Benefit-Cost and Economic Impact Assessment of Rail Connectivity Improvement Alternatives in Tennessee

Case Studies: Shelby, Marion, and Dyer Projects

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16. Abstract

Strengthening rail connectivity is widely recognized as a strategy for improving freight efficiency, regional development, social benefits, and the environment. This study develops a structured, transferable framework for evaluating the comprehensive impacts of rail infrastructure investments through a forward-looking 20-year benefit–cost analysis, incorporating capital expenditures, operating cost savings, environmental externalities, and broader social and regional development effects. The framework applies an integrated, systemwide assessment rather than isolated performance metrics, ensuring consistent treatment of cost and benefit streams across different project contexts. Three real-world rail connectivity improvement projects in Tennessee are evaluated through the proposed framework to illustrate the potential economic, social, and environmental outcomes with sensitivity analyses.

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Executive Summary

This report evaluated whether selected TDOT rail connectivity investments improved freight movement, reduced public burden, and generated economic returns sufficient to support continued program use. The assessment focused on the three completed projects available for review under TDOT's Rail Connectivity Grant Program in three counties: Shelby County, Marion County, and Dyer County. The purpose of the study was to provide TDOT with a common basis for validating past investments and informing future funding decisions.

The analysis applied a Layered Lifecycle Benefit-Cost Analysis (LL-BCA) framework. Project information, operating assumptions, and reference cost and valuation inputs were used to compare the No-Build and Build scenarios for each project. The analysis estimated both direct operating effects and public well-being related to emissions and safety. Furthermore, a lifecycle engineering economic analysis was conducted to compare net present value, benefit-cost ratio, payback period, internal rate of return, and equivalent uniform annual worth.

The results showed that the three projects did not produce the same type or scale of value. The project in Shelby County produced the strongest result because it displaced a large volume of truck activity and therefore generated substantial operating and public benefits. The one in Dyer County produced a positive but smaller return, indicating that modest rail-access improvements could still be favorable when the diverted freight volume and capital costs are aligned. The Marion County project remained within the analytical framework, but its final output tables still required normalization and quality assurance before it could be compared with the same confidence as the other two cases.

This report also showed that project value was not determined by direct freight cost alone. In the better-performing projects, improved rail access reduced truck operating burden and externalities, such as emissions, criteria air pollutant damage, and crash exposure. For TDOT, the distinction between direct logistics savings and public benefits mattered because some projects were supported mainly by direct logistics savings, while others relied more heavily on public benefits. Project-specific operating assumptions also affected the analysis results.

Key Findings

- The project in Shelby County was the strongest validated case. On an operating-only basis, it generated about $3.60 million in annual savings, with a 35-year NPV of $44.70 million and a BCR of 24.34. It also generated about $1.84 million per year in reduced environmental and safety external costs, increasing total economic NPV to $68.58 million and total BCR to 36.81. All analyses showed a large positive margin on both operating only and total economic bases.
- The Dyer project produced a strongly favorable result. It generated approximately $873,919 in annual direct operating savings and approximately $926,011 in total annual economic benefit including externalities. Over a 35-year analysis period, the project produced an operating-only NPV of $10,775,218 and a BCR of 20.95, and a total NPV of

$11,449,681 and a BCR of 22.20, indicating a robust economic return relative to the $540,000 capital investment.

- The Marion County project was evaluated under the same framework as the other two projects, but the transportation evidence available for this study was more limited. Within the quantifiable transportation effects captured in the current analysis, the project did not produce benefits at the same level as the Shelby County and Dyer County projects. This result should not be read as a complete statement of the project's broader economic or strategic value.
- Public benefits significantly affect the overall estimated benefit-cost ratios. The emissions reductions and lower truck-related crash exposure are substantial parts of the total value of the rail improvements, beyond direct freight savings alone.
- The performance of the investment projects studied was influenced by a small number of variables based on sensitivity analyses. Throughput, truck utilization, haul distance, and capital-cost treatment are the main drivers of the evaluated benefits across the projects.

Key Recommendations

- Use a common LL-BCA framework for evaluating future TDOT rail-connectivity and other projects. Such a framework provides a holistic evaluation of investment alternatives and helps TDOT make informed decisions that are well aligned with the mission of TDOT—to "provide a safe and reliable transportation to support economic growth and quality of life".
- Use the Shelby County project as a benchmark for future project screening and program reporting. It provides a clear example of a rail-connectivity investment that generated large freight savings, substantial reductions in external cost, and strong lifecycle returns.
- Evaluate smaller rail-access projects based on project fit rather than project size alone. The Dyer County project demonstrated that a facility-level rail connection can generate substantial economic returns when freight demand and logistics conditions are well suited to the mode shift, producing a BCR well above 1.0 under both operating-only and total benefit accounting frameworks.
- For rail-access projects whose expected value extends beyond quantifiable transportation benefits, TDOT should identify and preserve the data needed to evaluate broader outcomes such as business retention, follow-on investment, job creation, and site or port activity. The Marion County project suggests that these broader outcomes may matter, but they could not be fully evaluated in this study because supporting data were limited.

- Caution on assumptions, such as throughput and operating conditions. There is a need to conduct careful capital-cost validation during project development. This recommendation was justified by the sensitivity results, which showed that the assumed values had a significant impact on annual benefits and lifecycle investment outcomes across the cases.

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Glossary of Key Terms and Acronyms

Term / Acronym	Definition
BCR	Benefit-cost ratio. The ratio of discounted benefits to discounted costs over the study horizon.
Build scenario	The scenario in which the rail-connectivity improvement is implemented and available for freight movement.
Criteria air pollutants	Non-greenhouse-gas pollutants with monetized damage effects in the report, such as nitrogen oxides, sulfur oxides, fine particulate matter, hydrocarbons or volatile organic compounds, and carbon monoxide, depending on the source basis.
Drayage	A short truck movement used to connect a shipper, terminal, interchange, or plant with a longer-haul rail movement.
EUAW	Equivalent uniform annual worth. The annualized value of net present value over the study horizon.
GHG	Greenhouse gas. In this study, monetized greenhouse-gas effects are represented using carbon dioxide and the social cost of carbon.
Inventory carrying cost	The cost of capital tied up while freight is in transit. In this study, it reflects the value of shipment time in the logistics chain and is affected by travel time, dwell time, and the cargo value assumption.
IRR	Internal rate of return. The discount rate at which the project's net present value equals zero.
LCA	Lifecycle analysis. A general term for evaluation over the full study horizon. In this study, lifecycle results are developed through the LLBCA framework.
LL-BCA	Layered Lifecycle Benefit-Cost Analysis. The analysis framework incorporates direct operating effects, public effects, and lifecycle investment results.
Loaded share	The proportion of truck miles traveled while carrying freight rather than operating empty. It is used to convert vehicle-based truck cost inputs to a freight-service basis and to reflect empty return or repositioning trips in truck operations.
No-Build baseline	The scenario in which freight continues to move under existing infrastructure and access conditions without the improvement project.

NPV	Net present value. The discounted value of total benefits minus total costs over the study horizon.
Public-effect cost	The monetized cost of environmental and safety effects associated with freight movement, including greenhouse-gas emissions, criteria air pollutant emissions, and safety risk.
Payback period	The number of years required for cumulative undiscounted net benefits to recover the initial project investment.
ROI	Return on investment. The ratio of net return to project cost, used here as a supplementary investment indicator.
SCC	Social cost of carbon. The monetized damage value applied to carbon emissions in the environmental analysis.
STB Form R-1	The annual railroad financial and operating report used in this study as a reference source for rail cost and activity inputs.
Transloading	The transfer of freight between modes, vehicles, or facilities, such as rail-to-truck or truck-to-rail handling.
VSL	Value of statistical life. The monetized value is used in the safety analysis to represent the reduction in fatality risk.

Chapter 1 Introduction

This chapter establishes the statewide context for this study, describes the rail-investment problem examined, states the purpose and scope of the evaluation, and introduces the analytical basis for the three case studies. It is intended to articulate the objectives of reviewing these projects, questions that the report is to answer, and how the remainder of this document should be interpreted.

1.1 Background and Context

As Tennessee's economy continues to diversify and expand, the performance and adaptability of the State's transportation system are central to sustaining industrial growth, supporting regional access, and improving long-term system resilience. Freight transportation infrastructure plays a direct role in this broader public interest by connecting manufacturers, agricultural producers, distributors, and ports to domestic and international markets. In this setting, transportation investment is not only a mobility issue but also a driver of economic development, infrastructure stewardship, environmental performance, and the prosperity of rural and urban communities.

TDOT has a continuing responsibility to plan, preserve, and improve a multimodal transportation system that supports statewide mobility and economic competitiveness. This responsibility includes freight rail assets and rail-served industrial access, where targeted investment can improve network efficiency, expand shipper routing options, and mitigate pressure on the public roadway system. Enhanced rail connectivity is vital to the State economy because it can reduce freight transportation costs, improve first- and last-mile accessibility, and increase the marketability of industrial sites.

TDOT has invested in multiple rail connectivity projects and needs to evaluate past rail connectivity improvements and determine future projects regarding measurable statewide value. The three case studies in this report represent distinct freight settings in Tennessee. The Shelby County case represents a major freight gateway with intermodal relevance. The Marion County project represents an industrial rail-spur setting tied to site and supply-chain access. The Dyer case shows a regional rail-connectivity setting serving more dispersed freight demand. Although the three projects differ in scale and operating conditions, each faces the same strategic question: whether a targeted rail improvement can improve freight efficiency, reduce public system burden, and support TDOT's transportation and economic development objectives.

The central question in this study is not whether rail access is attractive in concept, but whether the proposed improvement produces measurable freight, public, and investment outcomes that matter to TDOT's decision-making.

1.2 Problem Statement

TDOT faces a practical investment decision problem: rail connectivity projects must be evaluated with a documented method that can be applied consistently across counties and used to rank competing uses of public funds. Those projects involve substantial capital costs, case-specific operating assumptions, and heterogeneous impacts across stakeholders, including shippers, rail operators, truck carriers, local communities, and the state transportation system. Some effects are directly associated with logistics costs, while others are related to public interest, such as lower emissions, reduced crash exposure, or avoided roadway deterioration. Without a consistent structure for measuring these effects, it is difficult to determine which projects have the highest comprehensive benefit-cost ratios and warrant further state support.

This study addresses the challenge that rail project proposals are often described in broad qualitative terms, while the actual funding question is quantitative and comparative. Traditional project summaries often do not clearly separate operation-level cost changes from societal benefits, and they may not fully document the effect of handling, dwell, transfer, and routing assumptions in rail-truck logistics chains. As a result, decision-makers may see a single headline result without being able to determine whether a project is justified through its economic values and/or public benefits. Decision-makers also need to understand how much conclusions depend on inputs and assumptions, which are often highly uncertain. This report answers the same questions for all three cases: what changes in freight movement occur, how much costs increase or decrease, which public effects are impacted, and whether the resulting benefit stream is large enough to support the capital investment.

1.3 Purpose and Objectives of the Report

The main purpose of this report is to provide TDOT with a decision-oriented assessment of selected rail connectivity improvement projects using a consistent analytical framework. The report is intended to support project evaluation by organizing project data, operating assumptions, and public-impact factors into a common evaluation basis and comparable findings across cases. In practical terms, the report is designed to show whether each project generates sufficient transportation and public benefits to justify its capital cost under a consistent evaluation approach.

The report's specific objectives are fourfold. First, it evaluates transportation impacts by examining changes in freight movement patterns, truck exposure, and multimodal connectivity under No-Build and Build conditions. Second, it evaluates operational impacts by estimating how each project affects logistics cost components such as line-haul, terminal, dwell-related, transloading, labor, and equipment costs. Third, it evaluates economic impacts by combining annual operating changes, monetized external effects, and capital cost requirements into lifecycle decision measures such as net present value, benefit-cost ratio, and payback. Fourth, it assesses how each project aligns with TDOT's program objectives for freight movement, industrial access, roadway preservation, and investment prioritization.

1.4 Scope of Analysis

The geographic scope of this report is statewide in intent but county-based in application. The analysis evaluates TDOT's broader rail connectivity objectives through three representative case studies in Shelby, Marion, and Dyer Counties. We will use county names to represent the three projects under study. This structure allows the report to evaluate individual projects and compare results across distinct freight settings.

The scope of analysis includes rail connectivity improvements, associated freight operational changes, and quantifiable lifecycle impacts. To ensure consistency, the report applies a standardized 35-year lifecycle horizon. While the evaluation framework is uniform, the baseline years vary by case. We used 2019 as the base year for the Shelby and Dyer projects, whereas the Marion project had a 2019–2021 implementation period and entered service in 2021. Where necessary, monetary values are normalized to a common reporting basis to enable accurate cross-case comparisons without disregarding the specific source-year conditions at each site.

The assessment is focused on project capital costs, operating impacts, selected externalities, and key economic indicators. To maintain a conservative and evidence-based assessment, the report excludes broader or speculative secondary effects—such as induced land-use changes or unverified spillover impacts—unless supported by direct project evidence. Additionally, the analysis is limited to truck-to-rail freight alternatives and does not extend to waterway or barge infrastructure.

1.5 Analytical Approach

This report applies a Layered Lifecycle Benefit-Cost Analysis (LL-BCA) approach. The method assesses direct operational effects first, then integrates them into overall investment assessment metrics to account for broader societal effects. The analysis proceeds from scenario definitions and engineering assumptions to annual cost and benefit estimates, and then to discounted lifecycle measures for informed decision-making. The methodological structure is intended to ensure that TDOT and other users can follow the same logic, from the project description, through scenario definition and annual results, to final investment measures.

The evidence base combines project documentation, engineering and capital cost information, freight operating assumptions, project-specific scenario inputs, and standardized valuation parameters for evaluating the impacts on emissions and safety. These inputs are organized so that each reported result can be traced back to a scenario definition and a corresponding set of unit rates or monetization factors.

The comparison framework is incremental and scenario-based. For each case, the report compares a No-Build baseline with a Build alternative representing the proposed rail connectivity improvement. Differences between the two scenarios are used to estimate transportation, operational, and public effects. This approach provides a consistent framework and procedure for comparing projects that differ in local context while maintaining a common evaluation structure across the report.

