Route Selection and Design of a Coal Shuttle Railroad: Experiences of a Recent Railroad Engineering Graduate

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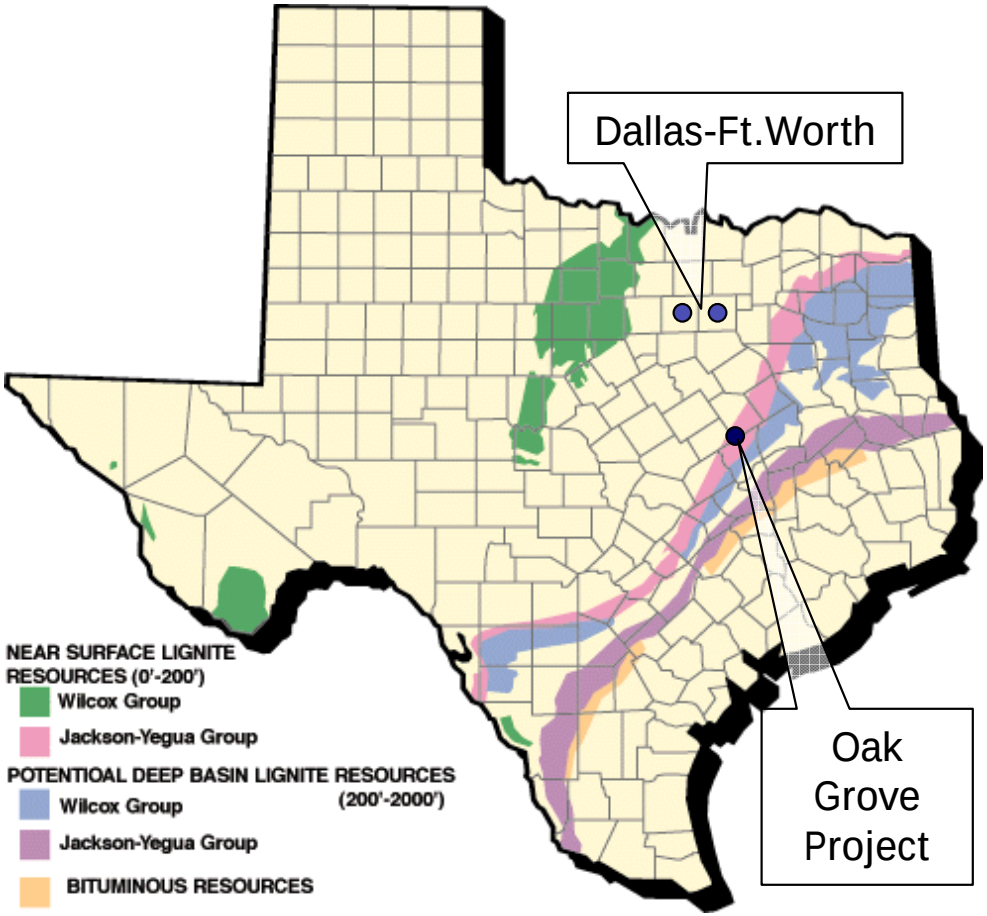
Outline

- Project Background and Overview
- Route and Alignment Selection
  - Comparison techniques
- Detailed Alignment Design
  - Snags and solutions
- Construction
  - Expecting the unexpected

Coal and Power in Texas

- Texas Lignite mined locally for electricital generation
- Several plants use short-haul railroads to transport lignite
- Oak Grove project currently under construction will use an 11-mile railroad



