Chicago Region Environmental and Transportation Efficiency Program Project WA1 Ogden Junction

Technical Memorandum Accompanying the Benefit-Cost Analysis

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Project area background

The railroad infrastructure in the Chicago region, the "Chicago Terminal" forms one of the most complex and busiest rail networks in the United States. This complex overlays the infrastructure of the third largest metropolitan area in the country, home to over 6.5 million persons. The rail network hosts freight trains (500 per day) and intercity and high frequency commuter passenger rail services (800 per day). It forms the primary hub for freight rail traffic in North America. This rail network interfaces with a dense road network at numerous at-grade crossings, running through densely populated commercial, residential, and industrial zones of the city, including disadvantaged communities. Elements of this rail network, belonging to many different freight railroads, face capacity challenges and a large backlog of capital assets coming to end of their functional life.

Following incidents in which limitations of the Chicago rail network impacted national freight rail service, public and private stakeholders came together to establish the Chicago Region Environmental and Transportation Efficiency (CREATE) Program. This is a first-of-its-kind partnership between the U.S. DOT, State of Illinois, Cook County, City of Chicago, Metra, Amtrak, and the nation's freight railroads. CREATE has embarked on a multi-billion-dollar effort to bring critically needed rail infrastructure improvements to the region through 70 capital projects, including roadway-rail grade separations, rail over and underpasses, viaduct improvements, grade crossing safety enhancements, freight rail track, switch and signal upgrades, and integration of railroad dispatch systems into a common operational picture while simultaneously developing a national model for Community Partnership.

The CREATE WA1 Ogden Junction Project

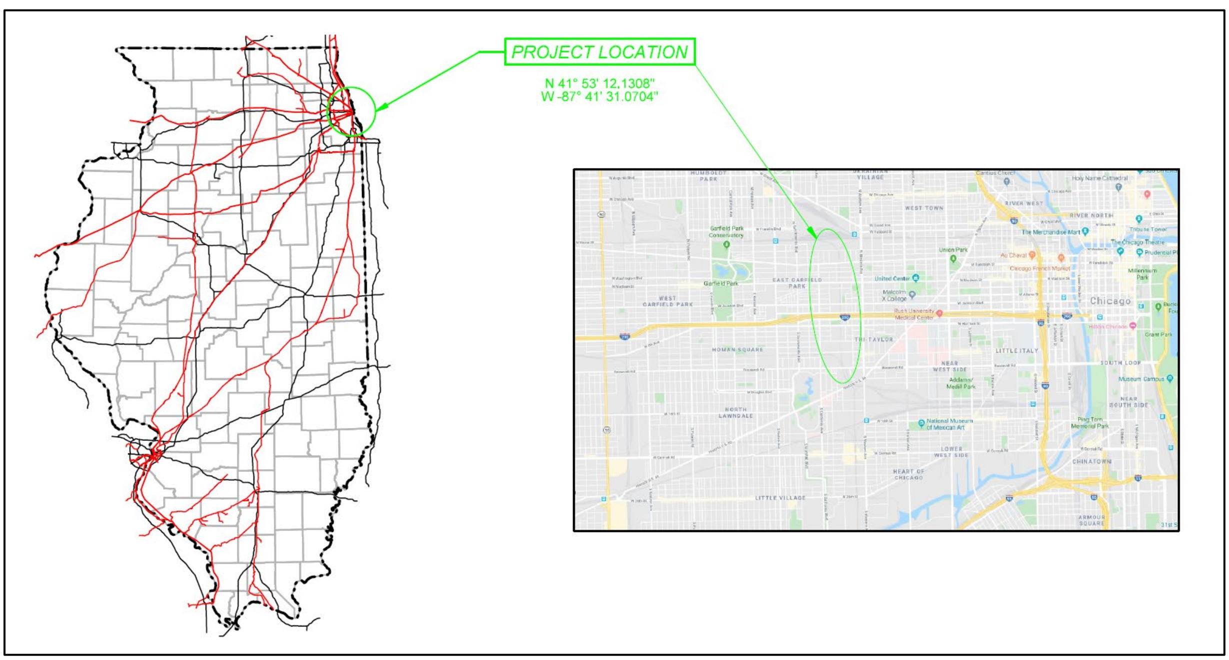

Figure 1: Project Location Maps

One of these projects is designated as **WA1 Ogden Junction.** This is a project to replace and rehabilitate 16 viaducts (rail bridges over roads), to remove 2 viaducts completely, and to replace and improve track and signaling. Most of this investment, and 16 of the bridges, are located on Union Pacific Railroad's (UP) Rockwell Subdivision. This track segment runs north – south from Kedzie to Ogden Junction, 2.3 miles. Two bridges just south of Ogden Junction, and associated track and signal work, are on the connecting infrastructure of Norfolk Southern Railway's (NS) Chicago Junction (CJ) and CSX Transportation's Blue Island subdivisions. This "project" segment carries freight trains from multiple railroads but does not carry passenger rail traffic.

These bridges are identified in the provided graphic, Figure 1, ordered from north to south. The build dates and expected lifespans are illustrated. Bridge lifespan has many factors, specifically being impacted by traffic dynamic loads over time, which may vary.