1.6 Expected Contributions

This report is intended to provide TDOT with more than a narrative description of project benefits. Its primary contribution is a reviewable framework for quantitatively evaluating rail connectivity investments using a common set of assumptions, accounting rules, and decision metrics. By including both financial and societal effects, the report clarifies whether a project's value is driven by direct logistics savings, public benefits, or a combination of both.

This report delivers a repeatable evaluation framework and a completed set of case assessments for TDOT's Rail Connectivity Grant Program. The deliverable includes case-specific scenario definitions, quantified operating-cost results, environmental and safety results, lifecycle investment measures, and sensitivity analyses for the Shelby, Marion, and Dyer projects. Together, these outputs provide TDOT with a consistent basis to validate completed rail connectivity investments, compare project performance across cases, and support future project selection, funding justification, and program refinement.

The findings are expected to support planning, prioritization, and future funding decisions in several ways. They provide cross-case comparisons on a common basis, identify the variables that control project performance, and show the conditions under which a project remains favorable or becomes sensitive to uncertainty. This report answers the main evaluative questions: which projects produce a clear operating benefit, which rely more on public benefits, which assumptions influence the evaluation results, and which cases appear most ready for further program advancement. The report is designed to help TDOT refine project selection and update future evaluations as better design and operating data become available.

1.7 Organization of the Report

The remainder of the report is organized as follows. Chapter 2 presents a literature review that summarizes prior freight rail evaluation work, benefit-cost practice, and the main methodological issues relevant to rail connectivity projects. Chapter 3 defines the study scope, scenario structure, and LL-BCA methodology used in the evaluation. Chapter 4 documents the data sources, assumptions, normalization rules, and quality-control considerations applied across the county cases. Chapter 5 presents the combined results and discussion for the three projects in Shelby County, Marion County, and Dyer County using a common reporting format that moves from case context and project description to operating results, public-effect results, lifecycle investment measures, and case-specific sensitivity discussion. The report then concludes with findings, program implications, and recommended next steps for TDOT.

Chapter 2 Literature Review

This chapter reviews the topics that support the need for this study and the methodologies used in the report. The review covers the public purpose of rail connectivity investment, the evaluation of freight transportation projects, and the specific analytical components required for county-level rail project assessment. The discussions on topic areas explain why a structured and replicable framework is needed to evaluate TDOT's rail connectivity investments and identify gaps in prior work.

2.1 Freight Rail Connectivity and Public Investment Context

State transportation agencies typically evaluate freight rail investments differently from private rail carriers. Private freight railroads generally allocate capital on the basis of expected commercial return and shareholder value, whereas public agencies assess rail investments against a broader set of public objectives and system-level outcomes (NCHRP, 2013). In the public sector, freight rail projects may be justified not only by direct operating or financial performance, but also by public benefits such as improved freight mobility, truck diversion, reduced highway maintenance needs, safety gains, environmental improvements, and regional economic development (USDOT, 2025). This difference is especially important for short-line, industrial access, and first/last-mile rail connectivity projects, which may offer limited direct returns to private carriers but still produce meaningful public value by preserving local freight service and supporting industrial activity in the served area (Miller & Stich, 2014).

TDOT's industrial access and rail-support programs have improved connections to manufacturing and distribution sites, and Tennessee's rail planning documents explicitly recognize rail access to industrial sites as an eligible public investment category linked to freight movement and economic competitiveness (TDOT, 2023). Similar programs in other states also treat industrial rail access as a tool for attracting new industry, supporting expansion, improving site marketability, and diverting truck traffic from public roads (GDOT, 2026; MNDOT, 2013). Rail access may make industrial sites more attractive than truck-only sites for bulk-oriented commodities such as fertilizers, aggregates, chemicals, and other dense materials, for which rail service is often operationally well suited (MNDOT, 2013). Rail access can also reduce dependence on the State highway system for heavy freight movement. In that way, the rationale for public investment extends beyond direct shipper cost savings to include reduced roadway and bridge maintenance burdens and broader system benefits (TDOT, 2023; USDOT, 2025).

At the national level, federal support for freight rail connectivity have expanded support for safety, efficiency, reliability, and broader network resilience under the Infrastructure Investment and Jobs Act and related Federal Railroad Administration (FRA) grant programs (FRA, 2025a, 2026b). Class I railroads invest substantial private capital in their own networks, but short-line and regional railroads often face more limited access to capital and larger infrastructure backlogs, especially for track, bridge, and access improvements needed to handle current freight demands (AAR, 2026; FRA, 2014). Federal programs such as the Consolidated Rail Infrastructure and Safety Improvements (CRISI) program respond to this gap by supporting short-line infrastructure and multimodal freight connections that improve rail safety, efficiency, and reliability (FRA, 2025a). These programs also require formal benefit-cost documentation as part of project evaluation, reinforcing the need for consistent assessment methods that can measure and compare returns across proposed investments in a transparent and systematic way (USDOT, 2025).

Public investment in rail connectivity projects can be justified when those projects improve freight access, support industrial activity, reduce highway burden, or improve site readiness for industrial users (AASHTO, 2005). However, those benefits are not uniform across projects, and the case for public support depends on project function, traffic base, and the type of benefit produced (Miller & Stich, 2014; NCHRP, 2006). Some projects are justified primarily by recurring transportation and logistics cost savings, while others improve industrial access, shipper retention, job creation, plant expansion, or broader development effects (AASHTO, 2005; NCHRP, 2007). Considering heterogeneous benefits across projects is central to this study, which evaluates rail investments with identical return mechanisms.

2.2 Economic Evaluation of Freight Transportation Projects

Benefit-cost analysis (BCA) remains the standard framework for evaluating public transportation investments because it places benefits and costs on a common monetary basis over time (Gühnemann et al., 2012; USDOT, 2025). In freight transportation, the method is used to determine whether a project generates sufficient value to justify its capital and operating costs and to compare competing investments under a common decision structure. Common performance indicators include net present value (NPV), benefit-cost ratio (BCR), internal rate of return (IRR), payback period, and equivalent uniform annual worth (EUAW). Each metric highlights a different aspect of project performance and supports a different type of decision.

A central issue in freight-project evaluation is the distinction between operator benefits and public benefits. Operator benefits include fuel savings, labor savings, as well as reduced equipment use. Public benefits include reduced emissions, lower crash exposure, and reduced infrastructure wear. This distinction matters because operator benefits may support private investment, whereas public benefits often provide the basis for public-sector justification (VTPI, 2017). If these categories are combined without separate accounting, it becomes difficult to determine whether a project is commercially attractive, publicly justified, or both.

Federal assessment guidance addresses this issue by requiring a credible No-Build baseline and separate accounting of project effects by category (USDOT, 2025). That requirement is especially important for rail connectivity projects. If a project is evaluated against an unrealistic baseline, estimated benefits can be overstated. If public effects are ignored, projects with durable public value can appear weaker than they are. A State program such as TDOT's rail-connectivity effort, therefore, needs a structure that holistically considers both operator and public effects through the full assessment process.

2.3 Rail-Truck Modal Shift and Cost Structure

Competition between rail and truck is not determined by a single average shipping rate. The difference between rail and truck lies in how costs are distributed across components. Truck-only service usually carries higher linehaul energy, labor, and equipment cost per ton-mile. Rail service can reduce those linehaul costs, especially when volume and distance are sufficient to support its scale advantage (EDF, 2023). This advantage matters most when shipping distances are long enough for lower rail linehaul costs to offset transfer and handling costs.

Rail service affects more than the linehaul segment. A rail movement may introduce switching, terminal handling, drayage, and additional time in the system. Each of these operations affects the total logistics cost. A project may appear attractive in a simple truck-versus-rail comparison, but become less favorable once transfer, waiting, and inventory costs are considered. Distance, shipment volume, commodity characteristics, and facility configuration all matter because they determine whether the cost advantage of rail linehaul is large enough to absorb those added burdens (Resat & Turkay, 2019; Winebrake et al., 2008).

These cost dynamics are especially important for evaluating rail connectivity projects such as spurs, sidings, and site-access improvements. These projects often do not change an entire longhaul corridor. Instead, they change one part of the chain: the last truck leg, the need for transloading, or the handling sequence at a facility. Furthermore, drayage, terminal dwell, and inventory time can matter as much as fuel and labor to total costs (Archetti et al., 2022; Karam et al., 2023).

For rail connectivity projects, separating direct freight costs into their main components is only the first step. The evaluation must also account for effects that are not borne directly by the shipper or carrier but still matter for public decision-making.

2.4 Environmental and Safety Externalities in Freight Project Evaluation

Freight transportation affects the public through emissions and safety. These effects are especially relevant in the evaluation of rail connectivity projects, because a project may reduce public burden even when direct operator savings are limited.

Rail uses less energy and emits fewer pollutants per ton-mile than truck freight (EDF, 2023). Criteria air pollutants such as nitrogen oxides, sulfur oxides, and fine particulate matter impose additional damage through health effects and local exposure. These damages are commonly monetized through unit values linked to emission quantities (EEA, 2021).

Enhanced safety enters the evaluation through the public cost of crashes, fatalities, and injuries. Truck freight shares public roads with passenger vehicles and other users, so reducing truck volumes can reduce crash costs. Rail is not free of safety risk, but its crash exposure and accident rate differ from highway freight, and the resulting public burden is often lower per unit of freight moved (USDOT, 2025). Public effects cannot be treated as an afterthought when evaluating rail projects and should be considered in project prioritization and selection from the first place in a holistic way.

2.5 Lifecycle and Layered Evaluation Approaches

Rail connectivity projects require lifecycle evaluation because costs and benefits accrue over a long period. Capital cost is concentrated at the beginning of a project, while freight cost savings, public effects, and maintenance impacts accumulate over many years. Discounted cash flow methods place these values on a consistent basis so that the project can be evaluated as one investment rather than as a set of disconnected annual effects (Rattanakunuprakarn et al., 2024; Soleimani-Chamkhorami et al., 2024).

Standard performance measures such as NPV, BCR, IRR, payback period, and EUAW are widely used for this purpose. Each measure serves a different function. NPV indicates whether total discounted benefits exceed total discounted costs at the very beginning of a project. BCR supports comparison across competing projects. IRR and payback are often used to describe investment recovery. EUAW converts lifecycle value into an annualized form, making it easier to compare across alternatives.

When lifecycle assessment (LCA) is used, projects with the same overall NPV may have different combinations of freight cost savings and public effects. Researchers have used decomposed or layered approaches that keep operator and public effects separate before integrating them into a final investment measure (Carteni & Henke, 2017; Macharis et al., 2004). This structure shows not only whether a project is favorable but also what drives the result.

This study calculated direct logistics effects, public effects, and lifecycle investment measures sequentially. Furthermore, this study built comparable Build and No-Build cases for railconnectivity projects that differ by location, targeted commodity, and facility setting.

2.6 Scenario-Based and Counterfactual Methods in Freight Analysis

Freight project evaluation often relies on scenario-based analysis because complete before-and after operating records are rarely available for direct comparison. Evaluating rail-access projects depends on this approach because the evaluation involves traffic estimations under both a realistic No-Build and a Build condition (NASEM, 2017). The No-Build case must represent the next best realistic alternative rather than an artificial do-nothing condition (USDOT, 2025). For a rail spur, siding, or access project, that baseline may be continued truck movement, continued indirect rail service with truck transfer, or another documented freight arrangement. The Build case must then reflect the actual change introduced by the project: reduced truck distance or volume, direct rail access, lower transfer burden, or some combination of these.

This approach is especially useful for TDOT because the Shelby, Marion, and Dyer cases do not share a single traffic pattern. Instead, they differ in freight scale, handling sequence, and project function. A representative scenario structure allows each project to be evaluated within its own operating context while still reporting results under a single common framework. Once those scenarios are defined, the final step is to test how robust the results remain when the inputs are uncertain.

2.7 Sensitivity Analysis in Transportation Benefit-Cost Studies

Transportation benefit-cost results usually depend on assumptions that are uncertain at the time of evaluation. Freight volume may change, the effective haul distance may differ from the representative case, truck utilization may vary, capital costs may shift during project development, and the discount rate may change, altering lifecycle value. For freight rail connectivity projects, annual throughput is often one major factor in evaluation because many direct and public benefits scale with the amount of freight shifted. Haul distance also matters because it controls the size of the truck-versus-rail cost differential. Truck utilization affects the per-ton cost of the baseline case. The discount rate affects how strongly long-run benefits contribute to the present-value result. Capital cost matters most in projects with a limited annual benefit margin (VTPI, 2017).

Sensitivity analysis assesses how sensitive performance metrics are to uncertainty in such inputs. It indicates whether a project remains favorable within a plausible range of operating and financial conditions. This function is especially important for smaller rail-access projects. A modest change in throughput or capital cost can significantly change the investment signal. That issue leads directly to the gap addressed by the present study.

2.8 Research Gap and Contribution of the Present Study

Prior work provides the main blocks needed to evaluate freight rail projects: public-investment rationale, freight cost decomposition, monetized public effects, lifecycle investment measures, scenario-based comparison, and sensitivity testing. What remains less developed is a repeatable framework that brings these elements together for completed county-level rail connectivity projects funded by a state agency.

Three gaps are especially relevant here. First, many studies emphasize either direct freight cost savings or public effects, but do not carry both through one consistent lifecycle evaluation framework. Second, much of the existing work is prospective, focusing on proposed projects rather than completed investments that need to be validated after implementation. Third, small rail-access projects serving industrial sites, transload locations, or local sidings receive less structured post-project evaluation than large corridor or network investments, even though these smaller projects are common in state rail-assistance programs.

TDOT's projects in Shelby, Marion, and Dyer counties fit exactly within these gaps. They differ in scale, purpose, and operating structure, but they still require a common basis for comparison so that TDOT can validate returns, explain program value, and improve future project selection. This study addresses that need through a layered BCA framework that separates direct logistics effects from public effects and then integrates both into LCA. In this way, the report provides a repeatable method for evaluating completed county-level rail connectivity projects under one consistent structure while preserving the differences that matter across cases.

Chapter 3 Methodology

This chapter defined the study boundary, the project-selection basis, the scenario structure, and the evaluation procedures used in this report. It explains how project information and reference data were converted into comparable project scenarios, how annual operating and public effects were estimated, and how those annual effects were converted into lifecycle investment measures. These elements establish a traceable, internally consistent, and repeatable methodology for comparing the three projects.

