methodology used to identify and prioritize grade crossing improvement projects, identify datasets Iowa DOT possesses and to understand what is (and is not) available for revising the process, confirm Section 130 approach and coordination, and to identify potential opportunities to improve the methodology used to prioritize improvements. Another purpose of the discussion was for HDR to learn more about Iowa DOT's process to facilitate the Section 130 program and for potential process improvements Iowa DOT can make actionable in the future.

The project Kick-Off Meeting and Working Session Interviews took place at Iowa DOT offices in Ames, Iowa, on September 7, 2017. HDR interviewed Iowa DOT staff representatives from the following offices:

- Office of Rail Transportation
- Office of Research and Analytics
- Office of Performance and Technology
- Information Technology
- Secondary Roads Research Engineer

HDR provided a list of potential Kick-Off Meeting and Working Session Interview discussion topics to Iowa DOT in advance of the coordination. A capture of that discussion and related findings, grouped generally by topic, as well as clarification and additional information and resources provided by Iowa DOT staff via subsequent coordination during September-December 2017, follows below.

Data Collection, Responsibility, and Maintenance

HDR asked Iowa DOT what data is used to either identify locations that are a priority for improvement and/or used to select/evaluate the improvement; who in Iowa DOT collects the data, how often is it collected, and who maintains it; and for a comparison of Federal Railroad Administration (FRA) data and methods to that which is currently used by Iowa DOT.

- Iowa DOT said that the Iowa grade crossing database it maintains only includes grade crossing data collected by Iowa DOT during the ongoing grade crossing inventory process and FRA data.
- The former Iowa grade crossing inventory was based on a previous FRA Highway-Rail Grade Crossing Accident/Incident Report Form that changed a few years ago. The new Iowa grade crossing database in the Iowa DOT Roadway Asset Management System (RAMS) matches the new FRA form and data. To populate the new Iowa database, it was initially mapped from the old database, but because the new form has some new fields, some of the columns in the RAMS database are missing data. FRA rail accident data from FRA is available every quarter and Iowa DOT downloads crashes from FRA each month and imports into Microsoft Access. Iowa DOT may make slight format modifications to the data. The data is exported to text and imported into Oracle for the current Iowa DOT grade crossing methodology tool to process. Iowa DOT developed a *Highway-Railroad Crossing Inventory Field Guide, Anatomy of a Crossing* document, and *Fulcrum User's Manual* in 2017 to support the data collection process in the field.
- Iowa DOT is completing field review and inventory of grade crossings in the state to update the database, on a three-year cycle. Field staff collect data on a railroad crossing inventory form in a Fulcrum Application on a portable iPad device. In 2016, about one-third of crossings were inventoried, and the plan is to complete one-third of the field inventories in summer 2017, and complete one-third of the field inventories in summer 2018. The data collected during this exercise is updated into the grade crossing inventory as staff time permits, and data entry takes approximately 10 minutes per crossing. Iowa DOT said there are approximately 4,835 public grade crossings in the state, and that "clean records" had been entered into the Iowa grade crossings database in RAMS for approximately 1,019 crossings as of September 7, 2017; the database for all of Polk County (Des Moines) and about 20 other Iowa counties was recently completed. Iowa DOT's preference is for any tools developed during the project to use "clean data" only. Iowa DOT noted that the grade crossing inventory includes grade separated crossings, and that the RAMS database also has data pertaining to the entire 114,000-mile public roadway network statewide, including pavement surface, number of lanes, and other characteristics. Iowa DOT noted that some of the "unclean records" show discrepancies in crossbuck counts between the FRA grade crossing data and the data acquired by Iowa DOT during the inventory, at some grade crossings.
- Iowa DOT noted that many of the state's railroads either do not provide data for the FRA grade crossing database or they don't provide it at regular intervals. Iowa DOT noted that only a railroad can add a new crossing or modify a crossing record in the FRA grade crossing database. Iowa DOT does not receive notice when a railroad adds or modifies a grade crossing record. Iowa DOT also noted that the data contained within the FRA grade crossing database may not reflect the most recent conditions at some Iowa grade crossings.

- Iowa DOT said that sidewalk data is being collected for the Iowa grade crossing inventory, but that it is not part of the FRA grade crossing inventory. This data is not yet being entered into Iowa grade crossing database on RAMS.
- Iowa DOT said that the Iowa grade crossing database does not include data about the length and width of grade crossings.
- Iowa DOT said that in terms of photo documentation to accompany its grade crossing inventory, it has images on the road looking at train crossing in both directions and photos looking down the track at each location.
- Iowa DOT said that there are some other fields in the Iowa grade crossing database that are not updated by the inventory, including school bus routes and emergency routes. Iowa DOT is currently working to get the data from the state's school districts (approximately 90 out of over 200 school districts had responded as of September 7, 2017).
- Iowa DOT said that the state traffic database automatically updates the state grade crossing database.
- Iowa DOT confirmed that it had FRA rail accident data / crash data from 2017 back to 1975, which totaled approximately 5,818 records.
- Iowa DOT said that the FRA rail accident data / crash data resides in the Iowa DOT database and it downloads from the 10-year tab. Iowa DOT said it believes it only keeps data for 10 years but will check if they keep only 10 years or if they are appending new data.
- Iowa DOT said that FRA accident data / crash data is available through the FRA website, and that it can also work internally to provide HDR with data it is using to update the grade crossing database.
- Iowa DOT said that it has available traffic data by truck type. Iowa DOT also expressed concern with short-queue storage of trucks near grade crossings and wondered if there is a way to incorporate that factor.
- Iowa DOT said consultation of the FRA guidelines on state grade crossing inventory and collection manual can be reviewed to better understand what data Iowa DOT is responsible for and how it is collected.
- Iowa DOT identified other data sources it is seeking to potentially include in an improved methodology, including sight restriction data (it was noted that North Carolina DOT did a full Light Detection and Ranging (LiDAR) survey for all grade crossings in its state) and complete documentation of Iowa grade crossings; Iowa DOT noted that its new grade crossing inventory does not presently include dimensional data at crossings (i.e. width and length of grade crossing panels and surface).
- Iowa DOT said it will decide internally who will update the database and how it will be maintained. At this time, Iowa DOT anticipates doing grade crossing field inventories on a three-year cycle.
- Iowa DOT said that the current data management process could be improved and made more organized and efficient.
- Iowa DOT will provide HDR with required data and resources and access to Iowa DOT databases to support project research.

Methods / Tools Used to Analyze Data and Identify Locations that are a High Priority for Improvements

HDR inquired about the data and tools used for the benefit-cost based approach to the Section 130 program and the related process for sustaining it.

- Iowa DOT said that the Iowa grade crossing inventory and FRA data is used to make a cursory view in an Oracle procedure.
- Of the Oracle report, Iowa DOT said:
  - Oracle procedure that uses the data and steps listed in the Iowa DOT's 2006 *Federal-Aid Railroad-Highway Grade Crossing Program Use of a Benefit-Cost Ratio to Prioritize Projects for Funding* (the current Iowa DOT methodology).
  - The exponents and constants have been updated by FRA approximately four times since the 2006 release of Iowa DOT's current methodology, but would need to confirm if anyone in Iowa DOT had updated any of the exponents and constants in the Oracle procedure.
- Iowa DOT wondered if it is feasible to create a state model, and if it is worthwhile to do this given the small number of railroad crossing crashes that occur in Iowa each year (about 50).
- The current process generates a printed report from the Oracle procedure that goes to the Iowa DOT Office of Rail Transportation, and is used in the annual letter and list that Iowa DOT sends to the cities, counties, highway agencies, and railroads. The letter and list includes an announcement of availability of and the process for applying for Section 130 funding and a table that has the score and a benefit-cost rating for all grade crossings in their applicable jurisdictions. The specific outputs are *Pa* (predicted accidents or crashes) and *BCR* (benefit-cost ratio). Process assumes upgrading of the grade crossing to the next level of protection as per FRA and FHWA Manual on Uniform Traffic Control Devices (MUTCD) guidance; for example, active warning device upgrade from flashing light signals only to flashing light signals and gates. Applicants can then apply for grant funding for either a grade crossing identified on the annual list sent by Iowa DOT or another grade crossing, if it is not included on the list. Local highway jurisdictions are also encouraged to field investigate grade crossings with limited sight distance. Iowa DOT will provide HDR with a sample annual letter and report and a full sample statewide report.
- Iowa DOT suggested that a process could be developed to walk away from a grade crossing project if what is observed in the field during a grade crossing diagnostic doesn't match the data. The current process doesn't allow Iowa DOT to walk away from a project where the crash prediction and benefit-cost ratio numbers are high.
- Iowa DOT has conducted line segment reviews in the past, which generally involves completion of a field diagnostic and benefit-cost analysis for various grade crossings in a rail corridor. These are precipitated on discrete line segments in the state for various reasons, including development of a new ethanol plant, implementation of Quiet Zones, report from a farmer indicating that it is unsafe to move farm equipment across tracks, crash events, and other conditions. This approach still requires a city, county, highway agency, or railroad to submit a funding application, but since they participate in the line

segment review they typically approve of the proposed improvements. Iowa DOT has not conducted a line segment review for several years.

- Iowa DOT understands that not all datasets are complete or may provide much value in terms of ranking grade crossings in the prioritization tool. Iowa DOT would like the HDR to identify in the report for the study datasets that are available and incomplete or that are not currently available but would be potentially worth incorporating into the prioritization spreadsheet in the future (i.e., risk factors for rail lines carrying crude by rail and ethanol, passenger rail routes, etc.).
- Iowa DOT said that county volumes are low and their grade crossings are often low on the prioritization ranking until a crash happens.
- Iowa DOT said that local agencies often don't pay attention to many grade crossings until someone or some event draws their attention to it, and that there are many misconceptions about who owns and maintains grade crossing signals. Iowa DOT could potentially identify a concise and high-level "myths and facts" educational discussion that could also be provided by Iowa DOT to potential applicants annually, along with the letter, report, and application.
- Iowa DOT said that some potential improvements to the methodology tool could include change of threshold, new monetization values, and new benefit categories.
- Iowa DOT Office of Rail Transportation said that its initial preference would be to have a tool internal to their office that they run without having to work through other Iowa DOT offices. Iowa DOT said that it prefers an Excel spreadsheet with a parameters section, and one that is page protected and capable of facilitating a batch process. It was noted that when Microsoft (MS) Excel (and other programs) are updated for future use, that macros may no longer work. Iowa DOT said that further internal discussion is required to ascertain who would fix the template in that instance, and whether or not the prioritization tool would be Excel or Oracle based. Iowa DOT will keep HDR apprised of those discussions as the project matures. HDR said that regardless of Iowa DOT's preferred approach for the prioritization tool deliverable that it would develop a base MS Excel spreadsheet to test the efficacy of its approach and methods.
- Iowa DOT will provide HDR with required data and resources and access to Iowa DOT databases to support project research.

Benefit-Cost Factors and Accident Rates

HDR inquired about the data (including accident rates) and tools used for the benefit-cost based approach to the Section 130 program and the related process for sustaining it.

- HDR said that it could potentially develop a diagnostic graph for the 0.075 threshold of FRA crash prediction, and said that different thresholds could be evaluated for rural versus urban and passive versus active grade crossings during the study.
- Iowa DOT downloads crash data from the Federal Railroad Administration database quarterly, and incorporates it into the existing prioritization tool.
- Iowa DOT receives grade crossing near-miss reports by grade crossing from some railroads in the state (including BNSF Railway [BNSF], Canadian Pacific Railway [CP], and Union Pacific Railroad [UP]) but these are incomplete and not incorporated into the grade

crossing inventory. Iowa DOT receives broken gate and Unsafe Motorist and Pedestrian reports only from UP on an intermittent basis. There is currently no policy that focuses on severe crashes, total crashes, etc.

- Iowa DOT said that if a data type is going to be used in the improved methodology/process, then Iowa DOT has to be able to get the data from/for all the railroads in the state in order to assure consistency.
- Iowa DOT said the 0.075 threshold (or other factor) is important because it is used to tell the county/city they need to look at the location and consider seeking funding for improvements.
- Iowa DOT said that if the Iowa DOT methodology remains a benefit-cost based approach, the tool will need an easy method to change all coefficients and constants.
- Iowa DOT said that the current methodology uses the economic values (societal costs) for fatality, injury, and property damage as noted below, and may need to be adjusted to match the any updated values indicated in U.S. DOT guidance for such analysis:
    - Fatalities – $4,500,000
    - Major Injuries – $325,000
    - Minor Injuries – $65,000
    - Possible Injuries – $35,000
    - Property Damage – $26,000
- Iowa DOT said that more information regarding the current approach to developing benefit-cost calculations and predicted-accident calculations for grade crossing investments could be found in the Iowa DOT's 2006 *Federal-Aid Railroad-Highway Grade Crossing Program Use of a Benefit-Cost Ratio to Prioritize Projects for Funding* (the current Iowa DOT methodology).

Iowa DOT Evaluation of Section 130 Applications, Agency Coordination, and Project Selection for Funding

HDR inquired about the evaluation and selection for funding of Section 130 applications and related coordination between Iowa DOT and applicant agencies.

- Iowa DOT said that Section 130 funding is not currently used to fund grade crossing separations; rather, it is used primarily to upgrade active warning devices and related appurtenances only.
- Iowa DOT provided a concise Section 130 annual program schedule and local agency coordination, as follows:
    - Letter, crossing report identifying and prioritizing grade crossings in jurisdiction by benefit-cost ratio, and Section 130 grant application goes out to potential eligible applicants in October of each year.
    - Completed applications from eligible parties are due to Iowa DOT in June of the following year. This schedule provides for coordination between the city/county, highway jurisdiction, and railroad and development of the application.
    - List of recommended projects selected by Iowa DOT goes to the Iowa Transportation Commission (ITC) during September-October.
    - List of projects awarded Section 130 funding sent to applicants in October.

- Diagnostics for grade crossings receiving funding is performed after ITC approval of projects.

- The current process to select and fund projects at Iowa DOT is to start at the top of the list of grant applications and provide funding for the grade crossing with the highest benefit-cost ratio and work down the list from top to bottom until the funding for the year is exhausted. There are instances in which two separate safety improvements could be identified for the same crossing in the same year (i.e., one improvement to install flashing light signals and another to install gates). For subsequent years, some applications, but not all, were able to be recalculated using newer information.
- Iowa DOT said that eligible past and funded or pending Section 130 funding applications are stored electronically and that unfunded applications are deleted only if the applicant requests that it be withdrawn.
- Iowa DOT said that the methodology to identify and prioritize grade crossing improvements needs to heavily consider the insights and outputs gained from grade crossing field diagnostics conducted by Iowa DOT and coordinated with the railroads, and should have weight in the final determination, rather than relying solely on the present top-to-bottom benefit-cost ratio approach. One of the problems with the current process, according to Iowa DOT, is that the highway authorities and the railroads are expected to do a grade crossing diagnostic, but these generally do not occur before the application is submitted. In some cases, the diagnostic may not be done or could be done by someone not properly trained/qualified. Iowa DOT said the grade crossing field diagnostic occurs after the Iowa Transportation Commission (ITC) approves the project. While in the field, the Iowa DOT may discover site issues and other general considerations that do not appear in the current methodology formula and those crossings can still be awarded the Section 130 funds. In order for this to occur, consensus would have to be built with the local highway agency.
- Iowa DOT said that better guidance in diagnostic is needed in order to identify when a grade separation is needed.
- Iowa DOT wondered the value of making the spreadsheet prioritization tool available to the local agencies. Iowa DOT thought that providing the spreadsheet tool to the agencies might encourage them to do some field work and help them with project application submittals. Iowa DOT said that any improved Iowa DOT grade crossing methodology should be simple and easy for applicants to understand and use.
- Iowa DOT said that the local agency coordination process should have the ability to provide feedback to the counties, cities, and railroads to let them know the status of their Section 130 applications. Iowa DOT said that the project prioritization tool should have a status level in the process. For example, when sending the list to each agency or railroad, place a flag on the crossing identification to show if it has an application pending. Iowa DOT suggested that the status of pending applications should be communicated to all related city/county and railroad representatives, and particularly every three years or more frequently, if possible, as there are no "stale dates" for applications under the current process.

- Iowa DOT said that Iowa is not a regulatory state which means the Iowa DOT cannot make a local agency implement projects. Iowa DOT can encourage project development, but the local agency may resist if they do not want to come up with the 10 percent non-federal match required to secure Section 130 funding.
- Iowa DOT said the 0.075 threshold (or other factor) is important because it is used to tell the county/city they need to look at the location and consider seeking funding for improvements. Some cities don't want the improvements and application for Section 130 funding can't go in even if the railroad is willing to pay for it. Since the Iowa DOT cannot order the highway agency to make the improvement, the Iowa DOT needs tools to convince people.
- Iowa DOT said that backlog for Section 130 projects is approximately $35 million, but some of the applications are up to 30 years old, and in many cases, a present city council member or county commissioner may have no idea of a pending older application for funding is still on the list maintained by Iowa DOT. Iowa DOT suggested that one improvement to the process could be to set an expiration on application (shorter-term applicability, like 5 years) or provide for annual coordination with applicants to inform them of application status. Iowa DOT said that project values on the funding applications are largely developed from conceptual high-level estimates generated by the railroads and may be too low or too high and that refined estimates are needed.
- Iowa DOT suggested that HDR review *National Cooperative Highway Research Program (NCHRP) Report 50 – Factors Influencing Safety at Highway-Rail Crossings* regarding potential approaches to prioritize grade separations and develop a tool for local and corridor level analysis.

6.2 Stakeholder Survey

The Iowa DOT Office of Rail Transportation conducted a five-year review of all of its administrative rule chapters in compliance with Iowa law and in April 2017 sought comments from select statewide stakeholders on questions regarding the rules and practices related to highway-railroad grade crossing improvements in the state enumerated in Iowa Code 761-811 (Highway-Railroad Grade Crossing Warning Devices), Iowa Code 761-812 (Classifications and Standards for Highway-Railroad Grade Crossings), and PPM 500.09 (Federal Aid Section 130 Railroad-Highway Safety Program). Iowa DOT also reported to stakeholders that it would conduct research about the Section 130 program and the methodology used to identify and prioritize grade crossing projects starting later in 2017 which could potentially provide future changes to Iowa Code 761-812 (Classifications and Standards for Highway-Railroad Grade Crossings) as well as internal Iowa DOT policy guiding the implementation of the Section 130 program (PPM 500.09). The input from responding cities and railroads in the state gathered during this initial outreach process in April-May 2017 was used to inform the scope of future research and stakeholder outreach conducted by Iowa DOT and its consultant HDR during this study.

As part of the study of the current Section 130 program and grade crossing methodology used by Iowa DOT to identify and prioritize grade crossing improvements, the Iowa DOT Office of Rail Transportation conducted an electronic survey of statewide stakeholders who are responsible for maintaining existing crossings and who are eligible to apply for Section 130 funding in Iowa. These stakeholders identified by Iowa DOT in October 2017 included representatives of cities, counties, highway jurisdictions, and railroads statewide. The survey was facilitated by HDR and provided the opportunity for a recent stakeholder assessment of the Section 130 program and the adequacies and inadequacies of the current Iowa process; solicitation of inputs into the data, methodology, and analysis presently used by the program; and identification of any potential program improvements and safety concerns for the future. Stakeholders were notified of the survey by Iowa DOT via a broadcast email sent by Iowa DOT on October 27, 2017. The stakeholders were provided 14 calendar days to participate and the survey period was from October 27 to November 10, 2017, inclusive. The survey was facilitated by HDR on an electronic Survey Monkey platform located as this web link. HDR developed an introduction and a concise set of questions and related survey logic for the survey with Iowa DOT review and input during October 2017 and these can be found in the following section.

Stakeholder Survey Introduction, Questions, and Format

Introductory Survey Slide: The Iowa Department of Transportation (Iowa DOT) administers Federal Highway-Railroad Grade Crossings Program (Section 130) funding for use in improving highway-railroad grade crossings and related infrastructure statewide. The program grants approximately $5.5 million annually. Iowa DOT is conducting an electronic survey of stakeholders to assess the Section 130 program, project selection, and any potential improvements to the program. Iowa DOT appreciates your participation in this short survey that follows.
[No user response required.]

1. **Each October, cities, counties, and railroads in Iowa receive a list of at-grade highway-railroad crossings within their jurisdiction along with instructions on how to submit a Section 130 grant application to fund grade crossing improvements. How familiar are you with:**
    - The list your agency receives each October
    - How at-grade crossings are evaluated and ranked for your agency
    - The process to submit a grant application
    - The projects your agency has already submitted for funding
    - How projects for funding are selected
    - What happens to projects that are not selected for funding

    [Each question has three options ranging from Very Familiar to Not Familiar. User selects the level he/she wants to report. Purpose is to help Iowa DOT determine how much stakeholder education may be needed in the future.]

2. **Has your agency applied for Section 130 funding?** ***[Response Required]***
    - No *[Survey Logic – If selected, skip to Question 4]*
    - Yes – in the last year
    - Yes – 1 to 5 years ago
    - Yes – more than 5 years ago
    - Unsure *[Survey Logic – If selected, skip to Question 5]*

[Uses radio button where user can select only one option.]

3. **Was your last project application selected for funding?**
    - Yes
    - No
    - Unsure
    - Other (with box to provide explanation)

    [Uses radio button where user can select only one option.]

4. **Please explain why you haven't applied for a grant application. (Select all that apply)**
    - Unaware (i.e., did not know I could submit grant applications).
    - Don't understand the process.
    - Too busy to complete application.
    - Don't think there is a safety problem in my area.
    - Unwilling to provide the 10 percent funding match required by the program because we don't think it is our responsibility to upgrade the grade crossing.
    - Unable to provide the 10 percent funding match required by the program because of greater needs elsewhere.
    - Elected officials do not support project.
    - Other (with box to supply response.)

    [Uses check boxes where more than one can be selected.]

5. **Do you know what makes for a good application to the Section 130 program?**
    - Yes
    - No
    - Unsure
    - Other (with box to provide explanation)

    [Uses radio button where user can select only one option.]

6. **In your experience with the Section 130 program in Iowa, are the at-grade crossings with the greatest need for improvement generally ranked the highest?**
    - No
    - Yes
    - Unsure
    - Other (with box to provide explanation)

    [Uses radio button where user can select only one option.]

7. **How important are the following to identify and prioritize eligible grade crossings in the state for Section 130 funding? *Assess each option on a scale of 1-5.***
    - Amount of highway traffic.
    - Amount of train traffic.
    - Amount of pedestrian traffic.

- Cost of the upgrade.
- Benefit-cost ratio for the improvement.
- Crashes at the crossing.
- Public safety (e.g., routes important for fire department and EMS providers; school bus routes).
- Other public benefits (e.g., traffic delays and emissions).
- Site considerations (e.g., sidewalks, proximity to school or business, etc.).
- Limited sight distance.
- Other *(with box to provide explanation).*

[Each question has five options ranging from Very Important to Not Important. User selects the level he/she wants to report.]

8. **What should be the single most important factor used to identify and prioritize eligible grade crossings in the state for Section 130 funding? *(Select only one)***
    - Amount of highway traffic.
    - Amount of train traffic.
    - Amount of pedestrian traffic.
    - Cost of the grade crossing upgrade.
    - Benefit-cost ratio for the improvement.
    - Crashes at the crossing.
    - Public safety (e.g., routes important for fire department and EMS providers; school bus routes).
    - Other public benefits (e.g., traffic delays and emissions).
    - Site considerations (e.g., sidewalks, proximity to school or business, etc.).
    - Limited sight distance.
    - Unsure.
    - Other *(with box to provide explanation).*

    [Uses radio button where user can select only one option.]

9. **What kinds of data do you need to collect to support an application for Section 130 funding?**
    - None, all is provided by Iowa DOT.
    - Basic information on project location, traffic, and current conditions.
    - Local knowledge of activities or behaviors near crossing.
    - Unsure.
    - Data from a grade crossing field visit. Information collected during the field visit includes the following: (with box to provide explanation)

    [Uses radio button where user can select only one option.]

10. **If your agency has applied for Section 130 funding, how could Iowa DOT enhance their communication practices with you during...**
    - The grant application process?
    - The application selection process?

o The engineering, design, and construction of approved projects? None
[Each has a box to provide explanation.]

11. **Are you interested in providing further direction and input on this study and serve on a Technical Advisory Committee (TAC) to offer stakeholder guidance? It is anticipated that serving on the TAC will involve reading some technical papers and three to four conference calls over the next six months. *[Response required.]***
    - o Yes
    - o No *[Survey Logic– If selected, skip to Question 13]*
    - o Unsure

    [Uses a yes/no check box. If "yes," open a text box to provide contact information.]

12. **Thank you for your interest. Please provide your contact information here so that we can reach out to you with more information.**
    - o First and last name
    - o Phone number
    - o Email address

    [Logic: This question only shows up if the answer to the previous question is yes or unsure.]

13. **Please share any additional comments you have about the Federal Highway-Railroad Grade Crossings Program (Section 130) funding administered by Iowa DOT.**

    [Uses a box to provide comments.]

14. **Thank you for your participation in this survey.**

    [Final survey slide; no user response required.]

Stakeholder Survey Results Summary

The results of the October 27-November 10, 2017, electronic stakeholder survey indicate that 53 surveys were taken with a 92 percent completion rate. The survey results are generally summarized in Table 2 below. A full presentation of the results and specific participant comments from the electronic stakeholder survey can be found in Appendix B.

Table 2: General Summary of Stakeholder Survey Results

Program Familiarity	100 percent of respondents identified their order of familiarity with several components of the Section 130 program – from most to least: The list your agency receives each October, process to submit a grant application, projects your agency has already submitted for funding, how at-grade crossings are evaluated and ranked for your agency, how projects for funding are selected, and what happens to projects that are not selected for funding.

Past Application Results	At least 61 percent of respondents have previously applied for Section 130 funding – and of those that applied – 46 percent were approved, 37 percent are unsure if they are approved, and 17 percent were not approved.
Application Process Knowledge	33 percent of the respondents are confident in their knowledge of how to submit a good application for the Section 130 program.
Application Selection Satisfaction	31 percent of respondents believe the at-grade crossings in most need of improvement are selected.
Ranking Application Criteria	At least 92 percent of respondents identified in order of importance how important the following criteria are to identify and prioritize eligible grade crossings for Section 130 funding – from most to least: Amount of highway traffic, public safety, crashes at the crossing, amount of train traffic, limited sight distance, benefit-cost ratio, cost of the upgrade, site considerations, other public benefits, and amount of pedestrian traffic.
Most Important Criteria	Amount of highway traffic and intersection crash numbers tied for ranking highest as the single most important approval criteria used to identify and prioritize eligible grade crossing improvements, according to at least 92 percent of respondents.
Information Need	33 percent of respondents believe that Iowa DOT provides all the information they need to apply for Section 130 funding; three respondents provided comments related to information that could be collected during a potential field visit and observation of a grade crossing to support a Section 130 application.
Process Improvements	At least 56 percent of respondents provided comments about potential improvements in the grant application process; application selection process; and the engineering, design, and construction of projects approved for Section 130 funding.
Comments	At least 24 percent of respondents provided additional comments about the Section 130 program.
Interest in Further Involvement	34 percent of respondents indicated an interest in participating in the Technical Advisory Committee (TAC) being assembled by Iowa DOT to provide further stakeholder direction and input during development of this study.

6.3 Class I Railroad Presentation

The Union Pacific Railroad (UP) contacted the Iowa DOT Office of Rail Transportation on November 10, 2017, and indicated that rather than participate in the electronic stakeholder survey undertaken for the project that it would prefer to present its new process and formula for identifying and prioritizing grade crossing investments to the study project team. The UP presentation occurred in Omaha, Nebraska, on December 20, 2017, and was attended by representatives of the Iowa DOT and HDR project teams. A general summary of UP's new process and formula for identifying and prioritizing grade crossing investments in Iowa and elsewhere on its U.S. network is presented in this section[7].

UP identified that its first priority is safety. UP said it endeavors to get the most out of time and limited resources and to have a maximum impact on public safety with its internal Crossing Assessment Process (CAP). The CAP is a regressive process to analyze public and private grade crossings against statistically significant factors. CAP does not rank crossings, but rather

[7] Note that UP reviewed, and on January 9, 2018, approved the general summary of its process and formula for identifying and prioritizing grade crossing investments that is included in this section of the report.

categorizes crossings into three tiers (1, 2, and 3). UP said that roughly 95 percent of its grade crossings fall into Tier 3, with no statistically significant factors. Tier 1 and Tier 2 make up the remaining 5 percent of crossings (at 2 percent and 3 percent of grade crossings, respectively).