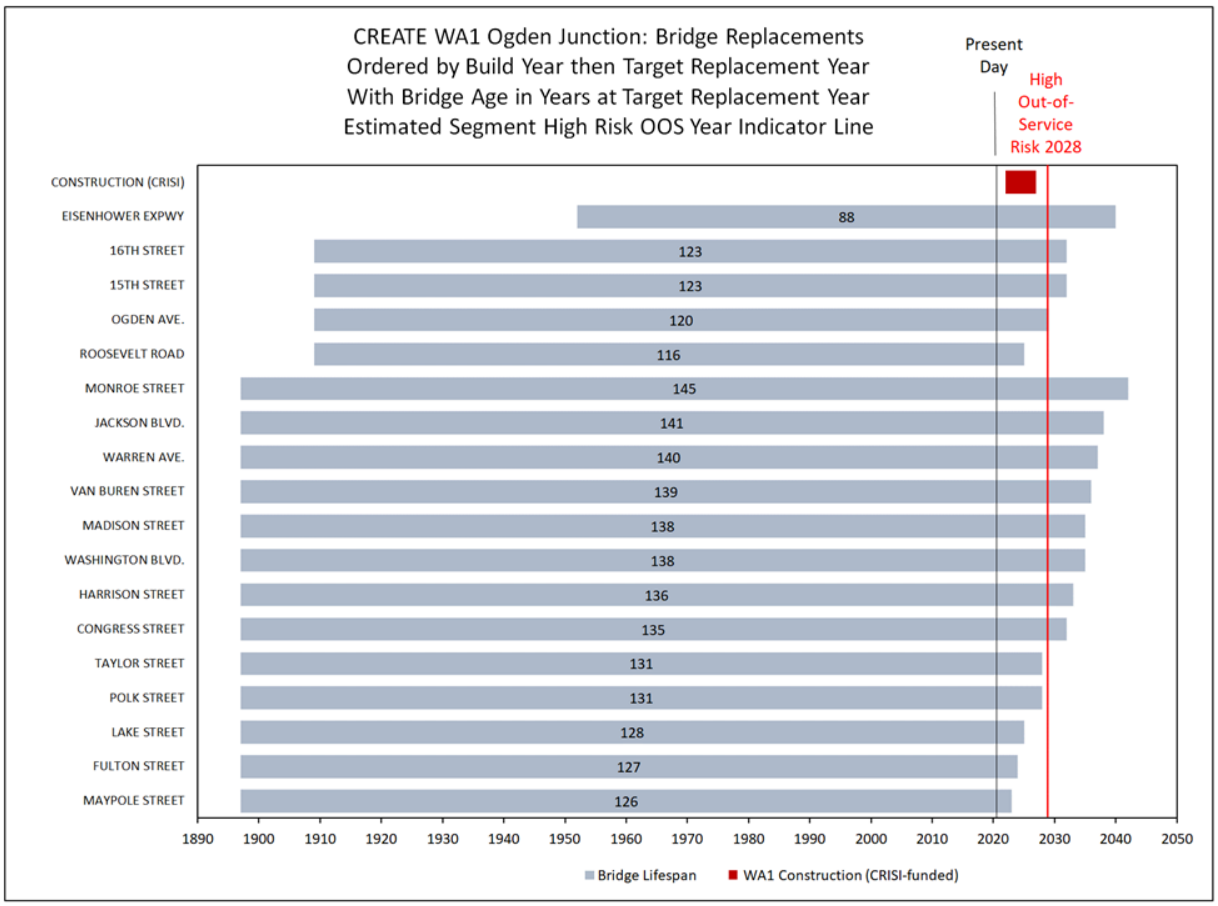

Figure 2: Project bridge projected lifespans

Due primarily to steel fatigue, the consensus of the engineering team is that by 2028 in the no-build scenario, this infrastructure is reaching the end of its useful life and the risk is high of one or more of these viaducts becoming unsafe for use. For purposes of the BCA only regular maintenance is assumed to occur, no significant capital investments that would extend the lives of the structures. 2028 is modeled as the year in the no-build scenario when the project segment is taken out of service.

Model structure

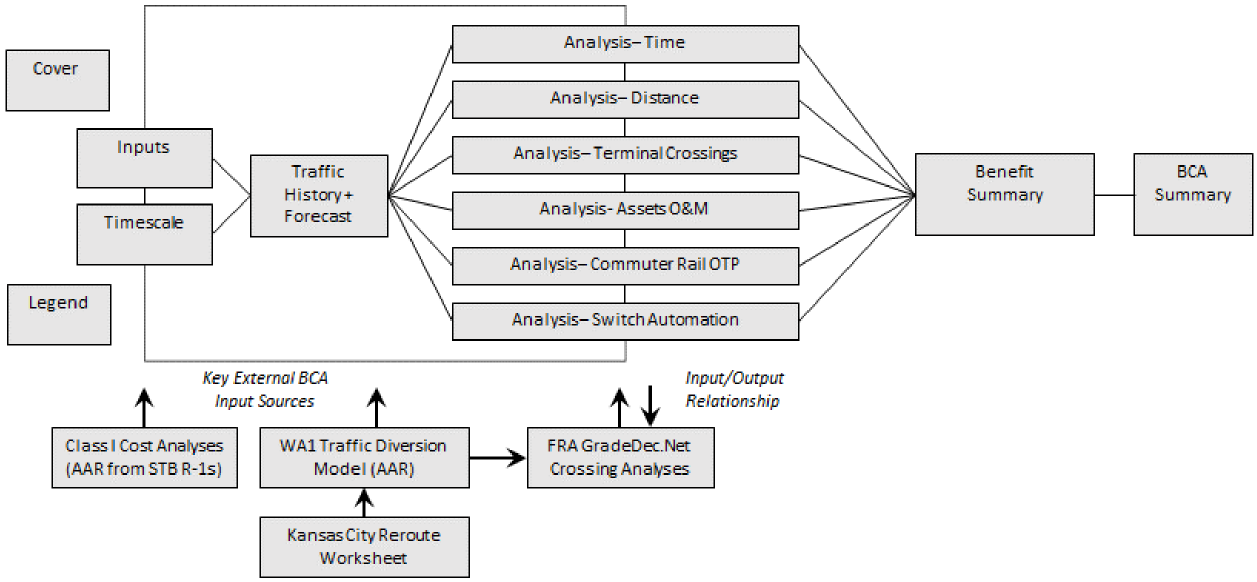

Figure 3: BCA model structure

The BCA is an input-output model constructed using Microsoft Excel. It is a dynamic model so that inputs may be adjusted by reviewers to adjust assumptions and test scenarios.