3.1 Geographic Scope and Case Selection

While this study maintains a statewide strategic intent, its implementation was guided by the operational status of TDOT's Rail Connectivity Grant Program. In 2018, TDOT allocated approximately $10 million to support a shift of freight movement from highway to rail, with the goals of improving industrial access and reducing highway maintenance burdens. At the time of this evaluation, the projects in Shelby, Marion, and Dyer Counties were the only ones to have reached full completion. Consequently, these three counties were selected to provide the primary empirical basis for a post-investment performance assessment.

Beyond their completion status, these cases were selected because they collectively represent the diversity of Tennessee's freight landscape. Each project serves as a distinct model for rail connectivity: the Shelby project acts as a high-volume intermodal gateway; the Marion project improves industrial-access through localized rail-spur operations; and the Dyer project captures regional connectivity within agricultural and industrial distribution networks. This three-project structure allows the study to evaluate how different project scales and operating conditions influence overall investment outcomes.

This case-based structure is more suitable than a single statewide model because it can capture site-specific factors that affect project performance. By focusing on individual cases, the analysis can incorporate detailed information—such as local drayage requirements, transfer conditions, and project configuration—while maintaining a consistent evaluation framework. This approach also ensures transparency and traceability, allowing TDOT to determine whether specific grant-funded improvements produced the measurable transportation and economic returns that can inform future funding decisions.

3.2 Scope of Analysis and Comparison Basis

The scope of the analysis includes the rail connectivity improvement itself, the related freight operating changes, and the lifecycle effects that can be quantified from available project and reference data. The analysis includes capital costs, recurring operating costs, selected environmental effects, selected safety effects, and standard discounted investment measures. The analysis does not include speculative secondary effects such as induced land development, broad regional multiplier effects, or unsupported land-use changes.

The three cases do not share the same base-year setting. The evaluation of the Shelby and Dyer projects rely primarily on a 2019 operating and valuation base, while the Marion project was constructed between December 2019 and 2021 and entered service in 2021. For that reason, the analysis does not use 2019 as the base year for all three cases. Instead, each case retains its own project timing in the narrative, while monetary values are normalized, where necessary, to a common reporting basis for economic comparison. Unless a case source file explicitly uses a different validated basis, LCA is presented on a 35-year horizon. This common horizon allows present-value measures to be interpreted on a comparable basis across projects.

3.3 Data Collection and Generation of Analytical Inputs

This study uses both collected data and derived analytical inputs. The inputs fall into four groups. The first group covers project-specific engineering and sponsor information, including project scope, track or siding length, switch count, sponsor-reported throughput, capital cost, and implementation assumptions. The second group includes freight operating information, including annual tonnage, representative route length, drayage conditions, dwell assumptions, and handling-event counts. The third group consists of operational unit-cost inputs, including fuel price, fuel efficiency, labor cost, equipment cost, maintenance cost, and infrastructure related cost parameters. The fourth group covers valuation inputs for public effects, including emissions factors, damage-cost parameters, and safety-valuation parameters.

Project-specific information was collected from TDOT files, sponsor materials, county project documentation, and supporting workbooks. Public reference inputs were obtained from institutional public sources, including the Surface Transportation Board (STB), the American Transportation Research Institute (ATRI), the U.S. Energy Information Administration (EIA), the Federal Highway Administration (FHWA), the U.S. Environmental Protection Agency (EPA), and the U.S. Department of Transportation (USDOT). Handling-cost assumptions were taken, where relevant, from tariff-based references already used in the county project materials. These sources provided the cost, activity, and valuation inputs needed to apply a consistent method across the three projects. Project descriptions and sponsor records provided the basis for scenario definition. Public reference sources provided the common unit values used to convert those scenarios into annual cost and public-effect estimates. More detailed source tables, parameter tables, and normalization records are discussed in Chapter 4 of this report, so that the methodology chapter could remain focused on the analytical procedure.

Several analytical inputs were derived rather than observed directly. Ton-miles were generated by multiplying annual tonnage by representative segment distance. Travel time was calculated based on route length and operating speed. Total Time in the system was derived from travel time and dwell assumptions. Mileage-based truck cost inputs were converted to a ton-mile basis using payload and loaded-share assumptions. Rail cost rates were estimated by dividing annual expenditure categories by annual rail ton-mile activity reported in reference rail statistics. These transformations were necessary because the source materials did not present all values in a directly comparable form. The same conversion logic was applied across the three projects to preserve consistency in the analytical structure.

This input-generation process was intended to support a consistent and traceable analysis across the three projects. Each derived variable was linked to a physical or economic quantity relevant to freight movement rather than assigned as an unsupported lump-sum assumption. This means that other studies could reconstruct the same variables from the same project records, reference sources, and conversion rules.

3.4 Scenario Design and Counterfactual Formulation

The analysis compares a No-Build scenario with a Build scenario for each project. The purpose is to estimate the incremental effect of the rail improvement relative to existing freight operations, rather than to describe project conditions in isolation. Under the No-Build scenario, freight is assumed to continue moving under existing access conditions and available modal options. Under the Build scenario, the rail improvement may change the freight movement pattern by altering rail access, drayage requirements, terminal handling, or routing.

Each project was translated into a scenario structure defined by annual tonnage, segment distance, ton-miles, travel speed, dwell conditions, and the number of transfer or handling events. This structure served as the link between project description and quantitative analysis. It allowed each cost and public-effect calculation to be tied to a specific activity measure rather than to a general statement about expected project value.

The counterfactual structure also improved comparability across the three projects. Although the projects differed in scale and operating conditions, all effects were measured as differences between the No-Build scenario and the Build scenario. This common structure allowed the results to be compared on a consistent basis without forcing the projects into a single uniform operating model.

3.5 Incremental Measures and Scenario Representation

Based on the scenario structure defined in Section 3.4, the analysis applies an incremental benefit-cost framework for each project. Incremental benefit, incremental cost, and incremental net benefit are defined as the differences between the Build and No-Build scenario in each year.

For each Build scenario s and year y, let $B_{,}$ denote annual benefit, $C_{,}$ denote annual cost, and $NB_{,}$ denote annual net benefit. Incremental benefit, incremental cost, and incremental net benefit are then defined as:

$$\Delta B_{,} = B_{,} - B_{,},$$

$$\Delta C_{,} = C_{,} - C_{,}, \text{ and}$$

$$\Delta NB_{,} = \Delta B_{,} - \Delta C_{,}.$$

The calculations are based on activity inputs including annual tonnage, segment distance, tonmiles, travel speed, terminal dwell, and the number of handling or transfer events. These inputs link project assumptions to the cost and benefit measures reported later in the study.

3.6 Layered Lifecycle Benefit-Cost Framework

The analysis applies a LL-BCA framework. This framework is used because the project effects do not fall within a single accounting category. Some effects appear directly in operator-facing logistics cost, while others appear as public effects such as lower emissions or reduced crash exposure. A layered structure is therefore used to estimate these effects separately and combine them only at the investment-assessment stage.

The framework is organized into three phases. Phase I estimates the direct operating and logistics costs. Phase II estimates public effects, primarily emissions and safety. Phase III combines the annual results from the first two phases with project capital cost to produce lifecycle decision measures. This structure, illustrated in Figure 3-1, reduces the risk of double counting and allows the analysis to distinguish whether project value arises from direct freight savings, public benefits, or both. Project data and scenario assumptions form the input layer. These inputs then pass through the operating-cost and public-effect layers before entering the lifecycle decision layer.

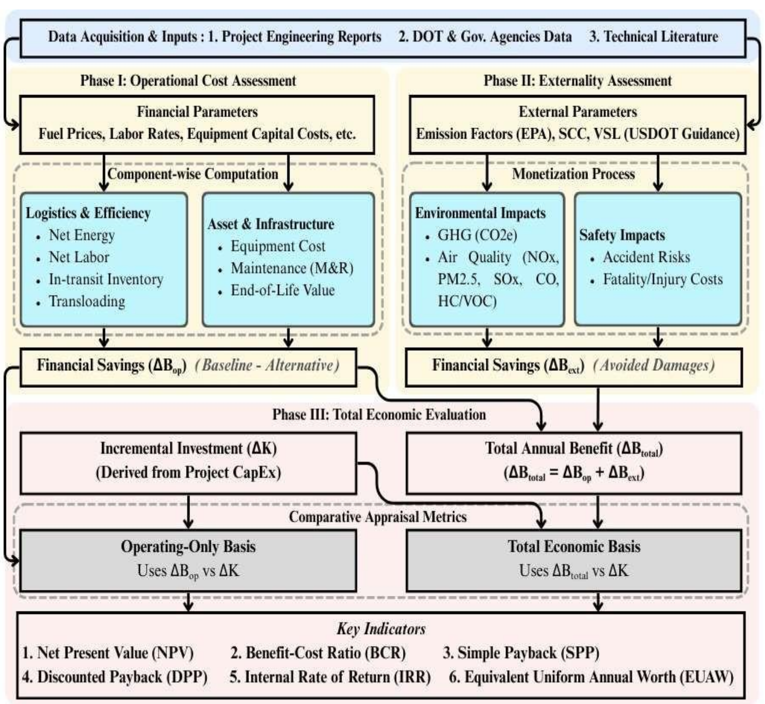

Figure 3-1 LL-BCA framework for the TDOT rail-connectivity evaluation

3.7 Phase I: Operational Cost Assessment

Phase I estimates the direct freight cost difference between each Build scenario and its corresponding No-Build scenario. The operational cost layer includes energy costs, labor costs, equipment ownership or use costs, maintenance costs, infrastructure-related costs where applicable, inventory carrying costs, and handling or transloading costs. These categories capture the direct cost effects associated with changes in freight routing, mode choice, terminal activity, and transfer conditions.

The analysis is conducted on a unit basis and then scaled to annual activity. Distance-based costs are calculated from ton-miles or vehicle-miles for the relevant segments. Time-based costs are influenced by travel speed and dwell assumptions. Event-based costs are related to the number of handling or transfer events. This structure makes it possible to identify the source of each cost change. A lower total operating cost can therefore be traced to reduced truck linehaul, lower fuel consumption, lower labor cost, or another specific cause rather than presented as a single unexplained result.

3.7.1 Linehaul and Terminal Operations (Energy, Labor, and Transloading)

This component covers the recurring cost of moving freight through the network and transferring it between modes or facilities. A rail connectivity project can affect both linehaul cost and the interface cost through changes in drayage, handling, and terminal activity. To preserve cost traceability, this component is estimated separately for energy, labor, and transloading.

Energy cost captures the energy consumption required to perform the freight task under each scenario. It is included because truck and rail movements consume energy at different rates per unit of freight activity, and those differences often account for a large share of the operating advantage associated with a shift from truck to rail. Energy unit cost for mode m is defined as u^{energy}. Annual energy cost for scenario s is then estimated as:

$$C\text{energy} = \quad u\text{energy}\, A_{\,,} \,,$$

$$\in$$

where $A_{\,,}$ denoted the relevant activity measure for mode m in scenario s, typically ton-miles for mode m in the freight network.

Labor cost represents the operator time burden associated with moving freight by truck or rail. It is included because labor is one of the largest recurring freight cost components and is significantly changed when long truck movements are replaced by rail linehaul or when additional terminal activity increases handling time. For truck-based movements, unit labor cost is derived from a vehicle-mile input converted to a freight-service basis:

$$\text{labor} = c\underline{\text{mile}}\text{labor} \,,$$

$$u_{\text{truck}} \qquad q\lambda$$

where $c_{\text{mile}}^{\text{labor}}$ denotes labor cost per vehicle-mile, q denotes payload, and λ denotes loaded share. Annual labor cost in scenario s is estimated as

$$C\text{labor} = \quad u\text{labor}\, A_{,} .$$

$$\in$$

Rail labor cost, $u^{\text{labor}}$is generated by dividing annual expenditure by annual rail activity (in tonmiles) in the source statistics.

Transloading cost is the handling cost incurred when freight is transferred between facilities, vehicles, or modes. Rail access often reduces long-haul truck movement while adding transfer events compared to a direct truck-only chain. Annual transloading cost in scenario s is defined as:

$$C^{\text{trans}} = Q \qquad h ,$$

$$\in\mathcal{E}_s$$

where Q denotes annual tonnage under scenario s and h denotes the unit handling charge associated with transfer event e. This event-based formulation was used so that the terminal cost increased only when a scenario introduces more handling activities.

3.7.2 Time-Related Cost Components: Inventory Carrying Cost

Inventory carrying cost captures the time-value burden associated with freight that remains in transit or in queues. It is included in this study because a rail-truck chain may reduce distance-based cost while increasing dwell time, transfer time, or average cargo cycle time. Without this term, a slower but lower-cost freight chain could be overstated. Inventory carrying cost for scenario s is estimated as

$$C^{\text{inv}} = V \cdot Q \cdot r^{\text{inv}} \cdot T ,$$

where V denotes cargo value, Q is annual tonnage, r^{inv} is the unit inventory carrying rate, and T denotes total time in the freight network. Total time in the system is calculated from segment travel time and terminal dwell time:

$$d_{,}$$

$$T = \qquad \frac{}{} + \qquad \tau_{,} ,$$

$$v_{,}$$

$$\in\mathcal{K}_s \qquad \in\mathcal{J}_s$$

where $d_{,}$, $v_{,}$, and $\tau_{,}$ denote the distance segment k, peed of segment k, and dwell time for event j in scenario s, respectively.

3.7.3 Asset and Infrastructure Cost Components: Equipment, Equipment Maintenance, Infrastructure Maintenance, and End-of-Life Value

This group represents the recurring and residual cost elements associated with freight equipment and the fixed infrastructure that supported freight movement. These components are included because operating costs changed not only through energy consumption, labor, and terminal handling. They also arise from equipment use, equipment maintenance, infrastructure maintenance, and the residual value of long-lived infrastructure assets at the end of the analysis period. In the Shelby project, these four elements are reported separately so that asset- and infrastructure-related cost effects can be distinguished clearly from linehaul and terminal operations.

