Optimizing Pipeline Routing in the 21st Century

Erik Potter & Wetherbee Dorshow PhD
Introduction

Presented by
Erik Potter – M3 Midstream (Momentum) &

Momentum

Wetherbee Dorshow, PhD – Earth Analytic, Inc.
Momentum’s Appalachian Assets

- Kensington Plant
- Leesville Plant
- Harrison Hub
- Canonsburg Regional Office
- Richeyville Office
- Twilight Station
- Daybrook Station
- Westover Office
Industry Changes / Challenges

Why do we need smarter routing?

• Better Public Safety
• Cost Control
• Repeatable
• Increased Regulation
• Price Collaboration
• Social Media
• Time and Speed to Market
• Traditional Corporate Methodologies are Antiquated
Opposition
Routing Methodology

We realized in practice...

• Tradition is sometimes the policy
• Ultimately procedure is policy
• Even “No” procedure is a policy

What is your corporate policy on routing?
Project Info

Project Participants

• M3 Midstream GIS staff, Pipeline PMs, ROW & Earth Analytics consultants

Data

• Pipeline and facilities data is in a PODS 4.2 database with a C&C Intrepid Esri geodatabase
• Routing
The Goal

M3 Midstream was in search of a more formalized and measurable pipeline routing process

The Problem

- Traditional routing processes were heavily vested in “on the ground ‘pipeliner’” review of field routes
- Traditional process did not provide a complete picture of all impedance factors in the routing process
- Subjective by nature and resulted in many costly reroutes
Tools

Routing

• A pipeline route selection tool in ArcToolbox that automates route selection and estimates construction costs

Cost Estimation

• A route line list reporting tool that summarizes the type, identification, and stationing of line crossing features (e.g. rivers, roads, land use, parcels) for proposed pipeline routes
• Advanced cost estimation reports are also included in this module
• Data is summarized into an Excel spread sheet

Elevation Profiler

• A route profile tool that generates a chart and an associated data table showing the elevation profile for a proposed route
Tools Used

Software
• Esri ArcGIS Standard 10.1
• Esri Spatial Analyst
• EAI SmartFootprint
• MS Excel

COTS Spatial Data
• CoreLogic - parcel data
• Hart Rextag – pipeline data
What is the Methodology?

- OBJECTIVE
- CONSISTENT
- REPEATABLE
- STANDARDIZED
- GUIDELINE
Methodology

Produces Routing Decisions that are **Quantifiable**, and **Consistent**

Improves **productivity** and analytical capabilities

**Reduces Risks** by public, political, regulatory and legal scrutiny
Characteristics

**Standardizes** routing

**Objective** routing

Uses computer **algorithms** and **models** to help identify alternative corridors
### Criteria Matrix: Defines How Cost Surfaces Are Generated & Combined

- Project criteria matrix defines the scheme for generating cost surfaces for each criteria (Component Model)
- Form is populated through a collaborative process with project stakeholders
- Standard metadata for SmartFootprint Data Pack is available upon request

<table>
<thead>
<tr>
<th>Component Model</th>
<th>Component Model Ranking Strategy</th>
<th>Notes</th>
<th>Component Model Weighting</th>
<th>Input Dataset(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land Value</td>
<td>0 to $500/acre, Cost = 1 &gt;8,000/acre, Cost = 5</td>
<td>As land value increases, costs for construction (acquisition of ROW) increase.</td>
<td>6%</td>
<td>Parcel data, general projected costs based surface owner type</td>
</tr>
<tr>
<td>Surface Ownership Type</td>
<td>Private Land, Cost = 1 BLM Land Cost = 5</td>
<td>Often, building pipelines or drilling on BLM land is more costly in terms of permitting ngor than private lands. Other categories might be protected lands, USFS, Indian land,...Some lands might be totally restricted--can't go there; need to use NoData for these areas</td>
<td>6%</td>
<td>BLM 100k surface ownership data, parcel data (digital or COGO or scanned), etc...</td>
</tr>
<tr>
<td>Landowner Issues</td>
<td>Typical Landowner = 1 &quot;Difficult&quot; Landowner = 5</td>
<td></td>
<td>6%</td>
<td></td>
</tr>
<tr>
<td>Recorded Archaeological Sites</td>
<td>Areas outside archaeological site boundary buffers = 0, Areas inside archaeological site boundary buffers = 5</td>
<td></td>
<td>6%</td>
<td>Digital data from State SHPO office(s) obtained through licensed Archaeologist</td>
</tr>
<tr>
<td>Recorded Threatened and Endangered Species</td>
<td>Areas within 100m, Cost = 5+ Areas Within 1 km, Cost = 3 Areas &gt;1 km, Cost = 0</td>
<td></td>
<td>6%</td>
<td>Digital data from State Natural Heritage office(s) or accessible field survey data from previous projects</td>
</tr>
<tr>
<td>Recorded Wetlands</td>
<td>Areas outside wetland boundary buffers = 0, Areas inside wetland boundary buffers = 5</td>
<td></td>
<td>6%</td>
<td>Digital data from National Wetlands Inventory (NWI) or biological field survey data from previous projects</td>
</tr>
</tbody>
</table>
## Cost Surface Creation