All calculations and formulas within the multi-tab workbook are functional, rather than rendered as static values. It is a stand-alone file and will work on a Windows computer running a current version of Excel. No scripts or programming are necessary for the model to function. The model consists of the shown worksheets and is accompanied by reference files, including other models, that provided inputs used in the BCA. The reference files and models are not linked to the BCA, their outputs were hard coded as inputs in the BCA to keep the workbook independent. Two of the reference files are models themselves.

The **cover** worksheet provides identifying information, points of contact, and technical notes for reviewers. The **legend** worksheet documents color coding and formatting used throughout the model, such as for line summations, model drivers or inputs, and references on or off the sheet. The **inputs** worksheet contains a wide range of referenced assumptions and analysis driving the benefit and cost calculation worksheets. The **traffic** worksheet is a specific type of input, providing time series of historical and projected traffic flows driving the calculation worksheets. This worksheet provides the forecasts for:

- Train traffic defined segments of the selected impacted routes in the diversion analysis area. This is denominated in trains per year. This projection was prepared by AAR with CTCO representatives including from UP, NS, CSX, IHB, BRC and METRA.
- Road traffic at the impacted grade crossings intersecting with the selected rail routes in the diversion analysis area. This is denominated in average annual daily traffic (AADT) with percentage of trucks. This projection was prepared by CMAP based on their latest regional model, ON TO 2050.

The **timescale** worksheet serves as a consistent template for the header used in all other sheets presenting the analysis period and the project construction period assumptions.

The calculation worksheets are organized by nature of the analysis performed.

(1) **Analysis - Time:** Rail operations out-of-route (OOR) time impacts.

(2) **Analysis - Distance:** Rail operations out-of-route distance impacts.

(3) **Analysis - Crossings:** Rail operations out-of-route crossing impacts.

(4) **Analysis - Assets O&M:** Maintenance costs for project area rail infrastructure assets, construction period emissions impacts, and the residual value of the assets to be constructed with federal funds.

(5) **Analysis – Commuter Rail OTP:** Project benefits in the form of on-time performance of the adjacent Metra UP-W line. Due to the BCA approach taken this is a disbenefit.

(6) **Analysis – Switch Automation:** Impacts of automation of track switches due to the project. Due to the BCA approach taken this is a disbenefit.

Each of these worksheets carries out various analyses of benefits and costs incurred relative to each metric over the forecast period, for each mode, netting the benefits and costs over the build and no-build scenarios.

The sheet **benefit summary** organizes the discrete streams of benefits and costs identified in the analysis worksheets and discounts them to present value. The sheet **BCA summary** provides a tabular and graphical presentation of the outputs of the model, including discounted and undiscounted benefit and cost flows and cumulative net benefits over time, total net benefits expected from the Project, and the benefit-cost ratio.

External inputs

There are important **external sources of calculations** supporting this model:

1. **Class I Cost Analyses:** This spreadsheet, developed by AAR, consolidates and analyzes publicly reported data from R-1 reports submitted annually to the Surface Transportation Board by the Class I railroads. This worksheet calculates a wide range of cost factors appropriate to use for measuring Class I railroad operations. The factors from this worksheet used in the BCA are hard coded into the BCA as inputs and footnoted. Reviewers may explore this separate workbook, provided as an accompanying attachment, if they wish to understand the specifics of the development of these factors. This worksheet is not linked directly to the BCA, selected outputs were hard coded as inputs in the BCA.
2. **WA-1 Traffic Diversion Model and Reroute Analysis:** This model was built specifically for this project diversion case, developed by AAR and Class I railroad staff. It is its own dynamic spreadsheet model, a tool that allowed analysts to calculate the line capacity and cascading of trains in the build and no-build scenarios, across the identified routes in the Chicago Gateway. The outputs of this model are hard coded as inputs within the BCA. Reviewers may explore this separate workbook, provided as an accompanying attachment, if they wish to understand the specifics of the development of these factors. An annex to this model in a separate spreadsheet provides the information for the forecast of trains diverted off terminal via Kansas City. This traffic diversion model follows a linear regression style logic, whereby operating constraints are held static in the model while allowing delay to

vary. This reflects a key management constraint in the Chicago Terminal for the operating railroads, which is a mandate to minimize systematic delay while maintaining fluidity while not increasing impacts on the intersecting highway mode or the passenger rail service carried on the network. Delay is a proxy for capacity in that capacity in the Terminal is set by acceptable delay, which is almost always below the full technical capacity of the lines. As an example: a line might be technically capable of carrying 80 trains per day, but the acceptable accrued delay threshold can be reached at far fewer trains than that. Operational decisions are made based on management of delay, not the purely physical constraints on the network. An important foundation of this analysis is capacity work developed by the University of Illinois, provided as an attachment to the CRISI application.[1]

3. **GradeDec.Net System for Highway-Rail Grade Crossing Investment Analysis:** This analytic tool is available for public use from the Federal Railroad Administration. It is a web-based framework to enable standardized, FRA-validated, benefit-cost analyses of at-grade crossing scenarios in support of federal funding initiatives. GradeDec.Net can be accessed at https://gradedec.fra.dot.gov/ The outputs of the GradeDec.Net analysis for the impacted crossings are inputs to this broader BCA. The detailed outputs of the GradeDec model runs, comparing crossing impacts on each segment in the current and diversion routes, of the build and no-build freight train traffic forecasts, are pasted within the **crossings** analysis tab of the BCA.