The analytics behind CAP rely on raw data that is collected through publicly available sources and private sources, including many internal UP datasets that are proprietary and confidential. This data is organized through feature identification, and is generally related to roadway and railroad physical and operating characteristics at grade crossings, various events where roadway and railroad intersect, and other considerations. Key features are then selected (statistically significant factors), which are then modeled to create the results. Feature selection can identify variables that are the most significant factors, frequency model significant factor, and severity model for significant factors. The modeling results are presented in a cluster plot. The clustering of results are not arbitrary, but rather are defined by predicted frequency and probability of high severity, and that weighting by frequency gives more weight to crossings with multiple incidents of a type. UP said that approximately 22 percent of grade crossing accidents result from 4 percent of crossings on the UP network, as determined through analysis of 2010-2015 data used to validate earlier modeling results.

During 2016, UP sent out specialists and outside traffic engineers to 1,000 Tier 1 and Tier 2 crossings identified by the UP model when the data suggested there could be potential issues with physical crossing features. During this assessment, the UP and consultant team utilized historical data, reviewed credible reports and intelligence from UP field managers and other employees, and onsite observations, and through a structured assessment process, identified realistic recommendations for potential improvements, as appropriate. The results of these assessments (700-800 of the 1,000 crossings assessed in 2016 received recommendations) were shared with the appropriate roadway jurisdiction via Crossing Assessment Summaries. UP said it will refresh its model during 2018-2019 and reassess factors to see if conditions at any of the Tier 1 and 2 crossings have improved and to see if a former Tier 3 crossing has been elevated to Tier 1 or 2 status.

UP said it has recently completed its new assessment on Tier 1 and 2 public crossings in Iowa, which included less than 40 total locations in the state. UP said that Iowa DOT can acquire this and related data in the future from UP via an agreement to use it for supporting the state's Section 130 funding process only. UP said it has already provided its data to other states on its network as an opportunity to share information, jointly prioritize, and enhance public safety and the diagnostics process.

6.4 Other State DOT Interview

As part of the study of the current Section 130 program and grade crossing methodology used by Iowa DOT to identify and prioritize grade crossing improvements, the Iowa DOT Office of Rail Transportation and HDR selected another state DOT to interview regarding its approach to similar issues in its state. The Nevada Department of Transportation (Nevada DOT) was selected for the interview, as it was in the process of completing its *Developing Revised Hazard Index for Highway Rail Grade Crossings in Nevada* study.

A telephone interview of the Nevada DOT railroad safety program coordinator was conducted by HDR and Iowa DOT on November 21, 2017. A list of the interview questions developed by HDR and Iowa DOT and a summary of key points from the Nevada DOT representative are presented below:

- Please explain the previous process/models/methods used to prioritize at-grade rail crossings for improvements and identify/select treatments.
  - What inputs were used by the previous model/method?
- What issues did you have with your previous process? Why did you study improvements to your state's methodology for identifying and prioritizing grade crossing investment?
- What changes in methods or factors were considered?
- How did you evaluate and compare alternative models?
- Please describe the process/models/methods you will be using in the future.
  - Are there any developments or changes that you feel are innovative?

Key points made by Nevada DOT during the interview included:

- Nevada DOT previously used a modified version of the New Hampshire Hazard Index. The index placed a heavy emphasis on vehicle and train volumes which resulted in an emphasis on urban crossings. Yet available information indicated that the risks and needs were greater in rural areas.
- Nevada DOT used an expert panel to identify factors that contribute to grade crossing crashes and evaluate alternative models.
- Several published crash prediction and hazard index models were evaluated, and the expert panel selected a hazard index that was created specifically for Nevada. The new Nevada hazard index includes factors for: exposure, crashes and near misses, protection, highway posted speed limit, railroad maximum authorized timetable speed, track configuration, and grade crossing skew angle.
- Developments and changes that were considered to be unique included using the square root of the exposure, incorporating the crash and near misses together, and treating flashing lights only as the same as passive grade crossing protection in the protection factor.
- Nevada DOT's process is to complete a field diagnostic at locations that were: scored high by the hazard index, recommended by the city or county, or recommended for further review through a field inspection. The field diagnostic team considers crash records, near miss reports, site conditions, and input from local agencies when determining what, if any, improvement to make. The Nevada DOT does not perform a benefit-cost analysis for recommended projects.

6.5 Literature Review

After completion of the kick off meeting and working session interviews, stakeholder survey, and state DOT interviews, HDR conducted a review of select existing literature to identify and compare key inputs to the prioritization processes of varying stakeholders regarding public highway-railroad grade crossings during November-December 2017.

This literature review intended to capture methods that maximize public investment at highway-railroad grade crossings. Particularly, the literature reviews sought to:

- Assess the practices of public agencies in the U.S. to screen public highway-railroad grade crossings for Section 130 improvement.
- Identify the best practices and innovative strategies for prioritizing public highway-railroad grade crossing improvements that maximize public investment.

6.5.1 Ohio Department of Transportation, Evaluation of Grade Crossing Hazard Ranking Models (2016)

Background

Approximately 39 of 50 states utilize some form of hazard ranking formula or index for grade crossing project prioritization. Approximately half of the states, including Ohio, identified the use of the U.S. DOT / FRA Accident Prediction Model as the primary hazard ranking method. The researchers concluded that the FRA model should continue to be used in the State of Ohio after it was compared to 10 other models.

Ohio State Programs

The Ohio Rail Development Commission (ORDC) uses the U.S. Department of Transportation (U.S. DOT) Accident Prediction Model to rank crossings based upon predicted number of collisions. Staff then reviews the preliminary list and selects those with passive warning devices eligible for Section 130 improvements. Data elements including train volumes and traffic counts are verified and crossings re-ranked as necessary. The final list is then compiled (approximately 40 crossings) and data is verified including rail conditions, train speed and volume, and annual average daily traffic (AADT). The final decision to implement a warning device project at a crossing location is based on professional judgment and input from a multi-disciplinary diagnostic review team based up comprehensive field reviews.

Similarly, the Public Utilities Commission of Ohio (PUCO) provides project funding based on objective scoring including predicted number of accidents, AADT, train volume and speed, and number of tracks as key variables in consideration.

Other approaches used by states to develop the preliminary grade crossing list include local highway authorities submitting applications, other public agency requests, FRA Web Accident Prediction System (WBAPS), near-miss locations, locations where a crash has occurred in the past year, and recommendations from the state grade crossing inspector team.

Other State Approaches – California

Similar to the Ohio methodology, the California Public Utilities Commission (CPUC) develops a preliminary list of grade crossings that are identified as potential candidates for improvement projects. This preliminary list includes crossings that are identified throughout the year due to a fatality and/or near-misses occurring at specific crossing locations, local highway authority requests, and top 100 most hazardous crossings in California as reported by the FRA Web Accident Prediction System (WBAPS). CPUC staff screens the compiled preliminary list for Section 130 program eligibility to arrive at a final list of approximately 10 to 30 crossings that will be examined in greater detail by a field diagnostic review team.

The CPUC utilizes the U.S. DOT Accident Prediction Model, as well as the accompanying crash severity formulas, for hazard ranking of grade crossing locations. The final project prioritization is established using a detailed matrix that consists of six factors, including the expected crash frequency as well as the frequency of fatal and injury crashes determined by the DOT model. Other factors considered in the matrix include an economic analysis and the potential danger posed by regular use of the crossing by pedestrians, bicyclists, school and transit buses, hazardous materials (hazmat) vehicles, and other state-specific factors.

Other State Approaches – Connecticut

The Connecticut Department of Transportation (Connecticut DOT) uses a modified version of the New Hampshire Hazard Index to prioritize grade crossings for project selection. The Connecticut DOT hazard ranking index is a more advanced version of the New Hampshire Hazard Index since it includes more protection factors for different types of warning devices at grade crossings as well as an adjustment for crash history.

Other State Approaches – Florida

The Florida Department of Transportation (Florida DOT) Safety Hazard Index formula is a hybrid accident prediction model/hazard index developed by Florida State University. It's based on a logistic regression model for crash prediction with adjustments for crash history, warning device type, and the presence of school buses at a crossing. Variables included in the Florida DOT model, but not currently used in the U.S. DOT model, include the highway vehicle speed, the total number of tracks, and the number of school buses at a crossing.

Other State Approaches – Illinois

The Illinois DOT grade crossing project development process consists of an annual letter distributed to counties, townships, and municipalities describing the grade crossing program and soliciting applications for grade crossing warning device improvement projects. Information requested on the application includes the grade crossing location and physical characteristics, highway and railroad traffic information, as well as a section for calculating the Expected Crash Frequency (ECF) determined by the NCHRP 50 Accident Prediction Model formula. Illinois DOT ultimately utilizes the NCHRP 50 Accident Prediction Model formula for grade crossing hazard ranking.

Other State Approaches – Kansas

The Kansas Department of Transportation (Kansas DOT) utilizes the New Hampshire Hazard Index for grade crossing hazard ranking. Kansas DOT's project development process includes an annual ranking of all crossings based on the hazard index value and field diagnostic review at approximately 40 to 50 crossings per year. Kansas DOT also uses a list of crossings provided by certain railroads where "near-miss" or other unsafe behavior is observed by train engineers to assist with the development of the annual program.

Other State Approaches – Michigan

The Michigan Department of Transportation (Michigan DOT) utilizes a modified version (additional protection factors developed by a multi-disciplinary team of experts) of the New Hampshire Hazard Index for grade crossing hazard ranking. In addition to prioritization, the index values are used to identify a state-wide distribution of relative safety risks and to develop an average hazard index for crossings that experience a crash within the previous five years.

The Michigan DOT project development process is an annual, multi-stage process. A preliminary list of approximately 250 crossings is developed, from which approximately 50 to 60 field diagnostic reviews are scheduled. Furthermore, Michigan DOT allows for each of the state's four grade crossing inspectors to nominate up to two locations as "inspector's choice" grade crossing location for diagnostic review. The inspector's choice option allows for crossings that would otherwise not be included in the annual program to be considered based on the inspector's knowledge of local conditions and other factors.

Other State Approaches – Missouri

The Missouri Department of Transportation (Missouri DOT) uses their own 'state-specific' hazard index for hazard ranking. The formula takes into account specific train types at crossings and respective speeds, in addition to AADT and vehicle speed. The project development process is informed by the hazard ranking, FRA WBAPS tool, as well as near-miss data.

Other State Approaches – New Mexico

The New Mexico Department of Transportation (New Mexico DOT) used the U.S. DOT Accident Prediction Model for hazard ranking in New Mexico through the FRA WBAPS tool. New Mexico DOT uses feedback from railroads, local highway authorities, and citizens in tandem with near-miss data to develop its annual program.

Other State Approaches – North Carolina

Similar to Missouri, the North Carolina Department of Transportation (North Carolina DOT) uses its own 'state-specific' hazard index for hazard ranking. The index incorporates variables such as sight distances, total number of tracks, protection factor adjustments for traffic signal preemption at nearby intersections, and AADT adjustments based on school bus passenger counts and passenger trains. The agency is planning to move towards a decision system based upon economic analysis taking into account the U.S. DOT Accident Prediction Model.

Other State Approaches – Texas

The Texas Priority Index was estimated using negative binomial regression models based on data from Texas grade crossings and crash history. It takes into account AADT, crash history, number, and speed of trains, and the type of in-place warning device (active or passive) being used. It uses a detailed collision prediction model and converts the predicted values into an index used for prioritization. The crash prediction component is an exponential function with binomial/dummy variables for paved roadways, urban and rural crossing areas, and nearby intersections. Other variables considered include a protection factor, number of roadway lanes and tracks, stopping sight distance, minimum and maximum train speed, roadway speed limit on approach, and AADT. Predicted crashes are then incorporated into the calculation of the index which further takes into account crash history.

The annual Texas DOT project selection process starts with a data integrity review to verify traffic counts, train volumes, crash data, and other data inputs. A preliminary project list of approximately 150 locations is developed and some locations are eliminated from consideration if a railroad is not willing to assume the cost of maintaining the warning device equipment. A diagnostic review team visits the remaining locations. Texas DOT further utilized a passive crossing warrant system as a component in its project development process. Other data sources used in the project development process include FRA crash data, broken gate reports, and state crash records.

Summary of Project Development Approaches

In general, the first steps across the 39 states involve developing a preliminary list of grade crossings, followed by field diagnostics to confirm whether the locations are eligible for Section 130 improvements. Hazard ranking models are then used to prioritize locations for improvement. In all states reviewed in the study, professional judgment and assessment is applied to the final list of projects for funding.

Development of the preliminary list varies by state. California, for example, utilizes multiple data sources including crossings that experienced a recent fatality and/or near-misses occurring at specific crossing locations, local highway authority requests, and top 100 most hazardous crossings in California as reported by the FRA WBAPS. Conversely, Illinois employs an application which is completed by local highway authorities to assist with developing its preliminary list.

6.5.2 Minnesota Department of Transportation, Rail Grade Crossing Safety Project Selection (2016)

Minnesota Department of Transportation's (Minnesota DOT) Rail Administration historically used the FRA Accident Prediction Model to prioritize and identify grade crossings for potential safety improvements. The model's results are heavily influenced by past crashes at the same location which wasn't a good fit for Minnesota's data since over 50 percent of crossings with an injury accident had no prior accident history. As a result, Minnesota DOT selected the Texas Hazard Index for developing the 2017 safety project list.

The study suggested risk factors that may ultimately be used as a systematic risk assessment for project prioritization. These risk factors are the product of data analysis from crossing inventory and state-provided data. The analysis produced threshold values for each factor identified, which is summarized by Table 3 below.

Table 3: Suggested Risk Factors

Risk Factors	Active		Passive	
	Minimum	Maximum	Minimum	Maximum
Volumes				
Roadway Annual Average Daily Traffic (AADT)	2,500	Unlimited	150	Unlimited
Total Trains per Day	10	Unlimited	4	Unlimited
Volume Cross Product	20,000	Unlimited	750	Unlimited
Speeds				
Roadway Speed Limit	45	Unlimited		
Maximum Time Table Speed	31	Unlimited	36	Unlimited
Design				
Number of Main Line Tracks	2	Unlimited		
Skew	≥15°		≥15°	
Surroundings				
Distance to Nearby Intersection	1 foot	99 feet	40 feet	160 feet
Distance to Nearest Crossing	0.5 miles	1 mile	0.5 miles	1 mile
Clearing Sight Distance	Any Quadrant Fails		Any Quadrant Fails	
Approaching Sight Distance			Any Quadrant Fails	

Source: Rail Grade Crossing Safety Project Selection, Minnesota DOT, 2016

Factors for active crossings include AADT, trains per day, the cross-product of AADT and trains per day, maximum roadway and railroad timetable speed, number of mainline railroad tracks and skew, distance to nearby intersection and crossing, and clearing sight distance. Roadway speed limit and the number of mainline railroad tracks were excluded as risk factors for passive crossings, however both approaching and cleaning sight distances were included. In summary, 10 risk factors are considered for active crossings while nine are considered for passive.

The factors ultimately inform a cross-sectional data analysis that group crossings based upon the warning device characteristics of each crossings (active or passive). Crossings are measured by the amount of risk factors identified. High-risk crossings possess at least seven of the 10 active or nine passive crossing risk factors. The assessment is intended to produce a small number of crossings with a majority of risk factors, thus providing solely high-priority crossings with crash densities above total crossing averages.

6.5.3 Federal Highway Administration Railroad-Highway Grade Crossing Handbook – Section 3 (2007)

In order to rank highway-rail grade crossings, various collision prediction models and hazard indices may be applied. These quantitative tools are ultimately used to identify crossings that will be the subject of a field investigation by diagnostic experts. As compared to a collision prediction model which estimates collision occurrence and severity, hazard indices provide a relative ranking of crossings.

In selecting a preferred method of hazard ranking, states typically use either an accident prediction model, hazard index, or a hybrid model which uses components of both. Accident prediction models, including the model developed by the U.S. DOT, consider traffic and train volume cross-product, number of railroad main tracks, maximum timetable speed for train operations, and factors for highway type and pavement, highway lanes, through trains per day, and maximum timetable speed for train operations. The initial prediction is then used as a component in a final collision prediction calculation which takes into account collision history at the crossing. Additional formulas allow for the computation of accident severity based upon many of the same factors including whether the crossing is located in an urban or rural area, through and switch trains per day, number of tracks, and maximum timetable speed.

Typically, crossings that rank highest either in terms of a hazard index of predicted collisions are investigated further by a diagnostic team. Investigations are necessary to determine potential Section 130 eligibility and may also be warranted due to public transportation and school routes, as well as the presence of hazmat vehicles which require necessary consideration as per the Federal Aid Policy Guide (FAPG). These considerations may be explicitly considered as a component in a hazard index or subjectively as a part of final project selection. Crossings may also be considered for investigation due to planned developments, requests from railroads and public agencies, as well as public complaints.

The diagnostic team should be interdisciplinary and representative of all stakeholders responsible for the safe operations of crossings within a particular state. Teams typically consist of highway maintenance engineers, signal control engineers, railroad signal engineers, and highway and railroad administrative officials, to list a few. The team inspects the crossing and its surroundings to objectively determine factors that influence safety operations. These factors include stopping and sight distances, potential sight impediments, adequate pavement markings and surfacing, and nearby intersection signaling operations. In specific cases, collision and traffic studies may be warranted to assess future directional traffic flow and understand collision trends.

6.5.4 National Cooperative Highway Research Program (NCHRP) Report 50 – Factors Influencing Safety at Highway-Rail Crossings (1968)

The National Cooperative Highway Research Program (NCHRP) Report 50 Accident Prediction Model investigated factors influencing safety performance at highway-rail grade crossings. It was determined that traffic at the crossing (AADT), trains per day, and the type of warning device are key variables to consider when evaluating safety at grade crossings. Based on these findings, the NCHRP ultimately developed a mathematical model for collision prediction which is used by Illinois as their primary method for ranking grade crossings. Similarly, Nebraska uses the NCHRP 50 model in tandem with the U.S. DOT Accident Prediction model to rank crossings. At its core, the NCHRP 50 model is fairly simplistic. It takes into account trains per day at the crossing, protection factor that varies depending on the current warning device, and a traffic factor which adjusts AADT by a multiplicative variable and constant. The model multiplies all three variables to predict the expected annual crash frequency at a crossing. Generally, a model-predicted expected accident frequency (EAF) of 0.02 or higher indicates the need for investment in the crossing's warning device system.

Although simplistic, the NCHRP 50 model presents a straight-forward approach to rank crossings. It's limited, however, by the variables considered. Other collision prediction models use volume cross-product as a key input but it is not the sole consideration. As a result, the model may be used as an initial screen of crossings to determine a preliminary list which is then assessed based upon other evaluation metrics including the number of railroad tracks and timetable speed for trains.

6.5.5 National Cooperative Highway Research Program (NCHRP) Project 8-36 – Return on Investment on Freight Rail Capacity Improvements (2005)

Case studies undertaken for the National Cooperative Highway Research Program (NCHRP) Project 8-36 – Return on Investment on Freight Rail Capacity Improvements identified five groups of public benefits from freight rail investments. These benefit classes are commonly included in transportation and infrastructure benefit-cost analysis and include economic, environmental, safety, transportation, and other benefits (e.g., national significance). Although this study primarily discusses benefits arising from modal diversion, the benefit structure may be applied to highway-rail grade separation projects.

Economic benefits arise from a reduction in pavement maintenance costs due to reduced vehicle miles traveled (VMT) and a reduction in costs to freight shippers. Studies further identified avoided highway construction costs and supported employment as key economic benefits. Avoided pavement maintenance costs, as well as reduced congestion costs, slightly overlap into overall transportation benefits. Studies additionally considered reduction in highway delays and associated efficiency improvements as important public benefits.

Environmental benefits accrue from reduced truck VMT results in fewer emissions and reduced fuel consumption due to favorable fuel efficiency by rail. Although benefits realized from reduced fuel costs are partially offset by reduced fuel tax revenues, diversion from truck to rail modes reduces greenhouse gas emissions and air pollution.

Noise impacts are based on reduced truck volumes on public highways. The impacts are rarely monetized, but are typically considered qualitatively as a component in a larger assessment framework.

Lastly, other benefits are typically project-specific, particularly whether they are designated as "nationally significant" since it has implications for the receipt of federal funding.

6.5.6 National Cooperative Highway Research Program (NCHRP) Report 755 – Comprehensive Costs of Highway-Rail Grade Crossing Crashes (2013)

The National Cooperative Highway Research Program (NCHRP) Report 755 – Comprehensive Costs of Highway-Rail Grade Crossing Crashes study provides estimates for costs associated with collisions at highway-rail grade crossings, including both primary and secondary costs, and creates an analytical framework which may be used to forecast grade crossing crash costs. Primary costs include direct (property damage and insurance), indirect (productivity and tax loss), and intangible (quality of life, pain and suffering, and environmental) costs. Secondary costs are comprised of increased supply chain and business disruption costs including rerouting, lost sales, inventory spoilage, and freight delays and reliability, to name a few. These fully inclusive costs may inform project prioritization decisions by ranking crossings by total crash costs and/or incorporating crash costs into a benefit-cost analysis framework. Similarly, thresholds may be established in order to exclude crossings of relatively minimal hazard and be used as part of a systematic risk assessment for crossing prioritization.

Primary costs may be determined through the use of collision prediction formulae or software, and monetized based upon state or federal DOT suggested values. Delay and rerouting costs require delay duration and cost per hour, rerouting distance with the associated cost per mile. Supply chain costs are typically estimated by taking into account delay hours and the associated supply chain unit cost, diversion rate, tons per vehicle, and the transfer cost. Similarly, inventory costs are determined by average shipment size, monetary value of shipments, and risk factors for reliability and loss.

6.5.7 National Cooperative Highway Research Program (NCHRP) Report 586 – Rail Freight Solutions to Roadway Congestion – Final Report and Handbook (2007)

While short-distance hauls may expand overall railroad potential, the benefits of freight rail are best realized through high-volume and long-distance shipments. In order to evaluate and assess freight rail solutions to alleviate highway congestion, the National Cooperative Highway Research Program (NCHRP) Report 586 – Rail Freight Solutions to Roadway Congestion – Final Report and Handbook study seeks to identify and develop assessment frameworks for determining the merits of public investment on freight rail solutions. Using the frameworks developed, a guide for planners is developed which may be used in assessing project feasibility, benefits, and project prioritization. In general, the project development process begins with identifying situations where freight rail solutions may be applicable. Various perspectives from both planners and decision makers are then considered as part of a technical assessment. Lastly, to maximize public benefits, an optimal implementation and funding plan is developed. In order to ensure an efficiency overall process, the study recommends a three-pronged strategy including an initial screening, detailed analysis, and ultimately decision-making.

A preliminary assessment/initial screening is conducted in order to identify rail solutions that address specific congestion issues. During this phase, traffic flows and other freight information is reviewed to identify potential solutions. Additionally, a preliminary benefit-cost analysis may be performed to assess both project feasibility and the project's ability to maximize social benefit. Following the preliminary assessment, a detailed analysis is performed. This phase typically includes the estimation of project cost and a traffic diversion study. Expanding upon initial findings from the initial phase, the detailed analysis seeks to capture total social benefits including both economic and environmental factors. Lastly, a decision-making process takes into account the results of the detailed analysis and assesses a comparative analysis of applicable alternatives. This comparative analysis is typically completed through a cost-benefit, cost-effectiveness, data envelopment, or multi-criteria assessment analysis. It is also possible to use a combination of these methods to assess and prioritize projects. A benefit-cost analysis may initially be used to justify and screen projects for feasibility, while a multi-criteria assessment may be used to select the project with the highest social return.

6.5.8 National Cooperative Highway Research Program (NCHRP) Project 8-42 – Assessing Rail Freight Solutions to Roadway Congestion – Final Report (2006)

Similar to NCHRP Report 588 – Rail Freight Solutions to Roadway Congestion, the National Cooperative Highway Research Program (NCHRP) Project 8-42 – Assessing Rail Freight Solutions to Roadway Congestion – Final Report study seeks to identify and develop assessment frameworks for determining the merits of public investment on freight rail solutions to alleviate highway congestion. The findings and final framework align with those developed in NCHRP Report 588.

6.5.9 Federal Highway Administration / Federal Railroad Administration – Highway-Railway Grade Crossing Action Plan and Project Prioritization Noteworthy Practices (2016)

The Federal Highway Administration (FHWA) / Federal Railroad Administration (FRA) – Highway-Railway Grade Crossing Action Plan and Project Prioritization Noteworthy Practices study provides suggested guidelines regarding the development of a State Action Plan (SAP) related to public highway-rail grade crossings and provides various methods used to prioritize projects for investment. The Railway-Highway Crossings Program (Section 130) requires each state to maintain an inventory of grade crossings that may require improvements including separation, relocation, or warning device upgrades. To adhere to these requirements, states use data-driven methods to prioritize projects that present the greatest risk to the general public.

Methods and variables considered in the prioritization framework vary by state. Some states use "near miss" occurrences reported by railroads as part of the evaluation process while others assess crossings grouped by warning device in order to separate active from passive crossings. States tailor their approach to take into account local factors including surface conditions and commodities transported by trains. New Jersey, for example, focuses on improving crossings along rail corridors carrying crude oil and documents issues related to surface condition since it's a locally identified issue. Other states such as Pennsylvania incorporate the FRA's GradeDec.net tool as a key component in their project prioritization process. The tool allows for scenario-based decision making which takes into account changing train traffic, train speeds, changes to physical infrastructure conditions, and the distribution of vehicle traffic.

An increasing amount of states incorporate benefit-cost analysis (BCA) either as a screening tool or key variable in the final ranking and prioritization process. BCA takes into account both direct and indirect costs for highways and railroads which allows for a comprehensive analysis of net project impacts. As an example, North Carolina prioritizes safety improvements based solely upon the results of the benefit-cost analysis while California includes BCA as part of a detailed matrix which includes other variables such as crash frequency. North Carolina's prioritization methodology is described in detail and begins with estimating crash costs at grade crossings. Crash costs are then used to screen for high-risk crossings using a Hazard Index approach. Lastly, a benefit-cost analysis is performed for each project taking into account both primary and secondary effects. Crossings are ultimately prioritized by considering the highest benefit-cost ratios.

6.5.10 Transportation Research Board – Current Issues in Highway-Railroad Grade Crossing Hazard Ranking and Project Development (2016)

A key issue faced by states in their project prioritization process is how to select a small number of crossings from a large, comprehensive list where the differences in crash risks become increasingly subtle. While Section 130 investments have been effective in reducing collision occurrences at highway-railroad grade crossings, as more improvement projects are implemented the project prioritization process has become increasingly nuanced.

A systematic method of identifying and ranking crossings is crucial in order to properly allocate limited funding and resources. Although mathematical and statistical models offer an objective means of comparing various crossings, results are difficult to interpret if a particular set of crossings has similar crash risks. The study discusses various formulae and hazard ranking processes used by various states, such as the U.S. DOT Accident Prediction model, New Hampshire Hazard Index, and other state-specific methods. Most models consider variables including AADT, train volume and speed, existing warning device, crash history, and the number of railroad tracks and highway lanes.

The Transportation Research Board – Current Issues in Highway-Railroad Grade Crossing Hazard Ranking and Project Development study recommends considering additional variables in the project consideration process including stopping sight distance, school bus/special vehicle traffic volumes, and highway traffic speed, among other things, in an attempt to offer a distinction amongst similar sets of crossings. Another recommendation is to use economic analysis in ranking grade crossings. With the goal of maximizing the use of scarce public funds, a benefit-cost analysis takes into account lifecycle project costs in addition to the net societal benefit from improvements. The benefit-cost ratio may be used in the project development process in order to offer a distinction between crossings of similar crash risk.

6.5.11 Center for Transportation Research and Education – Development of Railroad Highway Grade Crossing Consolidation Rating Formula (2015)

The study developed a quantitative approach to systematically evaluate and prioritize crossings by considering factors beyond safety and risk. A weighted-index method was developed to allow states the ability to assign specific weights to factors that are deemed most important given local conditions. Through use of a Technical Advisory Committee (TAC) and a broader stakeholder framework, the study identified auto and truck traffic volume, proximity to emergency services and schools, road system, access to businesses and residential areas, and out-of-distance travel as key variables. Counties further identified farm access as an additional variable for consideration.