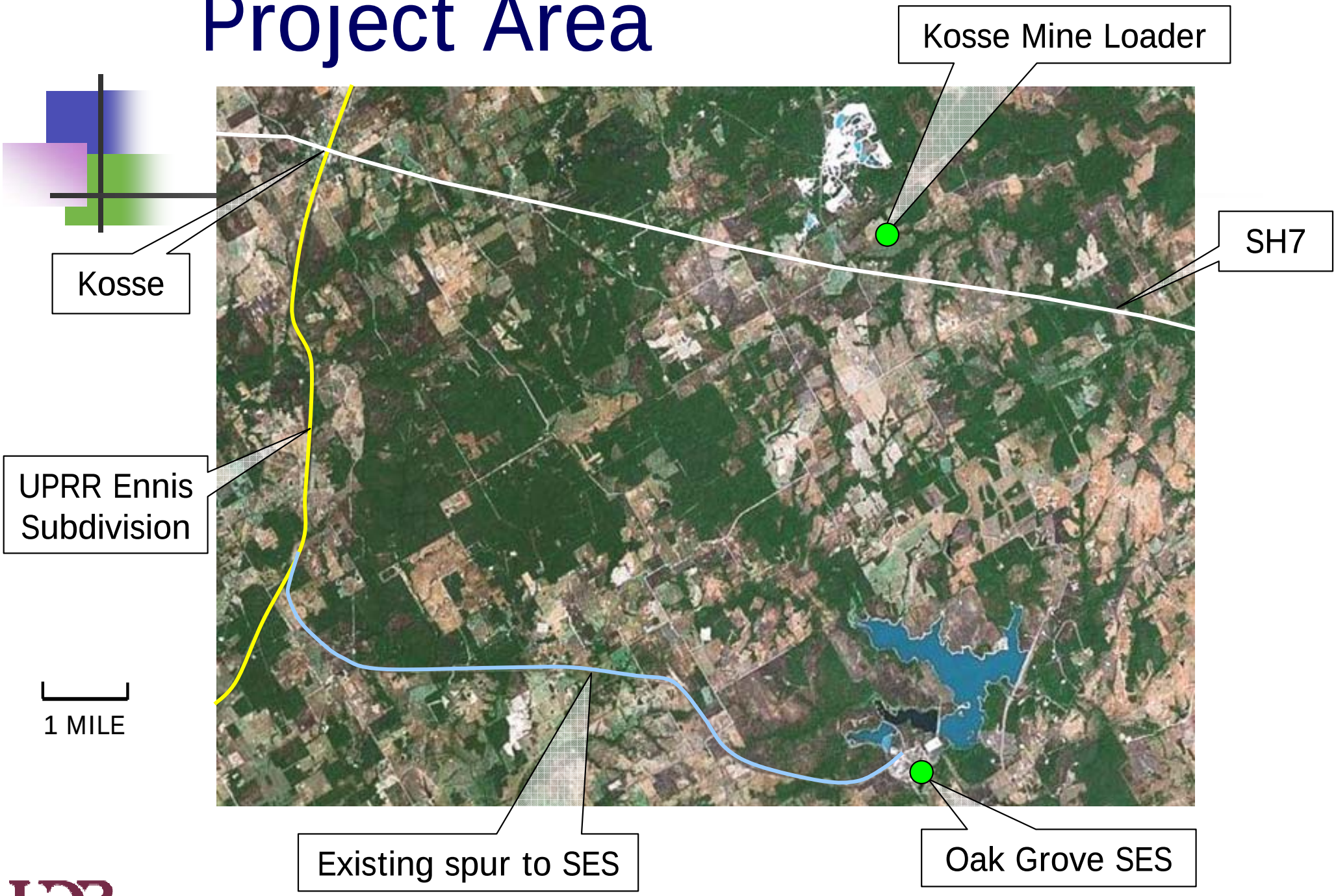
Oak Grove Project

- Twin Oak Reservoir
- Oak Grove Steam Electric Station (SES)
  - Two lignite-fired generation units, 1600 MW
  - Unit 1 online late 2009, Unit 2 in 2010
- Kosse Lignite Mine
- Oak Grove Railroad
- Owner: Luminant Energy (formerly TXU)

Oak Grove Railroad

- Deliver lignite from Kosse Mine to Oak Grove SES on dedicated rail line
- Approximately 9 million tons per year
- Two 40-car trains, push-pull operation
- Limited lignite storage at plant
  - needs to be highly reliable system
- Self contained with maintenance facility

Project Area



The Challenge – HDR Tasks

- Oak Grove 11-Mile Railroad
  - Railroad route/alignment study
  - Environmental permitting
  - Detailed design of preferred alignment and mine site yard facilities
  - Bidding and general construction support
- Oak Grove SES Plant Site
  - Design reconfigured plant site trackage
    - lignite unloading
    - Future bottom ash and flyash opertions

Project Timeline

- Route/alignment study: June ‘05 - Jan ‘06
- Environmental permitting: Oct ‘05 – May ‘06
- Detailed design: May ‘06 – May ‘07
- Earthwork construction: Jan ‘07 – Jan ‘08
- Bridge construction: Jul ‘07 – Dec ’07
- Trackwork construction: Jan ’08 – Fall ’08
- In-Service for “first-fire”: Early 2009

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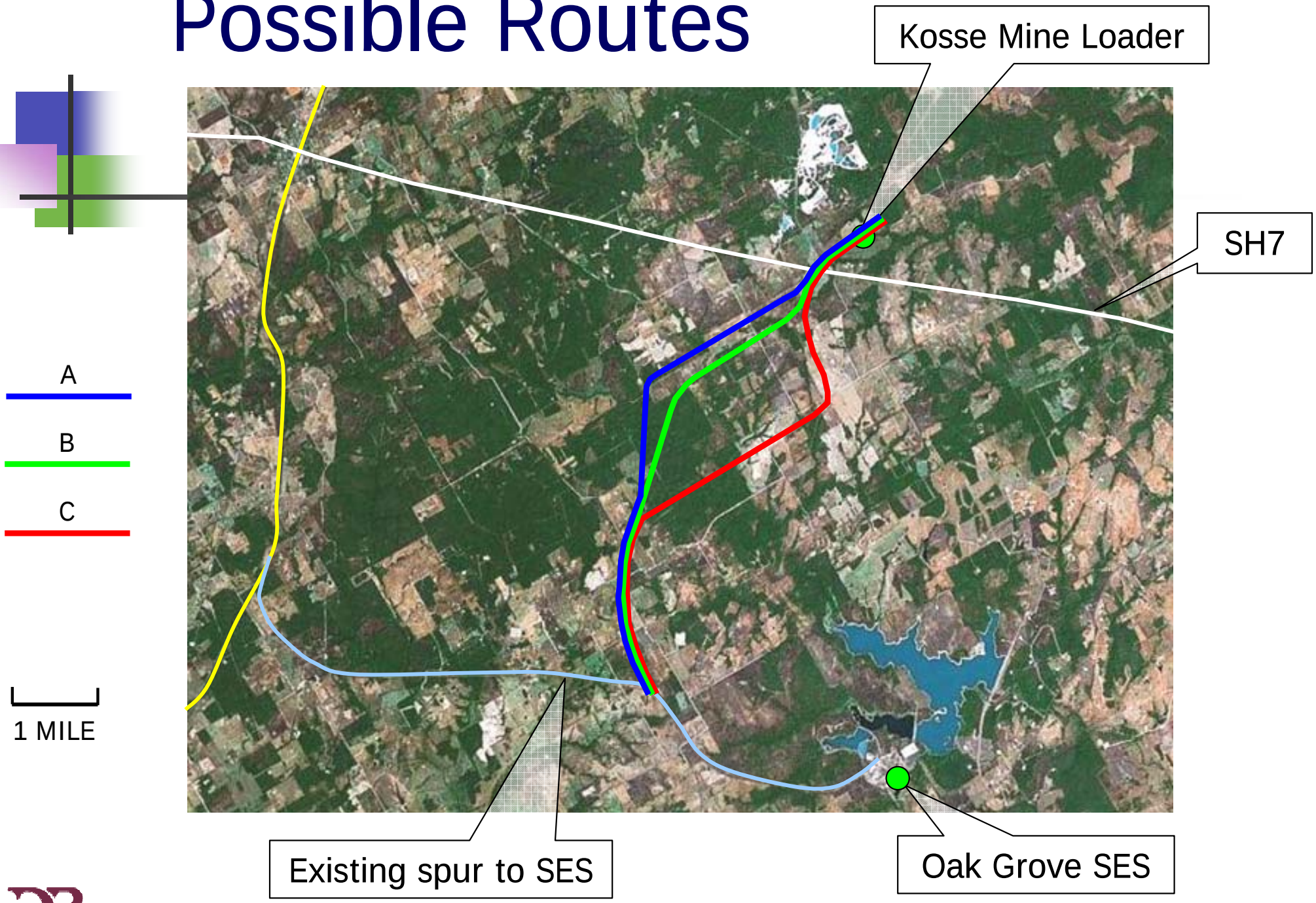
Route/Alignment Study