Internal inputs

The **Inputs** sheet is organized roughly into global constants, a set of recommended values from the U.S. DOT's formal BCA Guidance, and blocks of inputs associated with each calculation worksheet or different types of analyses. The sheet contains a footnotes section providing numerically coded references for sources of input assumptions, with website links, if available. Some inputs are developed through various calculations performed within the inputs sheet, for example drivers that average historical traffic rates and identify associated growth or decline rates. In a few instances, inputs are derived from analyst assumptions. Most inputs (constants) within the model are to be found here and referenced elsewhere in the model. This better enables reviewers to adjust inputs as necessary, such as to perform sensitivity analyses. The other sheets with many hard-coded values are traffic and timescale. Hard-coded values are minimized in all the analysis and summary sheets which we seek to drive almost completely through off-sheet references to hard-coded values in the inputs, time scale and traffic worksheets.

Timescale

The timescale sheet provides the template for the common time-oriented header in the traffic worksheet, all analysis worksheets and the benefits summary (discounting) sheet. This timescale begins in 2011 to potentially capture any historical data, as necessary, through an analysis period to capture a full 30-year projection from the end of the construction of the proposed project in the build scenario. This header includes rows for beginning and ending dates for periods, years in this case. The time periods for construction and the 20- and 30-year projection windows are identified by rows with binary flags. While these beginning and ending dates and period flags

[1] Sogin et al. Analyzing the transition from single- to double-track railway lines with nonlinear regression analysis. Journal of Rail and Rapid Transit/IMechE 2015. https://railtec.illinois.edu/article/analyzing-the-transition-from-single-to-double-track-railway-lines-with-nonlinear-regression-analysis/

may not be used in this model, we include them as part of the default timescale header to be available in case useful to drive calculations in the analysis worksheets.

Traffic projections and assumptions

The analysis area

The analysis area for this BCA is illustrated in the provided map, bounded in the northwest in the vicinity of UP control point (CP) 25th Avenue and IHB CP 359 in Belwood, IL. It is bounded to the southeast at NS CP 502 and IHB CP 100 near Gary, IN. This boundary encompasses the line segments subject to diversion of rail traffic in the project no-build scenario.

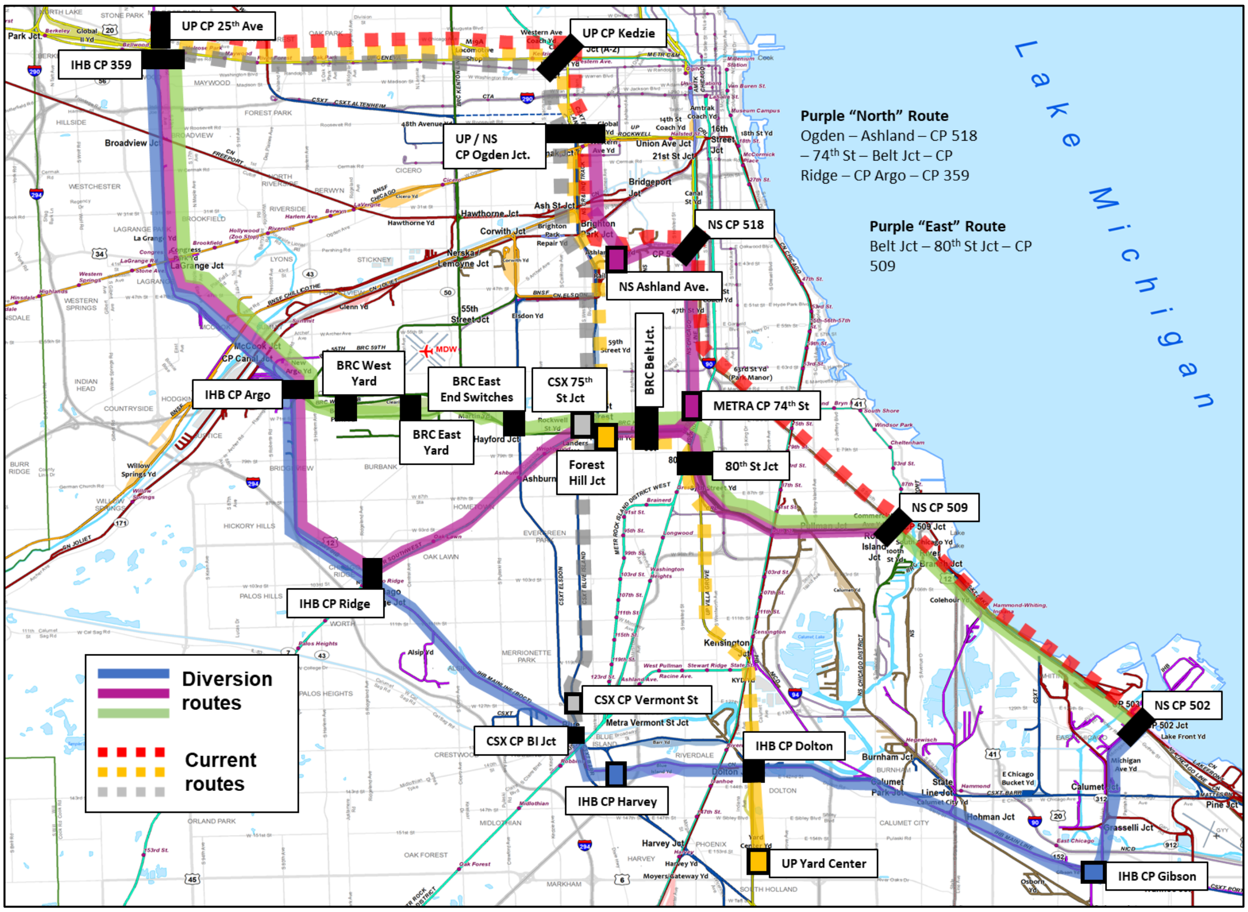

Figure 4: Transportation analysis area

The rail network in the vicinity of Chicago is extremely complex with many lines and a wide range of line ownership and access agreements. The network was analyzed to determine first, which line segments carry significant traffic that passes over the "project segment," primarily the UP's Rockwell Subdivision. The rail traffic over the project segment was evaluated then to determine the current most common paths through the Chicago region for those trains. Today these paths run between CP 25th Avenue in the northwest of the analysis area to CSX's CP Blue Island Junction, to IHB's CP Dolton and NS CP 502. The nodes within this analysis area are important; there are twenty nodes identified that bound segments analyzed within the model.