The weights used for each variable were developed in tandem with the TAC with consideration given to differences between urban and rural crossing locations. A matrix of factor weights was developed separately for urban and rural crossings and ultimately used to inform index estimation. The method developed allows for computing crossing risk and the impacts of crossing consolidation for individual crossings and may be integrated within existing project prioritization frameworks. A hypothetical crossing with high consolidation impacts and significant safety risks may be a key crossing considered for crossing improvements or grade separation.

Through use of a weighted-index method, all factors of interest are identified, ranked independently, and weighted according to priorities to create a single index. This index can then be used to rank crossings and weights can be adjusted if priorities change. Separate calculations were performed for urban and rural crossings due to inherent differences in economic and demographic characteristics. The prioritization process developed allows for the comparison of both consolidation and safety risk impacts for a holistic analysis approach. The study further suggests the inclusion of additional variables such as maintenance costs, economic impacts, and location-specific access among other characteristics to be considered within the framework.

7.0 Research Conclusions and Recommendations

This section summarizes conclusions from the research conducted for this study and offers recommendations for analysis and project development that can be implemented during the balance of the study.

7.1 Conclusions

In consideration of the assessment of the existing methodology used by Iowa DOT to identify and prioritize grade crossing investment in the state through the Section 130 program, the current Section 130 funding available annually, interviews and coordination with Iowa DOT and the project TAC, research conducted for the study, review of best practices of other state DOTs, and the nature of the problem identified by Iowa DOT for the study, the following conclusions were made by HDR in December 2017:

- The timeliness, reliability, and completeness of the data used to support the identification and prioritization of grade crossings in Iowa for improvement was not maintained. It was noted that the current statewide highway-rail grade crossing inventory did not include certain data categories (e.g., sight distance, skew angle, presence of sidewalks, etc.), and that these could be collected through future Section 130 grant applications or future statewide inventory data collection efforts.
- The list of countermeasures for grade crossing investment does not consider the full scope of potential levels of improvement.
- Crash costs, coefficients, and constants used in the benefit-cost analysis are inconsistent with the latest practices. In addition, some aspects of the benefit-cost methodology (e.g., discounting, growth of traffic) do not conform to best practices.
- The existing methodology used to support Section 130 funding applications places an emphasis on a narrow number of grade crossings, and the threshold that identified grade crossings that have the greatest need for safety investment should be evaluated.
- According to stakeholders, the most important approval criteria for identifying and prioritizing grade crossing investment and accruing public benefits of these investments are the amount of highway traffic and intersection crash numbers.
- The current process to engage eligible applicants (e.g., highway jurisdictions, railroads, and public agencies) and supply them with the information necessary to complete a Section 130 grant application and the current application selection process may need improvement. Enhanced communication and public education with regard to the Section 130 program, the application process, and application status were identified. Grade crossing field diagnostics and related inputs and outputs are an essential component of the process to identify and prioritize grade crossing investments, yet they are not typically completed until late in the process to advance Section 130 grant applications to the Iowa Transportation Commission for funding. It was also noted that there is a backlog of Section 130 grant applications, that some applications were up to 30 years old, and that one process improvement could include shorter-term applicability and an expiration time (e.g., 5 years) on grant applications.

7.2 Recommendations

Following the completion of the Iowa DOT and other state DOT interviews, stakeholder survey, Class I railroad presentation, initial TAC coordination, and evaluation of the current Iowa DOT methodology and literature review as outlined in the research plan and presented in the findings and conclusions in the sections above, in January 2018, HDR developed recommendations via a comprehensive list of activities that the Iowa DOT Office of Rail Transportation could undertake through the remainder of the project. HDR coordinated with Iowa DOT Office of Rail Transportation in January 2018 to select the specific action items based on the highest priorities of Iowa DOT and to determine a related final workplan. Through this approach, Iowa DOT Office of Rail Transportation addressed its most important needs, achieved its highest objectives, and provided the most initial value in terms of enhance safety and public benefits to Iowa. Items not selected in this phase will provide Iowa DOT with actionable items for future program methodological and process study and improvement.

Recommendations for potential future effort as prioritized by HDR are identified below:

- **Develop a Draft and Final Report** – HDR to develop a Draft Report and Final Report capturing all research, analysis, coordination, outreach, and work conducted under the study.
- **Hazard Ranking Analysis and Development of a Database / Hazard Ranking Tool** – HDR to analyze hazard ranking models used by other state DOTs to determine a best-fit for a revised Iowa DOT hazard ranking model based on available datasets; develop a tool to identify available, complete, and clean Iowa DOT datasets and links to their location; and to rank relative hazards for each grade crossing on a statewide, countywide, and railroad basis. Analysis and tool will be developed through coordination with Iowa DOT, the TAC, and HDR.
- **Implementation of Economic Analysis and Development of a Revised Project Prioritization Tool** – State agencies commonly use quantitative methodologies to assess the priority of proposed public highway-railroad grade crossing projects. These methodologies vary widely, ranging from hazard indices and crash prediction formulas to benefit-cost formulas. After study and analysis of the most commonly used approaches and best practices and innovative strategies used by select state agencies, consideration of inputs from Iowa DOT and stakeholders, and analysis of complete datasets available to Iowa DOT, HDR proposed that Iowa DOT could select one of the following approaches to HDR's development of a modified project prioritization tool:
    - Option 1: Update values in the existing benefit-cost approach used by Iowa DOT and develop a prioritization tool in Microsoft Excel format demonstrating updated approach (single entry; limited sensitivity analysis). This option would essentially retain the existing approach with improvements to reflect best practices in benefit-cost analysis.
    - Option 2: Develop a new cost-effectiveness approach using the new location ranking (hazard index) model and develop prioritization tool in Microsoft Excel

format demonstrating updated approach (single entry). This approach would allow Iowa DOT to compare the change in the hazard index used to rank locations to the cost of projects.
   - Option 3: Develop a hybrid model that includes elements of Options 1 and 2 identified above. This approach would provide Iowa DOT with both a benefit-cost ratio and a cost-effectiveness ratio for assessing projects.

For the approach selected by Iowa DOT above, HDR will develop one model as noted below:

- Preliminary model developed in Microsoft Excel to test proof of concept for the revised or new approach and methodology.
- A further enhancement would be to develop a batch process in Microsoft Excel that allows the model to run automatically for all highway-rail grade crossings in the state and link to the separate database / hazard ranking tool identified above.

Regardless of approach and development options selected above, HDR to develop a list of potential methodological improvements to the existing prioritization algorithm and will coordinate with Iowa DOT and the TAC to confirm which thresholds, values, and benefit categories to include and how they will be weighted, as appropriate for model type.

- **Develop a Section 130 Program and Process Educational Resource** – HDR to develop a clear and concise outreach and educational resource for Iowa DOT to use as a means of enhancing its annual communication with eligible Section 130 program applicants and providing additional information about the program, what improvements it funds and does not fund, what makes an effective application, how grade crossings are evaluated and ranked, and related topics. The document could also include "myths and facts" content with discussion about the responsibility for constructing and maintaining grade crossing infrastructure. It is suggested that Iowa DOT provide this document to potential applicants, along with the annual letter, report, and Section 130 application. Document would be developed in MS Word format using Iowa DOT template and standards.
- **Develop a List of Potential Additional Datasets for Identifying and Prioritizing Grade Crossing Investments in the Future** – HDR to develop a list that would be used for grade crossing project identification and prioritization, if it were possible for Iowa DOT to acquire complete and clean data, including average gate down time / train grade crossing occupancy data; complete near-miss reports from all railroads in the state; sight distance and restriction data at grade crossings; skew angles at grade crossings; dimensional data at grade crossings (i.e., width and length of grade crossing panels and surface); identification / risk assessment for rail routes carrying hazardous materials; such as crude oil, ethanol, etc.; and school bus traffic routes.
- **Develop Recommendations for Communicating Relative Grade Crossing Risks to Highway Authorities –** HDR to develop a recommended strategy for an easily understood method to communicate to statewide highway authorities the risks of crossings under their authority and to encourage Section 130 applications for crossings with the greatest safety risks.
- **Recommendation of a Methodology to Determine Most Advantageous Projects to Present to the Iowa Transportation Commission for Funding –** HDR to develop a strategy

for selecting the grade crossing projects that provide the maximum public safety benefit that can be presented to the ITC for funding.

- **Develop a List of Potential Iowa DOT Section 130 Program Policy and Process Enhancements** – HDR to develop the list for the Section 130 Program for future agency consideration and action.
- **Develop a Threshold Value for Grade Separations for Local and Corridor Level Analysis –** HDR to develop a threshold value that could be used to identify and prioritize investment in grade separations on a local and corridor level.
- **Develop an Enhanced Grade Crossing Consolidation Ranking Formula** – HDR to develop an enhanced formula that is supported by the previous Development of Railroad Highway Grade Crossing Consolidation Rating Formula Study (CTRE) for Section 130 program projects.

8.0 Confirmation of a Final Project Workplan for Implementation

Based on HDR's findings, conclusions, and recommendations, input from the project TAC, and the highest priorities for Iowa, the Iowa DOT Office of Rail Transportation selected the following activities and schedule for completion by HDR during the remainder of the project through the final project workplan in January 2018:

- **Develop a Draft and Final Report**
  - It was determined by Iowa DOT that HDR will develop a Draft Report in August 2018 and that a Final Report will be developed in September 2018 after receiving comments on the Draft Report from Iowa DOT and the TAC
- **Hazard Ranking Analysis and Development of a Database / Hazard Ranking Tool**
  - It was determined by Iowa DOT and HDR that the specific approach to the development of the tool and its functionality would be confirmed during subsequent project coordination and review with Iowa DOT, the TAC, and HDR during February-August 2018
- **Develop a Modified Project Prioritization Tool**
  - It was determined by Iowa DOT and HDR that the specific approach to development of the tool and its functionality would be confirmed during subsequent project coordination and review with Iowa DOT, the TAC, and HDR during February-August 2018
- **Develop a List of Potential Additional Datasets for Identifying and Prioritizing Grade Crossing Investments in the Future**
- **Develop Recommendations for Communicating Relative Grade Crossing Risks to Highway Authorities**
- **Develop Recommendation of a Methodology to Determine Most Advantageous Projects to Present to the Iowa Transportation Commission for Funding**
- **Develop a List of Potential Iowa DOT Section 130 Program Policy and Process Enhancements**

The steps to develop and implement each of these activities above are identified and described in the following sections of this study report.

Based on HDR's recommendations, the Iowa DOT Office of Rail Transportation did not select the following activities for completion during the remainder of the project, but identified them as valid and actionable for future study or process improvement by Iowa DOT, if additional project funding becomes available:

- **Develop a Section 130 Program and Process Educational Resource**
- **Develop a Threshold Value for Grade Separations for Local and Corridor Level Analysis**
- **Develop an Enhanced Grade Crossing Consolidation Ranking Formula**

9.0 Implementation of Hazard Ranking Analysis and Development of a Database / Hazard Ranking Tool

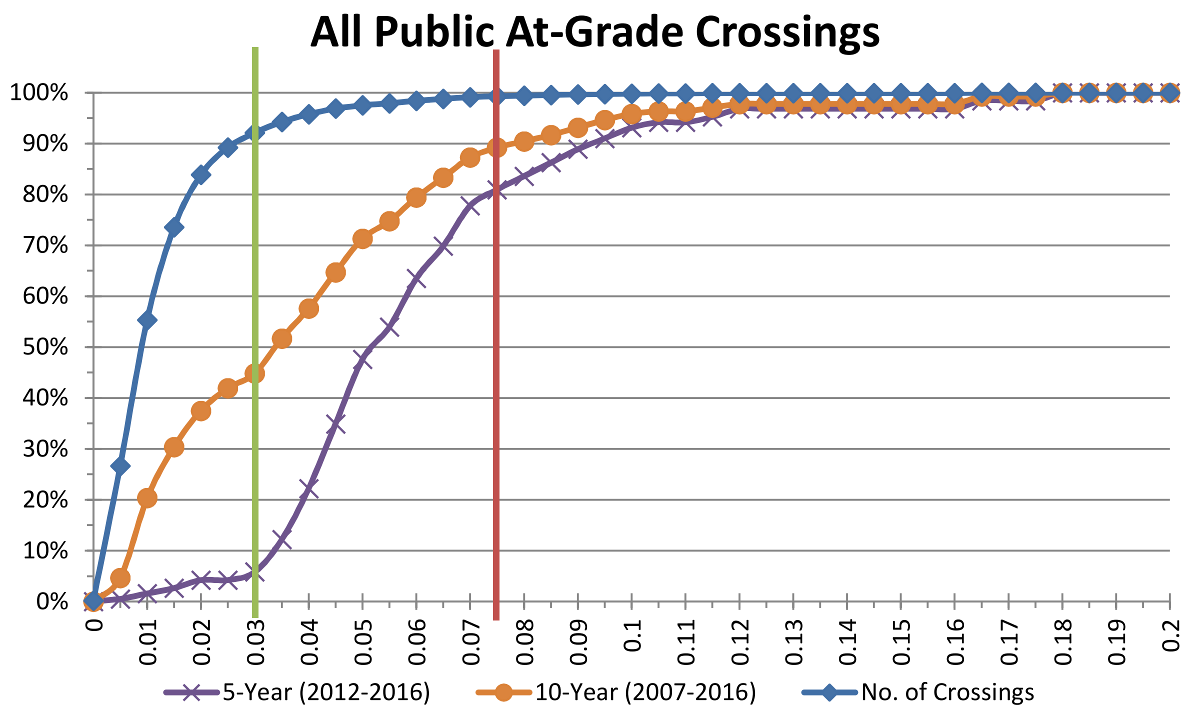
As noted previously in the study, the Iowa DOT approved the portion of the workplan to assess hazard ranking approaches and ultimately incorporate a preferred hazard ranking approach into a user-friendly database / hazard ranking tool. This section covers: 1) the value of Iowa's current hazard ranking process compared to historic crash data and past Section 130 projects; 2) capsule descriptions of the four hazard ranking formulations reviewed by the HDR project team, Iowa DOT, and the TAC; 3) process for using an expert ranking method to select the preferred hazard ranking scheme; and 4) implementation of preferred hazard ranking scheme and underlying datasets into a user friendly hazard ranking tool in an Excel-based spreadsheet format.

9.1 Evaluation of Current Iowa DOT Practice of Hazard Ranking

The current Iowa DOT hazard ranking process is based around the FRA GradeDec method of accident prediction. In Iowa DOT's application of the process, significance has been placed upon annual accident prediction values exceeding 0.075 predicted accidents per year. As an initial step in evaluating the current Iowa methodology, the HDR project team analyzed past crash prediction results to assess the significance of the 0.075 threshold to the distribution of the available highway-rail crossing crash data.

Figure 1 below looks at the cumulative distribution of three variables: distribution of all public highway-rail crossings against annual predicted accidents, distribution of 5-year crash history of public highway-rail crossings against annual predicted accidents, and distribution of 10-year crash history of public highway-rail crossings against annual predicted accidents. Annual predicted accidents are based on 2016 conditions.

Figure 1: Crash and Crossing Cumulative Distribution Curves versus Annual Crash Predictions for All Public Highway-Rail Grade Crossings



The available Iowa data shows that a very small percentage of all public at-grade highway-rail crossings exceed the 0.075 threshold, only 28 of 3,902 crossings statewide—or less than 1 percent of all public crossings. This supports Iowa DOT's perceptions that the 0.075 threshold denotes an exclusive class of crossings, which can be a positive given the current limits on Section 130 funding availability for Iowa. However, the drawback is the potential to be unnecessarily restrictive when identifying priority crossings for a safety improvement. The other two cumulative distributions are based on predicted accidents versus crash history. Both of these distributions show that the 0.075 value serves as a point of inflection in the trend of the curves, but the inflection is from a higher rate of increase in crash frequency to a more stable rate of cumulative crashes. Simply, the very few locations that are predicted to have more than 0.075 accidents per year experience between 10.8 percent and 19.1 percent of statewide crashes. As a result, the 0.075 threshold sets an emphasis on very few locations where less than a quarter of historic crashes occurred and validates the Iowa DOT's decision to review the 0.075 threshold.

By visual inspection, a lower threshold like 0.030 accidents predicted per year may increase the effectiveness of Section 130 funds. The 0.030 threshold aligns with an inflection point in the distribution curve for the number of crossings—the line flattens indicating that relatively few crossings are above the 0.030 threshold. However, at 0.030, the distribution curve for the 5-year crash history also has an inflection point to a steep line, indicating actual crash frequency quickly accumulates when compared to predicted crash frequency. At a 0.030 threshold, 308 locations are identified. These 308 locations account for nearly 8 percent of all public highway-rail grade crossings but represent 55.5 percent of the last 10 years' highway-rail crossing crashes statewide and 94.2 percent of the last 5 years' highway-rail crossing crashes statewide.

While the 0.030 threshold creates a larger pool of locations considered as a priority for investment, the HDR project team also evaluated if the locations resulted in a lower threshold would still result in cost-effective projects. The 2016 Iowa hazard ranking process also included an evaluation of potential projects and classified those projects based on the benefit-cost ratio (BCR). It is important to note that the BCRs are based on the legacy methodology used by the Iowa DOT and do not reflect the recommendations documented in the next section of this report. Each potential project was tabulated based on the range of predicted average annual accidents and range of benefit-cost ratio as shown in Table 4 below.

Table 4: Benefit-Cost Ratio versus Annual Predicted Crash Frequency

Predicted Crashes per Year	BCR < 1.0	1.0 ≤ BCR < 2.0	2.0 ≤ BCR < 3.0	3.0 ≤ BCR < 4.0	4.0 ≤ BCR < 5.0	5.0 ≤ BCR < 10.0	10.0 ≤ BCR < 15.0	Total
0 ≤ X < 0.030	5,767	457	58	57	15	0	0	**6,354**
0.030 ≤ X < 0.075	82	172	101	43	38	28	2	**466**
0.075 ≤ X	0	2	17	1	5	12	7	**44**
Total	**5,849**	**631**	**176**	**101**	**58**	**40**	**9**	**6,864**

Of 6,864 potential projects evaluated, 5,849 are not economically viable as they produce a BCR of less than 1.0, meaning the project benefits do not exceed project costs. The remaining 1,015 produce benefits exceeding project costs. Yet it is important to understand how the viable projects align with predicted crash frequency. At locations above the 0.075 threshold, all 44 evaluated projects resulted in a BCR above 1.0. The 0.075 threshold, however, means that 975 projects at locations have a BCR above 1.0 but are at locations below the threshold. This indicates a substantial number of opportunities to cost-effectively deploy safety countermeasures. At the locations between the 0.030 and 0.075 thresholds, 466 projects were evaluated. Of those, all but 82 have a BCR above 1.0. Therefore, most projects at locations above the 0.030 threshold are economically viable. While most projects at a location below the 0.030 threshold have a BCR that is below 1.0, it is important to acknowledge that 587 projects have a BCR above 1.0. This reveals that a lower threshold (such at 0.030) will capture many more viable improvement projects and a few project with a BCR below 1.0, but it will not necessarily capture all projects where the BCR is expected to exceed 1.0.

In summary, the Iowa DOT method currently used by Iowa DOT produces predictions of both the predicted crashes per year for statewide crossings and the predicted benefit-cost ratio of potential improvement projects. Reviewing the 2016 results of this process, the pool of preferred Section 130 candidates is limited to just 28 locations and 44 candidate projects where each of those projects would have a benefit-cost ratio over 1.0. Even without modifying the methodologies for predicted crashes or benefit-cost calculation, the data suggests that Iowa DOT's current threshold of 0.075 narrows the candidates projects down to only cost-effective projects, the use of a lower threshold could encourage wider use of the program and address a larger portion of statewide crashes if Section 130 dollars are allocated to communities that meet predicted crash thresholds above 0.030, benefit-cost ratio above 1.0, and that have the funding available for the public match in the near-term horizon.

9.2 Candidate Hazard Ranking Methods

HDR analyzed four alternative hazard ranking models in use by state DOTs and the FRA to determine a preferred methodology for a revised Iowa DOT hazard ranking model. The first alternative is the FRA GradeDec methodology, previously discussed in Section 5.2 of this report. The remaining three methods are the adjusted GradeDec method, the Missouri Exposure Index, and the Texas Priority Index. Table 5 below compares several of the models evaluated in this study on their inclusion of key explanatory variables.

Table 5: Comparison of Grade Crossing Prioritization Models Inputs

	U.S. DOT Accident Prediction Model (Model currently used in Ohio)	New Hampshire Hazard Index	Florida DOT Safety Hazard Index	Missouri DOT Exposure Index	North Carolina DOT Investigative Index	Texas DOT Priority Index
Type of Hazard Ranking Model	Crash Prediction	Hazard Index	Hybrid	Hazard Index	Hybrid	Hazard Index
Number of States using Model	19	5	1	1	1	1
Number of Variables	9	3	9	8	9	13
Additional Variables Needed in Database	None	None	HS SB	HS SD	SB SD	HS SD
Compatibility with Existing Practice						
Use of Crash Prediction Metric	✓✓	No	✓	No	No	✓
All Data Available in Inventory	✓✓	✓✓	✓	No	No	No
Includes Crash History	✓✓	No	✓✓	No	✓✓	✓
Applicability to Ohio Grade Crossings						
Additional Variables Relevant (based on Crash Analysis)	N/A	N/A	??	No	??	No
Accuracy of Model (Based on Expert Panel Analysis)	✓	Limited	Limited	Limited	✓	Limited
Model Functionality						
Model Complexity	Very	✓✓	✓	✓✓	✓	✓
Ease of Operation	Not	✓✓	✓	✓✓	✓	✓
Differentiate Among Passive Crossings	No	No	✓	✓✓	✓	✓✓
Compatible with Economic Analysis	✓✓	Not	✓	Not	Not	✓

Key - Performance of model with respect to criteria: (✓✓) Strong; (✓) Satisfactory; (??) Unknown; Others Noted.
Variables - HS: Highway Traffic Speed; SB: Volume of School Bus; SD: Sigh Distance

Source: Evaluation of Grade Crossing Hazard Ranking Models Final Report, Ohio Department of Transportation, 2016

9.2.1 Adjusted GradeDec Model

The Iowa DOT perceives their current projects for highway-rail grade crossing improvements focus heavily on recent crash activity even if that recent history is just one crash, which includes an element of random chance. The GradeDec crash prediction formula does in fact utilize a weighted average of crash prediction based on site conditions and exposure and recent crash history, so to limit the weight given to a location with a single crash a simple adjustment was made to the process. For location with one crash in the last 5 years, the formula is calculated as if the crossing experienced zero crashes. If the location experienced two or more crashes, then the crash history is used in the methodology without alteration. The result is the highest ranking locations are still those with a recent pattern of crash activity (2 or more crashes in the last 5 years) where the second tier of ranked locations are predominantly location with a high predicted likelihood of crashes with one or zero crashes occurring at the location in the last 5 years.

9.2.2 Missouri Exposure Index

The Missouri Exposure Index uses a process that focuses on a limited number of variables that combine to compute an index from high to low levels of risk exposure, but does not yield a predicted number of crashes. The key elements of this model are the number of train crossings and number of vehicles on the highway at the crossing with both sets of volume weighted by their respective speeds. For active grade crossings the weighted sum is left unadjusted, but for passive grade crossings, an adjustment factor is applied based on the availability of adequate sight distance. If sight distance is very limited then the adjustment factor can approach 1.0, which would result in the exposure index being multiplied by 1 plus 1, or exposure index multiplied by 2. The Missouri Exposure index does not have any sensitivity to recent crash history. Upon applying the model to a sample dataset, the Missouri Exposure index is likely to rank crossings with high rail traffic volumes operating at high speeds as the locations with the highest priority, regardless of current safety features at the crossing or recent crash history.

9.2.3 9.2.3 Texas Priority Index

The Texas Priority Index generates a predicted annual crash frequency for all crossings accounting for a wide cross section of input variables. The Texas model was chosen partially through interest of the Iowa DOT to evaluate methods flexible to make use of Iowa's highway-rail crossing dataset while including a few significant factors unaccounted for in the GradeDec model (e.g., sight distance for passive crossings). The Texas method does include an adjustment factor for crashes, which was similarly treated as the adjusted GradeDec method for locations with a single recent crash. The crash history adjusted prediction for annual crashes is used to determine the relative ranking of all active crossings. The passive crossings, though also included in the crash prediction calculations, are ranked separately through weighted average of risk factors. The lists of active crossings and passive crossings are then "shuffled" together, so the final rankings generally alternate between active and passive crossings. The "shuffling" method of final ranking development was developed since the scheme to rank all crossings on a crash prediction centric index highly skewed the rankings toward active crossings.

9.3 Selecting a Preferred Methodology

The HDR project team took the four models described above and implemented those models side-by-side in a MS Excel spreadsheet. The models were able to be broadly applied to all public highway-rail crossings in Iowa with only a few factors omitted due to data availability (e.g., sight distance, dip/hump). However, contrasting the four models over all crossings does not provide a strong indication of the value of one model over all others. To determine the "true" ranking of crossings the Iowa DOT solicited input from the project TAC. The TAC was convened to conduct an expert panel ranking exercise for 20 selected crossings in Iowa, which were selected randomly from the list of locations where field data collection was recently completed and available. The selected sites were compared to the statewide distribution for control (passive versus active), range of roadway volume, range of daily trains, and crash history. The 20 locations were ranked by expert opinion based on the data generally utilized in the candidate models using a Pugh Matrix format. The expert panel was shown two crossings that might be competing for Section 130 funding. Each panel member would vote on a scale of 1 (Much Less Important) to 5 (Much More Important) based on the question, "How would you rate the importance of crossing X compared to crossing Y?" as shown in Figure 2 below.

Figure 2: Sample Grade Crossing Summary Used in Expert Panel Evaluation

Crossing Location

Crossing ID:	191103A	E
Street Name:	JOSLIN AVE	
County:	POTTAWATTAMIE	
Municipality (if applicable):	RURAL	

Crossing and Rail Data

Daytime Trains:	10
Nighttime Trains:	10
Existing Warning Device	
Passive:	☐
Flashing Lights:	☑
Gates:	☑
Number of Tracks:	1
Max Timetable Speed:	60
Passenger Rail Service:	☐

Roadway Data

Traffic Volume (AADT):	430
Posted Speed Limit:	55
Cross Street Lanes:	2
Stop Signs:	☐
Medians:	☐
Cross Street Surface:	Concrete
Highway Type/Context:	Rural
Nearby Intersection:	☐

Sight Distance Data

Vehicle Stopping Distance:	535 ft
Smallest Crossing Angle:	90°
Required Sight Distance:	704 ft
Measured Sight Distance	
Quadrant 1:	420 ft
Quadrant 2:	Adequate
Quadrant 3:	Adequate
Quadrant 4:	Adequate

Crash Data

Crash History		
2012 - 2016		
	Fatal:	0
	Injury:	0
	PDO	0
2007 - 2016		
	Fatal:	1
	Injury:	1
	PDO	0

	SCORE
E compared to F is	2
E compared to G is	3
E compared to H is	3
E compared to I is	2
E compared to J is	3
E compared to K is	3
E compared to L is	3
E compared to M is	3
E compared to N is	2
E compared to O is	4
E compared to P is	2
E compared to Q is	3
E compared to R is	3
E compared to S is	4
E compared to T is	2

Scoring System
Much Less Important = 1
(Picture on Right)
Less Important = 2
Even = 3
More Important = 4
Much More Important = 5
(Picture on Left)

The seven panelists on the expert panel recorded their responses at nearly the same time, so as not to be influenced by other responses. However, if the group's initial responses varied widely, a moderator sought to understand the choice of score by the experts providing the outlier ranking and then re-polled the group to get a less variable set of responses. In total, 190 paired comparisons were made by the panel. The panel score was converted into a score that could be entered into the Pugh Matrix.

Once the scores were tabulated across each comparison in the matrix, the panel's relative scores created an expert preferred ranking of the 20 sample crossings as shown in Figure 3 below.