Equipment ownership cost is for the capital recovery, leasing, depreciation, or equipment-use cost associated with the freight equipment required to perform the movement. For truck-based movements, the unit equipment cost is generated by converting a mileage-based ownership or equipment-use cost to a freight-service basis:

$$u^{\text{equip}} = \frac{c^{\text{equip}}}{q\lambda},$$

where c^{equip} denotes equipment cost per vehicle-mile, q denotes payload, and λ denotes loaded share. For rail, the corresponding unit rate is calculated as annual equipment expenditure divided by annual rail ton-miles. The annual equipment ownership cost in scenario s is estimated as

$$C^{\text{equip}} = \sum_{m \in M} u^{\text{equip}} \cdot A_{m,s}.$$

Equipment maintenance cost is associated with the routine and corrective upkeep required to keep trucks, rail equipment, and related freight assets in service. It is treated separately from equipment ownership because the maintenance cost varies with use, wear, and operating conditions. Unit equipment-maintenance cost for mode m is calculated in this study as

$$u^{\text{eqm}} = \frac{c^{\text{eqm}}}{q\lambda},$$

where c^{eqm} is the maintenance cost per vehicle-mile. Annual equipment-maintenance cost in scenario s was then estimated as

$$C^{\text{eqm}} = \sum_{m \in M} u^{\text{eqm}} \cdot A_{m,s}.$$

Infrastructure maintenance cost captures the annual cost of preserving the transportation network used for freight movement. For highway segments, this cost reflects pavement, bridge, and related network maintenance allocated over freight activity. For rail segments, it reflects the infrastructure-maintenance cost embedded in the rail system. Unit infrastructure-maintenance cost for mode m is estimated as

$$u_m^{\text{infra}} = \frac{c_m^{\text{infra}}}{A_m^{\text{national}}},$$

where c_m^{infra} denotes the annual infrastructure-maintenance expenditure for mode m and A_m^{national} is the corresponding annual modal activity used to normalize that cost. Annual infrastructure maintenance cost in scenario s is estimated as

$$C_s^{\text{infra}} = \sum_{m \in M} u_m^{\text{infra}} \cdot A_{m,s}.$$

End-of-life infrastructure value is the remaining economic value of long-lived transportation assets at the end of the study horizon. Infrastructure assets such as pavements, track, and structural components are not assumed to be fully exhausted at the end of the accounting period; they retain remaining service life or recoverable salvage value. The unit end-of-life value for mode m is estimated as

$$u_m^{\text{eol}} = \frac{v_m^{\text{eol}}}{A_m^{\text{national}}},$$

where v_m^{eol} is the annualized end-of-life or salvage value for mode m. The annual end-of-life infrastructure value in scenario s is estimated as

$$C_s^{\text{eol}} = \sum_{m \in M} u_m^{\text{eol}} \cdot A_{m,s}.$$

Because this term is a credit rather than a cost, it is treated separately from recurring operating costs.

3.8 Phase II: Public-Effect Estimation

Phase II of this study estimates public effects that do not appear directly in freight costs but are relevant to public investment review. The analysis includes environmental effects and safety effects. Other categories are excluded unless a project provides case-specific evidence and a defensible basis for valuation.

This phase is necessary because the report is prepared for TDOT as a public transportation agency rather than for private shippers. A rail project could produce modest direct cost savings while realizing significant public benefits by reducing truck traffic on public roads. Estimating these effects separately improves the interpretability and comprehensiveness of the final investment evaluation.

3.8.1 Environmental Effects: Greenhouse Gases and Criteria Air Pollutants

Environmental effects are measured as the change in monetized emissions burden between the Build scenario and the No-Build scenario. The heavy freight activity affects both climate-related emissions and local air quality, and these effects are relevant to the public investment review. In this analysis, environmental effects are not treated as a single undifferentiated metric. They are divided into greenhouse-gas effects and criteria air pollutant effects so that climate-related impacts and localized damage effects could be interpreted separately.

Greenhouse gas effects represent the monetized climate burden associated with freight movement. In this report, greenhouse-gas cost is measured using carbon dioxide (CO) only and monetized using the social cost of carbon. This treatment is consistent with USDOT BCA guidance, which provides recommended treatment for greenhouse-gas cost and requires additional documentation when other environmental benefit categories are monetized. The greenhouse gas cost for scenario s is estimated as

$$\text{CGHG} = \sum_{m \in M} \left(\frac{e_m^{CO_2}}{10^6} \cdot \mathrm{A} \quad , \cdot \pi \quad , \right.$$

where e denotes the CO emissions intensity for mode m, A , denotes the relevant freight activity for mode m, and π denotes the monetized damage factor for CO .

Criteria air pollutant effects are the monetized human-health and environmental damage associated with non-greenhouse-gas emissions from freight transportation. These pollutants include nitrogen oxides (NO), sulfur oxides (SO), fine particulate matter (PM .), hydrocarbons or volatile organic compounds (HC/VOC), carbon monoxide (CO), and, in some source treatments, additional particulate categories such as PM . Criteria air pollutant cost for scenario s is estimated as

e ,

$$C\text{air} = \frac{\quad}{\quad} \cdot A \, , \; \cdot \pi \; ,$$

10

∈ ∈

where P is the set of the criteria-pollutants in the analysis, e , denotes emissions intensity of pollutant $p \in P$ for mode m, and π is the corresponding damage-cost factor for pollutant p.

3.8.2 Safety Effects

Safety effects represent the change in monetized crash burden resulting from changes in freight exposure across modes. Reducing truck movement on public roads lowers system-level crash exposure, even when the project itself is not a highway safety improvement project. The annual safety cost for scenario s is estimated as

$$C\text{safety} = \sum_{m \in M} \left(\rho_m^{\text{fatal}} \cdot X_{s,m} \cdot K + \rho_m^{\text{inj}} \cdot X_{s,m} \cdot U \right. ,$$

where ρ^{fatal} and ρ^{inj} are mode-specific fatality and injury rates, respectively, $X_{\,,}$ is the relevant exposure measure, and K and U are monetized fatality and injury values, respectively. Safety effects are included not to claim a direct project-site safety effect, but to estimate the change in system-level crash burden associated with changes in truck exposure under the Build scenario.

3.9 Phase III: Lifecycle Economic Assessment

Phase III converts the annual results from the first two phases into lifecycle investment measures. Capital cost is entered in accordance with the validated county project basis, typically as an initial cost. Annual net benefits are then discounted over the study horizon using the adopted real discount rate. Net present value, benefit-cost ratio, payback, internal rate of return, and equivalent uniform annual worth are reported where the source basis supports those measures.

Two assessment bases are used in this study. The first is an operating-only basis, which reflects the direct value of logistics and freight services. The second is a total economic basis, which combines direct operating effects with monetized public effects. These two bases address different decision questions. The operating-only analysis assesses whether a project produces direct cost savings in freight transportation. The total economic analysis shows whether public benefits change the investment result.

3.9.1 Annual Net Benefit Formulation

The LCA is based on the annual net benefit stream derived from the incremental benefits and incremental costs defined in Section 3.5. For scenario s in year y, annual net benefit is

$$\Delta NB_{\,,} = \Delta B_{\,,} - \Delta C_{\,,}$$

where $\Delta B_{\,,}$ denotes annual incremental benefit and $\Delta C_{\,,}$ denotes annual incremental cost. This annual net benefit stream provides the basis for the discounted lifecycle measures reported in Phase III.

3.9.2 Net Present Value and Benefit-Cost Ratio

NPV measures the discounted net return generated by the project over the study horizon. BCR represents discounted return per dollar of discounted cost. These measures are used because they are standard public-investment indicators and allow the three projects to be compared in terms of both absolute return and economic efficiency. For scenario s, the NPV is estimated as

$\Delta NB_{,}$

$$NPV = \frac{\quad}{\quad},$$

$(1 + r)$

and BCR is estimated as

$\Delta B_{,}$

$\sum$

$$BCR = \frac{\sum_{y=0} \overline{(1+r)^{y}}}{\sum \frac{\Delta C_{,}}{\quad}},$$

$(1 + r)$

where r denotes the real discount rate and T is the analysis horizon.

3.9.3 Payback, Internal Rate of Return, and Equivalent Uniform Annual Worth

Payback is the time required for cumulative net benefits to recover the initial investment. IRR measures the discount rate at which NPV equaled zero. EUAW represents the annualized value of the lifecycle result. These measures show how quickly benefits are recovered, what rate of return the project implies, and how lifecycle value translates into an annual equivalent. They are defined as follows:

$$\text{Payback} = \min y: \quad \Delta NB_{,} \geq I \quad ,$$

$\Delta NB_{,}$

$$IRR: \quad \frac{\quad}{\quad} = 0,$$

$(1 + IRR)$

$r(1 + r)$

$$EUAW = NPV \cdot \frac{\quad}{(1+r)^{T} - 1},$$

where I denotes initial project investment.

3.10 Method Scope, Consistency, and Reproducibility

The method is designed to match the decision purpose of this report. It does not attempt to estimate every possible consequence of each project. Instead, it focuses on the transportation, operating, environmental, safety, and investment effects that can be supported by available data and evaluated consistently across the three projects. This boundary makes the method suitable for TDOT's project-screening and project-comparison purposes.

Method consistency is supported by applying the same analytical sequence to all three project cases. Project information is first translated into scenarios, which are then converted into annual activity measures. Those activity measures are used to estimate costs and public effects, and the resulting annual estimates are then converted into discounted investment measures. Using the same structure across all three projects reduces the risk that differences in results are caused by changes in method rather than by differences in project conditions.

Method reproducibility is supported by tying each reported result to a defined scenario quantity and a stated unit input or valuation factor. Another analyst using the same project assumptions, reference values, and calculation steps should be able to reproduce the reported values, subject to rounding and source-file conventions.

3.11 Methodological Limits

Several methodological limits should be stated explicitly. First, the three project cases were not all documented in the same source year. Second, some project inputs were sponsor-reported or derived from representative rather than observed long-run freight operations. Third, certain categories of broader economic effect were excluded because no defensible project-level estimation method was available. Fourth, the three project cases did not all reach the same level of analytical readiness at the same time, particularly where workbook normalization and final quality checks were still pending.

These limits do not invalidate the framework, but they affect how individual results should be interpreted. The method therefore supports disciplined comparison, not false precision. Where a result depends heavily on a small number of assumptions, that dependence is carried forward to the sensitivity and discussion chapters rather than concealed in a single headline value.

Chapter 4 Data, Assumptions, and Normalization

This chapter documents the data structure, input assumptions, and normalization rules used in the three project evaluations. It identifies the source categories used in the analysis, distinguishes project-specific inputs from study-wide inputs, explains how values from different years were normalized where necessary, and summarizes the quality-control checks applied before results were reported. These elements provide the evidentiary basis for the results presented in the project chapters.

4.1 Data Structure and Source Traceability

The data used in this study fall into four main categories. The first category is project-specific engineering and capital-cost information, including project scope, construction elements, sponsor cost estimates, and any available funding split or implementation assumptions. The second category is freight demand and operating information, including annual tonnage, representative routing, segment distance, drayage requirements, dwell assumptions, handling events, and other scenario drivers needed to construct the No-Build and Build activity tables. The third category is unit-cost information used in Phase I, including fuel price, fuel efficiency, labor rates, equipment costs, maintenance costs, and infrastructure-related cost factors. The fourth category is valuation information used in Phase II, including emissions factors, damage-cost parameters, and safety valuation parameters.

Table 4-1 summarizes the principal source categories used in the study. The source base combines TDOT project files and sponsor materials with national reference sources for freight operations, fuel prices, emissions, safety valuation, rail cost statistics, truck cost statistics, and terminal or handling references where needed.

For reporting purposes, the inputs are separated into project-specific inputs and study-wide inputs. Project-specific inputs include project geometry, annual throughput, routing structure, capital cost, and logistics-chain design. Study-wide inputs include the common assumptions and reference parameters applied across the three evaluations. This distinction clarifies which inputs vary by project and which are held constant to preserve comparability.

This report applies a simple traceability rule: every reported result must be reproducible from a documented input or scenario activity measure and a referenced unit value or valuation parameter.

In practical terms, each annual cost or benefit estimate must be linked to (1) an input or activity measure such as tonnage, distance, ton-miles, dwell time, or number of transfers, and (2) a unit rate or valuation factor such as dollars per ton-mile, grams per ton-mile, or a safety valuation parameter. This rule is central to the reviewability of the report because it allows the analysis to be checked, updated, or rerun when better project-specific information becomes available.

Table 4-1 Principal source categories and typical inputs used in the project evaluations

Source category	Organization/source family	Typical inputs used in this study
Project engineering and sponsor records	TDOT project files, grant materials, sponsor applications, engineering cost documents	Project scope, track or siding length, switch count, construction elements, sponsor-stated throughput, capital cost estimates, funding split, implementation assumptions
Rail operating statistics and cost benchmarks	Surface Transportation Board (STB) Form R-1 reports and related rail statistics	Rail ton-mile activity, labor and equipment cost benchmarks, maintenance and infrastructure cost benchmarks, fuel-efficiency benchmarks, and denominators used for unit-rate conversion
Truck operating statistics and cost benchmarks	American Transportation Research Institute (ATRI) operating cost reports and related truck-cost benchmarks	Driver compensation, truck equipment and maintenance cost benchmarks, cost-per-mile inputs, payload assumptions, and loaded-share conversion assumptions
Fuel price references	U.S. Energy Information Administration (EIA)	Diesel price benchmark for energy-cost estimation
Highway infrastructure references	Federal Highway Administration (FHWA) and National Highway System data	Highway lane-miles, infrastructure maintenance benchmarks, national truck activity references, roadway preservation cost assumptions
Environmental valuation references	U.S. Environmental Protection Agency (EPA), federal emissions references, damage-cost references	Greenhouse-gas emission factors, social cost of carbon parameters, criteria air pollutant emission factors, pollutant damage-cost factors
Safety valuation references	U.S. Department of Transportation (USDOT) guidance and national safety statistics	Value of statistical life, injury valuation parameters, mode-specific fatality and injury risk rates, crash-cost monetization parameters

Scenario activity and logistics assumptions	Project narratives, routing assumptions, GIS or corridor-distance checks, terminal operating assumptions, tariff or handling references where available	Annual tonnage, segment distance, drayage length, dwell assumptions, handling-event counts, representative logistics chains

Note: Unless otherwise noted, institutional reference inputs are applied on a study-wide basis. Project-specific values are used where project records provide the necessary information. Year-basis adjustments and project-specific normalization procedures are described later in this chapter.

4.2 Common Evaluation Basis Across the Three Projects

The three project evaluations are conducted on a common evaluation basis. That basis includes the analysis period, discounting convention, timing convention for capital and annual flows, common modal cost logic, and shared valuation parameters for public effects. These elements are applied consistently across the three evaluations so that differences in reported results reflect project inputs and scenario definitions rather than changes in the evaluation basis.