While there are a wide range of what appear to be other paths in the analysis area, these are constrained. Some are at capacity, including some that carry high volumes of commuter trains. Others have physical limitations, such as interchange directionality, prohibiting flows to or from other lines. The traffic diversion analysis assumes that passenger traffic is not impacted by diversions, rather freight traffic must be rerouted to accommodate and not interfere with passenger service. It is also assumed that at-grade crossing blockages will not be allowed and crossing transit times (block times) will not be altered by the diversions. The model accrues delay as line usage rises due to train demand, but trains that are delayed awaiting path clearance by other trains are assumed to halt and idle outside of crossing blocks. Other constraints are infrastructure capacity, for example number of tracks, nature and directionality of connections, weight capacity or clearance restrictions. These hard constraints greatly reduce the potential paths in the region that can accommodate permanent increases in freight traffic from diversions off the project segment. This analysis assumed only freight trains would be subject to diversion or rerouting and passenger routes remain fixed as they are today. The analysis also assumed that generally the railroads in the region will be able to amicably work out commercial and contractual arrangements for access and rerouting as driven by operational and capacity needs.

The analysis eliminates multiple counting of trains where paths share segments. Diversion is driven first by the calculation of duration of a typical freight train to traverse the path. When the duration calculation exceeds the duration to traverse the next best path, the segment cascades the excess trains onto that path until the traverse time exceed the next best, and so on. The Chicago Terminal operates under constraints in terms of acceptable delay. The individual railroads have thresholds for delay tolerance for their operations and the elements of the infrastructure they manage. Collectively the railroads work together to manage overall congestion and delay in the terminal. STB monitors statistics provided by the railroads in terms of volume and delay. In the model, delay is the primary output variable. The additional trains cause acceptable delay tolerances to be exceeded on the diversion lines. Beginning in 2028 some trains are rerouted outside the analysis area, approximately 4 per day, rising corresponding to the demand growth rate. The trains transiting Ogden Junction have many origins and destinations across the continent, and there are many potential diversion scenarios. A best proxy of diversions for these trains was determined to be via Kansas City with the endpoints of North Platte, NE and Elkhart, IN, the junctions where the routing decisions are expected to be made for long-haul trains moving

No assumptions are made about significant capacity changes in the rail infrastructure analysis area except for major investments that are fully programmed and funded as of today. The Rockwell Subdivision today carries a negligible amount of TIH/PIH traffic. The model does not forecast any increase in TIH/PIH traffic on the Project segment that would be subject to diversion to alternative routes.

The project build scenario

In the build scenario, the project receives funding. The project is completed by 2027, with some closeout activities in 2028, in accordance with the summary schedule. The project construction plan considers the relative condition and ages of the bridges, prioritizing higher risk structures in the scheduling.

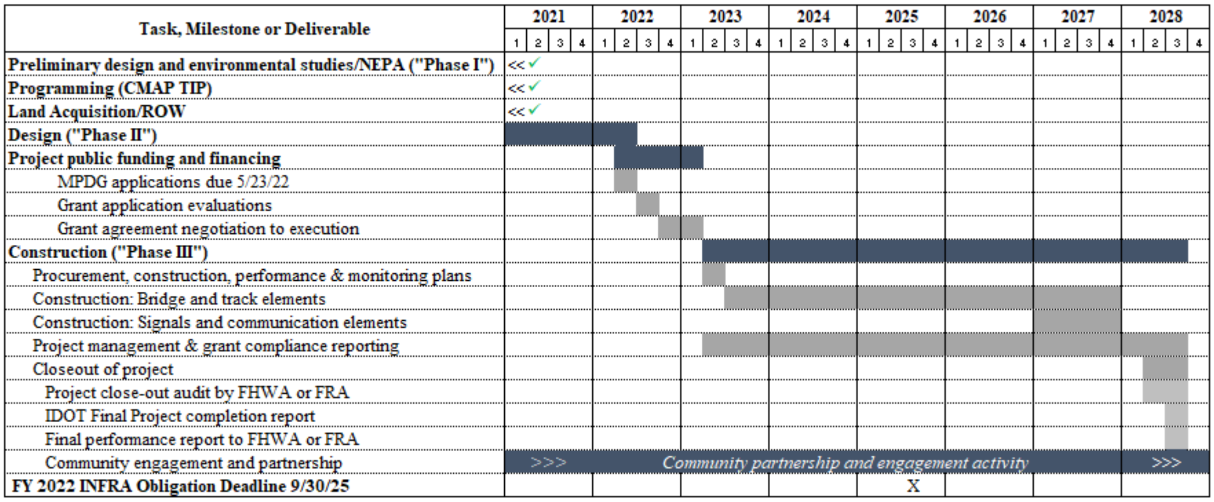

Figure 5: Project schedule

The demand for the segment is forecast to increase at 0.14% per year. This growth rate was selected to be conservative. It considers growth rates in recent years based on two sources. First, Class I national level traffic statistics, subtracting coal traffic, which it is thought has reached a trough in secular decline. Second, growth rates for selected Chicago Terminal metrics reported to STB were considered. The impact on the scenario of higher growth rates would be to reroute those additional trains outside of the Chicago Terminal because the thresholds for delay were already exceeded, resulting in the assumption of the 4 rising to 5 trains per day moving off-Terminal via Kansas City in the scenario. Accordingly, each additional train added to demand by a higher growth rate would go via this reroute.