Figure 3: Pugh Matrix for Sample Crossing

	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	SCORE	Rank
a		1	0.5	2	2	2	2	4	2	1	2	1	1	0.5	0.5	0.5	2	0.5	2	0.5	27.00	7
b	1		0.5	2	2	2	2	1	2	2	2	2	2	1	1	0.5	1	1	2	1	28.00	6
c	2	2		4	4	4	4	2	2	2	2	4	2	1	2	1	2	2	4	1	47.00	1
d	0.5	0.5	0.25		1	1	1	0.5	1	1	1	0.5	0.5	0.5	0.5	0.25	1	0.5	1	0.5	13.00	18
e	0.5	0.5	0.25	1		0.86	0.93	0.86	1	1	0.79	0.86	1.29	0.43	0.89	0.5	0.86	0.75	1.43	0.57	15.27	16
f	0.5	0.5	0.25	1	1.1628		1.14	0.46	1.21	1.29	1.07	1	1.5	1.04	0.93	0.43	1.07	0.86	1.57	0.5	17.48	12
g	0.5	0.5	0.25	1	1.0753	0.8772		0.36	1.21	1.14	0.93	0.64	0.79	0.43	0.79	0.39	0.79	0.61	1.36	0.46	14.10	17
h	0.25	1	0.5	2	1.1628	2.1739	2.7778		2.57	2.43	2.14	2.14	2.43	1.5	1.5	1.29	2	1.71	2.57	1.21	33.35	4
i	0.5	0.5	0.5	1	1	0.8264	0.8264	0.3891		1.29	1.07	0.93	1.29	0.5	0.75	0.46	1	1	1.71	0.5	16.04	13
j	1	0.5	0.5	1	1	0.7752	0.8772	0.4115	0.7752		0.54	0.68	0.79	0.61	0.5	0.39	0.71	0.54	1	0.36	12.96	19
k	0.5	0.5	0.5	1	1.2658	0.9346	1.0753	0.4673	0.9346	1.8519		1	1.07	0.54	0.57	0.5	0.71	0.68	1.07	0.39	15.56	15
l	1	0.5	0.25	2	1.1628	1	1.5625	0.4673	1.0753	1.4706	1		1	0.64	0.68	0.54	0.79	0.82	1.21	0.43	17.60	11
m	1	0.5	0.5	2	0.7752	0.6667	1.2658	0.4115	0.7752	1.2658	0.9346	1		0.57	0.82	0.39	0.71	0.75	1.21	0.43	15.97	14
n	2	1	1	2	2.3256	0.9615	2.3256	0.6667	2	1.6393	1.8519	1.5625	1.7544		1.36	0.54	1.29	1.46	2.36	0.54	28.64	5
o	2	1	0.5	2	1.1236	1.0753	1.2658	0.6667	1.3333	2	1.7544	1.4706	1.2195	0.7353		0.82	2.14	1.46	2	0.71	25.27	8
p	2	2	1	4	2	2.3256	2.5641	0.7752	2.1739	2.5641	2	1.8519	2.5641	1.8519	1.2195		1.86	1.36	2.29	0.93	37.33	2
q	0.5	1	0.5	1	1.1628	0.9346	1.2658	0.5	1	1.4085	1.4085	1.2658	1.4085	0.7752	0.4673	0.5376		0.86	1.71	0.61	18.31	10
r	2	1	0.5	2	1.3333	1.1628	1.6393	0.5848	1	1.8519	1.4706	1.2195	1.3333	0.6849	0.6849	0.7353	1.1628		1.86	0.86	23.08	9
s	0.5	0.5	0.25	1	0.6993	0.6369	0.7353	0.3891	0.5848	1	0.9346	0.8264	0.8264	0.4237	0.5	0.4367	0.5848	0.5376		0.36	11.73	20
t	2	1	1	2	1.7544	2	2.1739	0.8264	2	2.7778	2.5641	2.3256	2.3256	1.8519	1.4085	1.0753	1.6393	1.1628	2.7778		34.66	3

MUCH LESS IMPORTANT = 0.25
LESS IMPORTANT = 0.5
EVEN = 1
MORE IMPORTANT = 2
MUCH MORE IMPORTANT = 4

The expert rankings identified from the Pugh Matrix exercise then were compared to the rankings of the four alternative models using the Spearman's Rank Correlation Coefficient, the results of which are shown in Table 6 below.

Table 6 Spearman's Rank Correlation Coefficient Results

Crossing ID	Letter ID	Short Name	Warning Device Type	Panel Ranking	Texas	Missouri	FRA	FRA - Modified
909173F	A	25_ OLD PORTLAND RD	Passive	7	11	19	1	1
074077S	B	20_ KANSAS ST	Passive	6	2	20	3	16
190316G	C	8_ KEY LN	Passive	1	7	14	2	2
074359H	D	36_WAUBONSIEAVE	Gates	18	19	15	19	19
191103A	E	78_JOSLINAVE	Gates	16	12	11	18	18
190309W	F	8_MARIONST	Gates	12	4	2	9	7
191267R	G	67_WHITTIERST	Gates	17	20	18	17	17
074373D	H	65_LINCOLNAVE	Passive	4	3	13	6	4
063200H	I	88_NEWYORKAVE	Gates	13	10	8	8	6
603340D	J	25_UTEAVE	Gates	19	18	12	20	20
191248L	K	67_IOWAAVE	Gates	15	14	10	13	11
191077M	L	43_S6THST	Gates	11	8	5	7	5
074392H	M	65_BUNGEAVE	Gates	14	16	3	12	10
074046T	N	20_NMAINST	Gates	5	5	1	5	3
271484M	O	8_LINNST	Passive	8	6	17	11	9
603646H	P	77_RACCOONRIVERDRIVE	Flashing Lights	2	1	6	4	15
876006L	Q	77_HUBBELLAVE	Gates	10	13	4	10	8
377219U	R	77_ASHWORTHRD	Gates	9	15	9	15	13
074403T	S	78_SEXPRESSWAY	Gates	20	17	16	16	14
922305U	T	77_PARKAVE	Flashing Lights	3	9	7	14	12

The expert panel most resembles the results of the Texas Priority Index with a Spearman's Coefficient of 0.79. The FRA GradeDec method without the crash history adjustment was second at a very close 0.77 though the FRA GradeDec adjusted method dropped to 0.55 with just one amended step in the process, primarily because the method was very inaccurate in ranking crossing B and crossing P, which both had one crash in the last 5 years. The Missouri model was dissimilar from the expert rankings and the other models.

After discussing the results of these findings, the Texas Priority Index was selected as the preferred ranking methodology by Iowa DOT. The Texas Priority Index methodology involves the following three elements: Calculation of the Texas Priority Index for active crossings, calculation of the Texas Passive Crossing Index for passive crossings, and interweaving of the two crossing type ranking lists into a unified list.

9.3.1 Texas Priority Index

The Texas Priority Index is hazard ranking based on both multivariate exponential function to predict annual accidents and an adjustment factor for five year crash history. The calculation of predicted annual accidents is also appropriate for passive crossings, but passive crossings are likely to have lower values of predicted accidents and thus are ranked using a supplementary method.

The formulation of the Texas Priority Index (TPI) is as follows:

Predicted Accidents = EXP[-6.924 + Protection Factor Indicator + 0.2587 * Highway Paved +

-0.3722 * Urban / Rural + 0.0706 * Number of Roadway Lanes +

0.0656 * Total Number of Tracks at Crossing + 0.0022 * Actual Stopping Sight Distance for Approach + 0.0143 * Maximum Typical Train Speed + 0.0126 * Minimum Typical Train Speed for Switching + 1.0024 * LOG (Total Daily Trains + 0.5)

+ 0.4653 * LOG (Annual Average Daily Traffic) – 0.216 * Nearby Intersection + 0.0092 * Roadway Speed Limit on Approach

Where, Protection Factor Indicator = 0.5061 for Flashing Lights, -0.2006 for Gates, else 0

Highway Paved is 1 if yes, 2 if no

Urban Rural is 1 if Urban, 2 if Rural

Nearby Intersection is 1 if yes, 2 if no

The TPI = 1,000 * Predicted Accidents * (Five-year crash frequency + 0.1)

The active crossings ranking list is then based on highest TPI to lowest TPI.

9.3.2 Texas Passive Crossing Index

The Texas Passive Crossing Index (TPCI) uses a weighted average method to rank high need locations (locations with the highest TPCI values). The variables used in the TPCI were chosen to include the following: five-year crashes, daily trains, daily school buses, number of tracks, train speed, Annual Average Daily Traffic (AADT), nearby traffic signal, sight distance, trucks per day, nearby intersection, highway speed limit, approach angle, dip/hump. Each variable is rated on a scale of up to 100 based on the utility of a given location a given variable compared to all other locations when considering that variable, essentially where the variable of interest lies on a cumulative distribution function of that variable where the population is statewide passive crossings. For example, the number of tracks at a crossing may be one, and considering all other passive crossings in the state 79 percent have one track at the crossing. The score for that crossing for the number of tracks variable would be 0.79. The cumulative frequency distributions have been redeveloped from the Texas research to be based on the Iowa dataset, but the weight values have been left as the Texas values.

The formulation for the TPCI is as follows:

TPCI = [5 * U(Five-year crashes) + 4.778 * U(Daily Trains) + 4.778 * U(Daily School Buses) + 3.8568 * U(Number of Tracks) + 3.8568 * U(Train speed) + 3.2922 * U(Annual Average Daily Traffic + 3.016 * U(Nearby traffic signal) + 3.016 * U(Sight Distance) + 1.93 * U(Trucks per day) + 1.8038 * U(Nearby intersection) + 1.7132 * U(Highway speed limit) + 1.5016 * U(Approach angle) + U(Dip/hump)] / 39.5424

The TPCI is calculated for each passive crossings and then a ranking list is developed with the highest TPCI value with the preeminent rank.

9.3.3 Integrated TPI and TPCI Ranking

The TPI and TPCI ranking systems are relevant for comparing within their respective active and passive crossing classes, but do not represent a singular ranking system. The predicted accident value is consistent across both sets of crossings, but is biased toward passive crossings that carry risk per exposure above the levels of active crossings, but much lower levels of exposure. The Texas Priority Method opted to value top candidates from each list by scaling the TPCI ranks, integrating the lists of TPIs and scaled TPCIs, and then re-ranking the new integrated list. The research based the scale factor came from the ratio of active to passive crossings with a Texas-specific split of 62 percent active crossings and 38 percent passive crossings. The current Iowa scalar is essentially 38 percent active crossings and 62 percent passive crossings. Though the proportions are flipped, the result is still an integrated list where passive crossings are at nearly even weighting with active crossings in the hazard ranking list. Iowa DOT has the flexibility to adjust the priority between these two lists or leave it based on the count of crossings in each category based on their judgment.

9.4 Development of the Iowa DOT Grade Crossing Database / Hazard Ranking Tool

After selecting the Texas Priority Index as part of its revised Section 130 process and subsequent coordination, Iowa DOT requested that the HDR project team develop a tool that would allow for statewide calculation of grade crossing rankings as updates are made to Iowa DOT's grade crossing database and / or the FRA grade crossing crash history. The HDR project team addressed the tool and Iowa DOT's functional tool requirements by building a multi-tab Microsoft Excel spreadsheet populated by a data retrieval application written in C-sharp. The spreadsheet portion of the tool provides a balance between friendly user interface and transparency of the process. The Iowa DOT grade crossing database / hazard ranking tool spreadsheet has been developed utilizing the following tabs:

- Report
- AllXings_Models
- Frequency_Tables
- RR_Crashes
- Updates
- Lookups

The database / hazard ranking spreadsheet tool and related user instruction sheet developed for the project can be found in Appendix C; an overview of the tool's main page is presented in Figure 4 below. The following sections identify and describe components of the database / hazard ranking tool.

Figure 4: Database / Hazard Ranking Tool Overview

Jurisdiction: Any **Filter:** All **Railroad:** All

Date of Report: 8/27/2018
Date of Crossing Update: 7/19/2018
Date of Crash Update: 8/20/2018

Rank	FRA No.	RR	Distr	County	City	Street/Road Name	Present Warning Device	AAD	Train Speed (mph)	Predicted Accident Per Year
1	307671B	CC	3	Plymouth county	HINTON	MAIN ST.	Gates	1710	30	0.01444
1	074097D	BNSF	4	Union county	THAYER	TULIP AVE	Passive	80	79	0.04219
3	191223R	UP	4	Harrison county	LITTLE SIOUX	125TH ST	Gates	15	40	0.00800
3	074105T	BNSF	4	Union county	CRESTON	JAGUAR AVE	Passive	60	79	0.03981
5	079441U	BNSF	5	Jefferson county	FAIRFIELD	REDWOOD AVE	Passive	35	79	0.03570
5	079438L	BNSF	5	Jefferson county	FAIRFIELD	PINE AVE	Passive	25	79	0.03336
5	079232L	BNSF	5	Henry county	NEW LONDON	OAKBERRY AV	Passive	15	79	0.03008
5	062978F	BNSF	5	Wapello county	AGENCY	30TH AVE	Passive	20	79	0.03189
5	062972P	BNSF	5	Wapello county	AGENCY	56TH AVE	Passive	35	79	0.03570
10	191044A	UP	4	Harrison county	WOODBINE	LINCOLN WAY	Gates	2910	70	0.12424
11	190307H	UP	1	Boone county	BOONE	DIVISION ST	Gates	3030	70	0.11425
12	190763H	UP	3	Carroll county	GLIDDEN	COLORADO ST	Gates	1960	70	0.11172
13	079118L	BNSF	5	Lucas county	CHARITON	250TH AVE	Passive	10	79	0.02711
13	079094A	BNSF	5	Lucas county	LUCAS	127TH AVE	Passive	45	79	0.03674
13	079091E	BNSF	5	Lucas county	LUCAS	480TH LANE	Passive	40	79	0.03588
13	079087P	BNSF	5	Clarke county	WOODBURN	IDAHO LN	Passive	10	79	0.02711
17	190322K	UP	1	Boone county	OGDEN	N 1ST ST	Gates	2400	70	0.10899
18	190388K	UP	6	Clinton county	DE WITT	6TH AVE	Gates	5300	70	0.10878
19	190753C	UP	1	Greene county	RALSTON	APPLE ST	Gates	930	70	0.10817
19	074077S	BNSF	5	Clarke county	MURRAY	KANSAS ST	Passive	30	79	0.03461
21	079395V	BNSF	5	Monroe county	ALBIA	677TH AVE	Passive	15	79	0.03134
22	190300K	UP	1	Boone county	BOONE	STORY ST	Gates	2610	70	0.10738
23	074078Y	BNSF	5	Clarke county	MURRAY	160TH AVE	Passive	30	79	0.03461
24	190734X	UP	1	Greene county	JEFFERSON	LINWOOD AVE	Passive	10	70	0.04172
24	063028P	BNSF	5	Jefferson county	FAIRFIELD	N 4TH ST	Gates	5600	79	0.10671
26	191071W	UP	4	Harrison county	MISSOURI VALLEY	290TH ST	Passive	5	70	0.03626
26	190750G	UP	1	Greene county	SCRANTON	C AVE	Passive	15	70	0.04528
28	191023G	UP	4	Harrison county	DUNLAP	IA 37	Gates	1280	70	0.10524

Report | AllXings_Models | Frequency_Tables | RR_Crashes | _updates | _lookups

9.4.1 Spreadsheet Tool Report Tab

The report tab (shown in Figure 4 above) is the primary user interface for the spreadsheet tool. From the report tab, Iowa DOT or other agency users can review crossings sorted by statewide ranking for all highway-rail grade crossings in Iowa, state-owned crossings in an individual district, or crossings owned by a county or city and mix those options with filtering by railroad. Filtering operations on the Report sheet are accomplished with drop down boxes in cells C3 and G4:G4. Each crossing the in the report provides a variety of location information (i.e., district, county, city, street/road name), present grade crossing warning device, roadway volume, train speed, and predicted accidents per year. The report tab is also automatically dated with the print date of the report, the date of the last update for the crossing inventory, and the date of the last update of the crash data.

9.4.2 Spreadsheet Tool AllXings_Models Tab

The AllXings_Models tab is the primary back-end calculation sheet that feeds the output on the Report tab. Columns A through CW of this spreadsheet tab are a dynamic range that is linked to the highway-rail grade crossing inventory update application. Columns CX to DP are generally derived variables based on formulas that use the crossing inventory data as input. This input range of formulas is tied to the crossing inventory update application, so overwriting the formulas in this range will only persist until the next time the crossing inventory update application is run. The one caveat to the typical function of this range is in columns DD to DF which are available for user input sight distance variables. As sight distance should be reconfirmed frequently, but is not currently part of the Iowa DOT's statewide grade crossing inventory, the user is recommended to collect and store sight distance measurements in another file and then only add those measurements to the spreadsheet tool when evaluating Section 130 applications within the current evaluation cycle.

Columns DQ to EG calculate the component variable individual contributions to and resultant crash prediction, crash history adjustment, and active crossing ranking. Columns EH to EV calculate the component variables and resultant Texas Passive Crossing Index. Columns EW to FE calculate formulas to generate a combined ranking list and supportive calculations for the filter operations on the Report tab.

9.4.3 Spreadsheet Tool Frequency_Tables Tab

The Frequency_Tables tab is a set of cumulative distributions dynamically regenerated when the highway-rail grade crossing inventory update application is run. The cumulative distributions are part of the Texas Passive Crossing Index. Cumulative distributions are generated for Five-Year Crashes, Trains, School Buses, Number of Tracks, Train Speed (Max), AADT (Annual Average Daily Traffic), Nearby Traffic Signal, Sight Distance, Daily Truck Volume, nearby intersection, Highway Speed Limit, and Approach Angle. Manual updates to the Frequency_Tables tab are overwritten the next time the crossing inventory update application is run.

9.4.4 Spreadsheet Tool RR_Crashes Tab

RR_Crashes is a tab to store the latest output of the crash update application. Columns A through BA store the crash data table using the database infrastructure used in Iowa DOT's Oracle crash database based on the FRA's crash database. Columns BB through BG represent equations used to sort crash severity and tag crashes as being within the last 5 years or 10 years for potential use in the Texas Priority Index method.

9.4.5 Spreadsheet Tool _updates Tab

The tab _updates is included for transparency of the last use of the crossing inventory update and crash update applications. The dates stored in _updates are referenced in the report tab. Should the report tab be inadvertently modified in the header information, users would still have a record of the last runs of the two supportive data update applications by checking the _updates tab.

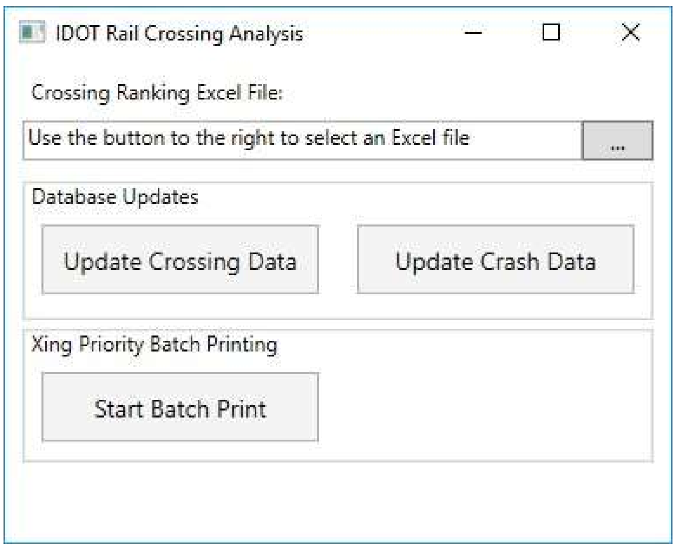
9.4.6 Spreadsheet Tool _lookups Tab

The tab _lookups is included for connecting numeric coded information with named values used in the reports tab and AllXings_Models tab. The tab _lookups includes names and numbers of all Iowa Counties, Railroads, Cities, and county relationships to districts.

9.4.7 Database Update Application

The database update and batch report applications provide a simple four-button user interface. The first button is used to navigate for the spreadsheet to be linked to the database update and batch reporting. The second and third buttons toward the top of the user interface are to call the crossing inventory update and to call the crash update. The lower button initiates a batch report print job for all Iowa DOT districts, cities, counties, and railroads with eligible highway-rail grade crossings. The database update and batch report applications user interface is shown in Figure 5 below.

Figure 5: Database Update and Batch Report Application



9.4.8 Crossing Inventory Update

The Crossing Inventory Update function connects to Iowa DOT's railroad crossing database feature class at the following location:

https://gis.iowadot.gov/public/rest/services/RAMS/Railroad_Crossiing/FeatureServer/0

Once the connection is made to the up-to-date data, key fields used in the Texas Priority Index calculations are written to the AllXings_Models tab of the linked spreadsheet. As the size of the crossing inventory is dynamic, all contents in Columns A through FE are cleared when the crossing inventory update is initiated. Once the crossing database values are written in Columns A through CW, the formulas in Columns CX through FE are pasted from row 1 to the maximum number of rows in the crossing inventory.

The crossing inventory update also pastes the current date into the _updates tab in cell B2.

9.4.9 Crash Update

The Crash Update function connects to Iowa DOT's Oracle database housing past FRA data received on crashes. The Crash Update should thus be run following known updates to the Oracle database.

Once the connection is made to the up-to-date data, the RR_Crashes tab is cleared and a dynamically sized array of the data is pasted in Columns A through BA. Formulas in Columns BB through BG are also pasted over past values to dynamically match the size of the up-to-date data array. The latest additions to the crash history data will then have a resultant impact on the Texas Priority Index and statewide rankings. The Crash Update function also pastes the current date into the _update tab in cell B1.

9.4.10 Batch Report

The batch report function utilizes the filtering capabilities in the related Microsoft Excel database / hazard ranking tool to isolate individual owner jurisdictions or individual railroad operators. The batch report function is linked to the set of Iowa DOT districts, counties, cities, and railroads within Iowa DOT's highway-rail grade crossing database, which should always be updated by the user before advancing to the batch report tool. If a jurisdiction or railroad should have zero eligible crossings, the procedure will skip over that entity without printing an empty report. All entities will be printed to PDF using a landscape 8.5-inch by 11-inch format in separate files within the same directory as the tool. The PDF files will use the following naming convention: "ENTITY TYPE"_"ENTITY NAME".pdf. An example might be RAILROAD_UNION PACIFIC.pdf. The PDFs may be multiple pages, but will be in separate files for each unique entity to allow Iowa DOT to attach the resulting PDFs to their annual request letter for Section 130 grant applicants.

9.5 Database / Hazard Ranking Tool Limitations and Potential Future Enhancements for Implementation

Development of the grade crossing database / hazard ranking tool and a simple user guide (see Appendix C) accounted for inputs and guidance from Iowa DOT and the project TAC, and was completed in August 2018. The database / hazard ranking tool balances ease of use of the spreadsheet with increased transparency of the new Texas Priority Index-based ranking system. The tool's primary interface is a filterable report tab that agencies can use to examine grade crossings within their jurisdiction for potential Section 130 funding. The tool provides a user friendly application for updating the state's crossing inventory and the FRA-published crash history into the spreadsheet to help improve the opaque process that formerly occurred within the Iowa DOT's Oracle system.

The grade crossing database / hazard ranking tool may gain enhanced value from future updates. The following upgrades are not a part of the initial version developed during this study, but are recommended for future consideration and implementation by Iowa DOT.

1. Estimate Texas Priority Index crash prediction coefficients based on Iowa-specific data – The current tool copied directly the formulation of the Texas Priority Index model for crash prediction. The model most closely matched the expert panel of rankings, but the project team did not have an opportunity to test the Texas Priority Index with Iowa-specific coefficients that would better match aggregate crash levels in Iowa as opposed to those in Texas. Coefficients could also be re-estimated for the passive crossing procedure based on Iowa preferences.

2. Merge the crossing database / hazard ranking tool with the project prioritization benefit-cost tool – The project generated two tools with independent utility in first finding locations with high safety needs and then evaluating those locations for potential improvements to confirm that the locations with a high safety need can be improved through a cost-beneficial project. The opportunity for the future would be to streamline the two tools into a single location, so stakeholder agencies could have positive guidance on how to use the two tools together. For more details about the project prioritization tool developed for this study, see Section 10.

3. Determine a new high-need threshold – By moving to the Texas Priority Index, the project team's work to consider the past Iowa DOT 0.075 predicted crashes per year threshold is less directly applicable. Future work may look to create similar cumulative distribution plots of statewide crash prediction calculations to determine natural points of inflection to set a similar reinforcing threshold, though hopefully a threshold that allows a wide variety of applicants for Section 130 funding.

4. Batch report functionality enhancements – The batch report process alleviates a time consuming task in printing the report sheet of database / hazard ranking tool for each entity (i.e., Iowa DOT district, county, city, or railroad). The next potential enhancement that could be developed would be to take the resulting multitude of PDF report files and automatically deliver to them to individual entities.

10.0 Implementation of Economic Analysis and Development of a Revised Project Prioritization Tool

As part of this project, HDR reviewed the existing Iowa DOT benefit-cost methodology for prioritizing grade crossing safety enhancements. HDR made several suggestions for improvements, including updating the existing benefit values and crash modification factors. HDR also developed a method to tie project prioritization to the database / hazard ranking tool through the use of cost-effectiveness calculations that compare the Revised Texas Priority Index (TPI) and the Texas Passive Crossing Index (TPCI) to the costs of proposed improvements. The result is a revised project prioritization tool called the Iowa DOT Grade Crossing Benefit-Cost Analysis and Cost-Effectiveness Tool by which proposals for grade crossing safety enhancements can be readily evaluated and prioritized.

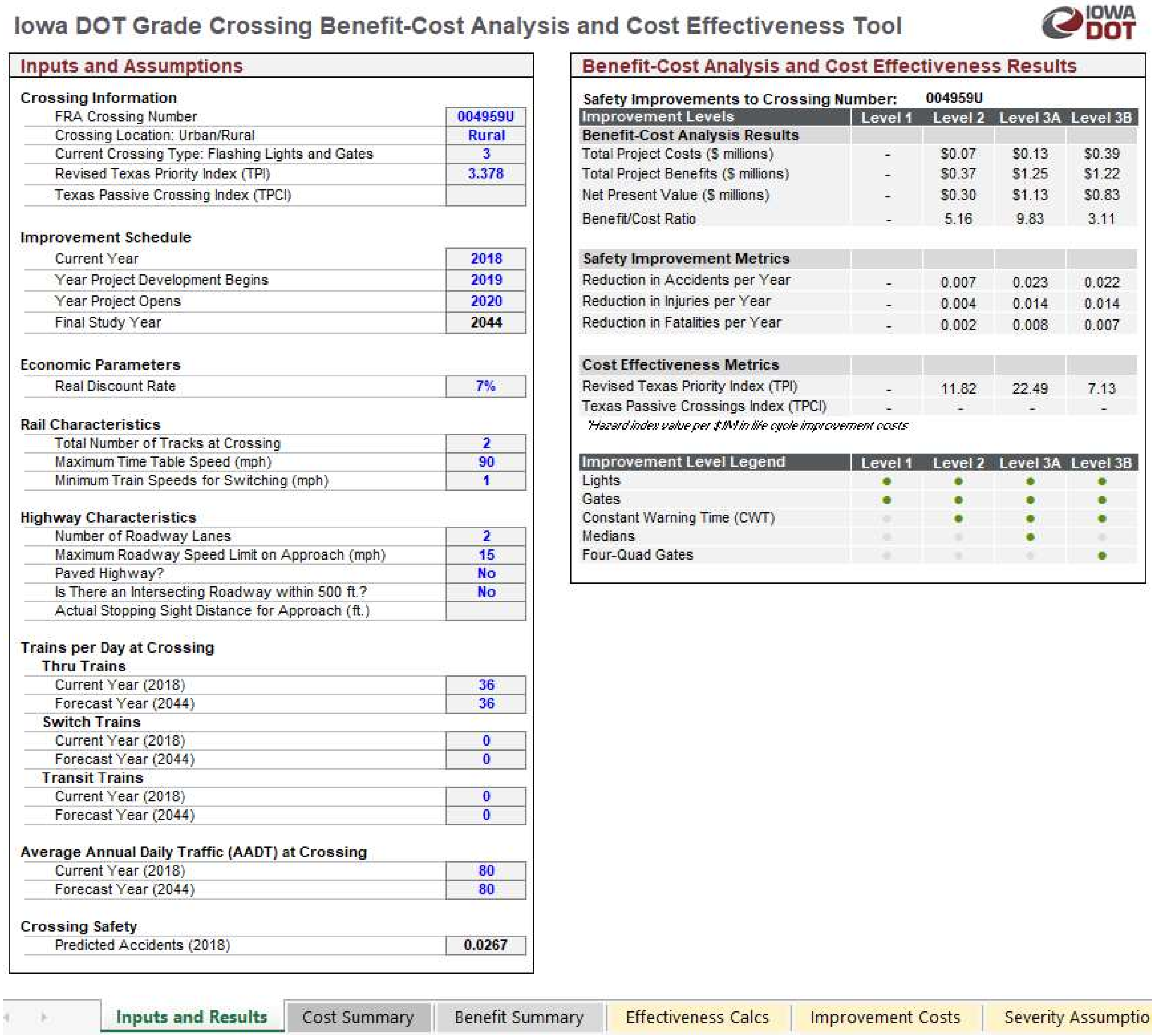
HDR developed the revised project prioritization tool as a user-friendly MS Excel-based spreadsheet for the Iowa DOT Office of Rail Transportation, through coordination and inputs from Iowa DOT and the project TAC, to assess the benefits and cost-effectiveness of constructing safety improvements at highway-rail grade crossings. These measures reflect not only the current expected reduction in crashes at the crossing, but also the potential change in hazards from a given improvement. This tool presents benefit-cost and cost-effectiveness measures for various levels of improvements, suggesting the improvement level that would limit the expected number of crashes while considering the cost of the various improvements.

