Infrastructure Needs:
North Dakota’s County, Township, & Tribal Roads & Bridges
2015-2034

July 8, 2014

Upper Great Plains Transportation Institute
North Dakota State University
Contents

- History/purpose of road studies
- Data collection/field studies
- Major factors influencing results
- Analysis procedures/models
- Results and distributions of impacts
  - Region
  - Time period
- Next steps
Road Infrastructure Studies

- 2010 study: UGPTI estimated road investment needs for the 2011 session
  - 21,500 new wells & increased ag. production
- 2012 study: updated investment needs
  - 46,000 new wells, ag. production, & initial bridge study
- Current study: more comprehensive data
  - Higher roadway costs, ag. production, & 60,000 new wells
Study Horizon

- 20 year time frame
- Traffic and investment needs estimated annually
- Results summarized by:
  - Biennium
  - Region
- Detailed results (by)
  - County
  - Jurisdiction
### Key Factors in Road Study (1)

<table>
<thead>
<tr>
<th>Oil and Gas</th>
<th>Agriculture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of wells</td>
<td>Cultivated acres</td>
</tr>
<tr>
<td>Well locations</td>
<td>Crop mix</td>
</tr>
<tr>
<td>Production rate/curve</td>
<td>Yield</td>
</tr>
<tr>
<td>Inputs/outputs</td>
<td>Crop densities</td>
</tr>
<tr>
<td>Gathering pipeline</td>
<td>Elevator network</td>
</tr>
</tbody>
</table>
### Key Factors in Road Study (2)

<table>
<thead>
<tr>
<th>Traffic</th>
<th>Road</th>
</tr>
</thead>
<tbody>
<tr>
<td>Truck trips</td>
<td>Surface type</td>
</tr>
<tr>
<td>Truck axles/weights</td>
<td>Width &amp; design</td>
</tr>
<tr>
<td>ESALs</td>
<td>Age &amp; condition</td>
</tr>
<tr>
<td>Avg. Daily Traffic</td>
<td>Soil</td>
</tr>
</tbody>
</table>
## Data Sources (1)

<table>
<thead>
<tr>
<th>Type</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil production</td>
<td>ND Oil &amp; Gas Division</td>
</tr>
<tr>
<td>Pipeline/transload</td>
<td>ND Pipeline Authority</td>
</tr>
<tr>
<td>network</td>
<td></td>
</tr>
<tr>
<td>Base road network</td>
<td>NDDOT GIS Hub</td>
</tr>
<tr>
<td>Crop production</td>
<td>USDA-NASS</td>
</tr>
<tr>
<td>Elevator demand</td>
<td>ND PSC</td>
</tr>
<tr>
<td>Data Sources (2)</td>
<td></td>
</tr>
<tr>
<td>---------------------------</td>
<td>--------------------------------------</td>
</tr>
<tr>
<td>Traffic</td>
<td>Vehicle counts and classifications</td>
</tr>
<tr>
<td></td>
<td>Surveys/elevator reports</td>
</tr>
<tr>
<td>Paved road condition</td>
<td>Pathways/surveys</td>
</tr>
<tr>
<td>Paved road structure</td>
<td>Falling Weight Deflector</td>
</tr>
<tr>
<td></td>
<td>Ground Penetrating Radar</td>
</tr>
<tr>
<td>Unpaved roads</td>
<td>Surveys</td>
</tr>
</tbody>
</table>
1000+ counts
670 classifications

County Traffic Counts
- Volume Only
- Truck Classification

2013
Pavement Data Collection

• Condition data
  – NDDOT Pathway van
  – Summer/fall 2013
  – 4,786 miles of paved county roads

• Pavement and shoulder width data
  – Scaled from video images – 4500 miles
Pavement Data Collection

- Non-destructive testing - verify prior estimates on subgrade strength
  - Falling Weight Deflectometer (FWD) and Ground Penetrating Radar (GPR)
  - Western ND – all rural pavements not recently improved, not under construction, and not in failure state (785 mi)
  - Eastern ND – selected based on agricultural production facilities and other major traffic generators (734 mi)
Modeled Movements

• Agriculture
  – Wheat (including durum), corn, soybeans, barley, canola, sunflowers, sugar beets, potatoes, & beans
  – Fertilizer movements
  – Transshipments

• Oil Exploration/Production
  – Freshwater, sand, equipment, supplies, pipe, outbound saltwater, & outbound crude oil
Agriculture Production Forecasts