- Develop three possible routes meeting design criteria
  - 40mph operation
  - 1 percent grades desirable
  - 12 MGT annual traffic
- Evaluate routes and select preferred alternative
- Develop feasible alignment along preferred route alternative

Possible Routes



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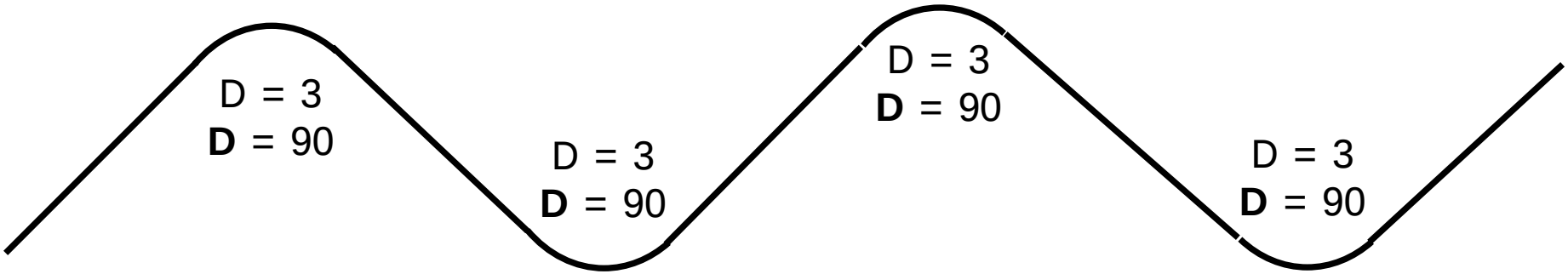
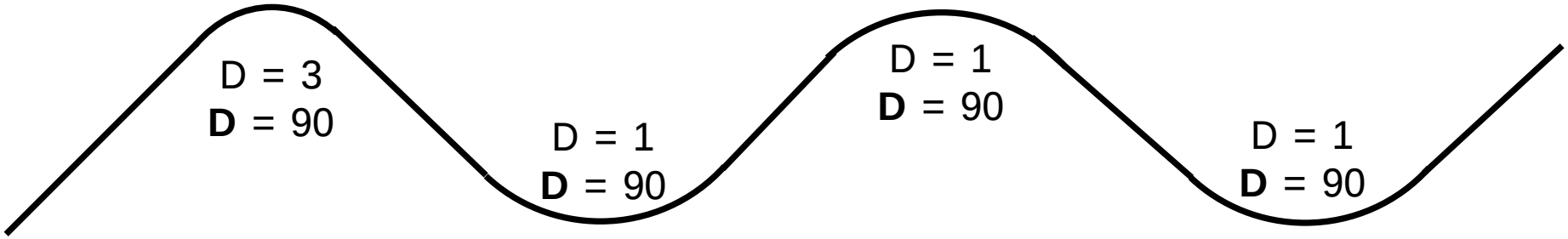
Which is preferred?

- "Minimize length, curves and grades" – Wellington & AREMA
- How to compare "curviness"?
  - Tightest degree curve
  - Total degrees central angle = **S** delta
  - "Curve Index" = **S** delta x degree
- How to compare "hilliness"?
  - Ruling grade
  - Rise and Fall = **S** length x |grade|
  - "Grade Index" = **S** length x grade x grade

Need for "Curve Index"

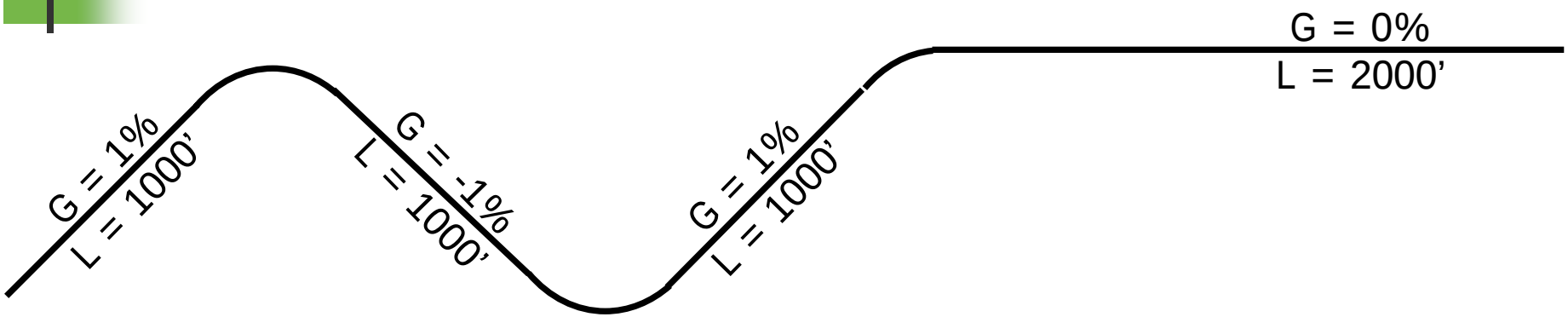


Tightest Curve = 3 degrees Total Central Angle = 360 degrees
"Curve Index" = 1080