4.2.1 Analysis Period, Discount Rate, and Timing Convention

A uniform analysis period and discounting convention are required because present-value measures are sensitive to both assumptions. If the three projects were evaluated with different horizons or discount rates, the resulting NPV and BCR values would not be directly comparable.

This study applies a 35-year analysis period. That horizon reflects the long service life typically associated with rail infrastructure and related freight-access improvements. A shorter horizon would understate benefits for projects with long-lived assets, while a much longer horizon would place greater weight on distant years that are inherently more uncertain.

A real discount rate of 7 percent is applied in the base analysis. This value is used consistently across the three projects to preserve comparability in present-value calculations. Alternative assumptions may be examined in sensitivity analysis, but they do not change the common basis used in the base evaluation.

Unless a project-specific implementation schedule requires explicit phasing, capital cost is treated as an initial investment, and annual benefits and costs are treated as recurring end-of year values over the study horizon. This timing convention is consistent with the discounted cashflow structure defined in Chapter 3 and is applied across the three projects to maintain a common assessment basis.

4.2.2 Common Modal Cost Logic and Valuation Basis

The three evaluations also share a common basis for converting scenario activity into operating costs and public-effect values. Where feasible, the same modal cost logic and valuation parameters are applied across the three projects so that differences in results reflect project inputs and scenario definitions rather than changes in parameter selection.

For Phase I, mode-specific cost estimates are developed from common unit-rate logic for fuel, labor, equipment, and maintenance. Truck cost rates are typically specified on a mileage basis and then converted using payload and loaded-share assumptions. Rail cost rates are derived from expenditure and activity relationships reported in national rail statistics. This approach provides a consistent basis for translating truck and rail activity into comparable operating cost estimates.

For Phase II, greenhouse-gas, criteria air-pollutant, and safety effects are monetized using shared valuation parameters. Greenhouse-gas effects are valued using the social cost of carbon in constant dollars. Criteria air-pollutant effects are valued using pollutant-specific damage factors. Safety effects are valued using standard transportation-assessment parameters, including the value of a statistical life and associated injury values applied to mode-specific fatality and injury risk rates.

Unit consistency is required throughout the analysis. Cost rates, emissions factors, and safety parameters are applied only after they have been aligned with the corresponding activity measure. This step is necessary because the analysis uses inputs expressed on different bases, including dollars per gallon, dollars per mile, dollars per ton-mile, grams per ton-mile, and monetized safety parameters.

4.3 Project-Specific Inputs and Scenario Definitions

Tables 4-2 through 4-4 summarize the project-specific inputs and scenario definitions used in the evaluations. Table 4-2 reports the principal case-definition inputs used to represent freight activity and transportation structure across the three projects. Table 4-3 reports the operating and valuation assumptions used in the project calculations. Because barge movements were modeled explicitly only in the Dyer project, the corresponding baseline barge inputs are reported separately in Table 4-4.

Table 4-2 Project-specific case-definition inputs used in the project evaluations

Input parameter	Unit	Shelby Project	Dyer Project	Marion Project
Project input year basis	year	2019	2019	2021 project inputs normalized to 2019
Project description	—	Presidents Island rail improvement	Helena Agri rail siding	Nickajack Industrial Park rail spur
Annual freight tonnage	tons/year	145,000	90,000	5,200
Baseline representative linehaul distance	miles	750	755 (barge)	18
Build origin drayage distance	miles	15	5	0

Build destination drayage distance	miles	55	7	0.6
Baseline annual ton-miles	ton-miles /year	108,750,000	69,840,000	93,600
Build rail line-haul distance	miles	750	417	8
Build rail annual ton-miles	ton-miles /year	108,750,000	42,300,000	41,600
Project capital cost	2019 $	1,915,000	540,000	3,584,000
Baseline transloading events	count	2	3	2
Build transloading events	count	4	3	2

Note: Baseline denotes the No-Build scenario, and Build denotes the project scenario used in the evaluation. Linehaul, drayage, ton-miles, and transloading events are reported as scenario-specific inputs used to define freight activity and transportation structure. For the Dyer project, the baseline representative linehaul distance is a barge movement.

Table 4-3 reports the operating and valuation assumptions used in the project calculations.

Table 4-3 Operating and valuation assumptions used in the project calculations

Input Parameter	Unit	Shelby Project	Dyer Project	Marion Project
Truck payload	tons	26 (linehaul), 20 (drayage)	26 (linehaul), 20 (drayage)	26 (linehaul), 20 (drayage)
Loaded-share	ratio	0.75 (linehaul), 0.60 (drayage)	0.75 (linehaul)	0.75 (linehaul), 0.60 (drayage)
Cargo value for inventory cost	$/ton	226	350	1,484.44
Inventory carrying rate	percent	20	20	20
Truck speed	mph	55	55	55
Rail speed	mph	22	22	22

Facility dwell time per stop	hours	2.20	2.20	2.20
Rail terminal dwell time per event	hours	22.53	22.53	22.53
Total dwell under Build	hours	49.46	70.23	49.46
Diesel price benchmark	$/gallon	3.055	3.055	3.281
Truck fuel efficiency	Ton miles/gallon	151	151	151
Rail fuel efficiency	Ton miles/gallon	472	472	498
Social cost of carbon	$/metric ton CO_2	49.39	49.39	49.39
Truck CO_2 intensity	g/ton-mile	140.7023	140.7023	140.7023
Rail CO_2 intensity	g/ton-mile	21.5678	21.5678	21.5678
Value of statistical life	2019 $	11,322,314.05	11,322,314.05	11,322,314.05
Injury value	2019 $	197,107.44	197,107.44	197,107.44

Because barge movements are modeled explicitly only in the Dyer project, the corresponding baseline barge inputs are reported separately in Table 4-4.

Table 4-4 Barge-specific baseline input parameters for the Dyer Project

Input parameter	Unit	Dyer Project
Baseline barge distance	miles	755
Baseline barge annual ton-miles	ton-miles/year	67,950,000
Barge fleet size	vessels	15
Barge tow capacity	tons	22,500
Barge upstream speed	mph	6
Barge crew size	persons	7
Barge crew wage	$/hour	22
Labor burden coefficient	ratio	1.5

4.4 Base Year, Price Basis, and Normalization Procedures

All costs and monetized benefits in this report are expressed in constant 2019 dollars. A common base year is required because the three projects were documented at different times and because several reference inputs are drawn from national sources reported in different nominal years. Without a consistent price basis, differences across the three projects would reflect inflation and reporting-year effects in addition to differences attributable to the projects themselves.

The analysis uses 2019 as the common base year because it provides a consistent pre-pandemic benchmark for freight activity, cost inputs, and valuation inputs and aligns with the principal national reference sources used in this study. Accordingly, capital costs, operating cost rates, labor and fuel prices, cargo values used in inventory calculations, and monetized damage-cost parameters are converted to the common 2019 basis where necessary. This convention is applied throughout the study so that present values, annualized values, and cross-project comparisons remain internally consistent.

When a monetary input is available only in a post-2019 source year, it is converted to 2019 dollars before being used in the analysis. For traceability, both the source-year value and the normalized 2019 value should be retained in the supporting calculation record so that changes in real project conditions are not confused with changes caused only by price-level movement.

Volume and activity adjustments are treated separately from inflation adjustments. If a project relies on demand, tonnage, or operating information from a year other than 2019, the quantity is not mechanically deflated in the same way as a monetary value. Instead, the analysis applies a documented representation rule, such as carrying observed throughput forward unchanged or applying a scaling rule supported by project information. This distinction is necessary because physical activity and monetary values do not change over time in the same way.

For the Marion project, selected project-specific quantities and sponsor-reported cost figures originate from a later documentation year and therefore require normalization before entering the common evaluation basis. Those adjustments are applied only where needed and do not alter the common evaluation basis used for cross-project comparison.

4.5 Data Quality Control, Proxy Use, and Conservative Treatment

Quality control is applied at both the input stage and the calculation stage. Input-stage checks focus on internal consistency in the scenario activity tables, including ton-mile reconciliation across legs, non-negative freight flows, reasonable route lengths, and consistency among distance, speed, and dwell assumptions. Calculation-stage checks focus on unit conversions and consistency between each activity measure and the corresponding unit rate or valuation parameter. These checks are necessary because even a small mismatch in units or scenario structure can propagate across multiple cost categories and distort the reported results.

Reproducibility is supported by the report structure and the underlying calculation record. Reported results must be traceable to an organized calculation file or workbook in which scenario quantities, unit rates, and final outputs are linked through documented intermediate steps. This structure supports the current report and allows the evaluation to be updated when project design, cost, or freight data change.

When a primary project-specific input is unavailable, the analysis uses a documented proxy drawn from project records, public reference data, or a comparable operating benchmark. Each substitution should be recorded in the supporting calculation record, and the likely direction of any resulting bias should be noted. If a proxy is likely to overstate benefit or understate cost, that risk should be stated explicitly.

The analysis is structured to avoid overstating project value. Speculative benefits are excluded unless they are supported by defensible evidence. Modal-shift assumptions must remain grounded in observed or documented operating conditions, and time-saving or transfer-related reductions must not exceed what the available information can justify. When a benefit category cannot be estimated with a defensible method, it is omitted from the base analysis rather than represented by an unsupported value.

Uncertainty is addressed through deterministic sensitivity analysis focused on the variables most likely to influence results. Depending on the project, these variables may include annual throughput, route length, dwell and transfer assumptions, fuel and labor rates, capital cost, and the discount rate. The purpose of this sensitivity analysis is not to replace the base analysis, but to show which assumptions have the greatest influence on the reported results and therefore most warrant validation as project development advances.

4.6 Interpretation Boundaries for the Reported Results

The reported results should be interpreted within the scope of the evaluation framework defined in this report. The analysis does not quantify every possible economic effect of rail connectivity. Induced-development claims, land-use effects, and broader regional spillover effects are excluded from the base analysis unless they are supported by defensible evidence and can be estimated through a documented method.

The emissions analysis is likewise bounded by the available mode-specific factors and valuation parameters used in the study. Reported public-effect estimates therefore reflect the quantified effects included in the framework rather than every possible environmental or safety consequence under all operating conditions.

The standardized assumptions documented in this chapter allow the three projects to be compared on a common evaluation basis. However, the completeness and strength of the underlying project evidence are not identical across cases. Some project findings can therefore be interpreted with greater confidence than others, especially where scenario activity and project-specific documentation are more complete.

Accordingly, the reported values should be treated as structured decision-support estimates rather than precise forecasts or ex post accounting measures. They are suitable for cross-project comparison and for illustrating how the framework can support future project screening, but they should not be interpreted as evidence for benefit categories that were not defensibly quantified in the base analysis.

Chapter 5 Results and Discussion

This chapter presents the results of the three projects and discusses their implications for TDOT's rail-connectivity program. The projects are analyzed within a single chapter so that operating results, public effects, and lifecycle investment outcomes can be compared on a common basis. The chapter first presents the results for each project and then compares the three projects in terms of freight setting, benefit composition, and investment outcome.

5.1 Overview of Project Results

The three projects do not represent three versions of the same project type. The Shelby project is a high-volume freight gateway with substantial truck line-haul displacement. The Dyer project is a smaller rail-siding improvement serving agricultural and industrial distribution. The Marion project is an industrial-access improvement whose main benefit comes from eliminating a recurring truck transfer leg serving a specific company. Accordingly, the results are interpreted in relation to project context as well as absolute economic performance.

The same layered structure is used to interpret all three projects. First, direct operating and logistics results are examined. Second, environmental and safety effects are assessed. Third, LCA measures are interpreted. This structure shows both whether a project performs well under the evaluation framework and which components drive the reported result.

5.2 Shelby Project: Presidents Island Multimodal Rail Improvement

5.2.1 Project Context and Role

Shelby County is a major freight gateway in Tennessee because it links interstate highway corridors, Class I rail service, river-based industrial activity, and major logistics facilities in the Memphis region. Presidents Island is a freight-intensive industrial area with heavy commodity movement and multimodal transfer activity. In this setting, rail-access improvements affect not only individual shippers or terminals, but also the way long-haul freight enters and exits the regional network and the extent to which that movement depends on long-distance trucking.

For TDOT, this project is important because it is a high-volume rail-connectivity project with clear relevance for future project screening. If the project reduces truck-intensive linehaul activity while maintaining reliable access for shippers and receivers, the resulting benefits can extend across operating cost, public roadway exposure, emissions, and safety. The Shelby project therefore serves as a strong case for evaluating how the LL-BCA framework performs in a large freight corridor and a mature intermodal setting.

5.2.2 Project Description and Implementation Assumptions

The Shelby project expands rail-handling capacity at the Presidents Island terminal in Memphis, Tennessee. The terminal is a major regional freight facility and transfer node for bulk and industrial cargo. The project includes approximately 4,900 feet of new on-terminal rail track and four new switches to improve rail access and increase the share of freight handled by rail.

For economic evaluation, the project is treated as an incremental rail-connectivity improvement that changes the feasible logistics chain for freight movement. The capital cost used in the base analysis is $1.915 million in constant 2019 dollars. The project funding split reported in the project source record is $1.7235 million in state participation and $191,500 in local participation. The base analysis excludes right-of-way cost from the project estimate.

The project assumptions are based on a representative 2019 operating case. Annual freight throughput is set at 145,000 tons. Freight movement is represented as a long-haul corridor in which shipments move either by direct truck under the No-Build scenario or by a rail-truck intermodal configuration under the Build scenario. The analysis uses a representative 2019 operating case to compare the pre-project and post-project logistics chains on a documented and internally consistent basis.

5.2.3 Scenario Definition and Logistics Chains

The Shelby project evaluation compares two scenarios. Scenario S0 is the No-Build scenario, in which freight moves by direct truck over the representative corridor. Scenario S1 is the Build scenario, in which the Presidents Island rail improvement allows freight to move through a railtruck intermodal chain consisting of origin drayage, rail line-haul, and destination truck delivery. Table 5-1 summarizes the scenario structure and annual activity measures.