- Production data: ND-NASS
- Production estimated at township level
- Elevator and plant demands from NDPSC and industry groups
- Forecasts of future production, yield and mix derived from multiple sources
  - USDA/NASS
  - NDSU/Extension
  - Industry
Oil Development

- 2,300 truck trips per new well (drilling related)
  - 3 million gallons of freshwater
  - 4 million pounds of sand
- Initial production (IP) rate varies by county
- Outbound oil to transload locations
  - Base year: 67% truck, 33% pipe
  - 2024: 20% truck, 80% pipe,
  - 2,400 new miles of gathering pipeline/year
<table>
<thead>
<tr>
<th>Forecasting/Modeling Process</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Trips generated</strong></td>
<td>Trips originated or terminated</td>
</tr>
<tr>
<td></td>
<td>E.g., wells and farms</td>
</tr>
<tr>
<td><strong>Trips attracted</strong></td>
<td>Rail &amp; pipeline transfer facilities</td>
</tr>
<tr>
<td></td>
<td>Grain elevators</td>
</tr>
<tr>
<td><strong>Routes taken</strong></td>
<td>Fastest path</td>
</tr>
<tr>
<td><strong>Truck trips: segment</strong></td>
<td>Oil-related, ag.-related, other</td>
</tr>
<tr>
<td><strong>Calibration</strong></td>
<td>Traffic data</td>
</tr>
<tr>
<td><strong>Truck types and loads</strong></td>
<td>Annual ESALs</td>
</tr>
</tbody>
</table>
Oil Exploration Traffic Projections

Example of predicted traffic flows over road network

Crude oil movements
Crop Movement Projections - Wheat
Unpaved Road Analysis

- Unpaved road miles grouped by traffic volume categories
- “Normal” practices established for each county based upon traffic observations and reported maintenance practices
- For traffic volumes above normal levels responses for oil impacted roads used to establish upper categories of maintenance
Unpaved Improvement Types

- **Traffic Category Improvement**
  - Low: low volume average
  - Baseline: county average
  - Elevated: county average increased by 50%
  - Moderate: county average increased by 100%
  - High: county average increased by 150%, dust suppressant
  - Very high: county average increased by 200%, dust suppressant
To Pave or Not?

- Conversion of gravel roads to hot mix asphalt (HMA) not directly considered, except for highest traffic roads
- Needs for the significantly increased gravel maintenance may be sufficient for paving of some road segments
- Surface type choice left to county
  - Reflect practices and local issues
  - Coordination with an overall planning effort
Life Cycle Cost Comparison
<table>
<thead>
<tr>
<th>Period</th>
<th>Statewide</th>
<th>Oil Patch</th>
<th>Non-Oil</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015-2016</td>
<td>$548.0</td>
<td>$299.4</td>
<td>$248.6</td>
</tr>
<tr>
<td>2017-2018</td>
<td>$547.9</td>
<td>$299.2</td>
<td>$248.7</td>
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<tr>
<td>2019-2020</td>
<td>$547.5</td>
<td>$298.6</td>
<td>$248.9</td>
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<tr>
<td>2021-2022</td>
<td>$545.6</td>
<td>$296.6</td>
<td>$249.0</td>
</tr>
<tr>
<td>2023-2024</td>
<td>$541.9</td>
<td>$292.7</td>
<td>$249.2</td>
</tr>
<tr>
<td>2025-2034</td>
<td>$2,667.5</td>
<td>$1,422.9</td>
<td>$1,244.6</td>
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<tr>
<td>2015-2034</td>
<td>$5,398.4</td>
<td>$2,909.4</td>
<td>$2,489.0</td>
</tr>
</tbody>
</table>
Paved Road Analysis Steps

- AASHTO 1993 Design Guide
- Predict year & type of improvement
- Improvement threshold based on pavement condition
- Year of improvement based on:
  - Existing structural capacity
  - Existing condition
  - Forecasted ESALs
ESAL Factors: Single Axle

- Single Axle Load in Thousand Pounds
  - 16
  - 18
  - 20
  - 22
  - 24

- ESALs
  - 0.645
  - 1
  - 1.47
  - 2.09
  - 2.89

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Paved Road Improvements/Maint.