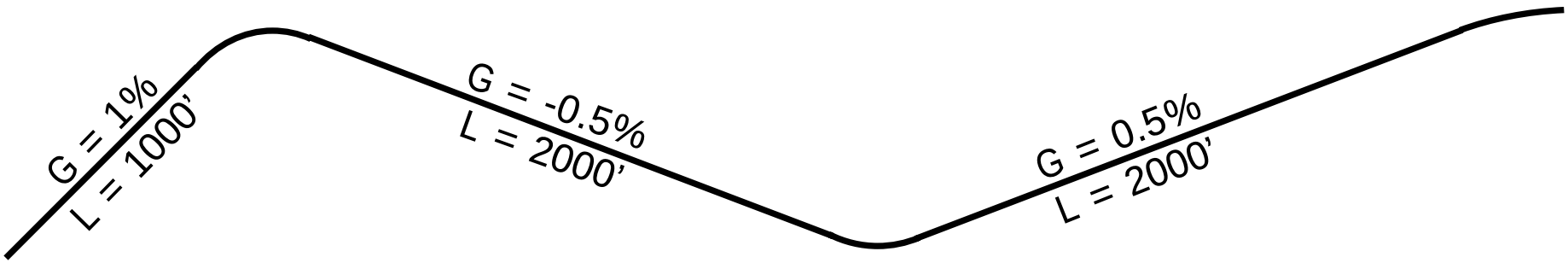


Tightest Curve = 3 degrees Total Central Angle = 360 degrees
"Curve Index" = 540

Need for "Grade Index"



Ruling Grade = 1.0% Rise and Fall = 30 feet "Grade Index" = 30



Ruling Grade = 1.0% Rise and Fall = 30 feet "Grade Index" = 20

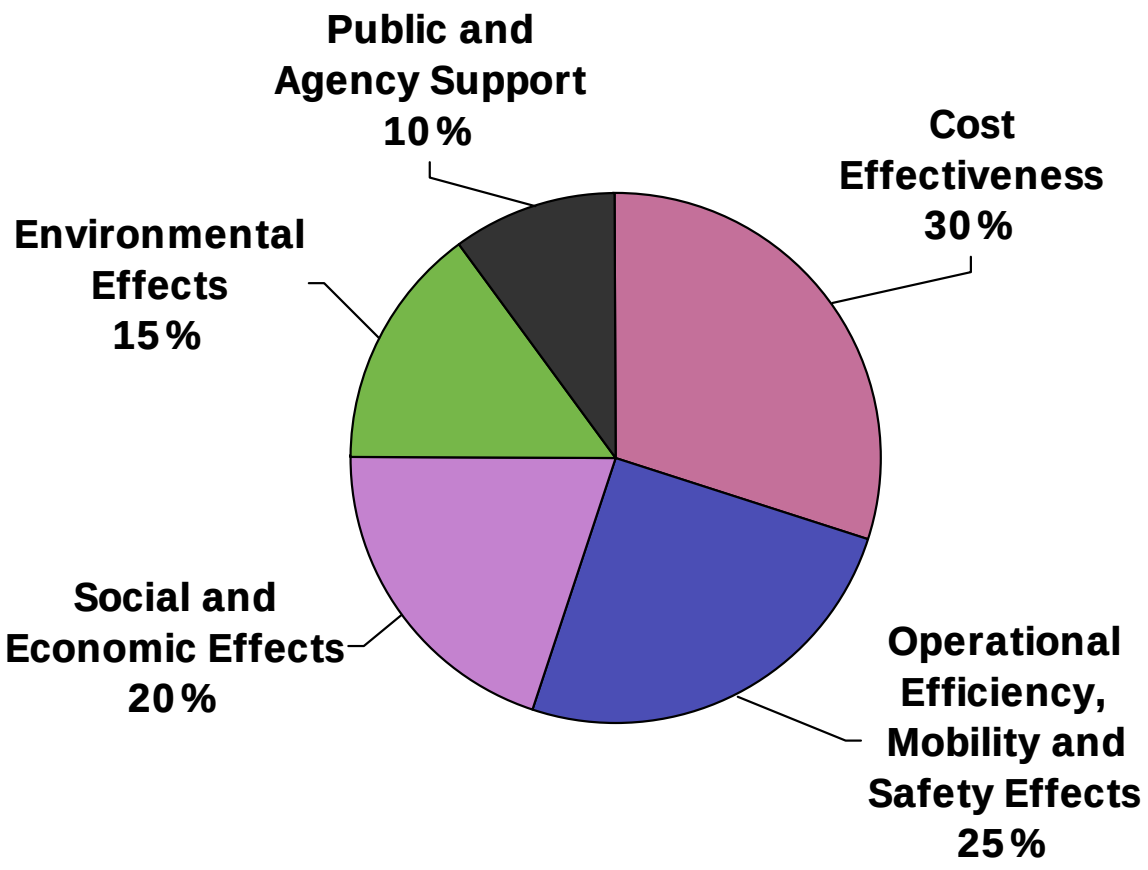
Route Characteristics

Parameter		A	B	C
Length	New Construction (mi)	9.05	**8.98**	9.58
	Total Route Length (mi)	12.55	**12.48**	13.08
Curvature	Total Degrees	**144**	158	258
	Curve Index	**285**	357	598
Grade	Ruling Grade	1.00	1.00	1.00
	Rise and Fall	**127**	146	148
	Grade Index	**93**	118	109
Bridges and Drainage	River Crossings	0	0	0
	Stream/Creek Crossings	9	9	9
	Culverts (lf)	3188	3318	**2657**
Road Crossings	Grade Separations	1	1	1
	Grade Crossings	8	8	8
Property Owners	Parcels Crossed / ROW (ac)	9 / 148	7 / 116	**0 / 0**