Table 5-1 Scenario structure and annual activity measures for the Shelby County project

Scenario	Leg	Segment	Mode	Distance (miles)	Annual ton-miles
S0	1	Origin to destination	Truck	750.0	108,750,000
S1	1	Origin to railhead	Drayage	15.0	2,175,000
	2	Railhead to Memphis terminal	Rail	750.0	108,750,000
	3	Memphis terminal to destination	Truck	55.0	7,975,000

S0: Baseline (No-Build)—Direct Highway Trucking

Under the No-Build scenario, freight moves entirely by truck over the representative 750-mile corridor. Both operating costs and public effects therefore arise entirely from highway freight movement. This scenario provides the reference condition for all incremental results reported for the Shelby project.

S1: Build Alternative—Rail-Truck Intermodal

Under the Build scenario, freight is first collected by short-haul drayage, then moved by rail for the main line-haul segment and then delivered by truck from the Memphis terminal to the destination. This configuration introduces additional terminal handling and dwell requirements but reduces long-haul truck exposure. The Shelby project results show whether those added terminal and transfer requirements are outweighed by lower line-haul cost and lower public-effect costs.

5.2.4 Results: Phase I (Operational Costs)

Table 5-2 summarizes annual operating cost results for the two scenarios in constant 2019 dollars. The Build scenario reduces total annual operating cost from $9.73 million to $6.13 million, generating annual operating savings of approximately $3.60 million. The largest cost reductions occur in energy, labor and administrative cost, equipment ownership, equipment maintenance, and infrastructure maintenance. These savings are partially offset by higher transloading cost and higher in-transit inventory cost associated with additional terminal handling and lower rail operating speed.

Table 5-2 Annual operating cost by scenario for the Shelby County project (2019 dollars)

Cost component ($/year)	S0 Baseline	S1 Build
Energy cost	2,200,206.95	918,215.72
Labor and administrative cost	3,864,807.69	2,097,705.47
Equipment ownership cost	1,444,423.08	366,891.20
Equipment maintenance cost	797,500.00	229,458.71
Infrastructure maintenance cost	1,233,890.28	579,839.26
End-of-life infrastructure value (credit)	(405,147.59)	(84,239.27)
In-transit inventory cost	13,494.33	63,462.80
Transloading cost	580,000.00	1,957,500.00
Total annual operating cost	9,729,174.74	6,128,833.89

This Phase I result shows that the Shelby project does not depend on public effects alone for a positive assessment result. Even after additional intermodal handling and transfer cost is introduced, the reduction in long-haul truck-intensive cost is sufficient to produce a positive operating-only result.

5.2.5 Results: Phase II (Public-Effect Costs)

Table 5-3 summarizes the Phase II results. Under the No-Build scenario, annual public-effect cost is estimated at $3.75 million. Under the Build scenario, annual public-effect cost declines to

$1.91 million, for annual public-effect savings of approximately $1.84 million. The largest single source of public-effect savings is the reduction in criteria air pollutant damage cost, followed by reductions in greenhouse-gas cost and safety cost.

Table 5-3 Annual public-effect cost by scenario for the Shelby County project (2019 dollars)

Externality category ($/year)	S0 Baseline	S1 Build
GHG cost	755,734.92	186,379.42
Criteria air pollutant cost	2,071,050.21	1,452,441.76
Safety cost	928,053.86	272,077.77
Total annual external cost	3,754,838.99	1,910,898.95

5.2.6 Results: Phase III (Economic Assessment and Investment Metrics)

Figure 5-1 illustrates the comparative cost structure of the two Shelby scenarios. It shows that the Build scenario raises terminal-related handling cost but substantially reduces distance-based long-haul truck costs. The combined effect is a lower annual operating cost and a lower annual public-effect cost.

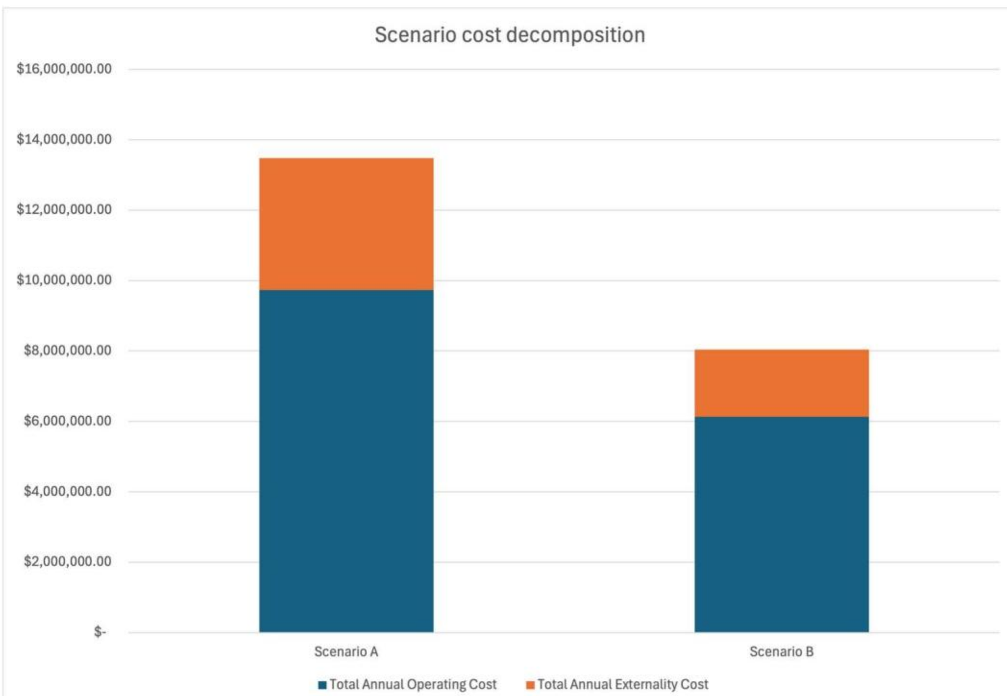

Figure 5-1 Annual cost decomposition by scenario for the Shelby County project (2019 dollars)

Table 5-4 summarizes the Phase III investment results for the Shelby project. On an operating only basis, the project produces a NPV of $44.70 million and a BCR of 24.34. When public-effect savings are added, total economic NPV rises to $68.58 million and the BCR rises to 36.81. Both discounted and undiscounted payback occur in less than one year.

Table 5-4 Incremental investment assessment for the Shelby County project (Build versus No-Build)

Metric	Operating-only basis	Total economic basis
Incremental capital cost ($)	1,915,000	1,915,000
Annual savings ($/year)	3,600,341	5,444,281
Present value of benefits ($)	46,616,133	70,490,916
Net present value ($)	44,701,133	68,575,916
Benefit-cost ratio	24.34	36.81
Simple payback (years)	0.53	0.35
Discounted payback (years)	0.56	0.37
Internal rate of return	188.01%	284.30%
Equivalent uniform annual worth ($/year)	3,452,438	5,296,378

For TDOT, the Shelby project is supported by strong direct operating savings and becomes even more favorable when public-effect savings are included. Within the LL-BCA framework, the project performs strongly under both the operating-only basis and the total economic basis.

5.2.7 Sensitivity Results and Discussion

The Shelby project sensitivity analysis includes one-way and two-way deterministic tests focused on annual operating savings. The one-way analysis tests annual throughput, baseline truck loaded share, and representative line-haul distance. The two-way analysis examines the combined effects of annual throughput with loaded share and annual throughput with line-haul distance.

The one-way analysis shows that annual throughput is the strongest driver of operating savings. A 30% reduction in throughput lowers annual operating savings to approximately $2.52 million, whereas a 30% increase raises them to approximately $4.68 million. Baseline truck loaded share is the second most influential variable. At a loaded share of 0.85, annual operating savings decline to approximately $2.93 million; at a loaded share of 0.65, they increase to approximately $4.47 million. Line-haul distance also affects the result, but less strongly within the tested range, with annual operating savings varying from approximately $3.20 million at 700 miles to approximately $4.00 million at 800 miles.

Figure 5-2 presents the one-way sensitivity summary for the Shelby project.

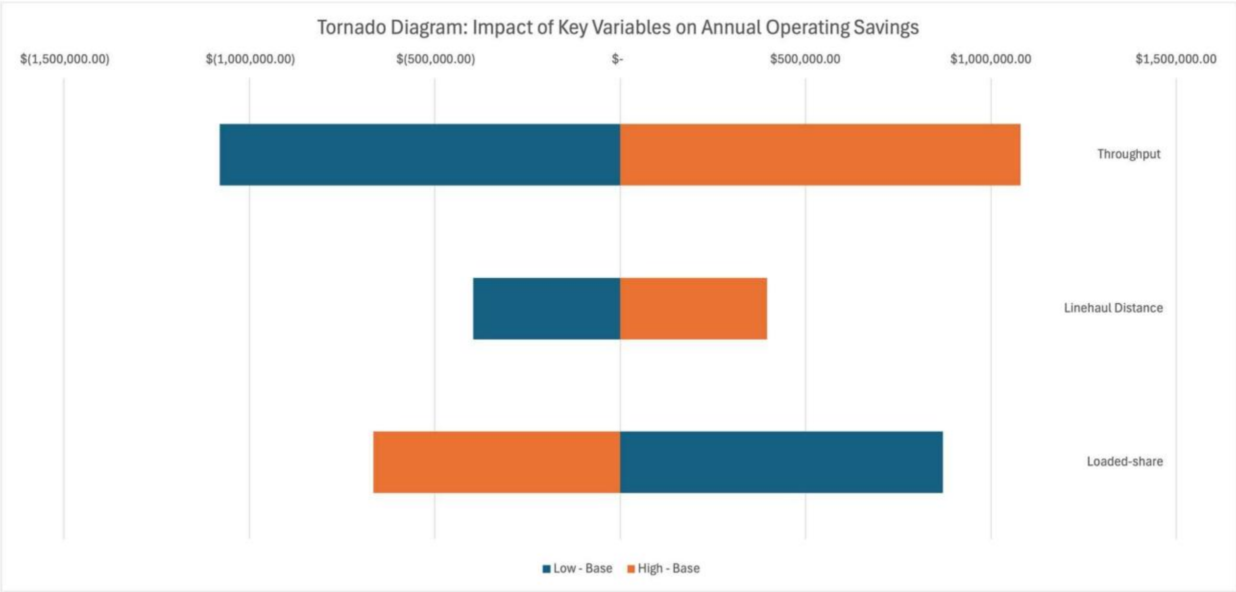

Figure 5-2 Tornado diagram for the Shelby County project: impact of key variables on annual operating savings

The two-way sensitivity analysis extends the robustness check by showing how annual throughput interacts with the other major variables. Table 5-5 reports the results for the two tested parameter pairs.

Table 5-5 Two-way sensitivity analysis results for annual operating savings in the Shelby County project

Panel A: Loaded Share versus Annual Throughput			
Loaded share \ Throughput	0.7 (Low: 101.5k)	1.0 (Base: 145k)	1.3 (High: 188.5k)
0.65 (Low)	3,129,659.00	4,470,941.43	5,812,223.86
0.75 (Base)	2,520,238.60	3,600,340.85	4,680,443.11
0.85 (High)	2,054,211.22	2,934,587.45	3,814,963.69
Panel B: Linehaul Distance versus Annual Throughput			
Distance \ Throughput	0.7 (Low: 101.5k)	1.0 (Base: 145k)	1.3 (High: 188.5k)
700 miles (Low)	2,242,964.52	3,204,235.03	4,165,505.54
750 miles (Base)	2,520,238.60	3,600,340.85	4,680,443.11
800 miles (High)	2,797,512.69	3,996,446.70	5,195,380.71

These results show that the Shelby project continues to generate substantial operating savings even under conservative combinations of lower throughput and higher baseline loaded share. In the two-way sensitivity analysis, the least favorable tested combination still yields annual operating savings above $2.05 million, while the most favorable tested combination yields approximately $5.81 million. This reinforces the conclusion that the Shelby project remains robust under the main operating uncertainties examined in the sensitivity analysis.

5.3 Dyer Project: Helena Agri Rail Siding Improvement

5.3.1 Project Context and Role

The Dyer County project is in northwestern Tennessee and is best understood as a freight-access project serving an agricultural and industrial distribution function rather than as a major regional gateway. The evaluated project centers on a fertilizer distribution terminal operated by Helena Agri-Enterprises in Dyersburg, serving agricultural demand across western Tennessee, eastern Arkansas, the Missouri Bootheel, and southern Kentucky. At present, inbound fertilizer supply depends entirely on barge movements along the Mississippi River followed by truck delivery to the terminal. That logistics pattern generates substantial truck traffic on local roads and exposes the facility to supply reliability risks during peak planting and growing periods.

For TDOT, the relevance of rail connectivity in this case lies in three linked benefits: lower inbound truck cost and road burden, improved supply speed and reliability during seasonal demand peaks, and the potential to support a future liquid fertilizer terminal whose feasibility would be strengthened by direct rail access.

5.3.2 Project Description and Implementation Assumptions

Helena Agri-Enterprises proposes a 1,927-foot railroad spur with 16-car push-back capacity at its facility at 200 Cow Lane in Dyersburg, Tennessee. The spur would connect the facility to the TENNKEN Railroad, which interchanges with the CN mainline at Dyersburg, and would provide direct inbound rail access for bulk dry fertilizer shipments from the Port of New Orleans. Base year annual throughput is set at 90,000 tons. That value is estimated from approximately 3,000 inbound truck trips documented in the 2018 project records at an average payload of 30 tons per trip, with an upward adjustment for the projected 30 percent year-over-year growth from 2018 to the 2019 base year. The economic evaluation applies the documented project capital cost together with the common base-case assumptions defined in Chapter 4.

Two scenarios are evaluated. Under the No-Build scenario, freight moves by barge from Nashville Avenue Wharf in New Orleans to Caruthersville, Missouri, over 755 river miles, and then by truck for 21 miles to the Helena terminal in Dyersburg. Under the Build scenario, freight moves by truck for 5 miles from the port to the CN rail interchange, then by rail for 417 miles along the CN mainline through Memphis to the TENNKEN interchange at Dyersburg, and finally by truck for 7 miles to the Helena distribution point.

5.3.3 Scenario Definition and Logistics Chains

The evaluation compares two logistics chains for the representative inbound fertilizer movement from the Port of New Orleans to the Helena Agri-Enterprises terminal in Dyersburg. In the NoBuild scenario, freight moves by barge and truck. In the Build scenario, the long-haul movement shifts to rail along the CN mainline, with truck drayage at the origin and destination ends. Transloading cost is retained in both scenarios because both logistics chains require freight handling, although the number and location of handling events differ. Table 5-6 summarizes the scenario structure and annual activity measures for the Dyer County project.