• Improvement type
  – Overlay
  – Sliver widening
  – Reconstruction
  – Mine & blend

• Normal maintenance
  – Chip seals
  – Crack sealing and patching
  – Other
Paved Road Improvement Criteria

• Reconstruction
  – Condition and traffic volume
  – Subgrade modulus
  – Rutting

• Mine & Blend
  – Condition and traffic volume
  – Widening needed but thin/weak base

• Overlay
  – Pavement condition
### Pavement Serviceability Rating (PSR)

<table>
<thead>
<tr>
<th>PSR Range</th>
<th>General Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 to 4</td>
<td>Very Good</td>
</tr>
<tr>
<td>4 to 3</td>
<td>Good</td>
</tr>
<tr>
<td>3 to 2</td>
<td>Fair</td>
</tr>
<tr>
<td>2 to 1</td>
<td>Poor</td>
</tr>
<tr>
<td>1 to 0</td>
<td>Very Poor</td>
</tr>
</tbody>
</table>
Effects of Soil Support

Resilient Modulus (thousand psi)

Equivalent Damage

Resilient Modulus (thousand psi)
# Paved Road Improvements

<table>
<thead>
<tr>
<th>Type</th>
<th>Miles</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resurface</td>
<td>5,005</td>
<td>88.1%</td>
</tr>
<tr>
<td>Reconstruct</td>
<td>253</td>
<td>4.5%</td>
</tr>
<tr>
<td>Mine/Blend</td>
<td>219</td>
<td>3.9%</td>
</tr>
<tr>
<td>Widen</td>
<td>201</td>
<td>3.5%</td>
</tr>
<tr>
<td>Period</td>
<td>Statewide</td>
<td>Oil Patch</td>
</tr>
<tr>
<td>----------</td>
<td>-----------</td>
<td>-----------</td>
</tr>
<tr>
<td>2015-2016</td>
<td>$377</td>
<td>$186</td>
</tr>
<tr>
<td>2017-2018</td>
<td>$323</td>
<td>$120</td>
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<tr>
<td>2019-2020</td>
<td>$285</td>
<td>$158</td>
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<tr>
<td>2021-2022</td>
<td>$236</td>
<td>$133</td>
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<tr>
<td>2023-2024</td>
<td>$138</td>
<td>$52</td>
</tr>
<tr>
<td>2025-2034</td>
<td>$1,326</td>
<td>$513</td>
</tr>
<tr>
<td>2015-2034</td>
<td>$2,685</td>
<td>$1,162</td>
</tr>
</tbody>
</table>
Bridge Analysis

- NBI: county and local
- Open bridges (other than culverts): 2,556
- Not considered: recently replaced or minimum maintenance roads
- Improvements considered: replacement or rehabilitation
- Maintenance
Bridges Costs (1)

• Unit cost model
  – Based on 2011-2014 NDDOT bid reports
  – Discussed with NDDOT & counties
  – Includes approach roadway, engineering, etc.

• Replacement cost projections:
  – Bridges: $250-$275/sf. deck area
  – Culverts: $400,000-$600,000 /project
Bridges Costs (2)

• Rehabilitation
  – Deck widening 50% replacement cost
  – Deck replacement 45% replacement cost

• Preventive maintenance
  – Annualized maintenance cost $0.24 per sq. ft./year
  – $0.29 per sq. ft. deck washing/sealing
Bridge Investment Needs

- 2015-2034: $327 million
- 77% of costs for replacements
- Backlog of 480+ bridges
- Backlog spread over 5 biennia
- Approx. $70 million per biennium
High Traffic Roadways

- Consideration of converting very high traffic (500+ trucks/day) gravel miles to asphalt
- 37 miles @ $1.5 million/mile = $58M
## Summary Compilation

<table>
<thead>
<tr>
<th>Category</th>
<th>2014 Dollars</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2015-2016 Biennium</strong></td>
<td></td>
</tr>
<tr>
<td>Gravel Roadway Needs</td>
<td>$548M</td>
</tr>
<tr>
<td>Paved Roadway Needs</td>
<td>$377M</td>
</tr>
<tr>
<td>Gravel to Pavement Option</td>
<td>$58M</td>
</tr>
<tr>
<td>Total Roadway Needs (excluding bridges)</td>
<td>$983M</td>
</tr>
</tbody>
</table>
Next Steps

- Feedback from Legislature, NDDOT, and counties
- Written report/documentation
- Maps and data tables posted on UGPTI webpage
- Additional study requests
Questions?

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701-231-7190
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Full Report: Spotlight Section at
www.ugpti.org/