Matrix Analysis Approach

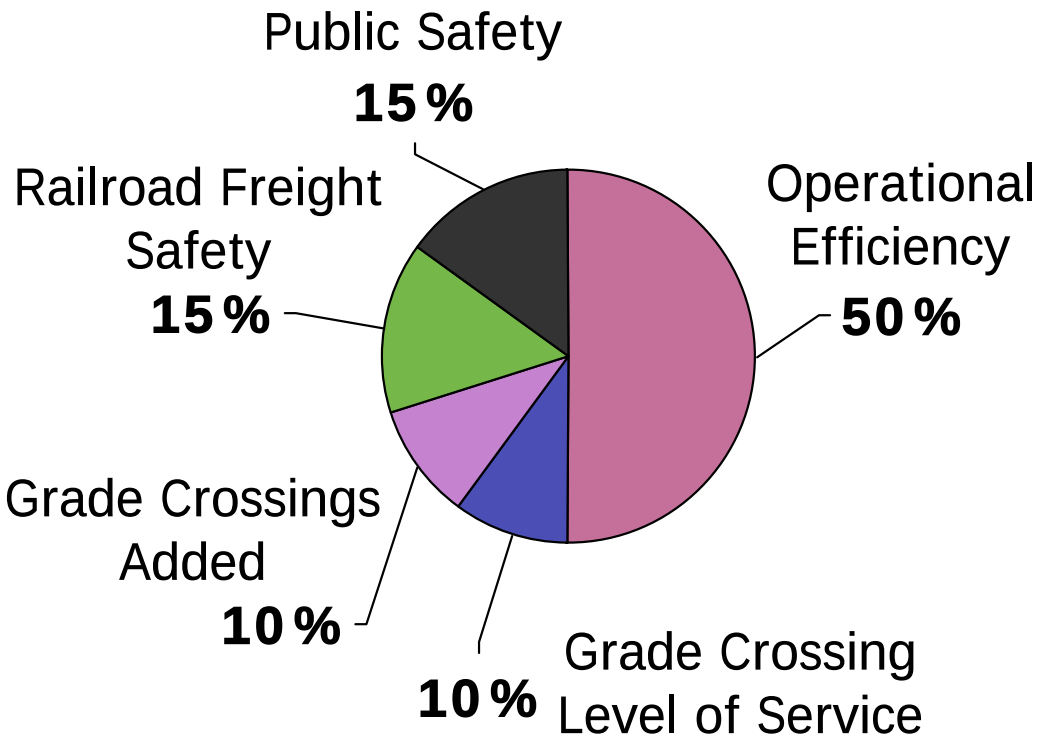
- Allows for comparison of alignments relative to multiple decision criteria
- Alignments judged in five evaluation categories
- Categories subdivided into several criterion
- Double weight scoring system
  - Criterion scores weighted to determine category score
  - Category scores weighted to determine overall score for the alignment

Evaluation Categories

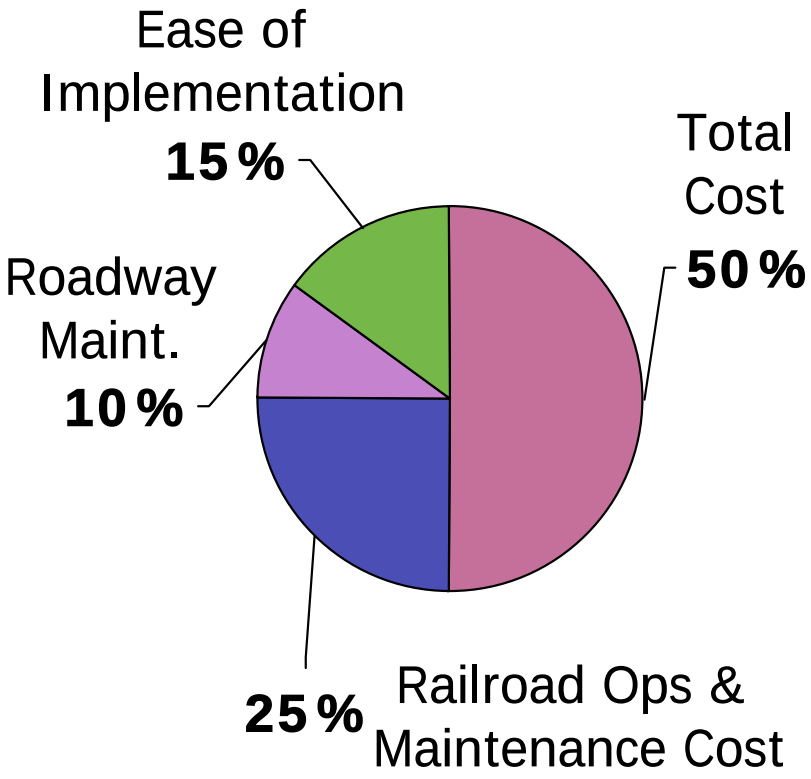


Sample Criterion

Operational Efficiency, Mobility and Safety Effects (25%)



Cost Effectiveness (30%)



Scoring Results

Category	A	B	C
Efficiency, Mobility and Safety	**88**	**88**	75
Cost-Effectiveness	98	98	**110**
Social and Economic Effects	56	56	**90**
Environmental Effects	49	**57**	51
Public and Agency Support	27	27	**37**
Total	316	325	**362**