<table>
<thead>
<tr>
<th>Rank</th>
<th>Criteria</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Side Slope Avoidance</td>
<td>10%</td>
</tr>
<tr>
<td>2</td>
<td>Slope</td>
<td>10%</td>
</tr>
<tr>
<td>3</td>
<td>RTE and Cultural Resources</td>
<td>8%</td>
</tr>
<tr>
<td>4</td>
<td>Surficial Geology</td>
<td>8%</td>
</tr>
<tr>
<td>5</td>
<td>Protected Areas</td>
<td>8%</td>
</tr>
<tr>
<td>6</td>
<td>Leases (No Data)</td>
<td>0%</td>
</tr>
<tr>
<td>7</td>
<td>Proximity to Proposed Wells (No Data)</td>
<td>0%</td>
</tr>
<tr>
<td>8</td>
<td>Existing ROW Proximity</td>
<td>7%</td>
</tr>
<tr>
<td>9</td>
<td>Existing Pipeline Corridor (no Data)</td>
<td>0%</td>
</tr>
<tr>
<td>10</td>
<td>Wetlands</td>
<td>5%</td>
</tr>
<tr>
<td>11</td>
<td>Parcel Size</td>
<td>4%</td>
</tr>
<tr>
<td>12</td>
<td>Dwelling Density</td>
<td>5%</td>
</tr>
<tr>
<td>13</td>
<td>Transportation</td>
<td>2%</td>
</tr>
<tr>
<td>14; Partially Restricted</td>
<td>Landowner Issue Avoidance</td>
<td>2%</td>
</tr>
<tr>
<td>15</td>
<td>Hydrology Avoidance</td>
<td>6%</td>
</tr>
<tr>
<td>16; Restricted</td>
<td>Rooftop Presence</td>
<td>9%</td>
</tr>
<tr>
<td>17; Partially Restricted</td>
<td>Mining</td>
<td>8%</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>100%</td>
</tr>
</tbody>
</table>

*Restricted cells will not be traversed by SmartFootprint Route*

SmartFootprint cost surface rasters have pixel values ranging from zero to five, where a score of zero indicates the absence of constraints on pipeline project implementation success and a score of 5 indicates the presence of a very significant constraint on pipeline project implementation success.
Slope class definitions:

- 0% to 6%, Score = 0
- 6% to 12%, Score = 1
- 12% to 18%, Score = 2
- 18% to 24%, Score = 3
- 24% to 30%, Score = 4
- >30%, Score = 5
Hydrology Systems were identified, buffered and grouped as follows:

- **Cold Water Fisheries**
  - Score = 3

- **Exceptional Value**
  - Score = 5

- **High Quality (CWF)**
  - Score = 5

- **High Quality (TSF)**
  - Score = 5

- **High Quality (WWF)**
  - Score = 5

- **Warm Water Fisheries**
  - Score = 3

- **Trout Stocking Fisheries**
  - Score = 3

- **Other Perennial Streams**
  - Score = 5

- **Intermittent Streams**
  - Score = 3

- **Ephemeral Streams**
  - Score = 3

- **Wild Trout Steams**
  - Score = 5

- **NHD of Delineated Water Body**
  - Score = 5
Transportation

Transportation Surfaces were identified, buffered 300ft and grouped as follows:

- **Turnpike**
  - Score = 5

- **Local**
  - Score = 2

- **Other State**
  - Score = 2

- **US Highway**
  - Score = 2

- **Interstate**
  - Score = 3

- **Railroads**
  - Score = 5
Rooftop Presence

Building’s Roof Tops were identified and buffered by 300 ft

Score = No Data

All other lands were identified and considered equal

Score = 3
Protected Lands

Sensitive and/or Protected Lands were identified and classed

Access Area, Habitat or Species Management Area, Local Conservation Area, Local Forest, Local Recreation Area, Military Land, National Forest, National Wildlife Refuge, State Forest, State Park, Wilderness Area, etc.