Table 5-6 Scenario structure and annual activity measures for the Dyer County project

Scenario	Leg	Segment	Mode	Distance (mi)	Annual ton-miles
S0	1	Origin to barge terminal	Barge	755.0	67,950,000
	2	Barge terminal to destination	Truck	21.0	1,890,000
S1	1	Origin to railhead	Truck	5.0	450,000
	2	Railhead to rail terminal	Rail	417.0	42,300,000
	3	Rail terminal to destination	Truck	7.0	630,000

5.3.4 Results: Phase I (Operational Costs)

The Dyer project generates net annual Phase I benefits of approximately $873,919 in constant 2019 dollars. As shown in Table 5-7, this result reflects the combined effect of eight operating cost components. Energy cost savings are the dominant positive contributor, reflecting the lower fuel use of rail relative to the No-Build barge-and-truck chain on the long-haul portion of the movement. Equipment cost savings and equipment maintenance savings also contribute positively. By contrast, labor and administration costs, infrastructure maintenance costs, and transloading costs produce negative net benefits under the Build scenario. End-of-life infrastructure value and in-transit inventory cost savings provide smaller positive contributions.

Table 5-7 Summary of annual quantified benefits for the Dyer County project

Phase	Benefit component	Annual benefit ($/year)
Phase I	Net energy cost savings	860,235.36
	Net labor and administration cost savings	-525,239.66
	Net equipment cost savings	517,001.93
	Net equipment maintenance savings	248,416.79
	Net infrastructure maintenance savings	-176,147.83
	Net end-of-life infrastructure value	16,549.09
	Net in-transit inventory cost savings	44,703.41
	Net transloading cost savings	-111,600.00

Phase II	Net greenhouse gas benefit	11,178.78
	Net criteria air pollutant benefit	69,415.70
	Net safety benefit	-28,503.06
Phase III	Total annual economic benefit	926,010.51

The Phase I results indicate that the project generates substantial operator-level benefits. Energy savings are the dominant contributor, reflecting the lower fuel use of rail on the long-haul portion of the movement relative to the No-Build barge-and-truck chain. The negative labor and administration component reflects the higher crew and administrative cost structure of rail relative to barge transport, which can move large cargo volumes with relatively low labor input. The negative infrastructure maintenance component reflects the fact that inland waterway infrastructure is maintained largely through the federal system rather than charged directly to the freight operator in the baseline scenario. The negative safety component reflects the comparatively low accident burden of barge transport on the inland waterway system.

5.3.5 Results: Phase II (Public-Effect Costs)

Phase II public-effect cost declines from $594,521 under the No-Build scenario to $542,430 under the Build scenario, yielding a net annual benefit of approximately $52,091 in constant 2019 dollars. As shown in Table 5-8, the largest contributor is the reduction in criteria air-pollutant cost, followed by greenhouse-gas cost.

Table 5-8 Phase II public-effect components for the Dyer County project

Externality category ($/year)	S0 Baseline	S1 Build
GHG cost	63743.39	52564.61
Criteria air pollutant cost	458192.28	388776.58
Safety cost	72585.45	101088.51
Total annual external cost	594521.12	542429.70

The criteria air-pollutant component declines from $458,192 under the No-Build scenario to $388,777 under the Build scenario, producing a net annual benefit of approximately $69,415. Greenhouse gas cost also declines, from $63,743 to $52,565, producing a net annual benefit of approximately $11,179. These reductions reflect the lower emissions intensity of the Build logistics chain relative to the No-Build barge-and-truck chain.

These positive Phase II effects are partially offset by a less favorable safety result under the Build scenario. Safety cost rises from $72,585 to $101,089, producing a net annual disbenefit of approximately $28,503. This result reflects the comparatively low accident burden of barge transport per ton-mile on the inland waterway system. As a result, shifting the primary long-haul movement from barge to rail improves emissions performance but makes the safety component less favorable under the Build scenario.

Overall, the Dyer project produces a positive Phase II result because the reductions in criteria airpollutant and greenhouse-gas cost outweigh the increase in safety cost. The public-effect benefit is therefore positive, but its composition differs from the Shelby project because the No-Build baseline in Dyer already includes a low-accident barge movement rather than a truck-only longhaul movement.

5.3.6 Results: Phase III (Economic Assessment and Investment Metrics)

Figure 5-3 compares annual operating cost and annual public-effect cost under the two Dyer scenarios. Under the Build scenario, both components decline, producing a lower combined annual cost than under the No-Build scenario. The reduction is driven primarily by lower operating cost, with additional benefit from lower public-effect cost.

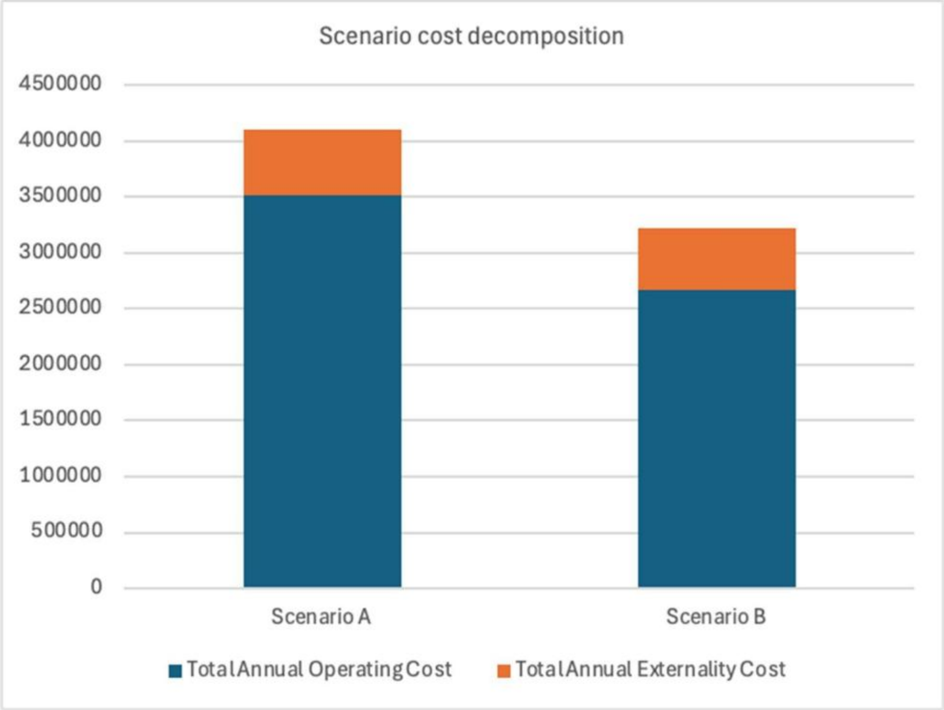

Figure 5-3 Annual cost decomposition by scenario for the Dyer County project (2019 dollars)

This annual cost advantage carries through to the Phase III investment metrics. The Dyer project is economically favorable under both the operating-only basis and the total economic basis. In both cases, the benefit-cost ratio exceeds 1.0 and payback occurs within the first year of the analysis period. These results indicate that the project remains favorable whether it is evaluated from the operator perspective alone or from the broader combined economic perspective.

5.3.7 Sensitivity Results and Discussion

The Dyer County project was evaluated using one-way and two-way deterministic sensitivity tests focused on operating-only NPV and BCR. The one-way tests varied annual throughput and discount rate separately. The two-way tests examined annual throughput with discount rate for operating-only NPV and annual throughput with capital cost overrun for operating-only BCR.

The one-way results show that annual freight throughput is the strongest driver of project performance. A 30 percent reduction in throughput, from 90,000 to 63,000 tons, lowers operating-only NPV from approximately $10.78 million to $7.38 million, while a 30 percent increase raises NPV to approximately $14.17 million. Discount rate is the second most influential variable. Across the tested discount-rate cases, operating-only NPV remains positive.

The two-way results show that the project remains favorable across all tested parameter combinations. Table 5-9 reports the results for the two tested parameter pairs. In Panel A, operating-only NPV remains positive across all tested combinations of throughput and discount rate. In Panel B, operating-only BCR remains above 1.0 across all tested combinations of throughput and capital cost overrun. The weakest tested case yields a BCR of 9.78, and the strongest tested case yields a BCR of 27.24.

Table 5-9 Two-way sensitivity analysis results for the Dyer County project

Panel A: Discount Rate versus Annual Throughput — NPV Operating ($)			
Discount Rate	0.7 (Low: 63,000t)	1.0 (Base: 90,000t)	1.3 (High: 117,000t)
5% (Low)	7,083,674.47	10,350,963.52	13,618,252.58
7% (Base)	7,380,652.60	10,775,218.00	14,169,783.40
10% (High)	4,668,116.10	6,900,165.86	9,132,215.62
Panel B: Capital Cost Overrun versus Annual Throughput — BCR Operating			
Capital Cost	0.7 (Low: 63,000 t)	1.0 (Base: 90,000 t)	1.3 (High: 117,000 t)
$540k (Base)	14.67	20.95	27.24
$648k (+20%)	12.22	17.46	22.70
$810k (+50%)	9.78	13.97	18.16

These results indicate that the Dyer County project remains economically favorable across the tested ranges of throughput, discount rate, and capital cost. Throughput has the largest effect on performance, but none of the tested combinations changes the overall conclusion that the project remains favorable.

5.4 Marion Project: Nickajack Industrial Park Rail Spur

5.4.1 Project Context and Role

The Marion project is an industrial-access case in which rail connectivity affects the operating position of a specific production site rather than a major regional freight gateway. The project is associated with the Nickajack Industrial Park and the Colonial Chemical, Inc., where inbound bulk material movement is linked directly to industrial production. In this setting, the relevant decision question is whether rail access can reduce truck-dependent final delivery, improve inbound supply reliability, and strengthen the operating position of a rail-served industrial site.

For TDOT, this project is informative because it represents a class of rail-connectivity investments that support industrial retention and site viability through short connecting infrastructure rather than large terminal expansion. Its benefit structure therefore differs from that of the Shelby project. Rather than depending on long-distance intermodal substitution across a high-volume freight corridor, the Marion project depends on whether a relatively short rail spur can remove a recurring truck transfer segment and improve site-level freight access.

5.4.2 Project Description and Implementation Assumptions

The Marion County project consists of constructing a new railroad spur, approximately 4,340 feet in length, to serve the Nickajack Industrial Park and the Colonial Chemical facility. The project is intended to provide direct rail access to the plant and remove the need for the final truck movement that currently occurs after railcars are received at the nearest CSX interchange in Bridgeport, Alabama.

The project represents a relatively modest industrial freight task. The evaluation assumptions indicate approximately 200 heavy freight trucks per year, equivalent to roughly 5,200 tons of annual material movement associated with bulk coconut oil service. The base-case capital cost is $3.584 million. Because several Marion inputs were documented in a later project year, they are normalized to the report's common 2019 basis before cross-project comparison.

For evaluation purposes, the pre-project condition is represented by a truck movement between the Bridgeport interchange and the Colonial Chemical facility, while the Build condition replaces most of that final truck segment with direct rail service and only a short final connection to the plant. The detailed scenario structure is presented in the following section.

5.4.3 Scenario Definition and Logistics Chains

The Marion project compares two scenarios. Scenario S0 is the No-Build baseline, in which railcars are received at the nearest interchange and the final 18-mile movement to the plant is completed by truck. Scenario S1 is the Build scenario, in which the new rail spur allows trains to reach the plant directly, reducing the truck-dependent final segment to a short final drayage movement near the plant. The scenario structure is summarized in Table 5-10.

Table 5-10 Scenario structure and annual activity measures for the Marion County project

Scenario	Leg	Segment	Mode	Distance (mi)	Annual Ton-miles
S0	1	Bridgeport Port to the facility	Truck	18.0	93,600
S1	1	Direct shipment to the new spur connection	Rail	8.0	41,600
	2	New spur connection to plant	Truck	0.6	3,120

Some Marion project-specific source values were documented in 2021, including selected sponsor-side cost and operating references. For cross-project comparison, those values are converted to constant 2019 dollars before they enter the project result tables.

5.4.4 Results: Phase I (Operational Costs)

The Marion project produces a weaker Phase I result than the Shelby project. The Build scenario reduces direct line-haul-related costs, including energy, labor and administration, equipment ownership, equipment maintenance, and infrastructure maintenance. However, those direct savings are more than offset by the increase in in-transit inventory cost associated with lower rail speed and added terminal dwell. Under the Marion assumptions used in this study, total annual operating cost increases from approximately $44.49 thousand under the baseline to $45.38 thousand under the Build scenario, resulting in an annual operating loss of approximately $0.89 thousand in constant 2019 dollars. Table 5-11 shows the annual operating cost comparison.

Table 5-11 Annual operating cost by scenario for the Marion County project (2019 dollars)

Cost component ($/year)	S0 Baseline	S1 Build
Energy cost	2,033.79	354.81
Labor and administrative cost	3,883.20	856.31
Equipment ownership cost	1,243.20	134.40
Equipment maintenance cost	686.40	98.12
Infrastructure maintenance cost	1,062.00	213.15
End-of-life infrastructure value (credit)	(348.71)	(156.31)
In-transit inventory cost	833.11	8,782.59
Transloading cost	35,100.00	35,100.00
Total annual operating cost	44,492.99	45,383.07

This result shows that the Marion project is not a long-haul truck-to-rail substitution case. The direct truck-cost reductions are real, but they occur on a relatively small freight task. The main offsetting effect is the time-related cost introduced by the rail-based movement, especially the terminal dwell assumption used in the evaluation. For that reason, the Marion project is better understood as an industrial site-access case in which logistics time and handling structure matter at least as much as line-haul substitution.

5.4.5 Results: Phase II (Public-Effect Costs)

The Phase II result shows a reduction in annual public-effect cost. Because the Build scenario replaces most of the truck movement with rail plus a short final drayage segment, the Marion project produces lower greenhouse-gas damage cost, lower criteria air-pollutant damage cost, and lower safety cost under the Build case. Under the Marion assumptions used in this report, total annual public-effect cost declines from approximately $3.23 thousand to $0.74 thousand, yielding annual public-effect savings of approximately $2.49 thousand. The annual public-effect cost comparison is reported in Table 5-12.