Preferred Alignment

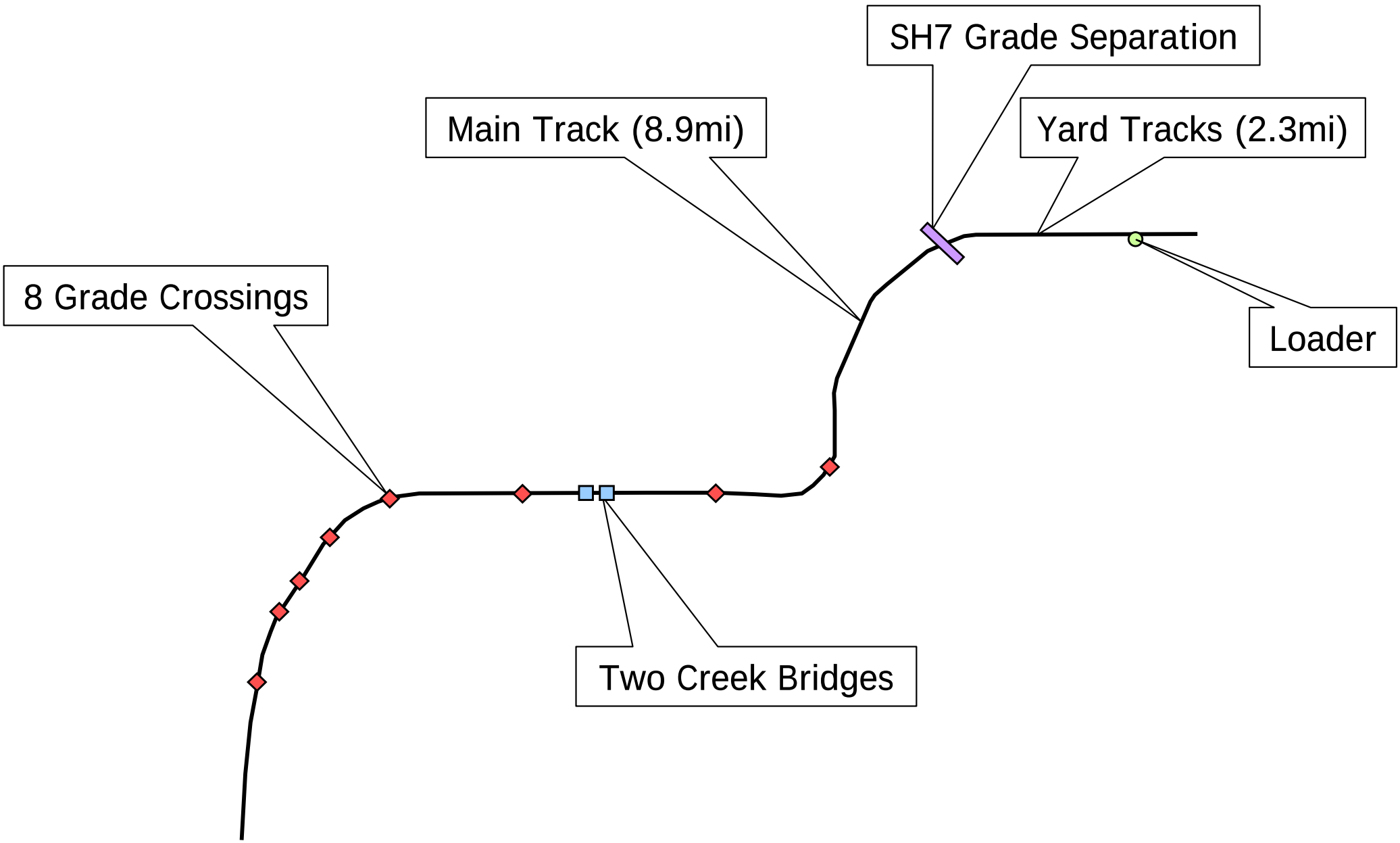
- Alternative C selected as preferred alignment for detailed design
- Deciding factors:
  - Minimizes right-of-way impacts
  - Ease of implementation
  - Public support
  - Cost of construction
  - Shorter alignments had environmental and/or access and constructability issues

Route Study Learning Points

- Beyond Wellington: need to consider range of environmental and social factors, not just engineering geometry and cost
- Curve Index and Grade Index are tools to quickly compare efficiency of alternatives
- Matrix analysis approach can weight various criteria relative to their importance and allow for easy comparisons between alternatives

Detailed Design

- Develop detailed design package for preferred alignment
  - Planset covering all construction tasks
  - Standard details
  - Specifications for earthwork, track and bridge
- Designed with MicroStation and Bentley InRail SelectCAD

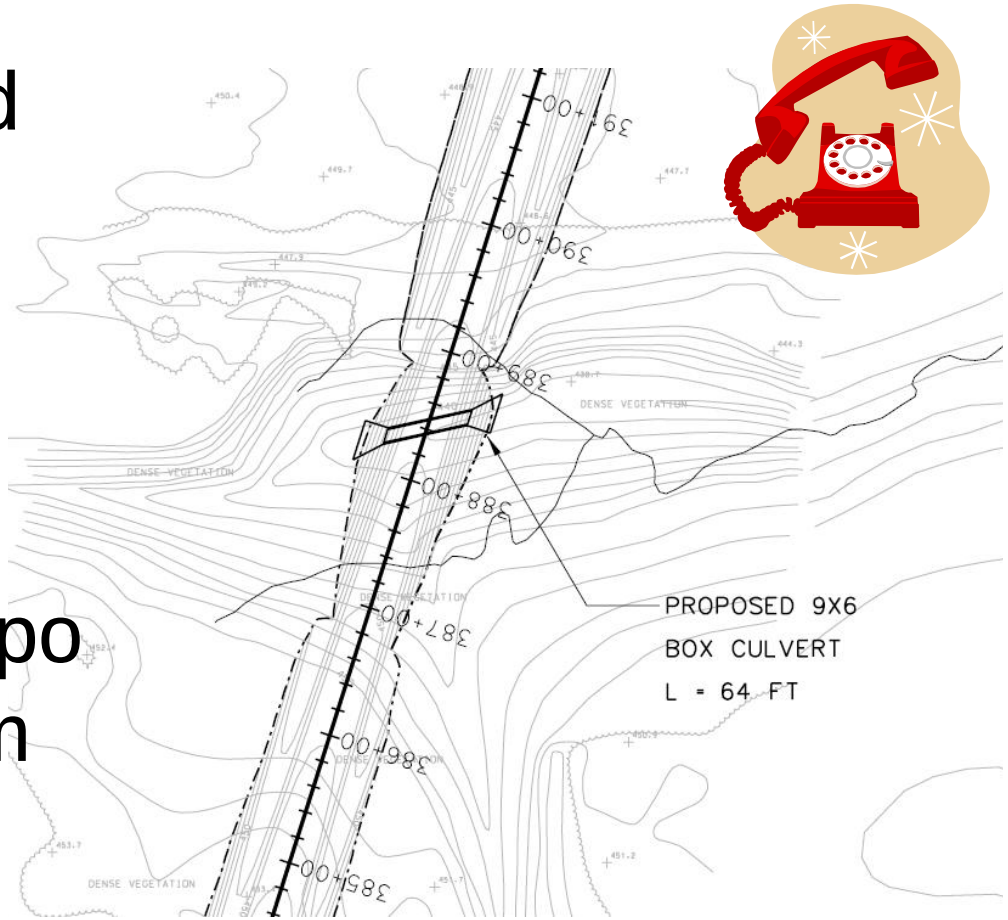

SH7 Grade Separation
Main Track (8.9mi)
Yard Tracks (2.3mi)
8 Grade Crossings
Loader
Two Creek Bridges

Detailed Design Workflow

- Aerial survey – 1000’ strip – 1’ contours
- Geotechnical field investigation
- Track design
  - Horizontal and vertical geometry
  - Subgrade, earthwork and basic drainage
  - Culverts and special ditches
  - Roadway crossings and signage
- Bridge design (by HDR bridge group)

Snag: Aerial Survey and Vegetation

- Aerial survey conducted in January 2006 to generate design topo
- Vegetation obscured many stream channels
- Culverts designed to topo don't match GPS stream traces used for Corps permit!!!