The project no build scenario

In the no-build scenario the proposed project is not built. One or more of the bridges to be rehabilitated is assumed to reach the end of its operating life by year 2028. This will take the project segment out of service (OOS) for all through freight traffic. This is an "unnatural" diversion due to loss of the facility. The anticipated demand for the project segment is than cascaded for each year over the alternate paths. When acceptable delay thresholds are reached on the diversion routes, the "overflow" trains are assumed to reroute through Kansas City, as previously described. In the no-build scenario the project is assumed not to be performed at all during the remainder of the analysis period. This enables a full accounting of the costs associated with the loss of the Project segment for operations loss and is in accordance with U.S. DOT guidelines and past accepted practice. This current model does not yet accommodate this function of an increased growth rate driving further benefits from the Kansas City reroute element.

Benefit-cost analysis worksheets

This is not a comprehensive analysis of all possible benefit and cost streams in the build and no-build scenario. The intent is to capture the most significant transportation diversions and the most significant impacts. Factors excluded should not materially reduce the net benefits and benefit cost ratio. In each analysis an effort was made to capture disbenefits as well as benefits.

Capital costs

The capital costs denominated in base year 2020 dollars were allocated over the periods through completion of construction based on the timing estimates of the project engineering team.

Rail operations time impacts

This analysis evaluates the differential in train operating time between the build and no-build scenarios. One factor evaluated is crew time, a second is the impact of increased transport time on costs accruing to rail shippers.

Rail operations distance impacts

This analysis evaluates the differential in distance traveled by trains between the build and no-build scenarios. The differential in train miles drives multiple cost calculations.

1. Train miles drive fuel consumption, this generates emissions.

2. Train miles generate marginal infrastructure costs in the form of wear and tear on track and structure.

3. Train miles generate costs associated with the use of the rolling stock, excluding the fuel and crew costs to avoid double counting.

To support this analysis a forecast was developed of the potential evolution of the Class I line-haul locomotive fleet by EPA tiers. This forecast was launched off the current fleet mix by tier from the Railinc UMLER system. This served to allocate fuel consumption or locomotive time to the proper emissions factors by criteria pollutant.

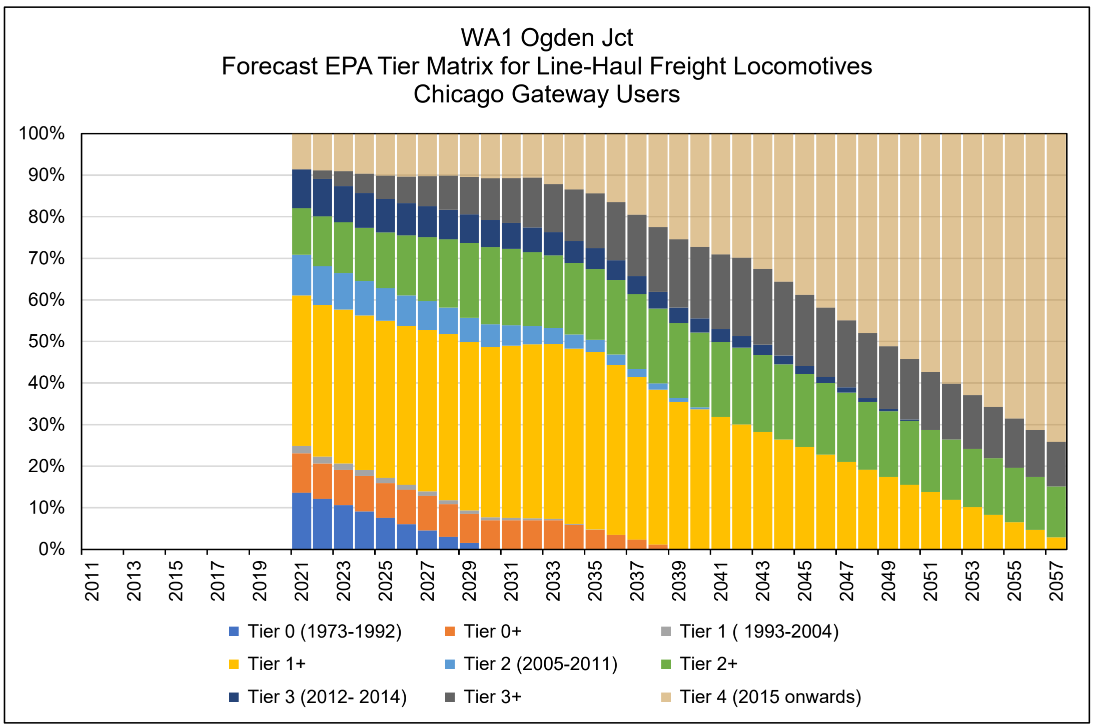

Figure 6: Forecast for Class I line-haul loco fleet

Rail operations crossing impacts

The Chicago Metropolitan Agency for Planning (CMAP) provided point forecasts of AADT and truck % of traffic for each location for 2050, developed using the growth and demand forecasts from the latest comprehensive regional plan, ON TO 2050. The years between 2018 and 2050 were interpolated, the forecast was extended with a simple linear projection to the end of the analysis period in 2058. Train lengths are assumed to hold static at an average of 7,500 feet per train. This reflects a multiple of approximately 1.4 of average train lengths nationally from 2010-2018. Nationally, average freight train lengths have been static during this period. For entry into GradeDec's Corridor Model, the daily trains were drawn from the per segment outputs of the traffic diversion model. The highway traffic characteristics were averaged over the crossings on the segments to be entered into the model which accepts point growth rates for the segments, not each individual crossing. The crossings in segments are in very close proximity, it did not appear that material precision was lost in the averaging.