Table 5-12 Annual public-effect cost by scenario for the Marion County project (2019 dollars)

Externality category ($/year)	S0 Baseline	S1 Build
Greenhouse gas damage cost	650.45	66.00
Criteria air-pollutant damage cost	1,782.53	556.79
Safety cost	798.77	116.98
Total annual externality cost	3,231.75	739.77

Among the public-effect categories, the largest reduction occurs in criteria air-pollutant damage cost, followed by safety cost and greenhouse-gas damage cost. The absolute magnitude is much smaller than in the Shelby project because the Marion freight task is much smaller. Even so, the Phase II result shows that the project reduces truck-related emissions and safety exposure for the Colonial Chemical movement represented in the analysis.

These quantified Phase II values are limited to the Colonial Chemical movement represented in the analysis and do not include broader local development effects or additional present or future park users that may change the scale of public-effect benefit.

5.4.6 Results: Phase III (Economic Assessment and Investment Metrics)

The quantified Marion results indicate a much narrower margin than in the Shelby and Dyer projects. The annual operating loss of approximately $0.89 thousand is offset by annual publiceffect savings of approximately $2.49 thousand, yielding a combined annual net benefit of approximately $1.60 thousand. Even so, that annual margin remains small relative to the documented project capital cost of $3.584 million.

This result indicates that the Marion project is not a high-return line-haul substitution case. Instead, it is an industrial site-access project in which quantified public-effect gains are positive, but direct operating performance is constrained by low throughput, short movement length, and time-related cost under the rail-served alternative.

At the same time, the quantified result reported here is limited to the Colonial Chemical movement represented in the analysis. It does not include broader effects associated with industrial retention, site use, or additional park users that may depend on direct rail access. For TDOT, the Marion result should therefore be interpreted in two steps: first, as a narrowly quantified result with limited margin under the assumptions used here; and second, as a case in which broader site-support value may exist but is not included in the reported LL-BCA totals.

A further implication is that the Marion result is especially sensitive to assumptions about throughput, rail dwell, service speed, and the extent to which the spur removes the final truck transfer requirement. These variables matter because the quantified margin is narrow and because time-related cost plays a larger role here than in the Shelby and Dyer projects.

5.4.7 Further Economic and Development Effects

The quantified results of the Marion project in this chapter should not be interpreted as the full effect of the Nickajack Rail Spur project. The analysis was limited to the Colonial Chemical movement represented in the project evaluation, so the reported LL-BCA results do not capture the broader role of the spur within the industrial park. In this setting, the project functions not only as a freight-movement improvement, but also as a foundational asset that could influence site occupancy, industrial retention, business expansion, and the attractiveness of the park to additional rail-dependent users.

This distinction matters because rail-access projects may create value beyond the direct freight benefits captured in a BCA framework. If rail connectivity is necessary for a firm such as Colonial Chemical to maintain efficient operations, expand production, or avoid less efficient logistics arrangements, then the project's value extends beyond measured reductions in fuel, labor, inventory, emissions, and safety cost. The same logic can apply at the industrial-park level, where direct rail access may support additional site use and private investment more effectively than sites without rail service.

For TDOT, the Marion result should therefore be interpreted in two parts. First, the quantified LLBCA result remains narrow and assumption-sensitive because it is based only on the Colonial Chemical movement. Second, the project may also provide broader industrial-site-support value that is not included in the reported LL-BCA totals. Those broader effects were not monetized in this report, but they remain relevant when Marion is interpreted alongside more transportation driven projects such as the Shelby project.

5.5 Cross-Project Discussion

5.5.1 Comparison of Operating Results

Across the three projects, the Shelby County project produces the strongest Phase I result because it displaces a large volume of truck-intensive line-haul movement. The Dyer County project also produces a strong Phase I result, driven mainly by the energy advantage of rail in the long-haul movement. The Marion County project produces the weakest Phase I result because its direct truck-cost savings are limited by the small freight task and offset by time-related cost under the rail-served alternative. These results show that Phase I performance depends not only on whether truck movement is reduced, but also on freight volume, movement structure, and the additional dwell, handling, or inventory cost introduced by rail access.

5.5.2 Comparison of Public Effects

The same general pattern appears in the public-effect results. The Shelby project produces the largest quantified emissions and safety benefit because it shifts a high-volume freight task away from truck movement. The Dyer project produces the same directional result at a smaller absolute scale. The Marion project also produces positive public-effect savings because it reduces the truck portion of the representative movement, although the absolute magnitude is limited by the small size of the freight task. Across the three projects, the Phase II ranking therefore follows the scale of truck exposure removed from the baseline case.

5.5.3 Comparison of Investment Results

Investment results also differ clearly across the three projects. The Shelby County project produces the strongest investment result under both the operating-only and total-benefit frameworks. The Dyer County project also performs strongly under both frameworks and shows a favorable investment case. The Marion County project shows the smallest quantified margin and therefore requires more cautious interpretation because its result is more limited and more dependent on site-specific conditions. For TDOT, this comparison indicates that project type matters. High-volume gateway projects can generate large direct operating and public-effect benefits, while smaller industrial-access and siding projects can still be favorable but are more sensitive to freight-task scale, operating assumptions, and the scope of quantified benefits.

The three cases demonstrate that a single rail-connectivity framework can be applied across very different project types, but the source of value differs substantially across them. The Shelby project is driven by large recurring freight savings and strong public-effect reductions. The Dyer case remains positive at a smaller scale and illustrates the potential of modest siding improvements in regional industrial distribution. The Marion project shows that some industrialaccess projects may have limited quantified freight savings even when they still support broader site-level objectives. For TDOT, this distinction means that cross-project comparison should consider not only headline metrics, but also whether value is created primarily through recurring operating savings, public-effect reductions, or broader site-support effects.

5.6 Practical Value for TDOT

The principal output of this study was not a single benefit-cost figure, but a reusable evaluation structure for TDOT's rail-connectivity program. That structure includes a common assessment framework, project-specific scenario definitions, operating and public-effect result tables, lifecycle investment indicators, and sensitivity tests showing which assumptions most affect the reported results.

For TDOT, this structure serves three practical purposes. First, it provides a post-investment assessment of completed rail-connectivity projects available for review under the program. Second, it allows unlike projects to be compared on a common analytical basis without ignoring differences in local operating conditions. Third, it provides a repeatable method that can support future grant screening, project prioritization, funding justification, and program updates.

Chapter 5 brings these elements together in a form that TDOT can use directly. It translates project data, assumptions, and analytical methods into results that show which projects generate the strongest direct operating benefits, which projects add broader public-effect value, and which cases are most sensitive to assumptions such as throughput, capital cost, and project scope.

Chapter 6 Conclusion

This chapter summarizes the study's main findings and explains their implications for TDOT. It brings together the results of the three project analyses, discusses their relevance to rail-program prioritization, and presents recommendations for future project evaluation, project development, and funding justification. This chapter also shows how a common evaluation framework improves comparison of rail-connectivity investments across different project types and local conditions.

6.1 Summary of Findings

This study evaluated completed TDOT rail-connectivity investments using a LL-BCA framework. The framework separates direct freight and logistics effects from monetized environmental and safety effects and then combines both in LCA. The study was designed not only to determine whether individual projects produced recurring transportation benefits, but also to show how those benefits were generated, how sensitive they were to key assumptions, and how the results can inform future TDOT program decisions.

The evaluated projects show that rail-connectivity investments should not be judged by a single summary measure. Project performance depends on the interaction among freight volume, haul distance, handling structure, inventory time, capital cost, and monetized public effects such as emissions reduction and safety improvement. For that reason, the LL-BCA framework provides TDOT with a stronger basis for evaluation than a single overall result. It shows whether a project is supported primarily by direct operating savings, by public effects, or by a combination of both.

Among the completed projects evaluated in this report, the Shelby project produced the strongest result. On an operating-only basis, it generated approximately $3.60 million in annual savings and produced a 35-year NPV of $44.70 million with a BCR of 24.34. When monetized environmental and safety effects were included, total NPV increased to $68.58 million, and the total BCR increased to 36.81.

The Dyer County project produced a strongly positive result. The evaluated results indicate approximately $873,919 in annual direct operating savings and approximately $926,011 in total annual economic benefit including externalities. Over a 35-year analysis period at a 7 percent real discount rate, the project produced an operating-only NPV of $10,775,218 and a BCR of 20.95, and a total NPV of $11,449,681 and a BCR of 22.20.

The Marion project must be interpreted more cautiously. Its quantified transportation and externality analysis was based only on the Colonial Chemical, Inc. movement represented in the evaluation and therefore captured only part of the Nickajack Rail Spur's potential effect. Under that narrow-quantified scope, the direct operating result was weak, and the public-effect result was positive but modest. At the same time, the project may provide broader value through industrial access, employment support, private investment, and industrial park development that were not monetized in the reported LL-BCA results.

This study points to an important implication for TDOT's future rail-connectivity evaluations. Railaccess projects often serve multiple public functions at the same time. They may reduce freight cost, improve industrial site access, reduce truck exposure on public roads, lower emissions, and support local economic development. TDOT therefore needs a framework that separates these effect categories if unlike projects are to be compared in a consistent and defensible manner.

6.2 Implications for TDOT Program Prioritization

The results indicate that TDOT should not prioritize rail-connectivity projects by a single summary ranking alone. Cross-project comparison requires attention to at least three dimensions: lifecycle economic efficiency, the magnitude and composition of monetized public effects, and the implementation conditions under which those results are produced. A project with a strong BCR may differ substantially from another project in the source of its value, the scale of its freight task, and its sensitivity to assumptions about throughput, handling, dwell, or capital cost.

The three evaluated projects illustrate different patterns of justification. The Shelby project is a freight-efficiency case in which large recurring operating savings and substantial public-effect reductions reinforce one another. The Dyer project also produces positive results, but at a smaller scale and with a narrower margin, showing that smaller rail-access projects can remain viable when freight demand, haul distance, and capital cost are aligned appropriately. The Marion project represents a different type of case. Its quantified transportation evidence captures only part of the spur's potential role, which means that its narrow-quantified margin should not be interpreted in the same way as the margin in a high-volume corridor project.

These differences matter for TDOT because rail-access projects do not all create value in the same way. Some are supported mainly by direct freight efficiency. Some combine direct savings with measurable environmental and safety gains. Others may serve a broader industrial-access or site-support function for which the quantified freight result captures only part of the project's public purpose. Program prioritization should therefore distinguish between differences in project scale and differences in project type.

The results also imply that projects with narrower quantified margins require more careful interpretation. In those cases, the strength of the result depends more heavily on local operating conditions, project scope, and the boundary of what is included in the quantified analysis. This is especially relevant for industrial-access cases such as Marion, where the quantified result is tied to a specific identified movement and does not fully represent broader site-level or park-level effects. For TDOT, this means that cross-project comparison should consider not only headline metrics, but also the type of value each project is expected to create and the scope of evidence on which that value is assessed.

6.3 Strategic Recommendations

Five strategic recommendations follow from the findings of this study. These recommendations are based on the cross-project results and are intended to guide future project screening, evaluation, and program development for TDOT's rail-connectivity efforts.

First, TDOT should continue using a common LL-BCA framework for future rail-connectivity evaluation. The results of this study show that rail-access projects create value through different channels, and those channels should be separated rather than collapsed into a single summary measure. A common framework allows TDOT to distinguish direct operating savings from monetized environmental and safety effects, compare unlike projects on a consistent basis, and prepare stronger economic justification for both state and federal funding programs.

Second, TDOT should use the Shelby project as a benchmark case for future screening and program reporting. Among the completed projects evaluated in this study, Shelby produced the strongest result under both the operating-only basis and the total economic basis. It provides a clear example of a high-volume rail-connectivity investment in which large recurring freight savings and substantial public-effect reductions reinforce one another. For future project review, Shelby can serve as a reference point for identifying the characteristics of rail-connectivity investments that generate strong direct and public returns.

Third, TDOT should evaluate smaller rail-access projects based on project fit rather than project size alone. The Dyer project shows that smaller projects can still produce positive operating and lifecycle results when freight demand, haul distance, and capital cost are aligned appropriately. This implies that screening should not rely only on project scale. Instead, TDOT should ask whether the proposed improvement matches the freight task it is intended to serve and whether the expected recurring benefits are sufficient for the size and cost of the investment.

Fourth, TDOT should preserve the data needed to evaluate broader industrial and development effects in projects whose value may extend beyond quantified transportation benefits. The Marion project shows why this is necessary. In that case, the quantified results were based only on the Colonial Chemical movement represented in the analysis, which means the reported LLBCA totals captured only part of the spur's potential effect. For projects of this type, TDOT should preserve evidence on plant retention, site use, additional industrial occupancy, follow-on private investment, and related development outcomes whenever those outcomes form part of the project rationale. Without that information, projects with a real site-support or development role may appear weaker than they actually are under a narrow freight-only calculation.

Fifth, TDOT should place explicit emphasis on validating throughput assumptions, operating conditions, and capital cost during project development. The sensitivity analysis in this study shows that throughput, haul distance, dwell assumptions, service conditions, discount rate, and capital cost can materially affect annual benefits and LCA results. For future project development, TDOT should therefore require early documentation of key operating assumptions and should update those assumptions as better project-specific information becomes available. Capital-cost validation is especially important because even relatively strong recurring benefits can be weakened if project cost grows materially during design and implementation.

Together, these recommendations suggest that future rail-connectivity review should be structured, comparative, and evidence-based. Some projects will be justified mainly by direct freight efficiency, some by a combination of operating and public-effect benefits, and some by a broader industrial-access role that requires additional supporting evidence beyond the quantified freight ledger. TDOT's evaluation process should be able to recognize those differences explicitly rather than forcing all projects into the same narrow definition of value.

6.4 Final Observations

Rail-connectivity investments in Tennessee should not be treated as a single project type. Some projects are high-volume freight-efficiency investments. Some are smaller industrial-access projects. Others may function mainly as access infrastructure that supports economic development. The value of this report therefore lies not only in the project findings themselves, but also in showing that these different project types can still be evaluated under one consistent structure without losing the differences that matter for TDOT decisions.

This report also points to an important principle for future TDOT project evaluation. BCA is most useful when it shows not only whether a project produces a positive result, but also what kind of value the project creates and where the limits of the available evidence remain. For TDOT, that approach supports better project selection, stronger funding justification, and a clearer understanding of how rail investments contribute to freight movement, industrial access, economic development, and public benefits.

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