Solution:
Aerial Survey and Vegetation

- Tried to incorporate GPS traces into aerial topo date but some differences too great
- Conduct ground survey at key jurisdictional water crossings
- Replaced aerial topo with ground survey data then redesigned earthwork and culverts

Snag: Horizontal Obstructions

- Unmarked pioneer graves and abandoned well near working alignment
- Fortunately outside limits of cut/fill construction
- Alternative solutions if needed:
  - Steepen side slopes
  - Retaining walls
  - realignment

Crossing Streams & Floodplains

- Bridges at Duck Creek and Pool Branch, both in FEMA designated floodplains
- Railroad must create “no rise” in floodplain – HEC-RAS analysis
- How to set profile across bridge?
  - Too high = costly fill and tall bridge bents
  - Too low = interferes with flood flows and unnecessary grades

Top of Rail Elevation over Bridges

- Baseline: 100-year water surface elevation from FEMA flood maps
- Add 2’ of freeboard to structure low chord to clear debris during flood
- Add structure depth approx = span/12
- Add allowance for deck, ballast, track

- Total is 7 feet above flood elevation
- Use to set low point of sag curve over Duck Creek

Duck Creek Bridge – 170’

Duck Creek
5-10’x10’ Relief Culvert

Snag:
Mine Loader Elevation

- Confused top of subgrade with top of rail elevation at mine loader
- Loader designed and parts fabricated
- Need to lower railroad 3 feet at loader
- Grades allowed redesign for clearance
- Added 3 feet of climb for loaded train starting from stop up the ruling grade!

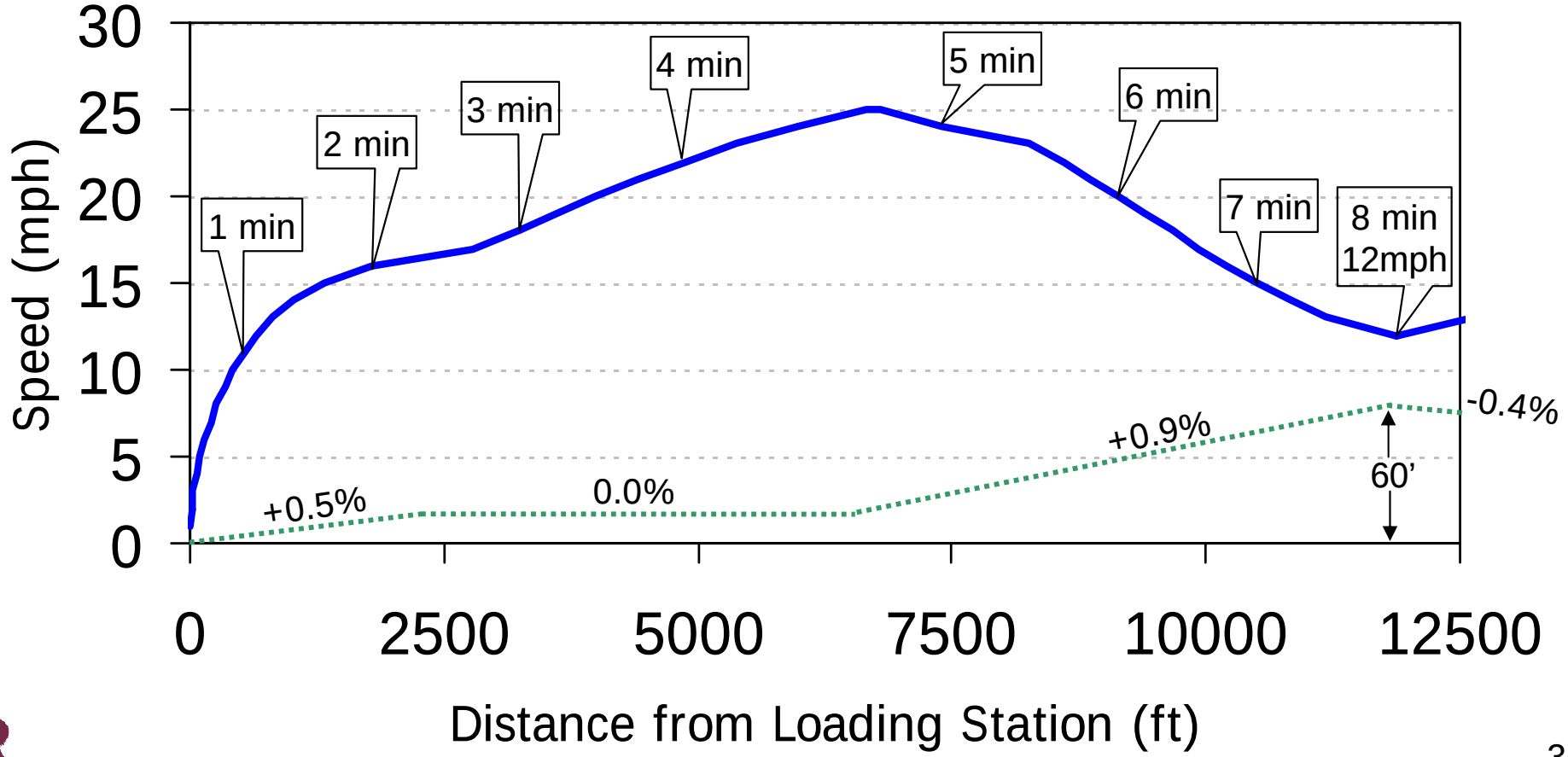
Solution: Train Performance Calculation

- Change in elevation at loader negated previous operations analysis by Canac
- Volunteered to run analysis
- Went back to U of I grad school spreadsheet for train acceleration

Speed	TE	R	F'a	F'a bar	L step	T step	L tot (ft)	T tot (s)
1	100880	62581	7.44					
2	100880	62818	7.39	7.42	28	13	28	13
3	100880	63059	7.35	7.37	47	13	76	26
etc...								