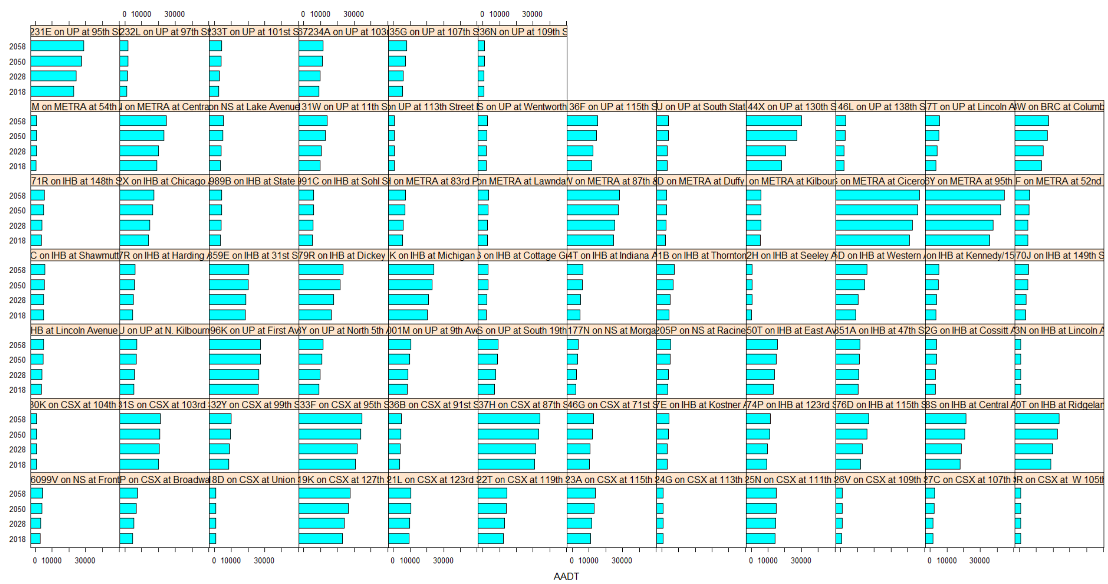

Figure 7: AADT at crossings forecast through 2058

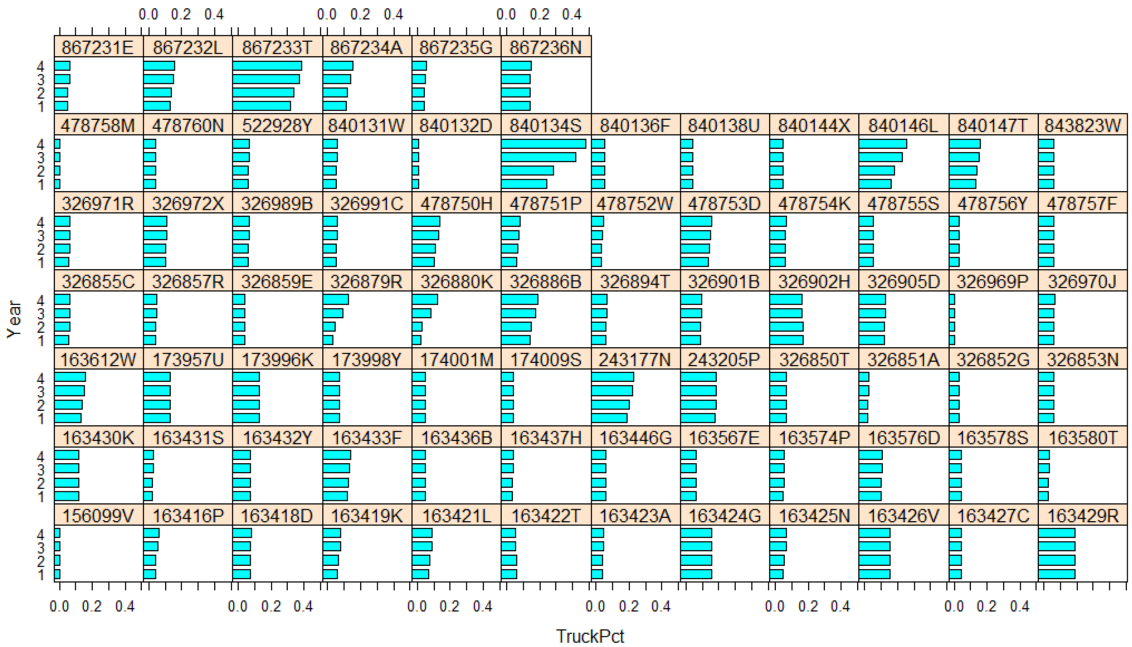

Figure 8: Truck % at crossings forecast through 2058

The crossing BCA analysis is performed using the Federal Railroad Administration's GradeDec.NET analysis software. This tab in the BCA spreadsheet organizes and presents the different inputs for the GradeDec.Net analysis and presents the outputs from that analysis, which are integrated into this overall BCA.

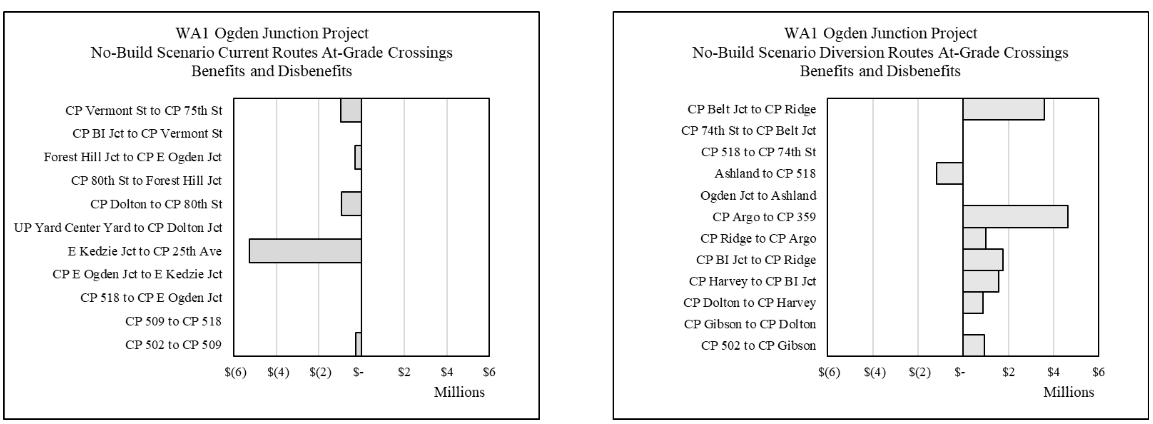

Figure 9: Benefits/disbenefits at segment crossings between build/no-build scenarios