The following nine worksheets are contained within the tool:

- Inputs and Results – Contains the user inputs and the results.
- Cost Summary – Summarizes the total capital cost and annual operations and maintenance (O&M) costs for each improvement level.
- Benefit Summary – Summarizes the annual safety benefits for each improvement level.
- Effectiveness Calcs – Contains the accident reduction assumptions for each improvement level.
- Improvement Costs – Contains the capital costs and the annual O&M cost assumptions by improvement level.
- Severity Assumptions – Contains the assumptions for the average number of injuries and fatalities by accident type (fatal or injury accident).
- Accident Costs – Contains the assumptions for the average cost of fatalities, injuries, and property damage accident.
- Safety Calcs – Contains the annual predicted number of accidents.
- Safety Calcs Sources – Contains the formulas and sources for the accident prediction methodology.

An overview of the main page of the tool is presented in Figure 6 below.

Figure 6: Iowa DOT Grade Crossing Benefit-Cost Analysis and Cost-Effectiveness Tool Overview



Iowa DOT Grade Crossing Benefit-Cost Analysis and Cost Effectiveness Tool

Inputs and Assumptions

Crossing Information	
FRA Crossing Number	004959U
Crossing Location: Urban/Rural	Rural
Current Crossing Type: Flashing Lights and Gates	3
Revised Texas Priority Index (TPI)	3.378
Texas Passive Crossing Index (TPCI)	
Improvement Schedule	
Current Year	2018
Year Project Development Begins	2019
Year Project Opens	2020
Final Study Year	2044
Economic Parameters	
Real Discount Rate	7%
Rail Characteristics	
Total Number of Tracks at Crossing	2
Maximum Time Table Speed (mph)	90
Minimum Train Speeds for Switching (mph)	1
Highway Characteristics	
Number of Roadway Lanes	2
Maximum Roadway Speed Limit on Approach (mph)	15
Paved Highway?	No
Is There an Intersecting Roadway within 500 ft.?	No
Actual Stopping Sight Distance for Approach (ft.)	
Trains per Day at Crossing	
Thru Trains	
Current Year (2018)	36
Forecast Year (2044)	36
Switch Trains	
Current Year (2018)	0
Forecast Year (2044)	0
Transit Trains	
Current Year (2018)	0
Forecast Year (2044)	0
Average Annual Daily Traffic (AADT) at Crossing	
Current Year (2018)	80
Forecast Year (2044)	80
Crossing Safety	
Predicted Accidents (2018)	0.0267

Benefit-Cost Analysis and Cost Effectiveness Results

Safety Improvements to Crossing Number: 004959U

Improvement Levels	Level 1	Level 2	Level 3A	Level 3B
Benefit-Cost Analysis Results				
Total Project Costs ($ millions)	-	$0.07	$0.13	$0.39
Total Project Benefits ($ millions)	-	$0.37	$1.25	$1.22
Net Present Value ($ millions)	-	$0.30	$1.13	$0.83
Benefit/Cost Ratio	-	5.16	9.83	3.11
Safety Improvement Metrics				
Reduction in Accidents per Year	-	0.007	0.023	0.022
Reduction in Injuries per Year	-	0.004	0.014	0.014
Reduction in Fatalities per Year	-	0.002	0.008	0.007
Cost Effectiveness Metrics				
Revised Texas Priority Index (TPI)	-	11.82	22.49	7.13
Texas Passive Crossings Index (TPCI)	-	-	-	-

Hazard index value per $IM in life cycle improvement costs

Improvement Level Legend	Level 1	Level 2	Level 3A	Level 3B
Lights	●	●	●	●
Gates	●	●	●	●
Constant Warning Time (CWT)		●	●	●
Medians			●	
Four-Quad Gates				●

Inputs and Results | Cost Summary | Benefit Summary | Effectiveness Calcs | Improvement Costs | Severity Assumptio

This tool was developed in support of the database / hazard ranking tool (described in Section 9 of this report) to provide the user additional information in determining the highway-rail grade crossings which would benefit from safety improvements. In particular, the database / hazard ranking tool provides the list of crossings ranked by the TPI and the TPCI, while the revised project prioritization tool quantifies the benefits of improving the grade crossing and potentially indicate what improvements would provide the most value.

The user should note that collisions between trains and motor vehicles at grade crossings are referred to as crashes in the Texas Hazard Index methodology, and as accidents in the Federal Railroad Administration's prediction methodology. Both terms are synonymous and are used interchangeably in this report.

10.1 Overview of Tool Instructions

To operate the tool, the user provides project information such as project schedule, grade-crossing characteristics, volume forecasts (i.e., train counts and vehicle traffic at grade crossing), and the TPI or TPCI, depending on the crossing type. This information should be entered within the Inputs and Assumptions table in the Inputs and Results tab, as seen in Figure 7 below. While the project schedule and volume forecasts may require external sources, the grade-crossing characteristics information can be extracted from Iowa DOT's Rail Crossing Inventory Database.

Figure 7: Inputs and Assumptions Table

Inputs and Assumptions	
Crossing Information	
FRA Crossing Number	004959U
Crossing Location: Urban/Rural	Rural
Current Crossing Type: Flashing Lights and Gates	3
Revised Texas Priority Index (TPI)	3.378
Texas Passive Crossing Index (TPCI)	
Improvement Schedule	
Current Year	2018
Year Project Development Begins	2019
Year Project Opens	2020
Final Study Year	2044
Economic Parameters	
Real Discount Rate	7%
Rail Characteristics	
Total Number of Tracks at Crossing	2
Maximum Time Table Speed (mph)	90
Minimum Train Speeds for Switching (mph)	1
Highway Characteristics	
Number of Roadway Lanes	2
Maximum Roadway Speed Limit on Approach (mph)	15
Paved Highway?	No
Is There an Intersecting Roadway within 500 ft.?	No
Actual Stopping Sight Distance for Approach (ft.)	
Trains per Day at Crossing	
Thru Trains	
Current Year (2018)	36
Forecast Year (2044)	36
Switch Trains	
Current Year (2018)	0
Forecast Year (2044)	0
Transit Trains	
Current Year (2018)	0
Forecast Year (2044)	0
Average Annual Daily Traffic (AADT) at Crossing	
Current Year (2018)	80
Forecast Year (2044)	80
Crossing Safety	
Predicted Accidents (2018)	0.0267

Once the necessary information has been inputted into the tool, the benefit-cost analysis and cost-effectiveness results from the various levels of safety improvements are presented on the right in the Inputs and Results tab, where the improvement levels are identified under the Improvements Level Legend Table. An example of a result can be seen in Figure 8 below. Detailed user instructions and guidance can be found in Appendix D.

Figure 8: Benefit-Cost Analysis and Cost-Effectiveness Results

Benefit-Cost Analysis and Cost Effectiveness Results

Safety Improvements to Crossing Number: 004959U

Improvement Levels	Level 1	Level 2	Level 3A	Level 3B
Benefit-Cost Analysis Results				
Total Project Costs ($ millions)	-	$0.07	$0.13	$0.39
Total Project Benefits ($ millions)	-	$0.37	$1.25	$1.22
Net Present Value ($ millions)	-	$0.30	$1.13	$0.83
Benefit/Cost Ratio	-	5.16	9.83	3.11
Safety Improvement Metrics				
Reduction in Accidents per Year	-	0.007	0.023	0.022
Reduction in Injuries per Year	-	0.004	0.014	0.014
Reduction in Fatalities per Year	-	0.002	0.008	0.007
Cost Effectiveness Metrics				
Revised Texas Priority Index (TPI)	-	11.82	22.49	7.13
Texas Passive Crossings Index (TPCI	-	-	-	-

**Hazard index value per $1M in life cycle improvement costs*

Improvement Level Legend	Level 1	Level 2	Level 3A	Level 3B
Lights	●	●	●	●
Gates	●	●	●	●
Constant Warning Time (CWT)	○	●	●	●
Medians	○	○	●	○
Four-Quad Gates	○	○	○	●

10.2 Tool Methodology

This section presents the general methodologies and assumptions used in the revised prioritization tool. The user should note that various assumptions can be adjusted or updated. For more information see Appendix D of this report.

10.2.1 Benefit Calculations

As the tool generates benefits through reduced vehicle accidents, a key calculation within the tool is the expected number of accidents. The tool applies the predicted crashes methodology imbedded in the TPI, which follows the same index methodology used in the Hazard Ranking Tool. This methodology calculates predicted crashes at the crossing based on the crossing's characteristics, daily train volume, and daily vehicle counts at the crossing. While the majority of grade crossing information is user input that can be readily extracted from the Iowa DOT Rail Crossing Inventory Database, sight distance data is currently unavailable. If sight distance is not provided by the user, the tool assumes 0 feet of sight distance on approach, which will result in a conservative understatement of the expected number of crashes.

The tool further splits the expected number of accidents by type (i.e., fatal accident, injury accident) using the U.S. DOT's crash probability formulas for fatal and injury crashes. Using the accident types, the expected number of fatalities, injuries, and property damage can be derived using Iowa DOT's historical number of fatalities, injuries, and property damage count by accident type.

The reduction of accident counts by injury severity is determined through a crash modification factor. With the exception of Constant Warning Time (CWT), the crash modification factors are derived using the latest effectiveness values from the FRA's GradeDec tool. CWT effectiveness values remain unchanged from the ones used in the prior Iowa DOT prioritization tool because HDR was unable to identify additional reliable sources on CWT benefits. The crash modification factor for a specific improvement depends on the current safety equipment at the crossing and the improvement. For additional levels of improvement, the crash modification factor takes into account the crash modification for the improvement level and all relevant previous crash modification factors. Given the crash modification factors, the new expected number of crashes from the improvement is simply the product of the crash modification factor and the original expected number of crashes, fatalities, and injuries.

The difference between the reduced values and the original values generates the number of fatalities, injuries, and property damage incidents avoided through safety improvements. The avoided counts are then monetized over the 25-year post-construction study period, using the societal cost per fatality, injury, and property damage accident. For the cost per fatality, the tool uses the latest Statistical Value of Life from the U.S. DOT's *BCA Guidance*.[8] Injury costs follow the cost MAIS Injury Severity Scale and KACBO-AIS Conversion if Injury Unknown, but adjusted to reflect the increase severity of injuries from a grade crossing accident.[9] Property damage costs were obtained from *NCHRP 755: Comprehensive Costs of Highway-Rail Grade Crossing Crashes*[10] to better reflect the severity of property damage relative to that of highway accidents. The annual monetized safety benefits are then summed and discounted using a 7 percent discount rate[11] to generate a total "present value"[12] estimate of the life cycle benefits associated with the safety improvements. Additional overview and information regarding the benefits calculation done in the tool can be found in Appendix D of this report.

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[8] USDOT 2018 BCA Guidance. Values based on *Guidance on Treatment of the Economic Value of a Statistical Life in U.S. Department of Transportation Analysis* (2016).

[9] Adjusted based on the increased severity in a grade crossing accident relative to highway accident. Adjustment data obtained from the Bureau of Transportation Statistics' National Transportation Statistics Table 2-17 (Motor Vehicle Safety Data), Table 2-39 (Railroad and Grade-Crossing Fatalities by Victim Class), and Table 2-40 (Railroad and Grade Crossing Injury Persons by Victim Class).

[10] Brod, Daniel; Weisbrod, Glen; Williges, Chris; Moses, Susan Jones; Gillen, David B.; and Martland, Carl D. *Comprehensive Costs of Highway-Rail Grade Crossing Crashes. National Cooperative Highway Research Program Report 755*. 2013. Values in 2011 dollars and inflated to 2017 dollars using the GDP Deflator.

[11] Discounting is included to address the principle where benefits and costs realized in the short-term are valued greater relative to realized in the long-term. The current default discount rate in the tool follows: *Circular A-94: Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs*. White House, Office of Management and Budget. November 2016.

[12] The present value reflects the current value of the total discounted future value using the discount rate.

10.2.2 Cost Calculations

As part of the benefit-cost and cost-effectiveness analysis, the tool uses the average safety improvement costs extracted from the FRA GradeDec Tool. The GradeDec tool provides both the average capital cost for the improvement and the annual maintenance costs. Thus, for a level of improvement, the capital costs are equally distributed across the construction period and annual maintenance costs are incurred after construction period. The life cycle costs are then discounted to a present value estimate of the life cycle costs associated with each particular level of improvement. The user should note that the costs for additional levels of improvement also consider costs from previous improvement levels. Additional overview and information regarding the cost calculations can be found in Appendix D of this report.

10.2.3 Benefit-Cost Analysis and Cost-Effectiveness

Using the respective benefits and costs are varying levels of improvement, the tool presents both the net present value and the benefit cost ratio. Both measures reflect the total benefits from the project relative to the cost of improvements, where a benefit-cost ratio greater than 1.0 implies benefits from the safety improvements exceed the costs of the improvement.

Another measure to assess the potential safety improvements at a grade crossing is the cost-effectiveness measure. In particular, the cost-effectiveness measure in the tool presents the change in the index value (i.e., TPI or TPCI) per million dollars in lifecycle improvement costs. The change in the index value used in the cost-effectiveness measure is estimated using the respective crash modification factor for a given level of improvement.

10.3 Project Prioritization Tool Limitations and Potential Future Enhancements for Implementation

The current tool can handle only one grade crossing at a time. In terms of future implementation, the tool could incorporate additional functionality to conduct the same analysis for multiple grade crossings at a time and present the results in a table. Such a process would require the ability to extract the correct characteristics based on the crossing ID and a database with potential future volume projections. However, if no reliable future projections are available, a conservative estimate would assume constant volumes.

11.0 Identification of Potential Additional Datasets and Countermeasures for Identifying and Prioritizing Grade Crossing Investments

Following the completion of the Iowa DOT interviews, the stakeholder survey, the literature review, and coordination with the TAC undertaken during research to develop findings that will help inform Iowa DOT of recommendations and actionable steps for implementing changes into Iowa's current prioritization methodology, HDR identified several additional data sets that, if available in a complete and clean format, could potentially be used in the database / ranking and prioritization tools developed for this project to enhance the grade crossing project prioritization process in the future. Identification of any data sets that could potentially be used to enhance Section 130 Program project selection are presented below at Iowa DOT's request only for future agency consideration.

- Average crossing gate down time / train grade crossing occupancy data
- Sight distance and other restriction data at grade crossings
- Roadway skew angles at grade crossings
- Dimensional data at grade crossings (e.g., width and length of grade crossing panels and surface and presence of sidewalks)
- Average train volumes at grade crossings, including:
    - Through trains during daylight
    - Through trains during nighttime
    - Train switching movements
- Minimum typical train speed through grade crossing
- Maximum typical train speed through grade crossing
- Identification / risk assessment for rail routes carrying hazardous materials (e.g. crude oil, ethanol, etc.)
- Identification / risk assessment of rail routes carrying passenger trains
- Number of main tracks in grade crossing
- Number of other tracks in grade crossing
- Number of roadway lanes in grade crossing
- Identification of grade crossings on designated school bus traffic routes
- Identification of grade crossings on prevailing emergency vehicle routes
- Estimated truck counts by grade crossing
- High-wide event count by grade crossing
- Rough crossing event
- Vehicle on track event
- Actual number of incidents that have occurred at grade crossing
- Complete near-miss reports from all railroads in the state
- Interconnects to roadway traffic signals
- Grade crossings included in a Quiet Zone
- Vehicle queuing distance from grade crossing to adjacent roadway intersections or driveways

Iowa DOT could also consider within the revised prioritization methodology developed for this project additional supplemental safety countermeasures that initiate improvements actions and apply an appropriate effectiveness rate for each (e.g., one-way street with gate, photo enforcement, and permanent closure of a public-highway grade crossing).

12.0 Recommendations for Communicating Relative Grade Crossing Risks to Highway Authorities

During interviews and research conducted for the study, the Iowa DOT Office of Rail Transportation sought recommendations for communicating relative grade crossing risks to highway authorities statewide. Iowa is not a regulatory state and Iowa DOT does not have the authority to make a highway authority implement highway-rail grade crossing improvement projects, so Iowa DOT can work to convince agencies to apply for Section 130 funding by communicating relative highway-rail grade crossing risks and other strategies to encourage Section 130 grant applications that enhance public safety in areas with the greatest safety risks. The stakeholder survey and coordination with the TAC during development of the project revealed that the current process to engage eligible applicants (including highway jurisdictions) regarding the Iowa Section 130 grant program needs improvement, and therefore may also potentially present the best initial method for communicating relative grade crossing risks to highway authorities statewide.

The following recommendations can be considered by Iowa DOT for potential future implementation:

- Develop a clear, concise, and easily understood public and stakeholder education resource that identifies the scope and available budget for the Section 130 program, what types of improvements and to what level the program funds improvements (include recent project development examples), the process for identifying and prioritizing grade crossings for Section 130 funds, the process to conduct a grade crossing diagnostic, the process for applying for grant funding, and the schedule for awarding and constructing improvements with Section 130 funding. The resource could be made available on the Iowa DOT Office of Rail Transportation website and included with the annual Iowa Section 130 program letter sent by Iowa DOT to all eligible stakeholders to make them aware of the grade crossing risks within their respective jurisdictions.
- Enhance communication between the Iowa DOT Office of Rail Transportation and eligible stakeholders with regard to the Section 130 program schedule, the application process, and application status. Iowa DOT could potentially communicate with the eligible stakeholders via email and website content about the Section 130 program every three months, in order to provide information about highway-rail grade crossing safety in Iowa, novel approaches by Iowa DOT and other state DOTs to improve safety at highway-rail grade crossings, a reminder of general grade crossing risks, and any updates on the Section 130 program including guidance, impending application deadlines, and an announcement of recent projects that have been awarded Section 130 funding.
- Expand the grade crossing field diagnostic process to include a broader discussion between participating highway authority, railroad, public agency, and Iowa DOT representatives and documentation of relative risks by grade crossing and to provide an opportunity for additional highway-rail grade crossing safety.
- The Operation Lifesaver Iowa Chapter, as a partner of the Iowa DOT, could potentially provide additional communication, education, and awareness to highway jurisdictions in

areas with the most at-risk highway-rail grade crossings in the state, as a means of encouraging additional Section 130 grant applications.

13.0 Recommendation of a Methodology to Determine Most Advantageous Projects to Present to the Iowa Transportation Commission for Funding

Based on the findings and conclusions from project research; interviews with Iowa DOT, the TAC, and stakeholders, and results and outputs from the development of the database / hazard ranking and prioritization tools during the implementation of the final project workplan, HDR developed the following recommended methodology for determining the most advantageous projects for Iowa DOT to present to the Iowa Transportation Commission for funding annually:

- **Data Collection** – Iowa DOT continues to update its highway-rail grade crossing inventory using available federal databases, information from railroads, and field inspections. Field inspections will collect information not currently available (e.g., crossing angle and sight distance). The database / hazard ranking tool will be able to accommodate this data. Future field inspections will occur before hazard ranking.
- **Hazard Ranking** – Iowa DOT will rank crossings based on their hazard potential. Iowa DOT will use the revised Texas hazard formulas (TPI for active crossings and TPCI for passive crossings) described in Section 9 of this report. These formulas have been automated in the database / hazard ranking tool developed for this study, so Iowa DOT will be able to run the script included in the tool to generate reports for local jurisdictions and railroads. Similar to the Texas approach, Iowa DOT will interweave the rankings of active and passive projects using the approach described in Section 9 of the report. Iowa DOT's new hazard ranking system does not currently utilize a predicted accident threshold (such as the GradeDec threshold of 0.075 accidents per year) above which highway-rail grade crossings are preferred for funding.
    - Texas Priority Index (TPI)
        - Predicted Accidents (all crossings) – Exponential function of the following variables, where the full algorithm is described in Section 9 of this report:
            - Protection Factor – flashing lights, gates
            - Highway Paved – Yes or no
            - Urban / Rural
            - Number of Roadway Lanes
            - Total Number of Tracks at Crossing
            - Actual Stopping Sight Distance for Approach
            - Maximum Typical Train Speed
            - Minimum Typical Train Speed for Switching
            - Total Daily Trains
            - Annual Average Daily Traffic (AADT)
            - Nearby Intersection – Yes or no
            - Roadway Speed Limit on Approach
        - Revised Texas Priority Index – Function of predicted accidents and accident history within the last 5 years; used to rank active crossings only.

- Texas Passive Crossings Index (TPCI) – Weighted average of the utility of each attribute, where utility is defined by the value taken by the crossing in question on the cumulative distribution of a given attribute. TPCI applies to the ranking of passive crossings only. Attributes included in the TPCI include:
  - Five-year Crashes
  - Daily Trains
  - Daily School Buses
  - Number of Tracks
  - Train Speed
  - AADT
  - Nearby Traffic Signal
  - Sight Distance
  - Trucks per Day
  - Nearby Intersection
  - Highway Speed Limit
  - Approach Angle
  - Dip / Hump

- **Improvement Applications** – Iowa DOT will share the hazard ranking lists with local jurisdictions and railroads, which will apply for Section 130 grant funding on projects believed to improve hazard conditions.
- **Project Prioritization** – Iowa DOT will prioritize projects using the project prioritization tool described in Section 10 of this report. This tool will calculate benefits / priorities for all potential improvements using a four-tiered approach:
  - Level 1: Lights and Gates
  - Level 2: Constant Warning Time (CWT)
  - Level 3A: Medians
  - Level 3B: Four-Quad Gates

  Note that Levels 3A and 3B are considered to be mutually exclusive.

- **Prioritization Metrics** – Iowa DOT will rely on two sets of prioritization metrics to prioritize projects. Both sets of metrics are calculated in the prioritization tool and are generally expected to show a similar prioritization. Iowa DOT will use the benefit-cost ratio as the primary prioritization metric, but the cost-effectiveness measures will be considered a secondary measure that can be used to justify projects that do not qualify using a benefit-cost ratio.
  - **Benefit-Cost Ratio:** Project safety benefits discounted to a present value divided by total costs (capital and operating / maintenance) discounted to a present value

$$\text{Benefit-Cost Ratio} = \frac{\text{Discounted Safety Benefits}}{\text{Discounted Project Costs}}$$

  - **Cost-Effectiveness Measures:** Calculated for TPI if an active crossing or TPCI if passive crossing using the crash reduction factors described in Appendix C of this report.

$$\text{Cost-Effectiveness} = \frac{\text{TPI or TPCI} \times \text{Crash Reduction Factor}}{\text{Discounted Project Costs}}$$

14.0 Recommendation of Potential Iowa Section 130 Program Policy and Process Enhancements

Following the completion of the Iowa DOT interviews, the stakeholder survey, the literature review, and coordination with the TAC undertaken during research to develop findings that will help inform Iowa DOT of recommendations and actionable steps for implementing changes into Iowa's current prioritization methodology, HDR identified several potential policy and process changes for Iowa's Section 130 program that Iowa DOT could review and consider for future program improvement. Identification and presentation of potential policy and process changes for the Section 130 Program are presented below at Iowa DOT's request only for future agency consideration.

- The current risk calculation does not take into account crossing skew angle, sight lines, interconnects to traffic signals, or potential queuing on the tracks from adjacent intersections, driveways, and so on. Iowa, as a non-regulatory state, lacks the authority to mandate safety improvements and alternatively relies upon an application process. Iowa DOT can consider enhanced communication and modified engagement with potential applicants in terms of what crossings should be considered for improvements from a safety standpoint. It was noted that in some other states, an agency will request estimates or diagnostic meetings based on their prioritization methods (e.g., risk index or benefit-cost ratio). Iowa DOT could potentially select projects, request conceptual cost estimates, and conduct diagnostics based off their prioritization – after taking into account every crossing in the state, as opposed to only considering those that have been subject to application.
- Iowa DOT could potentially regularly review and update all datasets feeding the methodology and generally improve the internal data management process.
- Iowa DOT could potentially enhance annual communication with eligible Section 130 program applicants about the program by letter, email, website content, or webinar. As one approach, Iowa DOT could potentially develop a Section 130 program and process educational resource to provide a clear and concise outreach and educational resource for Iowa DOT to use as a means of enhancing its annual communication with eligible Section 130 program applicants and providing additional information about the program, what improvements it funds and does not fund, what makes an effective application, how grade crossings are evaluated and ranked, and related topics. The resource could also include "myths and facts" content with discussion about the responsibility for constructing and maintaining grade crossing infrastructure. Iowa DOT could provide this document to potential applicants, along with the annual letter, report, and Section 130 application, and also include it on its website.
- Iowa DOT said that the effort to identify and prioritize grade crossing improvements needs to more heavily consider the insights and outputs gained from grade crossing field diagnostics conducted by Iowa DOT and coordinated with the railroads and other stakeholders. Iowa DOT could consider a project prioritization process that involves completion of a field diagnostic by a multi-disciplinary team at locations that were: scored

high by the hazard index, recommended by the city or county, or recommended for further review through a field inspection. The field diagnostic team could consider crash records, near-miss reports, site conditions, and input from local agencies when determining what, if any, improvement to make.

- Iowa DOT said it needs to develop a process to walk away from a grade crossing project if what is observed in the field during a diagnostic does not match the data. Iowa DOT could potentially develop a process to allow it to walk away from a project where the crash prediction and benefit-cost ratio numbers are high.
- Iowa DOT could consider grouping together multiple grade crossings in a Section 130 application to form a corridor. It was noted that, in some instances, grouping grade crossings together in this manner will result in greater economies of scale, a reduction in improvement costs per grade crossing, and other synergies to all project stakeholders and enhance the value of Section 130 funding statewide.
- Iowa DOT could consider utilizing the federal or state cost of a potential grade crossing improvement project in a benefit-cost calculation, as opposed to using the full project cost. This approach could allow the benefit-cost calculation to take into account a higher contribution from a railroad or highway authority, and cure the higher benefit-cost of the public funding being invested at grade crossings with more railroad or local agency participation.
- Iowa DOT could assess any additional consideration given to future benefits of a grade crossing improvement based on an increase in predicted Annual Average Daily Traffic (AADT), which may unduly prioritize potential urban projects versus potential rural projects.
- The status of pending Section 130 applications could potentially be communicated by Iowa DOT to all related city, county, roadway, and railroad representatives, and particularly every three years or more frequently, if possible, as there are no “stale dates” for applications under the current process. Applicants could be made aware when Iowa DOT receives their application and could be kept informed of the status of pending applications and potential next steps by Iowa DOT, at regular intervals.
- Iowa DOT said that the backlog for Section 130 projects is approximately $35 million, and that some of the applications are up to 30 years old. Iowa DOT could potentially consider that one improvement to the process could be to set an expiration or “stale date” on Section 130 applications (shorter-term applicability, like 5 years). Applicants would have the potential, in these instances, to submit subsequent applications with more recent data.
- Iowa DOT could potentially digitize all funded past and pending Section 130 applications.