Train Performance Calculation: SD50 and Loaded 40-car Train

- Accelerating from rest at loading station



Used Locomotive Shopping

- “We’re up here at NRE in Mt. Vernon looking at used SD50s and wanted your opinion…”
- Advised client on features to look for such as traction control, de-rating etc.
- Use ALL of your railroad knowledge to assist client: value-added service!

Detailed Design Learning Points

- Ground survey is still important
- Leave room for expansion in yards and industrial track designs
- You can’t miss everything, but miss the expensive things
- Bridge basics help set efficient profiles
- Use full rail knowledge of operations to optimize design and aid client

Bidding and Construction

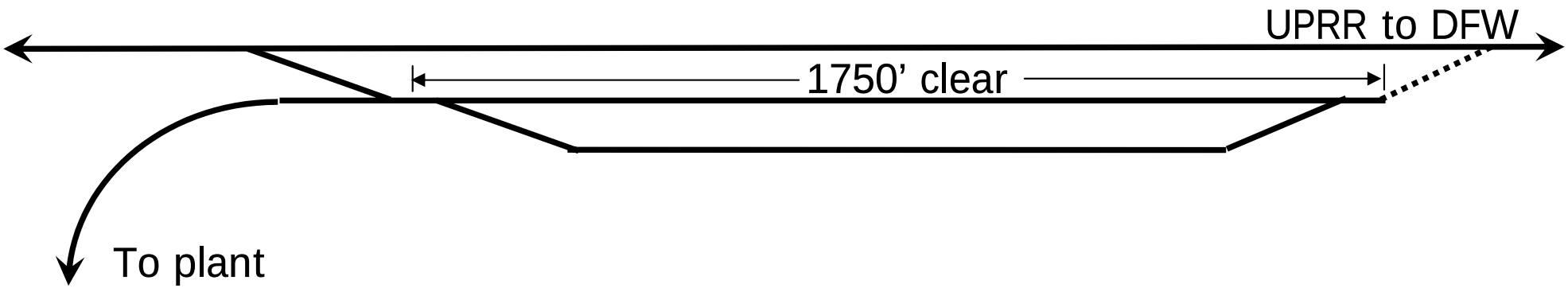
- Detailed design yielded 230-sheet planset
- Bidding also required:
  - Specifications (track, earthwork, bridge)
  - Material breakdowns and bid tabulations
- Construction phase also entailed advising owner on suitability of materials procured by the contractor

Material Lead Times

- Time to procure materials can hamper fast-track projects
  - Timber ties – 9 to 12 months
  - Rail – 6 months
  - Special trackwork – 6 to 8 months
  - Ballast – wait for break in Class 1 poduction schedule
- Price volatility and fuel charges hamper getting a fixed price from suppliers

Snag: UPRR Connection and CWR Train

- Facing point turnout at UPRR removed

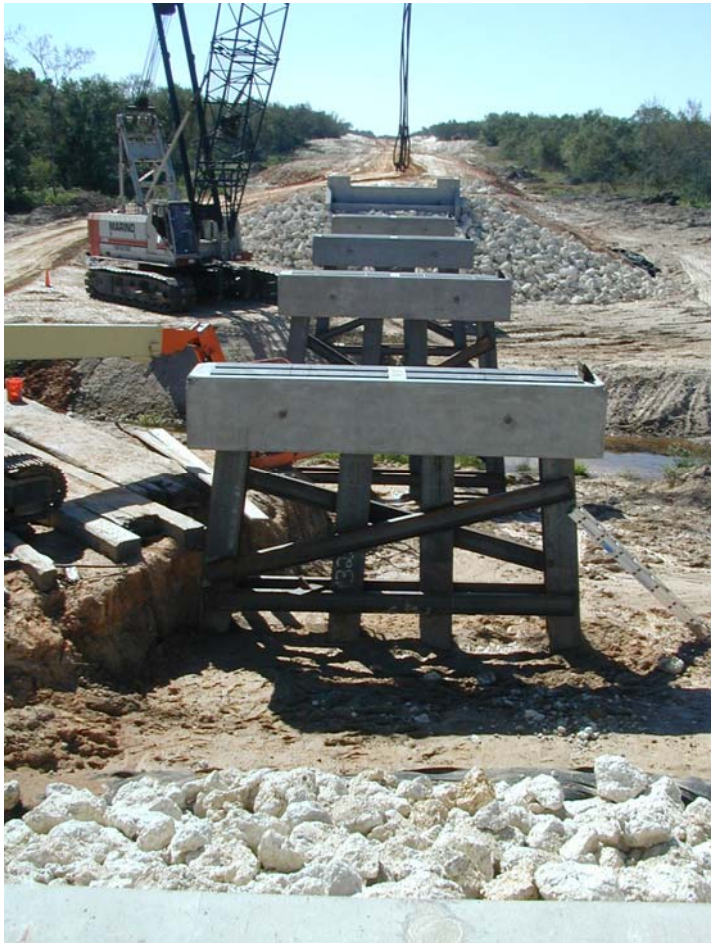


- Contractors to use 1600’ CWR strings
- CWR train: ramp & threader cars, two locos
- Can’t bring 1850’ train into plant!

Solution:
On-Site Rail Welding Plant

Construction Progress: Earthwork and Subgrade

Construction Progress: Duck Creek Bridge



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Construction Progress: Subballast

Trackwork Progress: Tie Layout

Trackwork Progress: Plating

Trackwork Progress: Threading Rail and Spiking

Trackwork Progress: Skeleton Track

Summary

- Can find oneself designing a “whole new railroad” a few years out of school
- Modern alignment study considers many more factors than just rail geometry and cost
- Rail design is more than just track
- Expect the unexpected and be creative!