Commuter rail on-time performance

The limitations of the project segment today have a specific impact on Metra. The UP-W line runs from Elburn in Kane County east to Downtown Chicago, 44 miles. This service is operated by UP for Metra over the Geneva Subdivision. The line connects with the project segment at the wye between the Kedzie and Ogilvie stations, where freight trains passing through the project area transition on or off the Geneva Subdivision. Due to slow freight train speeds, and halts for manual dispatch and for crews to line switches, the movement of the freight trains between these subdivisions has variability that can conflict with the scheduled commuter train windows. The result is that commuter trains must slow or stop to accommodate delays in the planned movement of freight trains. Detailed station passenger count surveys found an average of 409 riders per train in 2019 on the junction segment, with this service carrying 7.8 million annual passenger trips in that year. Metra and UP track on-time performance (OTP) incidents. All delays to UP-W trains resulting from freight rail operations that deviate more than 6 minutes from the Metra timetable targets are logged. In 2019, a typical pre-pandemic year, there were 60 recorded delays caused by the project segment. UP dispatch estimates that delays of less than 6 minutes occur at a rate of 20% of the logged 6-minute threshold incidents, for a total of 72 incidents that year, with non-reportable incidents averaging 3 minutes and reportable incidents on average slightly over 6 minutes. These delays are estimated to have cost UP-W riders collectively some 2,697 hours of lost time in 2019, the last pre-pandemic year of normal service. The BCA approach taken removes the project segment from service in the no-build scenario. Because of this, future costs of these delays are calculated as a disbenefit. This analysis does quantify for the reader a negative impact experienced by Metra users due to the poor infrastructure conditions, one that this project would mostly remedy in the build case. With completion of the project a 75% reduction in these freight train-caused Metra OTP incidents at the junction is anticipated. This would translate to just under 90,000 passenger hours of delay avoided over the analysis period, based on a conservative UP-W ridership growth forecast of 1.2%.

Track switch automation

A net of nineteen new power switches will be installed in the project corridor and the number of hand-throw switches will be reduced. This will enable the through trains moving over the project segment to proceed without having to stop for employees to dismount, line switches, and reboard, the current procedure. This reduces train delay, as well as employee exposure to train operations and slip and fall hazards on the right-of-way. Due to the out-of-service scenario used in the BCA this impact is recorded as a disbenefit. If the segment is taken out of service in the no-build scenario, this operation would be eliminated. This calculation does quantify the impacts of this problem, which would be eliminated by the project. 160,000 hours of personnel time will be saved over the forecast period that would have otherwise been spent by train crews halting trains to manually line switches. Based on discussions with operating personnel, through trains typically halt for roughly 18 minutes prior to entering the Rockwell subdivision. This is for two reasons that the project will eliminate. First, the dispatchers amongst the three freight railroads must coordinate to handoff the trains and provide authority to proceed from territory to territory, block to block. Second, the train must halt for the lining procedure described. This is multiplied by the crew size of two to determine crew time impacts of the procedure.

Assets and operations and maintenance

Residual value

The residual value of the assets to be constructed or improved by the project at the end of the analysis period become a benefit in the model, representing some consideration of the ongoing benefits of the project still accruing to users. In this case the new or improved bridges are the only facility elements expected to have useful lives beyond 2058. Other infrastructure elements such as rail, ties and signaling systems would have been replaced prior to 2058. The average lifespan to date of the present bridges is 118 years. The expected lifespan of the bridges applied in the model is a more conservative 100 years.

Operations and maintenance

There is additional maintenance cost imposed in the no-build scenario due to additional train miles generated by OOR paths. This analysis is carried out on the distance worksheet in the

BCA. The analysis is of net train miles, considering the reduction in train miles on the current routes, shifted to the diversion routes.

Outputs and benefits summary

This worksheet provides four elements. First, a vertically organized table of the flows of benefits, costs and net benefits, showing undiscounted versus discounted flows. The second element consists of two charts of benefits and costs. The first shows the discrete annual streams, the second is cumulative over time. The third element is an "income statement" style presentation of the benefits and costs organized by analysis area and factors analyzed.

Finally, this sheet presents a summary of the separate "benefits only" analysis that, separately from the rest of the BCA, shows a scenario comparing the benefits associated with the improvements in speed on the project segment relative to a scenario without the project but where the segment stays in service. This is a different view of the project and is not incorporated into the overall BCA benefits calculations and outputs of net benefits and benefit-cost ratio. It was included as it was thought this could provide reviewers with another way of looking at the project besides the diversion case scenario.

Glossary

AADT	Average annual daily traffic
AAR	Association of American Railroads
CMAP	Chicago Metropolitan Agency for Planning
CREATE	Chicago Region Environmental and Transportation Efficiency Program
CSX	CSX Transportation
CIROC	Chicago Integrated Rail Operations Center
CTCO	Chicago Transportation Coordination Office
IDOT	Illinois Department of Transportation
NS	Norfolk Southern Railway
OOR	Out of route, distance traveled by a vehicle away from the most efficient path between origin and destination.
OOS	Out of service
R-1	Annual Report of Finances and Operations submitted annually to STB by Class I railroads.
STB	Surface Transportation Board
UP	Union Pacific Railroad