Appendix A – Iowa DOT's Federal-Aid Railroad-Highway Grade Crossing Program – Use of a Benefit-Cost Ratio to Prioritize Projects for Funding (2006)

FEDERAL-AID RAILROAD-HIGHWAY
GRADE CROSSING PROGRAM

Use of a Benefit-Cost Ratio to Prioritize Projects for Funding

January 2006

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Note: *The Iowa Department of Transportation prefers to use the term "crash" to refer to a collision involving a motor vehicle. However, throughout this report, the term "accident" is used in lieu of "crash" to be consistent with the reference material, historically used formulas and Federal Railroad Administration's source data.*

Executive Summary

The Iowa Department of Transportation (Iowa DOT) administers the Federal-Aid Railroad-Highway Grade Crossing Program for the State of Iowa.

The purpose of the Federal-Aid Railroad-Highway Grade Crossing Program is to eliminate hazards to vehicles and pedestrians at existing railroad crossings. This program is authorized by Title 23, United States Code, Section 130 (23 U.S.C. 130).

In Iowa, funding is application-based, and railroad and highway jurisdictions are eligible to submit applications. From the applications submitted, the Iowa DOT currently selects projects for funding using a two-tiered process, giving top priority to those projects with a predicted-accident calculation that equals or exceeds .075.

The Iowa DOT reviewed the existing selection process seeking a more sophisticated benefit-cost ratio calculation that would result in a more effective method of selecting projects for funding. As a result of the review, the Iowa DOT will use a benefit-cost ratio to prioritize projects competing for funding in the fall of 2006 (projects to be constructed in 2008).

The benefit-cost ratio calculation moves beyond a measure of the predicted accidents at a crossing to a calculation that allows the Iowa DOT to maximize the public benefit in relationship to the public investment. The Iowa DOT's use of the benefit-cost ratio to prioritize projects for selection is projected to result in five fewer fatalities and an increased safety benefit that totals nearly $10 million, over a 10-year period.

Current Application Selection Process

The Iowa DOT's Office of Rail Transportation administers the Federal-Aid Railroad-Highway Grade Crossing Program for the State of Iowa. Iowa does not have regulatory authority over crossing-safety improvements, except for the 185 crossings on the state's Primary Highway System. Consequently, the Iowa DOT uses an application-based system to select projects that will receive funding through the Federal-Aid Railroad-Highway Grade Crossing Program.

Applications are accepted throughout the year, and those received by August 1 are reviewed for potential funding. Selected projects are funded for preliminary engineering in the next fiscal year with funding for construction in the following calendar year. The appropriate highway authority or railroad may submit an application. A 10 percent match is required by either party or jointly. Unfunded applications remain active for consideration in future years.

Selection of projects for funding has historically used a two-tiered process.

1. Applications which include a predicted-accident (PA) calculation equal to or higher than .075 receive first priority for funding. The PA calculation, developed by the Federal Railroad Administration (FRA), computes the expected number of accidents at crossings based on information available in the grade-crossing inventory and accident history.

2. If funding is available after selection of projects with a qualifying PA, the applications are further ranked by dividing the estimated cost of the improvement by an exposure index[1]. This calculation encourages the completion of low-cost projects.

The current selection process is flexible and allows additional consideration for statewide initiatives and crossings with special circumstances, such as sight restrictions, increasing traffic density, rail passenger traffic, etc.

The current selection process does not take into consideration several significant factors.

- The risk of an accident at a crossing is identified by the PA, but a minor property damage incident and a fatal accident are weighted the same way in the formula. At any particular crossing there is the danger of an accident, but the unique combination of vehicle/train traffic and physical characteristics of a crossing make some crossings more likely to have accidents of a more serious nature.
- Any particular improvement at a crossing will increase the safety, but the effectiveness varies for different types of improvements. For example, adding lights at a passive crossing increases the safety; however, if both lights and gates are added to that same passive crossing, the effectiveness of that improvement would be far greater.
- The cost of improvements at crossings varies widely. Using the PA alone makes no distinction between a high-cost improvement that has limited effectiveness and a lower cost improvement that is very effective.

The Iowa DOT undertook a review of this selection process to determine if a methodology could be developed that would adequately address these deficiencies. As stewards of public funds, a methodology that more specifically targets funding to those projects that have the highest safety benefit, in relationship to the public investment, was the overriding goal.

[1] The exposure index used in the second tier of the current selection process is a different calculation than the exposure calculation included as a portion of the predicted-accident calculation. See Appendix A for a definition of the exposure index calculation.

To achieve that goal, the Iowa DOT:

- examined, in detail, the current predicted-accident (PA) calculation to determine its strengths and weaknesses;
- evaluated how various factors affect the PA calculation (Appendix B includes a brief synopsis of the lessons learned from this analysis);
- reviewed pertinent literature; and
- studied the selection processes used by other states.

The Iowa DOT developed a new methodology for prioritizing future projects for federal-aid funding. The balance of this report details the newly developed benefit-cost ratio calculation approach.

Benefit-Cost Ratio Calculation in Brief

The benefit-cost ratio calculation (B-C) consists of seven steps. The specific calculations are fully detailed in the next section of this report, but in brief include the following steps.

Step 1: **Calculate exposure** (used as a variable in the predicted-accident calculation)

- The exposure calculation uses train traffic, annual average daily traffic counts and a time-of-day index to quantify the probability of a highway-railroad conflict at a crossing.
- The exposure calculation is adapted from *Reference Manual for GradeDec 2000, version 2.0*, January 2002, published by the Federal Railroad Administration[2].

Step 2: **Calculate predicted accidents**

- The number of predicted accidents at a crossing is calculated by using the exposure calculation from Step 1, a number of train-movement factors, roadway and crossing characteristics, and type of crossing protection. An adjustment factor is applied to take into account the accident history at the crossing.
- The predicted-accident calculation is derived from *Reference Manual for GradeDec 2000, version 2.0*, January 2002, published by the Federal Railroad Administration.

Step 3: **Calculate the severity**

- The severity calculation uses the number of train movements and environment factors associated with the crossing to further refine the number of predicted accidents and project the number of accidents that will involve fatalities, injuries and property damage at a crossing.
- The severity calculation is adapted from *Reference Manual for GradeDec 2000, version 2.0*, January 2002, published by the Federal Railroad Administration.

Step 4: **Calculate the societal cost**

- Using Iowa's historical accident data, fatality and injury rates were calculated.
- The cost to society of a fatality, injury or property damage was determined.
- The fatality and injury rates and societal costs are used to calculate the total cost to society for accidents of varying severities.
- The total cost to society for each type of accident is multiplied by the number of each type of accident projected at a crossing.
- The societal cost is a modification of the methodology used by the Iowa Department of Transportation's Office of Traffic Safety to determine societal costs for highway crashes.

Step 5: **Calculate benefit**

- In determining the benefit of the improvement, the societal cost is adjusted to reflect the projected benefit of the proposed improvement. An effectiveness factor estimates the accident reduction that would occur as a direct result of the proposed improvement. The societal cost is multiplied by the effectiveness factor and the assumed lifespan of the improvement to derive the lifespan benefit in dollars.
- The effectiveness factor is a modification of that included in *Reference Manual for GradeDec 2000, version 2.0*, January 2002, published by the Federal Railroad Administration.

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[2] The calculations in *Reference Manual for GradeDec 2000, version 2.0* were in large part based on an earlier study, *Summary of the DOT Rail-Highway Crossing Resource Allocation Procedure – Revised*, Edwin Farr, June 1987

Step 6: **Calculate cost**

- The cost is the estimated improvement cost, as supplied on the funding application. If the proposed improvement involves upgrading from a passive to an active crossing, the public share of the cost of the average annual signal maintenance (see Appendix C), calculated over the assumed lifespan of the improvement, is included in the calculation.

Step 7: **Calculate the benefit-cost ratio**

- The benefit-cost ratio is calculated by dividing the benefit by the cost.

Benefit-Cost Ratio Calculation in Detail

Step 1 - Calculate Exposure

The exposure calculation, as in the past, is based upon the AADT (Average Annual Daily Traffic) times the number of daily trains. The value has been refined to account for the time of day. The purpose of this is to better reflect the probability of highway-railroad traffic conflict. For example, a train that only operates during daylight hours could not collide with a motor vehicle using the crossing at night. To make this calculation two values must be used: (1) a constant with the value of 1.35; and (2) the variable EF (time-of-day exposure correlation factor). If the grade crossing inventory includes only a "Total Train" value, an equal time distribution will be assumed.

EF =

[(% of AADT between 12:00 AM and 6:00 AM) * (% of TRAINS between 12:00 AM and 6:00 AM)]
+ [(% of AADT between 6:00 AM and 12:00 PM) * (% of TRAINS between 6:00 AM and 12:00 PM)]
+ [(% of AADT between 12:00 PM and 6:00 PM) * (% of TRAINS between 12:00 PM and 6:00 PM)]
+ [(% of AADT between 6:00 PM and 12:00 AM) * (% of TRAINS between 6:00 PM and 12:00 AM)]

divided by the GREATER of

[(% of AADT between 12:00 AM and 6:00 AM)^2 + (% of AADT between 6:00 AM and 12:00 PM)^2]
+ [(% of AADT between 12:00 PM and 6:00 PM)^2 + (% of AADT between 6:00 PM and 12:00 AM)^2]

OR

[(% of TRAINS between 12:00 AM and 6:00 AM)^2 + (% of TRAINS between 6:00 AM and 12:00 PM)^2]
+ [(% of TRAINS between 12:00 PM and 6:00 PM)^2 + (% of TRAINS between 6:00 PM and 12:00 AM)^2]

EXPOSURE = (1.35 * EF) * AADT * Total Trains

Step 2 - Calculate Predicted Accidents

The calculation for predicted accidents (PA) remains the same as it has been in the past. The exposure value has been modified as described in Step 1. The adjustment to the PA for accident history also remains unchanged. This calculation uses a mathematical constant, *e*, the natural logarithmic base, which is equal to 2.71828. The paved variable equals two, if the crossing is on a dirt or gravel road; and one, if on a paved road. The calculation varies slightly depending on the type of existing crossing protection as detailed below.

Passive Crossings

Predicted Accidents (PA) $= 0.0006938 * [(\text{Exposure}+0.2)/0.2]^{0.37} * [(\text{DayThruTrains}+0.2)/0.2]^{0.1781} * e^{(0.0077*\text{MaxTimeTable})} * e^{[-0.5966*(\text{Paved}-1)]}$

Adjustment of Predicted Accidents $= \dfrac{(\{PA * [1/(0.05+\text{Predicted Accidents})]\}+\text{Number of Accidents in the Last 5 Years})}{\{[1/(0.05+\text{Predicted Accidents})]+5\}} * 0.65$

Flashing Lights

Predicted Accidents (PA) $= 0.0003351 * [(\text{Exposure}+0.2)/0.2]^{0.4106} * [(\text{DayThruTrains}+0.2)/0.2]^{0.1131} * e^{(0.1917*\text{NumberofTracks})} * e^{[0.1826*(\text{Lanes}-1)]}$

Adjustment of Predicted Accidents $= \dfrac{(\{PA * [1/(0.05+\text{Predicted Accidents})]\}+\text{Number of Accidents in the Last 5 Years})}{\{[1/(0.05+\text{Predicted Accidents})]+5\}} * 0.5001$

Lights and Gates

Predicted Accidents (PA) $= 0.0005745 * [(\text{Exposure}+0.2)/0.2]^{0.2942} * [(\text{DayThruTrains}+0.2)/0.2]^{0.1781} * e^{(0.1512*\text{NumberofTracks})} * e^{[0.142*(\text{Lanes}-1)]}$

Adjustment of Predicted Accidents $= \dfrac{(\{PA * [1/(0.05+\text{Predicted Accidents})]\}+\text{Number of Accidents in the Last 5 Years})}{\{[1/(0.05+\text{Predicted Accidents})]+5\}} * 0.5725$

Step 3 - Calculate Severity

The severity calculation is a new enhancement. Using the train speed, number of tracks, number of through trains, number of switching trains and type of location (rural or urban), the probability of a fatal accident or a casualty accident can be projected. The predicted accidents remain the same, so the probability of an injury accident is the casualty accidents minus the fatal accidents. The probability of property damage-only accidents is the predicted accidents minus the casualty accidents.

Predicted Fatal Accidents =

$$\frac{\text{Adjusted Predicted Accidents}}{1 + [440.9 * (\text{MaxTimeTable}^{-0.9931}) * (\text{ThruTrains}+1)^{-0.0873} * (\text{Switches}+1)^{0.0872} * e^{(0.3571*\text{Urban})}]}$$

Predicted Casualty Accidents =

$$\frac{\text{Adjusted Predicted Accidents}}{1 + [4.481 * (\text{MaxTimeTable}^{-0.343}) * (e^{(0.1153*\text{NumberofTracks})}) * e^{(0.2960*\text{Urban})}]}$$

Predicted Injury Accidents = Predicted Casualty Accidents – Predicted Fatal Accidents

Predicted Property Accidents = Adjusted Predicted Accidents – Predicted Casualty Accidents

Step 4 – Calculate the Societal Cost of Accidents

The fatality and injury rates were calculated using the Federal Railroad Administration's Highway-Railroad Grade Crossing Accident/Incident Data for Iowa from 1977 to 2004. All non-casualty accidents are assumed to have damage to a single vehicle. The fatality and injury rates are:

	Fatalities	Injuries	Property Damage Only (PDO)
Average per Fatal Accident	1.6	1.0	1.0
Average per Injury Accident	0.0	1.3	1.0

A societal cost was determined for each type of accident as shown in the following table.

Accident Type	Societal Cost
Fatality	$1,000,000
Injury	$320,000
Property Damage	$26,000

These values were adapted from the methodology used by the Iowa DOT's Office of Traffic Safety.

- **Fatalities -** The rail program will be using the same societal cost for a fatality used in the highway crash methodology ($1,000,000.)
- **Injuries -** The highway crash methodology uses a value of $160,000 per injury. The highway crash methodology averages the cost of a large number of relatively minor highway crashes, as well as those that are more critical. The DOT's Office of Rail Transportation believes that injuries sustained in a highway-railroad accident are likely to be more severe on average, than those sustained solely on the highway system. For purposes of this calculation, the value used in the highway crash methodology was doubled to $320,000 for highway-railroad accidents.
- **Property Damage -** The highway crash methodology uses a value of $26,000 for property damage associated with a highway intersection crash that typically involves multiple vehicles. Damage at a highway-railroad crossing is likely to involve only a single motor vehicle, but that damage is likely to be more severe than that at a highway intersection, so the Office of Rail Transportation chose to retain the same value as that used for a highway intersection crash ($26,000).

Using the societal costs of an accident and the fatality/injury rates, the annual societal cost is calculated for each type of accident.

	Fatalities	**Injuries**	**Property Damage Only**	**Total Cost per Accident**
Average per Fatal Accident	1.6	1.0	1.0	
	$1,000,000	$320,000	$26,000	
	$1,600,000	$320,000	$26,000	$1,946,000
Average per Injury Accident	0.00	1.3	1.00	
	$1,000,000	$320,000	$26,000	
	$0	$416,000	$26,000	$442,000

Every accident is assumed to involve property damage valued at $26,000.

Annual Societal Cost = (Predicted Fatal*$1,946,000) + (Predicted Injury * $442,000) + $26,000

Step 5 – Calculate the Benefit

The benefit for a crossing upgrade is defined as the “societal cost” multiplied by the reduction in accident rate at the crossing expected from the proposed improvement. The reduction in accident rate is the effectiveness factor. This calculation is multiplied by the expected life of the improvement to determine a lifetime benefit. For purposes of this calculation, the life span of any crossing improvement is assumed to be 25 years.

The effectiveness values were derived from *Summary of the DOT Rail-Highway Crossing Resource Allocation Procedure – Revised*, Edwin Farr, 1987, (also included in *Reference Manual for GradeDec 2000, version 2.0*, January 2002, published by the Federal Railroad Administration), with some modifications by the Iowa DOT. Since the publication of Farr’s 1987 report, improvements in circuitry, in particular the more common use of constant warning time, have taken place. The effectiveness values were modified by the Iowa DOT to account for these changes, as shown in the following table.

	Ten or Fewer Trains Per Day		***More than 10 Trains Per Day***	
Proposed Improvement	**Single Track**	**Multiple Tracks**	**Single Track**	**Multiple Tracks**
Passive to flashing lights	75%	65%	60%	55%
Passive to lights and gates	90%	85%	80%	80%
Flashing lights (with accidents in past five years) to gates and constant warning time (CWT)*	90%	65%	70%	65%
Flashing lights (with accidents in past five years) to gates*	65%	50%	50%	45%
Flashing lights (no accidents in past five years) to gates and CWT*	50%	50%	50%	60%
Flashing lights (no accidents in past five years) to gates*	40%	40%	40%	45%
Upgrade to CWT*	25%	25%	25%	25%
Median at crossings with gates	80%	80%	80%	80%

* Effectiveness values modified by Iowa DOT

Therefore the benefit calculation is:

Benefit = Annual Societal Cost * effectiveness factor * 25 (the longevity of the crossing upgrade)

Step 6: Calculate Project Cost

The estimated project cost of the improvement as supplied on the application (based on the specifics of the crossing improvement) will be used in the calculation for funding determination. If the improvement is an upgrade from a passive crossing to an active crossing, the public cost of the signal maintenance over the assumed life of the crossing is included (currently calculated at $1850 annually - See Appendix C). A 25-year life span for the improvement is assumed.

Improvement from a Passive to Active crossing: **Cost** = improvement cost + (annual maintenance cost*25)

Improvements to Active Crossing: **Cost** = improvement cost

Step 7: Calculate the Benefit-Cost Ratio

The earlier calculations resulted in a single value that quantifies the benefits of an improvement, taking a large number of factors into consideration. Likewise, a single cost has been determined. The “benefit-cost ratio” is simply the ratio between these two values.

Benefit-cost ratio = benefit/cost

Project Selection Process for Future Federal-Aid Funding

The benefit-cost ratio calculation methodology outlined in this document will replace the current method of application selection for federal-aid crossing safety projects beginning in the fall of 2006 (for projects slated for construction in 2008). The benefit-cost ratio will be calculated for each project application. Applications will be ranked from those with the highest benefit-cost ratio to those with the lowest. The estimated project cost included on the funding application will be used in the analysis.

Flexibility will be retained to allow consideration for statewide initiatives or projects that exhibit other characteristics or safety deficiencies that are not reflected in the benefit-cost ratio. These could include sight obstructions, rail passenger traffic or unique physical characteristics of the crossing that lead to motorist confusion or errors in judgment. A site review, in conjunction with the benefit-cost ranking, will be used to document and assess those unique characteristics that may warrant special consideration.

The impacts of the change in the selection process include the following.

1. **The use of the benefit-cost ratio in the selection process will allow the Iowa DOT to target crossing improvements toward those crossings that are more likely to have a fatal accident.**

   The use of “predicted accident” in the past to prioritize projects for crossing improvements was effective in targeting crossings that were likely to have an accident, but did not provide any weighting for the type of accident. There is a significant difference in the impact and cost to society between a property damage accident and one that results in a fatality.

   By including a calculation of the expected severity of an accident at the crossing, the benefit-cost ratio gives priority to those crossings that are the most likely to experience casualties.

2. **The use of the benefit-cost ratio in the selection process yields a greater benefit for the same expenditure of public funds.**

   The use of a benefit-cost ratio will allow the Iowa DOT to determine where limited funding can best be spent to generate the most public benefits. By better targeting those crossings that are more likely to result in a fatality (which carries higher societal costs), and factoring in the cost and effectiveness of the improvement, the funding will be utilized in a way that generates greater safety benefits for each dollar spent.

   The use of the benefit-cost ratio in project selection is projected over a 10-year period to reduce fatalities by five and yield increased benefits of nearly $10 million.

   Figure 1 (next page) shows the accidents projected out to 2015, in two different ways:
   - projected accidents, injuries and fatalities, if improvements were selected for funding using the benefit-cost ratio; and
   - projected accidents, injuries and fatalities, if improvements were selected for funding using the current selection process.

   Note that the number of accidents and injuries are similar, but five fewer fatalities are projected with improvements selected using the benefit-cost ratio.

Figure 1

Year	Benefit-cost Ratio System			Current System		
	Accidents	Fatalities	Injuries	Accidents	Fatalities	Injuries
2005	65	8	25	65	8	25
2006	65	8	25	65	8	25
2007	62	8	24	62	8	24
2008	61	7	23	60	8	23
2009	59	7	22	58	8	22
2010	58	7	22	57	7	22
2011	57	7	21	56	7	21
2012	56	7	21	55	7	21
2013	55	6	20	54	7	20
2014	54	6	20	53	7	20
2015	53	6	20	52	7	20
10-Year Projection (2006-2015)	**645**	**77**	**243**	**637**	**82**	**243**

3. **Selection of projects for funding using the benefit-cost ratio will change the character of those projects that receive priority consideration for funding by identifying those projects where the most public benefit is gained in relationship to the public cost. Good projects that were not considered in the past will now be funding candidates.**

   Figures 2 and 3 on the next page illustrate the potential pool of applicants that have a favorable benefit-cost ratio. The calculations for these maps use the "average improvement costs" (see table in Appendix C), which may vary considerably from the estimated costs included in an application due to the unique characteristics of an improvement.

Figure 2 shows those crossings that currently are eligible for funding with a PA that is equal to or greater than .075. Using the "average improvement costs" (see table in Appendix C), all of the crossings in Figure 2 ***also*** have a positive benefit in relationship to cost (a B-C greater than 1).

Figure 2

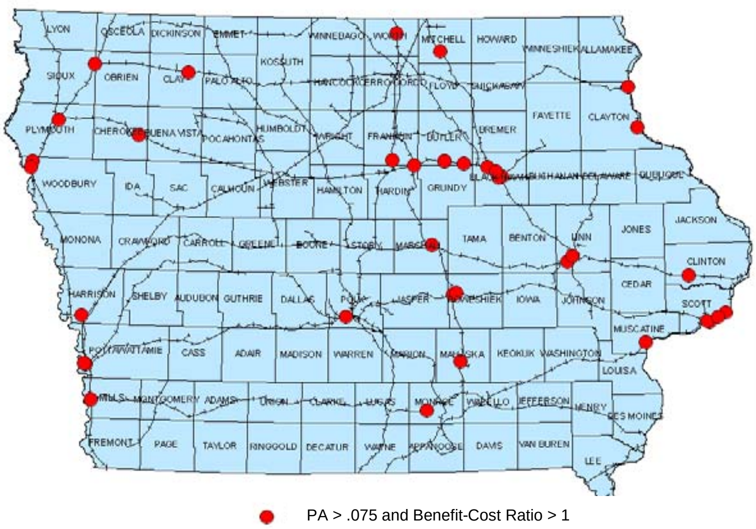
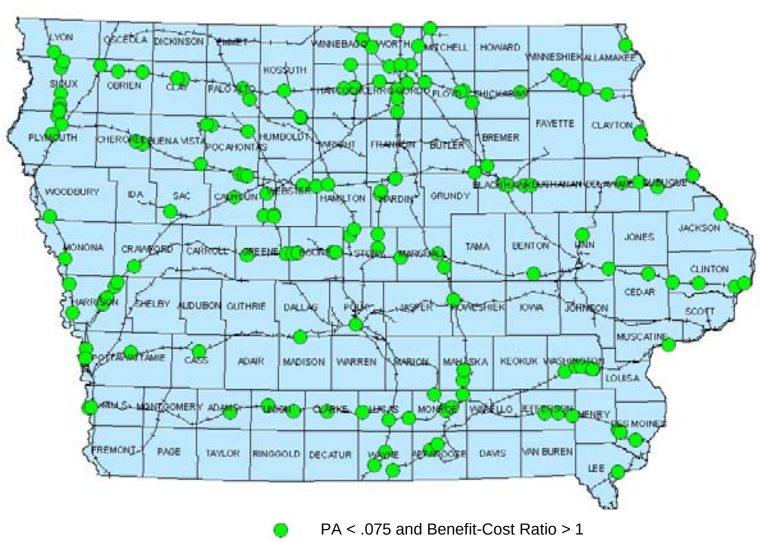


Figure 3 illustrates the crossings that are not currently funding candidates (a PA less than .075) that have a positive benefit in relationship to cost (a B-C greater than 1) using the "average improvement costs" (see table in Appendix C).

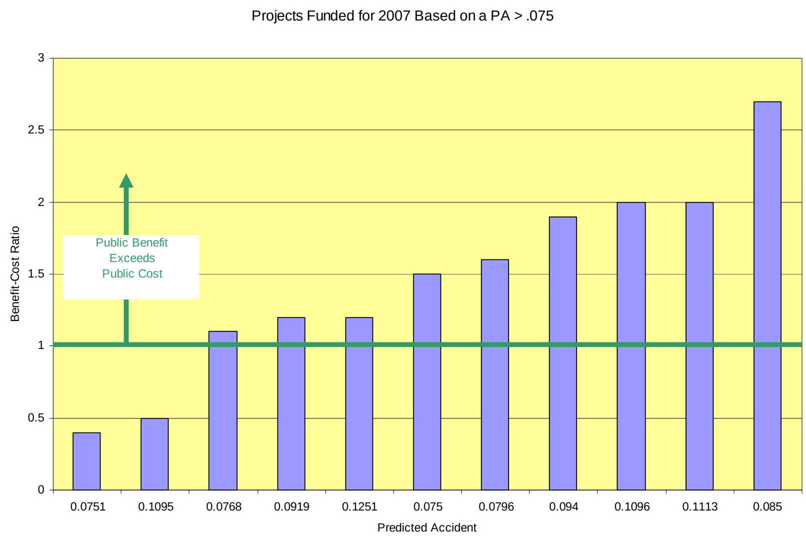
Figure 3



Average improvement costs can vary significantly from the estimated cost of an improvement included on an application due to the unique physical characteristics at a crossing. Figure 4 illustrates a more “real-life” scenario. The benefit-cost ratio was calculated for those projects selected for funding in FY2007 that qualified based on having a PA equal to or greater than .075.

Most of the projects have a positive benefit-cost ratio, where benefits exceed cost. The probability of these projects being funded under the new selection process would depend upon where they fell within the overall priority list. Note that two projects selected for funding in 2007 show a negative cost-benefit ratio, where public cost exceeds public benefit. Though these potential projects would be prioritized with all others, it is very unlikely that these would be funded under the new process since they do not appear to be cost effective.

Figure 4



Figures 5 and 6 on the next page illustrate the number of crossings by type, where improvement benefits would outweigh costs (i.e. that have a benefit-cost ratio of 1 or greater) assuming the average cost of an improvement (see table in Appendix C).

- Figure 5 indicates that over 200 passive crossings would have positive benefits, if upgraded to flashing lights and gates.
- Figure 6 indicates that nearly 200 crossings with existing flashing lights would have a positive benefit, if upgraded to include gates.