Score = 3 to 5

All other lands are considered equal

Score = 2
Surficial Geology

- Lithology is Limestone, Dolomite, Feldspathic Quartz, Gneiss, etc.
  - Score = 5
- Conglomerate Lithology
  - Score = 4
- Identified Karst Geology
  - Score = 1
- Average Soil Depth to Bedrock < 5ft
  - Score = 3
Land Owner Issues

Problem Land Owners Due to Financial Expectations
Score = 4

Problem Land Owners Due to Refusal
Score = No Data

Problem Landowner Due to Other Reasons
Score = 4

All Other Lands, Problems with Landowner Unknown or Non-Existing
Score = 0
Leases

Customer Leases
Score = 2

All Other Lands (non-leased)
Score = 3
Existing Right of Way

ROW - Multi-Line Rights
Score = 0

Existing Leases
Score = 2

ROW - Other
Score = 1

All Other Lands
Score = 3
Mining

Quarries and Mining Operations

Score = No Data

All other lands are considered to not be a Mining Operation

Score = 0
Parcel Size is <= 1 acre
Score = 5

Parcel Size is >= 1 acre
Score = 0

All other lands are considered an unknown size
Score = 3
Map Algebra

Criteria 1: Land Use Suitability
- Very Low Suitability (High-Density Residential, Score = 1)
- Low Suitability (Low-Density Residential, Score = 2)
- Moderate Suitability (Developed Open Space, Score = 3)
- High Suitability ( Undeveloped, Non-riparian, Score = 4)
- Very High Suitability (Riparian, Score = 5)

Criteria 2: Slope Suitability
- Very Low (Slope > 30%, Score = 1)
- Low (24 - 30% Slope, Score = 2)
- Moderate (18 - 24% Slope, Score = 3)
- High (6 - 18% Slope, Score = 4)
- Very High (Slope < 6%, Score = 5)

Combined Suitability Surface
- Very Low Suitability (1)
- Low Suitability (2)
- Moderate Suitability (3)
- High Suitability (5)
- Very High Suitability (5)
Least Cost Path & Corridor Analysis

Weighted Overlay of Multiple Cost Surfaces yields SmartFootprint Cost Surface

RouteFinder Tool integrates Least Cost Routing Algorithms
Crossing Reports and Profiles

Elevation Profiles

Comprehensive Linelists

<table>
<thead>
<tr>
<th>StationBegin</th>
<th>StationEnd</th>
<th>PARCEL_ID</th>
<th>APN</th>
<th>APN2</th>
<th>OWNER</th>
<th>ADDR</th>
</tr>
</thead>
<tbody>
<tr>
<td>7010.0915</td>
<td>7067.0068</td>
<td>401548253</td>
<td>5311100001</td>
<td></td>
<td>HUTTER CHAD R &amp; TRICE CHRISTY</td>
<td>NEIDERHISER RD</td>
</tr>
<tr>
<td>3501.2196</td>
<td>3695.8118</td>
<td>401546784</td>
<td>5310150020</td>
<td></td>
<td>TURNLEY LYNN B &amp; KATHRYN S</td>
<td>101 CHERRY BLOSSO</td>
</tr>
</tbody>
</table>
Cost Estimation

Base Lay Values are identified & aggregated:
- Land-use (Timber)
- Run Length (> 5 miles)
- Rock Occurrence
- Slope (0 to 6%)
- PI’s

Allows user to input (EA) items
- Diameter
- Valves
- Futures
- Launcher/Receiver
- Meters

Identifies HDDs vs. Conventional bores & incorporates associated costs
Crossings Report and Cost Estimation Tool
ArcGIS Geoprocessing Model Example
Desktop Route & Corridor Selection and Reporting Tool Examples
Web-Based Route Selection Tool - Example
Lessons Learned...

Key Points

1. Forced us to do our homework
2. Importance of current quality data
3. Traditional “Pipeliner” routing methods misses information
   Reduction reroutes
4. Creates an instant “real” cost analysis and reporting
5. Allows manual edits of automated routes
6. Type of pipeline routing is important to consider approach
Closing

• There is a need for an **objective, transparent, inclusive, and consistent** methodology

• EAI has developed a **repeatable** methodology to meet the routing need in your business logic

• Cost Surface based modeling for **linear and site selection**
Questions?

stay curious