Figure 5

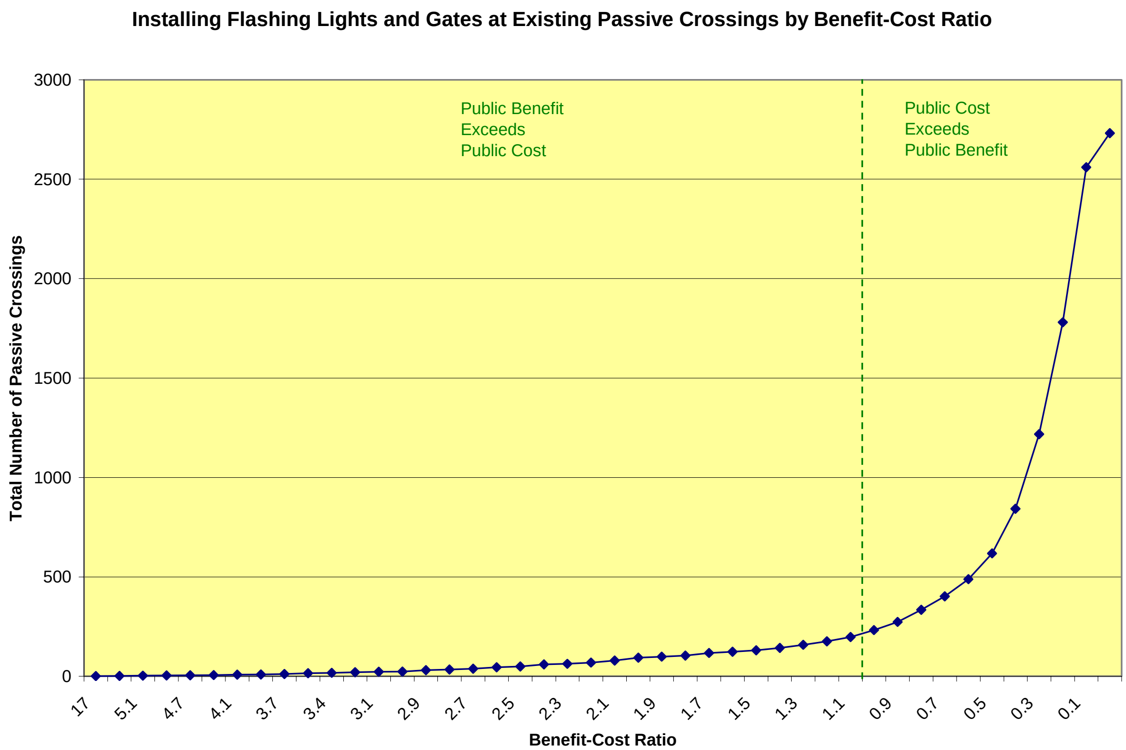
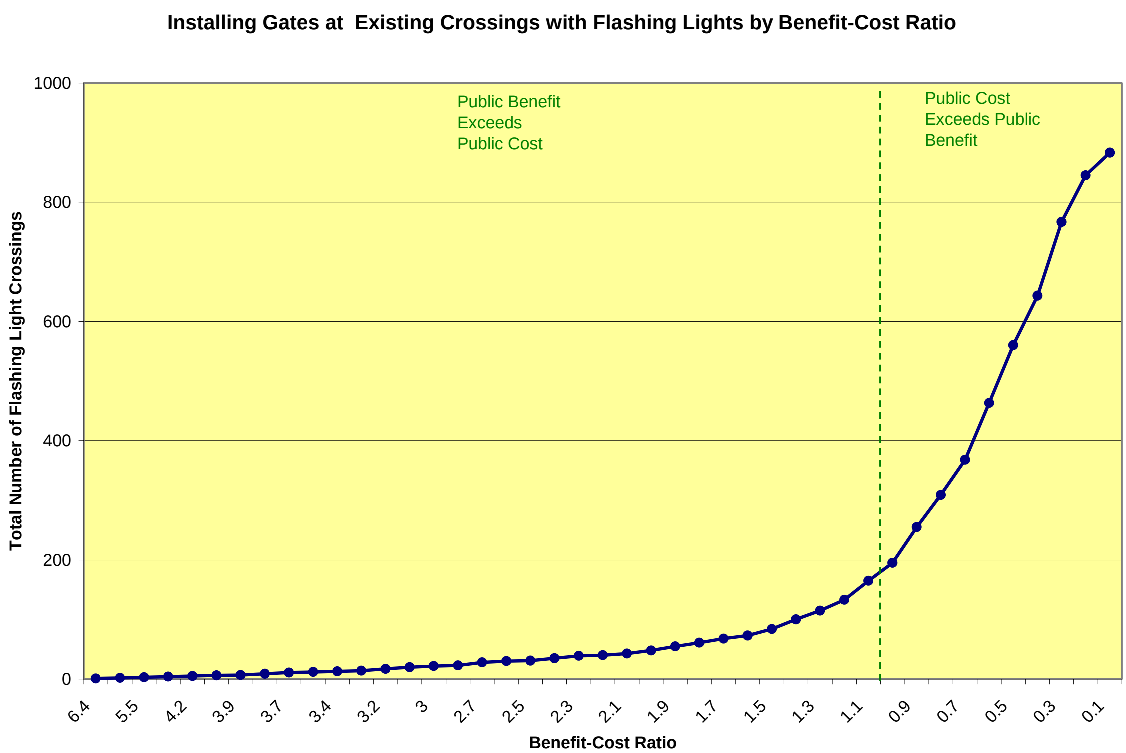


Figure 6



Appendix A – Definitions

Accident data – see U.S. DOT's Highway-Railroad Grade-Crossing Accident/Incident Data

Annual average daily traffic (AADT) – traffic counts obtained on Iowa's streets and highways by Iowa DOT's Office of Transportation Data using a series of traffic counters

Benefit-cost ratio (B-C) – a ratio derived from dividing identified and quantifiable benefits by the estimated project cost

Casualty – an injury or death

Accident history – a record of accidents at highway-railroad grade crossings obtained from the U.S. DOT's Highway-Railroad Grade-Crossing Accident/Incident Data, which is maintained by the Federal Railroad Administration

Crossing – see highway-rail grade crossing

DOT's accident and severity prediction formula (PA) – commonly called "predicted accident"; a formula developed by the Federal Railroad Administration to compute the expected number of accidents at crossings based on information available in the grade-crossing inventory and crossing accident data files. The formula utilizes five years of accident history at the crossing, highway and train traffic, number of through trains per day, maximum timetable train speed, number of main tracks through crossing, highway paved (yes or no), and number of highway lanes. (More information may be found in the August 1987 FRA/FHWA User's Guide, Third Edition, "Rail-Highway Crossing Resource Allocation Procedure".)

Exposure index – a method of measuring the conflict of highway traffic with train traffic at highway-railroad grade crossings for developing accident rates; the formula takes into account the number of trains, crossing angle, maximum train speed, and number of tracks; the exposure index is calculated as follows:

Calculating the Exposure Index

Trains = ((day through + night through) + ((day switch * 0.5) + (night switch * 0.5)))
If trains = 0, assign 0.5 to trains

If crossing angle < 30, then AF = 2
If crossing angle > 29 and angled < 60, then AF = 1.2
If crossing angle > 59, then AF = 1

If typical maximum speed > 59, then SF = 1
If typical maximum speed < 60 and speed > 39, then SF = 0.9
If typical maximum speed < 40 and speed > 24, then SF = 0.8
If typical maximum speed < 25, then SF = 0.7

If main tracks > 1, then RF = 1
If main tracks = 1 and other tracks > 0, then RF = 0.85
If main tracks = 1 and other tracks = 0, then RF = 0.8
If main tracks = 0 and other tracks > 0, then RF = 0.75

Exposure = ((Trains * AADT) * AF * SF *RF)

Grade-crossing inventory – see U.S. DOT/AAR National Highway-Railroad Crossing Inventory

GradeDec **(GD)** - a highway-rail crossing investment analysis tool developed by the Federal Railroad Administration to provide a full set of standard benefit-cost metrics for a rail corridor, region or an individual crossing; the calculations in *GradeDec* were in large part based on an earlier study, *Summary of the DOT Rail-Highway Crossing Resource Allocation Procedure – Revised*, Edwin Farr, June 1987

Highway crash – a collision that does not involve on-track railroad equipment

Highway-railroad grade crossing – a location where a public highway, road, street or private roadway, including associated sidewalks and pathways, crosses one or more railroad tracks at the same grade

Highway-railroad grade-crossing accident - an impact between on-track railroad equipment and a highway user at a designated crossing site; sidewalks, pathways, shoulders, and ditches associated with the crossing are considered to be part of the crossing site; the term "highway user" includes automobiles, trucks, buses, motorcycles, and other types of motor vehicles, bicyclists, pedestrians, and all other modes of surface transportation

Inventory – see U.S. DOT/AAR National Highway-Railroad Crossing Inventory

Passive traffic control device – those types of traffic control devices, including signs, markings and other devices, located at or in advance of grade crossings to indicate the presence of a crossing, but which do not change aspect upon the approach or presence of a train

Predicted accident (PA) – see DOT's accident and severity prediction formula

U.S. DOT/AAR National Highway-Railroad Crossing Inventory – an inventory of all highway-railroad crossings that is maintained by the Federal Railroad Administration, an agency within the United Stated Department of Transportation; crossing inventory data is updated by the railroads and state agencies responsible for rail transportation

U.S. DOT's Highway-Railroad Grade-Crossing Accident/Incident Data - a database of all rail-related accidents or incidents, including highway-rail crossing accidents, maintained by the Federal Railroad Administration; accidents are self-reported by the railroad(s) involved in an incident

Appendix B - Lessons Learned About the Predicted-Accident Calculation (PA)

The benefit-cost ratio uses as a portion of the calculation the "predicted-accident" calculation. As a preface to developing a revised project selection process, the Iowa DOT undertook an analysis of the PA to better understand the factors included in the calculation and their influence on the outcome.

Projected increase in AADT
The AADT in Iowa is expected to see only modest growth from 1.494 percent per year over the next 20 years[3].

The projected growth in the AADT is not expected to have enough impact to significantly increase the value of the PA or increase projected accident rates.

Train speed
Higher train speeds increase the probability of a casualty when an accident occurs at a crossing.

The predicted accident formula uses train speed as a factor only at passive crossings, despite having an impact on the casualty rate at all crossings.

Increase in number of trains
It is not an increase in the number of trains, but the percentage of the increase in train traffic that is most significant. For example, if the train numbers are low and subsequently double, the PA is very sensitive to this change (example four to eight trains per day). However, on rail lines with 40 to 60 trains a day, an increase of four trains per day has a relatively low impact on the PA.

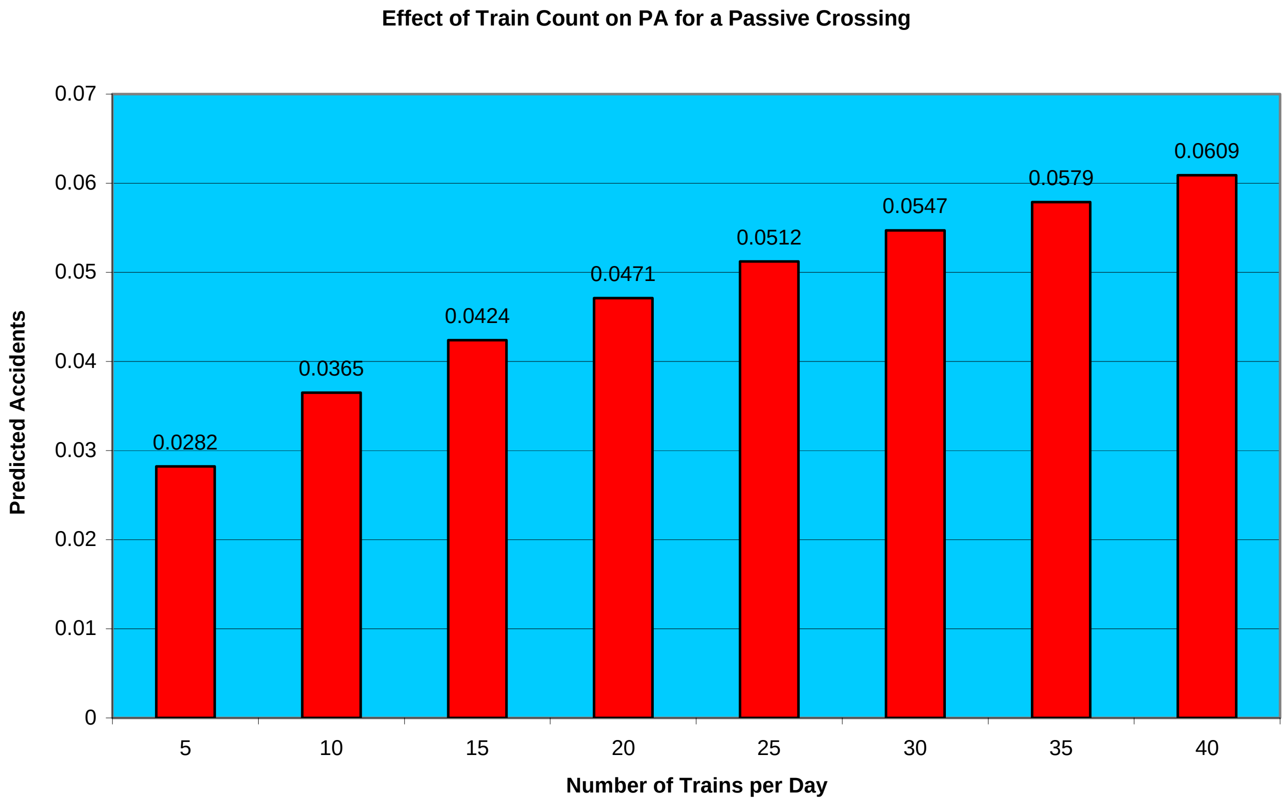
Whereas, the AADT for the most part experiences gradual growth, the increase in train traffic is more subject to sudden and abrupt changes, i.e. as the result of a new or expanded industry, routing changes, etc.

Proper calculation of the PA and newly developed benefit-cost ratio (which includes the PA calculation) is highly dependent on accurate train traffic data in the grade-crossing inventory.

Figure 7 on the next page illustrates the impact on the PA when train counts are increased at a theoretical, typical Iowa passive crossing (mid-range AADT and no history of accidents).

[3] The increase experienced in the past five years in the AADT was used to project traffic counts 20 years into the future.

Figure 7



Severity of highway-rail accidents

A comparison of the Iowa accidents that occur on the highway system, and those that occur at highway-railroad crossings for the years 1988 through 1998 showed a:

- 33.2 percent casualty rate for highway accidents;
- 32.6 percent casualty rate for highway-railroad accidents;
- 0.6 percent fatality rate for highway accidents; and
- 6 percent fatality rate for highway-railroad accidents.

Although casualty rates were very similar for highway and highway-railroad accidents, the fatality rate for highway-railroad accidents was 10 times higher than that of highway accidents.

Appendix C – Average Improvement Costs

The following average improvement costs were used in the data analysis as the Iowa DOT examined different methods and ways in which to include the costs of improvements in the selection process.

The table below includes the public cost of maintaining a signal system over 25 years (currently calculated at $1,850 per year), if the improvement is from a passive device to an active device.

Average Improvement Costs

Existing Protection	Improvement	Single Track	Multiple Tracks	Maintenance
Passive	Flashing lights	$95,000	$110,000	$46,250
Passive	Lights and gates	$130,000	$180,000	$46,250
Flashing lights	Lights and gates	$90,000	$105,000	
Lights and gates	Add median	$65,000	$65,000	

The calculation of the benefit-cost ratio for funding purposes will use the estimated cost of the improvement, as supplied on the application, rather than these average improvement costs.

Appendix B – Iowa DOT Highway-Railroad Grade Crossing (Section 130) Program Stakeholder Survey Results and Comments (2017)

Highway-Railroad Grade Crossings Program

Feedback Survey Analysis

November 13, 2017

Summary

Iowa DOT Highway-Railroad Grade Crossings Program

Tool: Survey Monkey
Distribution: Online
Runtime: 2 weeks (10/27/17-11/10/17)
Link: https://www.surveymonkey.com/r/IowaDOTSection130Grant *(closed)*
Content: 13 questions with logic

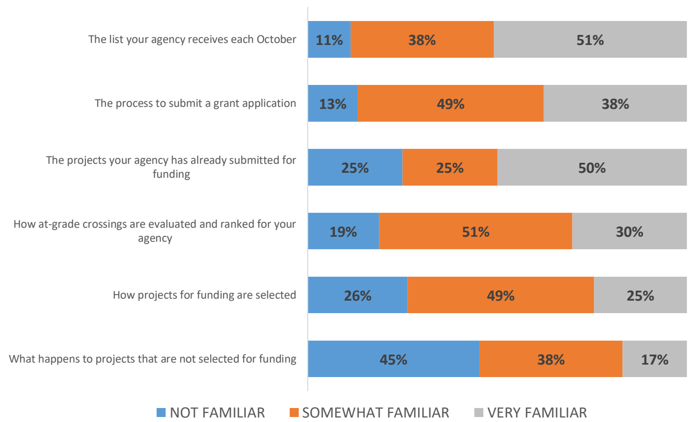
53	Surveys taken
92%	Completion Rate

Program Familiarity

Question 1 (53 answers): Each October, cities, counties, and railroads in Iowa receive a list of at-grade highway-railroad crossings within their jurisdiction along with instructions on how to submit a Section 130 grant application to fund grade crossing improvements. How familiar are you with:

In Order of Familiarity
(Most to least)

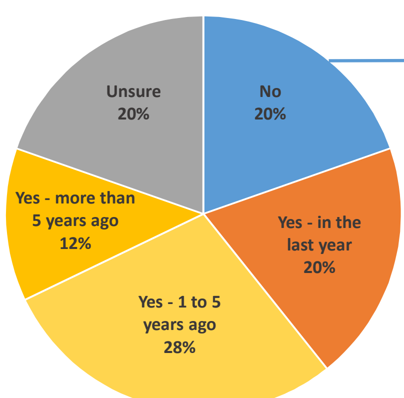
1. October list their agency receives
2. The grant application process
3. Which projects their agency have previously submitted
4. How at-grade crossings are ranked
5. How projects are selected
6. What happens to projects that are not selected



Past Application Results

Question 2 (56 answers): Has your agency applied for Section 130 funding?
Question 3 (35 answers): Was your last project application selected for funding?
Question 4 (11 answers): Please explain why you haven't applied for a grant application. (Select all that apply)

At least 61% (34) respondents have previously applied



If they didn't apply, their reasons:	#
Unaware of the opportunity	5
Don't have a need for it	3
Don't meet application criteria	3
Process is difficult	2
Unable to provide the 10 percent funding match	2
Don't understand the process	1
Too busy to complete application	1

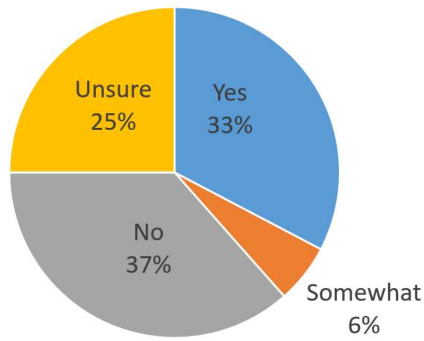
Those that applied:

- 46% were approved
- 37% are unsure if they were approved
- 17% were not approved

Application Process Knowledge

Question 5 (52 answers): Do you know what makes for a good application to the Section 130 program?

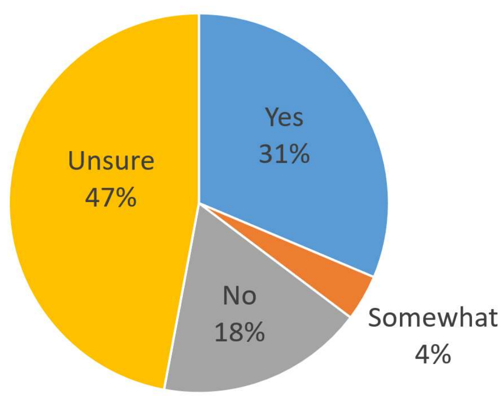
33% are confident in their knowledge of how to submit a good application.



Application Selection Satisfaction

Question 6 (52 answers): In your experience with the Section 130 program in Iowa, are the at-grade crossings with the greatest need for improvement generally ranked the highest?

31% believe the at-grade crossings in most need of improvement are selected.

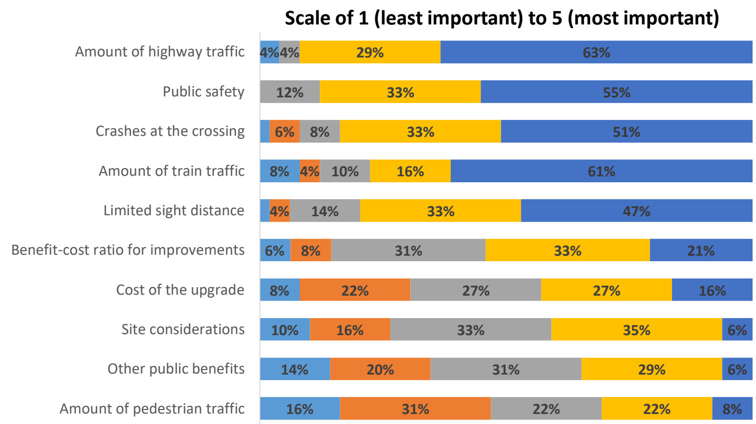


Ranking Application Criteria

Question 7 (49 answers): How important are the following to identify and prioritize eligible grade crossings in the state for Section 130 funding? Assess each option on a scale of 1-5.

In Order of Importance
(Most to least)

1. Amount of highway traffic
2. Public safety
3. Crashes at the crossing
4. Amount of train traffic
5. Limited sight distance
6. Benefit-cost ratio
7. Cost of the upgrade
8. Site considerations
9. Other public benefits
10. Amount of pedestrian traffic



Most Important Criteria

Question 8 (49 answers): What should be the single most important factor used to identify and prioritize eligible grade crossings in the state for Section 130 funding?

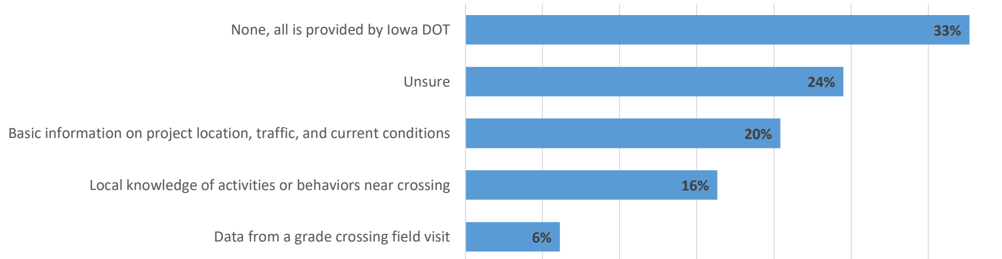
Highway traffic & intersection crash numbers ranked highest as single most important approval criteria.

Answer	#
Amount of highway traffic	10
Crashes at the crossing	10
Amount of train traffic	6
Benefit-cost ratio for the improvement	6
Public safety	5
Limited sight distance	3
Conditions of current equipment and road	3
Cost of the grade crossing upgrade	2
All of the above	2
Site considerations	1
Unsure	1

Information Need

Question 9 (49 answers): What kinds of data do you need to collect to support an application for Section 130 funding?

33% believe Iowa DOT provides all the information they need to apply.



Comments for the 'data field visit option':

- Need to evaluate the condition of the intersection.
- safety of crossing with regards to vehicle traffic, emergency vehicles etc.
- numbers from DOT provide a basic where to start but a field visit is necessary to determine if the crossing needs improvement or should be closed and traffic directed to a better crossing

Process Improvements

Question 10 (30 answers): If your agency has applied for Section 130 funding, how could Iowa DOT enhance their communication practices with you during...

5 respondents noted that nothing needed to be changed in any of the processes.

The grant application process
Clear guidelines and requirements for consideration
Give us a list of crossings that the Railroads consider a priority- can't go forward without their support.
Just an e-mail to confirm they have received the application.
keep updated on status of project
make sure the electronic submission method works
provide an example application
There's some odd information requested

The application selection process
Clear guidelines and requirements for consideration
Distribute a list of projects funded.
Notification of the selected crossings to improve
where ranked in selection process
If a project fall short of scoring, what are our options?
an outline for proper filing of an application
Web site is not totally user friendly and intuitive

The engineering, design & construction of approved projects
Notice when the railroad might install the improvement
what type of construction is being considered
provide 100 % funding
provide examples
a listing of different types of engineering solutions and requirements
Outline better who (County/City or Railroad) is responsible for what.
When changes are made in the field, all contract parties should have to approve the change.
Have a website that shows what has been awarded and what applications are still active on file for the next cycle.
the issue is lack of funding not the process

Comments

13 respondents provided comments.

Todd Kinney - How do grade separation projects get considered?
Nikolas Shepard - I appreciate the guidance I have received from your office, and look forward to working with you to upgrade Crossings in the interest of Crossing Safety.
nick burwell - need to increase funding of the Iowa Highway-Railroad Crossing Safety Program Fund from the 700,000 that has not been increased since inception in 1982. it is great to pay for the new devices once but the maintenance costs continue to increase year over year.
Kurt D. Bailey, P.E. - While this program is worthwhile, the biggest safety concern we have and source of complaints from the public is the poor condition of crossing surface- need funding to consider condition as a safety issue and find a way to speed up repairs. Railroads seem to have limited staff to complete repairs until crossing is a hazard.
Douglas Julius Sioux County Engineer - Good program. Due to the interest in the program hard to get a qualifying project.
David Shanahan - need more familiarity with the program
Brenna Fall - I am fairly new to the City, but will have involvement in the program in the future. Looking forward to learning more about how the program works.
Better public relations with rr would be a nice fit.
I just started as Union County Engineer this year and would like to know more about the program
Needs more funding. For rail freight and wheeled vehicles to work in harmony we need more crossing $$$
This program has allowed railroads to lean on its use and they tend to not maintain crossings that need simple maintenance and wait for funding to be available. Many times I have called the railroads representative and asked them to do basic maintenance only to have them refer me to this program.
We have a crossing approved for improvements but the railroad has held up the installation of the lights and signals pending an agreement on maintenance. I would hope this issue is resolved so that the railroad can complete the approved improvement. The crossing is U.S. DOT # 307632K.

Additional comment made by Calvin Nutt ('Also sent as an email 5/18/17'):
1) Iowa as a non-regulatory state lacks the authority to mandate safety improvements and alternatively relies upon an application process. How can Iowa better communicate to potential applicants what crossings from a safety standpoint should be considered for improvements? In some other states, the agency will request estimates or diagnostic meetings based on their prioritization methods (risk index or B/C ratio). Iowa DOT could select projects, request rough estimates, and conduct diagnostics based off their prioritization – after taking into account every crossing in the state, as opposed to only considering those that have been subject to application.
2) In your experience, do other states use a methodology to identify candidates for improvement or funding that you feel is more effective or equitable? Why? Some states distribute funds based on the proportion of crossings that a railroad has in the state. This ensures that safety funds are being distributed evenly.
3) A benefit cost analysis developed in 2006 is currently used to select candidates for funding from among the applications received. Details on the formula and factors used in the formula can be found on the following pages (both in-brief and detailed). Are there factors or conditions that you feel are not taken into consideration in the benefit cost analysis that should be? Or are there factors included that should not be? What are they and why? The cost factor should consider only the portion of the project to be paid for by the DOT. If a railroad or authority is willing to contribute more than the required 10% of a project, there is a greater safety value per Section 130 dollar. Similarly, multiple crossings should be able to be grouped together in an application to form a corridor. In some cases, grouping crossings together will result in economies of scale and reduced cost per crossing. If each crossing is broken out separately, those economies of scale disappear and the cost goes back up.
4) Does reliance on a benefit cost analysis to select projects for funding disqualify riskier crossings that have characteristics that cannot be easily quantified? What are those characteristics? The current risk calculation does not take into account crossing skew angle, site lines, interconnects to traffic signals, or potential queueing on the tracks (from adjacent intersections, driveways, etc.).
5) The Iowa DOT has developed a Crossing Consolidation formula that ranks each public crossing in the state by the level of convenience it provides to the traveling public. Would using this ranking as an additional threshold be a good way to maximize the program effectiveness of program dollars? Yes, particularly for closures. If crossings identified as having a high convenience factor could qualify for increased closure incentive funding, there would be a much better chance of consolidating crossings.

Interest in Further Involvement

Question 11 (49 answers): Are you interested in providing further direction and input on this study and serve on a Technical Advisory Committee (TAC) to offer stakeholder guidance?
Question 12 (19 answers): Thank you for your interest. Please provide your contact information here so that we can reach out to you with more information.

18 respondents are interested in participating in TAC.

Yes		
Name	Phone	Email
Ben Merta	3198926430	ben.merta@linncounty.org
Brenna Fall	319-286-5732	b.fall@cedar-rapids.org
Calvin Nutt	763-782-3495	calvin.nutt@bnsf.com
Charles Bechtold	7122432442	cbechtold@casscoia.us
Cory Hoffmann	(319) 786-3618	coryhoffmann@alliantenergy.com
David Shanahan	641-672-2897	shanahan@mahaskacounty.org
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Todd Kinney	5632440564	tkinney@clintoncounty-ia.gov

Unsure		
Name	Phone	Email
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Greg Reeder	712-328-4636	greeder@councilbluffs-ia.gov
Jake Hotchkiss	319-385-0762	jhotchkiss@henrycountyiowa.us
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Mary Kelly	641-424-9037	mkelly@co.cerro-gordo.ia.us
Nikolas Shepard	1-715-379-4686	nshepard@progressiverail.com
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Appendix C – Iowa DOT Data / Hazard Ranking Spreadsheet Tool and User Instruction Sheet (2018)

This appendix serves as a user guide to the Iowa DOT database / hazard ranking tool. Note that the actual spreadsheet-based tool has been provided to Iowa DOT as a separate electronic file.

Memo

Date:	Thursday, July 19, 2018
Project:	Iowa DOT Rail Xing
To:	Phil Meraz, Iowa DOT Ed Engle, Iowa DOT
From:	Chris Goepel, HDR Richard Storm, HDR Jon Markt, HDR
Subject:	Iowa DOT Rail Crossing Rank / Prioritization Tool, Version 1.0 User Guide

Introduction

This technical memorandum serves as a user guide to the Iowa DOT rail crossing rank / prioritization tool, Version 1.0 (published July 19th, 2018).

The tool has been setup to accomplish three key functions:

1) Import the latest crossing data from the Iowa DOT - https://gis.iowadot.gov/public/rest/services/Rail/Railroad_Crossings/FeatureServer.
2) Import the latest crash data compiled by Iowa DOT from FRA.
3) Calculate and Report the rail crossing ranking of each ranking in the state and predicted crashes according to the Texas priority method and report the findings in a similar format to the existing rail crossing report provided to rail crossing owners and railroad operators each year.

The tool has been updated based on Iowa DOT Office of Rail comments received on June 20th, 2018. The tool has been enhanced to run an Iowa DOT specified variation of the Texas prioritization method for passive crossings based on crash data. The tool has also been augmented to set the filtering up to only show crossings within either the DOT District, County, or City that has jurisdiction over the roadway crossed (as identifiable from provided data). The tool now also date stamps the report for transparency of the data utilized in the report generation. All of these functions were added or modified within the tool's code and / or the functionality of the associated workbook in addition to other minor bug fixes.

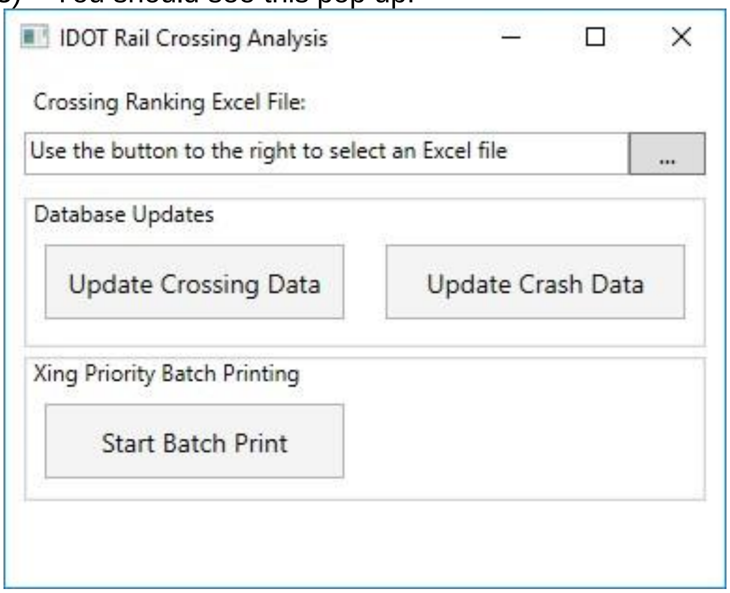
User Steps

First Time Use

1) Unzip the folder IDOT_Crashes_IowaDOT.RAIL

Periodic Updates to Rankings based on Refreshed Data Files

2) Click on IDOT_Crashes.exe
3) You should see this pop up:



4) Use the button to the right to select an Excel file -> make sure to select the All_Xing_Rankings_20180719.xlsx file we are also sending
5) Click the Update Crossing Data button, all of the data from the Iowa DOT rail crossing layer is added to the Excel file and the Texas calculations generate an updated priority
6) Click the Update Crash Data button, the latest file containing historic FRA crash data is pasted into the workbook and the Texas calculations generate an updated priority based on the latest 5 years of crashes
   a. Note: Current testing version looks at 2012 to 2016
7) Close the IDOT_Crashes.exe using the 'X' in the top right corner

Review of Rankings / Report

8) Open All_Xing_Rankings_20180719.xlsx; you will be on the report tab
9) The up-to-date statewide crossing rankings / report will be populated on opening Excel
10) To review crossings for a desired combination of jurisdiction (statewide, district, county, or city) and railroad use the filters in D3 and G3-G4. The filter in D3 should first be set to the jurisdiction of the roadway crossed (DOT district, county, or city). Then the cell G3 can be changed to select either a specific district roadway owner (#1 – 6), specific county roadway owner (e.g. Adair county), or specific city owner (e.g. Ackley). The railroad filter in G4 can either be used to view all statewide crossing primarily operated by a particular railroad (set D3 to Any and G3 to All) or it can be used to look at individual railroad primary operators within a specific district, county, or city.

Batch Reporting

11) Re-open IDOT_Crashes.exe

12) Click on the Batch Report button on lower panel of graphic user interface
13) Review contents of folder IDOT_Crash_IowaDOT (generated in step 1) for PDF files of each individual entity (DOT District, County, City, Railroad)

Review of Rankings Process – Authorized Use Only

14) Re-open All_Xing_Rankings_20180719.xlsx; you will be on the report tab
15) The tab AllXings_Models is left unhidden for reference should Iowa DOT wish to review the intermediate calculations in the Texas model. Generally, the user need not interact with this tab
16) There are also several additional hidden tabs. These tabs are intended to be left unmodified. If the data in these tabs was reviewed and found erroneous or out of date, the best method would be to make changes in the source code (in the IDOT_Crash_IowaDOT folder from step 1).

Appendix D – Iowa DOT Grade Crossing Benefit-Cost Analysis and Cost-Effectiveness Tool and User Instruction Sheet (2018)

This appendix serves as a user guide to the Iowa DOT Grade Crossing Benefit-Cost Analysis and Cost-Effectiveness Tool. Note that the actual spreadsheet-based tool has been provided to Iowa DOT as a separate electronic file.

The following nine worksheets are contained within the tool:

- **Inputs and Results** – Contains the user inputs and the results.
- **Cost Summary** – Summarizes the total capital cost and annual operations and maintenance (O&M) costs for each improvement level.
- **Benefit Summary** – Summarizes the annual safety benefits for each improvement level.
- **Effectiveness Calcs** – Contains the accident reduction assumptions for each improvement level.
- **Improvement Costs** – Contains the capital costs and the annual O&M cost assumptions by improvement level.
- **Severity Assumptions** – Contains the assumptions for the average number of injuries and fatalities by accident type (fatal or injury accident).
- **Accident Costs** – Contains the assumptions for the average cost of fatalities, injuries, and property damage accident.
- **Safety Calcs** – Contains the annual predicted number of accidents.
- **Safety Calcs Sources** – Contains the formulas and sources for the accident prediction methodology.

The tool allows the user to assess the benefits and cost-effectiveness of implementing safety improvements at specific highway-rail grade crossings based on accident prediction and accident reduction estimates.

Key user inputs pertaining to the study period within the tool include:

- User inputs for the construction period
    - Construction cost spending is divided evenly across the years defined as the construction period
- A service life of 25 years (e.g., 25 years of benefits following construction)

Figure D-1 below shows an overview of the Iowa DOT grade crossing benefit-cost analysis and cost-effectiveness tool. Additional details and information regarding the tool's methodology and processes can be found in subsequent sections.

Figure D-1: Iowa DOT Grade Crossing Benefit-Cost Analysis and Cost-Effectiveness Tool Overview

Iowa DOT Grade Crossing Benefit-Cost Analysis and Cost Effectiveness Tool

Inputs and Assumptions

Crossing Information	
FRA Crossing Number	004959U
Crossing Location: Urban/Rural	Rural
Current Crossing Type: Flashing Lights and Gates	3
Revised Texas Priority Index (TPI)	3.378
Texas Passive Crossing Index (TPCI)	
Improvement Schedule	
Current Year	2018
Year Project Development Begins	2019
Year Project Opens	2020
Final Study Year	2044
Economic Parameters	
Real Discount Rate	7%
Rail Characteristics	
Total Number of Tracks at Crossing	2
Maximum Time Table Speed (mph)	90
Minimum Train Speeds for Switching (mph)	1
Highway Characteristics	
Number of Roadway Lanes	2
Maximum Roadway Speed Limit on Approach (mph)	15
Paved Highway?	No
Is There an Intersecting Roadway within 500 ft.?	No
Actual Stopping Sight Distance for Approach (ft.)	
Trains per Day at Crossing	
Thru Trains	
Current Year (2018)	36
Forecast Year (2044)	36
Switch Trains	
Current Year (2018)	0
Forecast Year (2044)	0
Transit Trains	
Current Year (2018)	0
Forecast Year (2044)	0
Average Annual Daily Traffic (AADT) at Crossing	
Current Year (2018)	80
Forecast Year (2044)	80
Crossing Safety	
Predicted Accidents (2018)	0.0267

Benefit-Cost Analysis and Cost Effectiveness Results

Safety Improvements to Crossing Number: 004959U

Improvement Levels	Level 1	Level 2	Level 3A	Level 3B
Benefit-Cost Analysis Results				
Total Project Costs ($ millions)	-	$0.07	$0.13	$0.39
Total Project Benefits ($ millions)	-	$0.37	$1.25	$1.22
Net Present Value ($ millions)	-	$0.30	$1.13	$0.83
Benefit/Cost Ratio	-	5.16	9.83	3.11
Safety Improvement Metrics				
Reduction in Accidents per Year	-	0.007	0.023	0.022
Reduction in Injuries per Year	-	0.004	0.014	0.014
Reduction in Fatalities per Year	-	0.002	0.008	0.007
Cost Effectiveness Metrics				
Revised Texas Priority Index (TPI)	-	11.82	22.49	7.13
Texas Passive Crossings Index (TPCI)	-	-	-	-

****Hazard index value per $1M in life cycle improvement costs***

Improvement Level Legend	Level 1	Level 2	Level 3A	Level 3B
Lights	●	●	●	●
Gates	●	●	●	●
Constant Warning Time (CWT)		●	●	●
Medians			●	
Four-Quad Gates				●

User Guide: Benefit-Cost Analysis and Cost-Effectiveness Tool

D.1 Tool Inputs

To use the benefit-cost analysis and cost-effectiveness tool, the user will be required to complete the Inputs and Assumptions table under the Inputs and Results tab, as seen in Figure D-2 below.

Figure D-2: Inputs and Assumptions Table

Inputs and Assumptions	
Crossing Information	
FRA Crossing Number	004959U
Crossing Location: Urban/Rural	Rural
Current Crossing Type: Flashing Lights and Gates	3
Revised Texas Priority Index (TPI)	3.378
Texas Passive Crossing Index (TPCI)	
Improvement Schedule	
Current Year	2018
Year Project Development Begins	2019
Year Project Opens	2020
Final Study Year	2044
Economic Parameters	
Real Discount Rate	7%
Rail Characteristics	
Total Number of Tracks at Crossing	2
Maximum Time Table Speed (mph)	90
Minimum Train Speeds for Switching (mph)	1
Highway Characteristics	
Number of Roadway Lanes	2
Maximum Roadway Speed Limit on Approach (mph)	15
Paved Highway?	No
Is There an Intersecting Roadway within 500 ft.?	No
Actual Stopping Sight Distance for Approach (ft.)	
Trains per Day at Crossing	
Thru Trains	
Current Year (2018)	36
Forecast Year (2044)	36
Switch Trains	
Current Year (2018)	0
Forecast Year (2044)	0
Transit Trains	
Current Year (2018)	0
Forecast Year (2044)	0
Average Annual Daily Traffic (AADT) at Crossing	
Current Year (2018)	80
Forecast Year (2044)	80
Crossing Safety	
Predicted Accidents (2018)	0.0267

The Inputs and Assumptions table requires the user to provide information regarding the grade crossing characteristics. With the exception of a few variables, this information is available in the Iowa DOT's Rail Crossing Inventory Database. The crossing characteristics are divided into: Crossing Information, Rail Characteristics, and Highway Characteristics.

D.1.1 Crossing Information

This section includes the general FRA Crossing ID, the location of the crossing (urban/rural), the current safety equipment at the crossing, and the TPI or TPCI, depending on whether the crossing is active or passive.

D.1.2 Rail Characteristics

The Rail Characteristics section specifies the number of tracks and the minimum and maximum speed range for trains.

D.1.3 Highway Characteristics

This section highlights various characteristics regarding the roadway conditions both at the crossing and around the crossing. This includes the number of roadways at the crossing, the roadway speed limits, whether the roads are paved, whether there are nearby roadway intersections, and the stopping sight distance on approach.

Beyond the rail characteristics, the tool requires both the current train volumes and the vehicle traffic volumes at the crossing. While current volumes may be available on the Iowa DOT Rail Crossing Inventory Database, the projected future daily train counts and daily vehicle counts would require additional assumptions or sources. If such information is not readily available, the user can assume constant volumes for a conservative estimate of the safety benefits.

The user is also required to indicate the project schedule and the real discount rate. The project schedule should reflect the expected construction period determined by Year Project Development Begins and Year Project Opens. Both the project schedule and the real discount rate are imperative to the calculation of the life cycle benefits and costs.

D.2 Cost Calculations

Improvement cost calculations can be found in the Cost Summary tab (see **Error! Reference source not found.**Figure D-3 below). The tab presents multiple tables, where each table presents a different improvement level. Each table presents the Total Capital Costs, which is the cost of the improvement equally distributed over the construction period. The table then presents 25 years of operations and maintenance (O&M) costs for the improvement. These tables present both costs in constant dollars and in discounted present value terms. Two examples of cost tables are presented in Figure D-3 and in Figure D-5 below.

The user should also note that capital and operations and maintenance costs at each improvement level factor are cumulative and include the costs of previous improvement levels. An exception is in cases where the crossing already has certain safety measures that are in line with what otherwise be construed as an “improvement” level. For instance, Figure D-3 below presents no costs for the level 1 improvement as the current crossing already has the safety equipment reflective of a level 1 improvement. Meanwhile, subsequent improvements, such as level 3B improvements presented in Figure D-5, would include cumulative costs for level 2 improvements as well as level 3B improvements, excluding level 1 costs as the crossing is already considered to be equivalent to level 1.

Figure D-3: Cost Summary Tab - Overview

Iowa DOT Grade Crossing Benefit-Cost Analysis and Cost Effectiveness Tool

Crossing Improvement Costs

Crossing Number:	004959U
Current Crossing Type:	Flashing Lights and Gates

Level 1 Improvement
Flashing Lights and Gates

Year	Capital Costs	Maintenance Costs	Total Costs	
			Constant	Present Value
Total Capital Costs	$ -		$ -	$ -
2020		$ -	$ -	$ -
2021		$ -	$ -	$ -
2022		$ -	$ -	$ -
2023		$ -	$ -	$ -
2024		$ -	$ -	$ -
2025		$ -	$ -	$ -
2026		$ -	$ -	$ -
2027		$ -	$ -	$ -
2028		$ -	$ -	$ -
2029		$ -	$ -	$ -
2030		$ -	$ -	$ -
2031		$ -	$ -	$ -
2032		$ -	$ -	$ -
2033		$ -	$ -	$ -
2034		$ -	$ -	$ -
2035		$ -	$ -	$ -
2036		$ -	$ -	$ -
2037		$ -	$ -	$ -
2038		$ -	$ -	$ -
2039		$ -	$ -	$ -
2040		$ -	$ -	$ -
2041		$ -	$ -	$ -
2042		$ -	$ -	$ -
2043		$ -	$ -	$ -
2044		$ -	$ -	$ -

Inputs and Results | Cost Summary | Benefit Summary | Effectiveness

D.3 Benefit Calculations

Life cycle benefit calculations can be found in the Benefit Summary tab (see Figure D-4 below). The tab presents multiple tables, each highlighting the benefits corresponding to different levels of improvement. The tables showcase annual counts of expected fatalities, injuries, accidents, and safety benefits for the 25 years.

Each table displays the predicted number of accidents, fatalities, injuries, and property damage based on the current safety standards and the expected reduction following the safety improvements. Based on the predicted events, accidents costs are calculated using the respective cost of each event (i.e., fatality, injury, and property damage). The safety benefits are calculated as the difference in annual accident costs between the current safety standards of the crossing and after the safety improvements. The benefits are presented in both constant dollars and present value terms. Each table also presents the annual avoided fatalities, injuries, and property damage events.

Figure D-4: Benefit Summary Tab - Overview

Iowa DOT Grade Crossing Benefit-Cost Analysis and Cost Effectiveness Tool

Safety Improvement Benefits

Crossing Number: 004959U

Current Crossing Type: Flashing Lights and Gates

Level 2 Improvement

Flashing Lights, Gates, and CWT

Crash Modification Factor 0.75

Year	No Build				Build				Accident Costs		Safety Improvement Benefit		Safety Improvement		
	Accidents	Fatalities	Injuries	PDO	Accidents	Fatalities	Injuries	PDO	No Build	Build	Constant	Present Value	Fatalities Avoided	Injuries Avoided	PDO Accidents Avoided
2020	0.027	0.009	0.017	0.027	0.020	0.007	0.012	0.020	$ 135,493	$ 101,620	$ 33,873	$ 29,586	0.002	0.004	0.007
2021	0.027	0.009	0.017	0.027	0.020	0.007	0.012	0.020	$ 135,493	$ 101,620	$ 33,873	$ 27,651	0.002	0.004	0.007
2022	0.027	0.009	0.017	0.027	0.020	0.007	0.012	0.020	$ 135,493	$ 101,620	$ 33,873	$ 25,842	0.002	0.004	0.007
2023	0.027	0.009	0.017	0.027	0.020	0.007	0.012	0.020	$ 135,493	$ 101,620	$ 33,873	$ 24,151	0.002	0.004	0.007
2024	0.027	0.009	0.017	0.027	0.020	0.007	0.012	0.020	$ 135,493	$ 101,620	$ 33,873	$ 22,571	0.002	0.004	0.007
2025	0.027	0.009	0.017	0.027	0.020	0.007	0.012	0.020	$ 135,493	$ 101,620	$ 33,873	$ 21,095	0.002	0.004	0.007
2026	0.027	0.009	0.017	0.027	0.020	0.007	0.012	0.020	$ 135,493	$ 101,620	$ 33,873	$ 19,715	0.002	0.004	0.007
2027	0.027	0.009	0.017	0.027	0.020	0.007	0.012	0.020	$ 135,493	$ 101,620	$ 33,873	$ 18,425	0.002	0.004	0.007
2028	0.027	0.009	0.017	0.027	0.020	0.007	0.012	0.020	$ 135,493	$ 101,620	$ 33,873	$ 17,219	0.002	0.004	0.007
2029	0.027	0.009	0.017	0.027	0.020	0.007	0.012	0.020	$ 135,493	$ 101,620	$ 33,873	$ 16,093	0.002	0.004	0.007
2030	0.027	0.009	0.017	0.027	0.020	0.007	0.012	0.020	$ 135,493	$ 101,620	$ 33,873	$ 15,040	0.002	0.004	0.007
2031	0.027	0.009	0.017	0.027	0.020	0.007	0.012	0.020	$ 135,493	$ 101,620	$ 33,873	$ 14,056	0.002	0.004	0.007
2032	0.027	0.009	0.017	0.027	0.020	0.007	0.012	0.020	$ 135,493	$ 101,620	$ 33,873	$ 13,137	0.002	0.004	0.007
2033	0.027	0.009	0.017	0.027	0.020	0.007	0.012	0.020	$ 135,493	$ 101,620	$ 33,873	$ 12,277	0.002	0.004	0.007
2034	0.027	0.009	0.017	0.027	0.020	0.007	0.012	0.020	$ 135,493	$ 101,620	$ 33,873	$ 11,474	0.002	0.004	0.007
2035	0.027	0.009	0.017	0.027	0.020	0.007	0.012	0.020	$ 135,493	$ 101,620	$ 33,873	$ 10,723	0.002	0.004	0.007
2036	0.027	0.009	0.017	0.027	0.020	0.007	0.012	0.020	$ 135,493	$ 101,620	$ 33,873	$ 10,022	0.002	0.004	0.007
2037	0.027	0.009	0.017	0.027	0.020	0.007	0.012	0.020	$ 135,493	$ 101,620	$ 33,873	$ 9,366	0.002	0.004	0.007
2038	0.027	0.009	0.017	0.027	0.020	0.007	0.012	0.020	$ 135,493	$ 101,620	$ 33,873	$ 8,754	0.002	0.004	0.007
2039	0.027	0.009	0.017	0.027	0.020	0.007	0.012	0.020	$ 135,493	$ 101,620	$ 33,873	$ 8,181	0.002	0.004	0.007
2040	0.027	0.009	0.017	0.027	0.020	0.007	0.012	0.020	$ 135,493	$ 101,620	$ 33,873	$ 7,646	0.002	0.004	0.007
2041	0.027	0.009	0.017	0.027	0.020	0.007	0.012	0.020	$ 135,493	$ 101,620	$ 33,873	$ 7,145	0.002	0.004	0.007
2042	0.027	0.009	0.017	0.027	0.020	0.007	0.012	0.020	$ 135,493	$ 101,620	$ 33,873	$ 6,678	0.002	0.004	0.007
2043	0.027	0.009	0.017	0.027	0.020	0.007	0.012	0.020	$ 135,493	$ 101,620	$ 33,873	$ 6,241	0.002	0.004	0.007
2044	0.027	0.009	0.017	0.027	0.020	0.007	0.012	0.020	$ 135,493	$ 101,620	$ 33,873	$ 5,833	0.002	0.004	0.007

Inputs and Results | Cost Summary | Benefit Summary | Effectiveness Calcs | Improvement Costs | Severity Assumptions | Accident Costs | Safety Calcs | Safety Calcs Sources

D.4 Tool Results

As seen in Figure D-1 and D-5, the Inputs and Results tab presents both the benefit-cost analysis and cost-effectiveness results from the various levels of safety improvements on the right, where the improvements are identified under the Improvements Level Legend table.

Figure D-5: Benefit-Cost Analysis and Cost-Effectiveness Results

Benefit-Cost Analysis and Cost Effectiveness Results

Safety Improvements to Crossing Number: 004959U

Improvement Levels	Level 1	Level 2	Level 3A	Level 3B
Benefit-Cost Analysis Results				
Total Project Costs ($ millions)	-	$0.07	$0.13	$0.39
Total Project Benefits ($ millions)	-	$0.37	$1.25	$1.22
Net Present Value ($ millions)	-	$0.30	$1.13	$0.83
Benefit/Cost Ratio	-	5.16	9.83	3.11
Safety Improvement Metrics				
Reduction in Accidents per Year	-	0.007	0.023	0.022
Reduction in Injuries per Year	-	0.004	0.014	0.014
Reduction in Fatalities per Year	-	0.002	0.008	0.007
Cost Effectiveness Metrics				
Revised Texas Priority Index (TPI)	-	11.82	22.49	7.13
Texas Passive Crossings Index (TPCI	-	-	-	-

**Hazard index value per $1M in life cycle improvement costs*

Improvement Level Legend	Level 1	Level 2	Level 3A	Level 3B
Lights	●	●	●	●
Gates	●	●	●	●
Constant Warning Time (CWT)		●	●	●
Medians			●	
Four-Quad Gates				●

D.5 Updating Default Assumptions

While default assumptions should remain constant within the tool, this section outlines the approach to modifying default values for the purposes of future updates to the tool.

D.5.1 Effectiveness Values

To update the effectiveness values, the user can update the values in the table highlighted in red in Figure D-6 below. The user **should not** update the table under the Supporting Calculations section in Figure D-6 as the table only extracts values based on the highlighted table.

Figure D-6: Effectiveness Values

Effectiveness of Safety Improvement

Model Inputs

Improvement Levels	Effectiveness Value	Crash Modification
Level 1	0%	**1.00**
Level 2	25%	**0.75**
Level 3 A	80%	**0.15**
Level 3 B	77%	**0.17**

Supporting Calculations

Trains Per Day	36
Tracks	Multiple Track

Current Crossing Type	Flashing Lights and Gates

Effectiveness Value	≤ 10 Trains per Day		> 10 Trains per Day		Improvement Level
Proposed Improvement	Single Track	Multiple Track	Single Track	Multiple Track	
Passive Crossing to Flashing Lights and Gates	-	-	-	-	1
Flashing Lights to Flashing Lights and Gates	-	-	-	-	1
Flashing Lights and Gates to Flashing Lights, Gates, and CWT	-	-	-	25%	2
Flashing Lights, Gates, and CWT to Median	-	-	-	80%	3A
Flashing Lights, Gates, and CWT to Four-Quad Gate	-	-	-	77%	3B

Data Sources

GradeDec

Effectiveness Value	≤ 10 Trains per Day		> 10 Trains per Day	
Proposed Improvement	Single Track	Multiple Track	Single Track	Multiple Track
Passive Crossing to Flashing Lights and Gates	90%	86%	80%	78%
Flashing Lights to Flashing Lights and Gates	89%	65%	69%	63%
Flashing Lights and Gates to Flashing Lights, Gates, and CWT	25%	25%	25%	25%
Flashing Lights, Gates, and CWT to Median	80%	80%	80%	80%
Flashing Lights, Gates, and CWT to Four-Quad Gate	77%	77%	77%	77%

Source: Effectiveness values are for national averages derived from FRA internal data. Data extracted from: *GradeDec.Net Tool*. Retrieved from: https://gradedec.fra.dot.gov/default.aspx

D.5.2 Improvement Costs

Safety improvement costs can be updated in in the table presented in Figure D-7 below, found in the Improvement Costs tab. By default, the tool assumes that the capital costs for improvements for single track and multiple tracks are the same.

Figure D-7: Safety Improvement Costs

Safety Improvement Costs

Model Inputs

Existing Protections	Improvement	Single Track	Multiple Tracks	Annual Maintenance
Passive Crossing	Flashing Lights and Gates	**$114,376**	$114,376	**$2,695**
Flashing Lights	Flashing Lights and Gates	**$33,741**	$33,741	**$755**
Flashing Lights and Gates	Flashing Lights, Gates, and CWT	**$62,000**	$62,000	**$1,240**
Flashing Lights, Gates, and CWT	Median	**$16,170**	$16,170	**$3,773**
Flashing Lights, Gates, and CWT	Four-Quad Gate	**$280,281**	$280,281	**$5,390**

D.5.3 Severity Assumptions

To update the severity values used in the tool, the user can update the table presented in Figure D-8 below, in the Severity Assumptions tab.

Figure D-8: Severity by Accident

Severity by Accident

Model Inputs

	Values Used
Fatalities per Fatal Accident	**1.6**
Injuries per Fatal Accident	**1.0**
Injuries per Injury Accident	**1.3**

D.5.4 Accident Costs

Accident cost assumptions by severity can be found in the Accident Costs tab. To update the assumptions the user only needs to update the Value column in the table presented in Figure D-9 below.

Figure D-9: Accident Costs

Accident Costs

Model Inputs

	Unit	Value	Source
Statistical Value of Life	$ / fatality	**$9,600,000**	USDOT 2018 BCA Guidance; Guidance on Treatment of the Economic Value of a Statistical Life in U.S. Department of Transportation Analyses (2016) https://www.transportation.gov/officepolicy/transportation-policy/reviseddepartmental-guidance-on-valuation-of-astatistical-life-in-economic-analysis
Average Cost per Accident Injury	$ / injury	**$2,999,284**	Based on US DOT, BCA Guidance 2018. Based on MAIS Injury Severity Scale and KACBO-AIS Conversion if Injury Unknown. Guidance on Treatment of the Economic Value of a Statistical Life in U.S. Department of Transportation Analyses (2016). Adjusted based on the increased severity in a grade crossing accident relative to highway accident. Adjustment data obtained from the Bureau of Transportation Statistics' *National Transportation Statistics* Table 2-17 (Motor Vehicle Safety Data), Table 2-39 (Railroad and Grade-Crossing Fatalities by Victim Class), and Table 2-40 (Railroad and Grade Crossing Injury Persons by Victim Class).
Average Cost per Property Damage Accident	$ / accident	**$25,088**	Brod, Daniel; Weisbrod, Glen; Williges, Chris; Moses, Susan Jones; Gillen, David B.; and Martland, Carl D. Comprehensive Costs of Highway-Rail Grade Crossing Crashes. National Cooperative Highway Research Program Report 755. 2013. Values in 2011 dollars and inflated to 2017 dollars using the GDP Deflator.