CEE4905 Senior Design Project

Mackinac Straits Underground Utility Corridor

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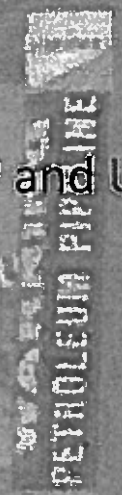
Why a Mackinac Straits Utility Corridor?

1. **Environmental Protection**
   - Addresses ALL underwater Utilities
   - Protects the Waters of the Great Lakes
   - Protects the Straits Bottom Lands
2. **Economic Development**
   - Provides improved Utility Connection between LP and UP
   - Reduces Utility Cost in the UP
   - Promotes Economic Development of the UP
3. **Improved Utility Performance**
   - Controlled Environment
   - Visual inspection
   - Longer Life, Better Maintenance
4. **Potential Emergency Access Corridor**



CE 4905 – YOUR MISSION

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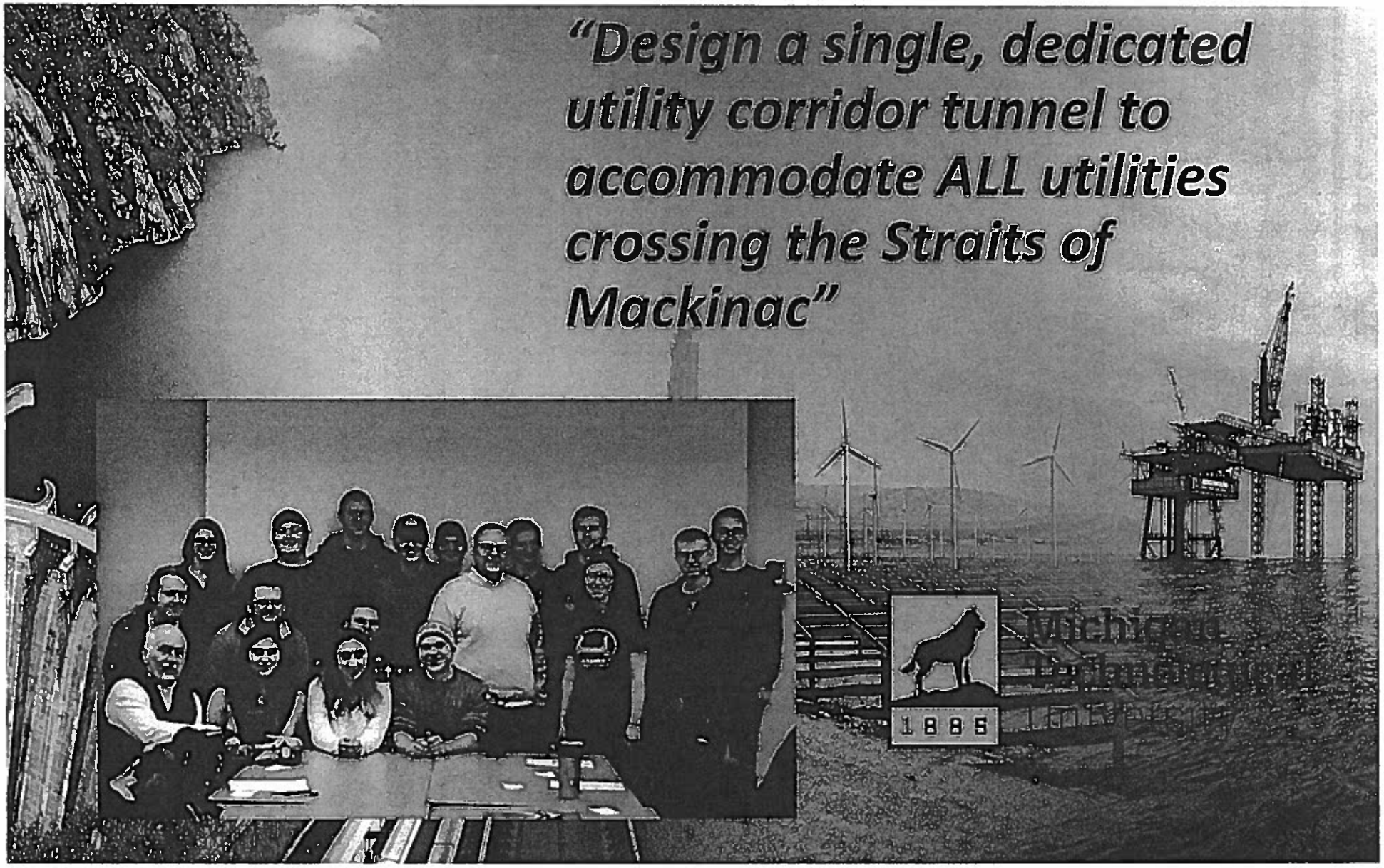
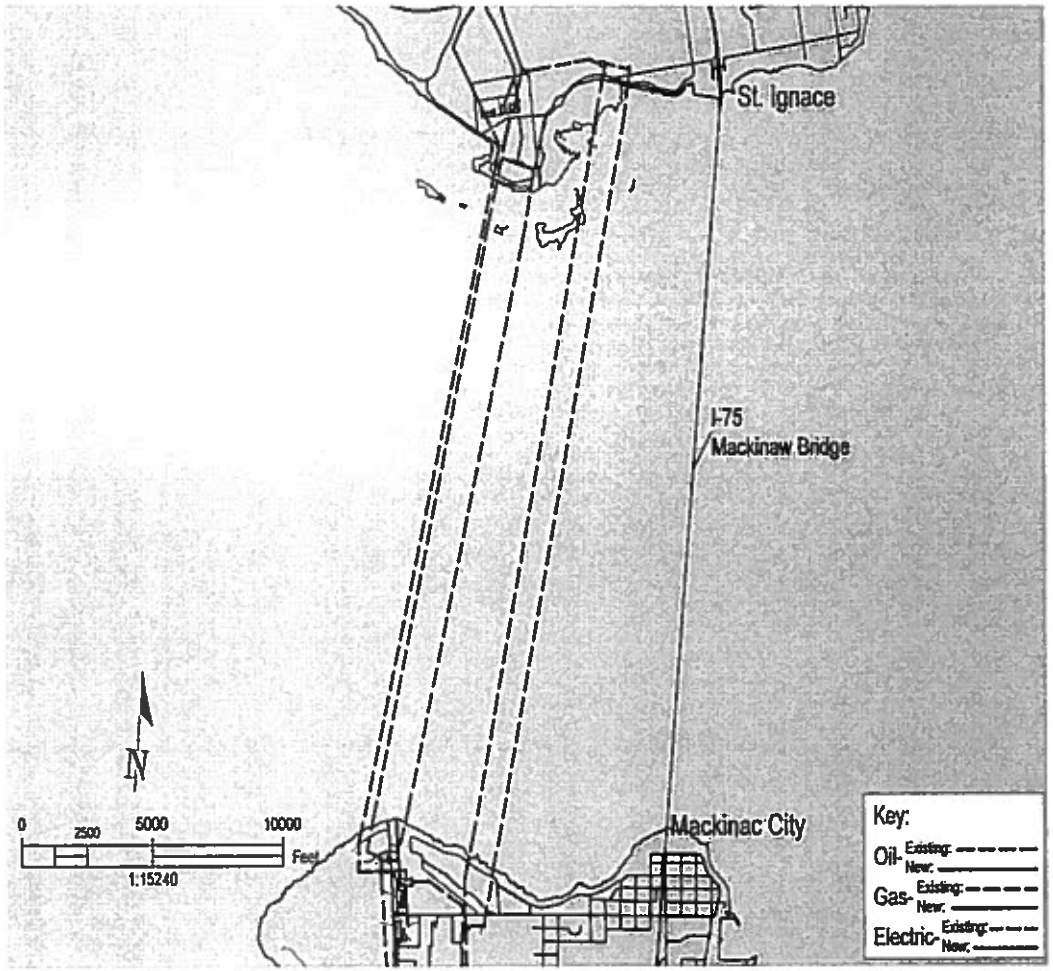


Existing Utilities



- Enbridge Energy (oil pipeline 1953)
- Cloverland Electric Cooperative (high voltage electric lines 1956)
- TransCanada's Great Lakes Transmission Company (natural gas pipeline 1968)
- American Transmission Company (high voltage electric lines 1975)

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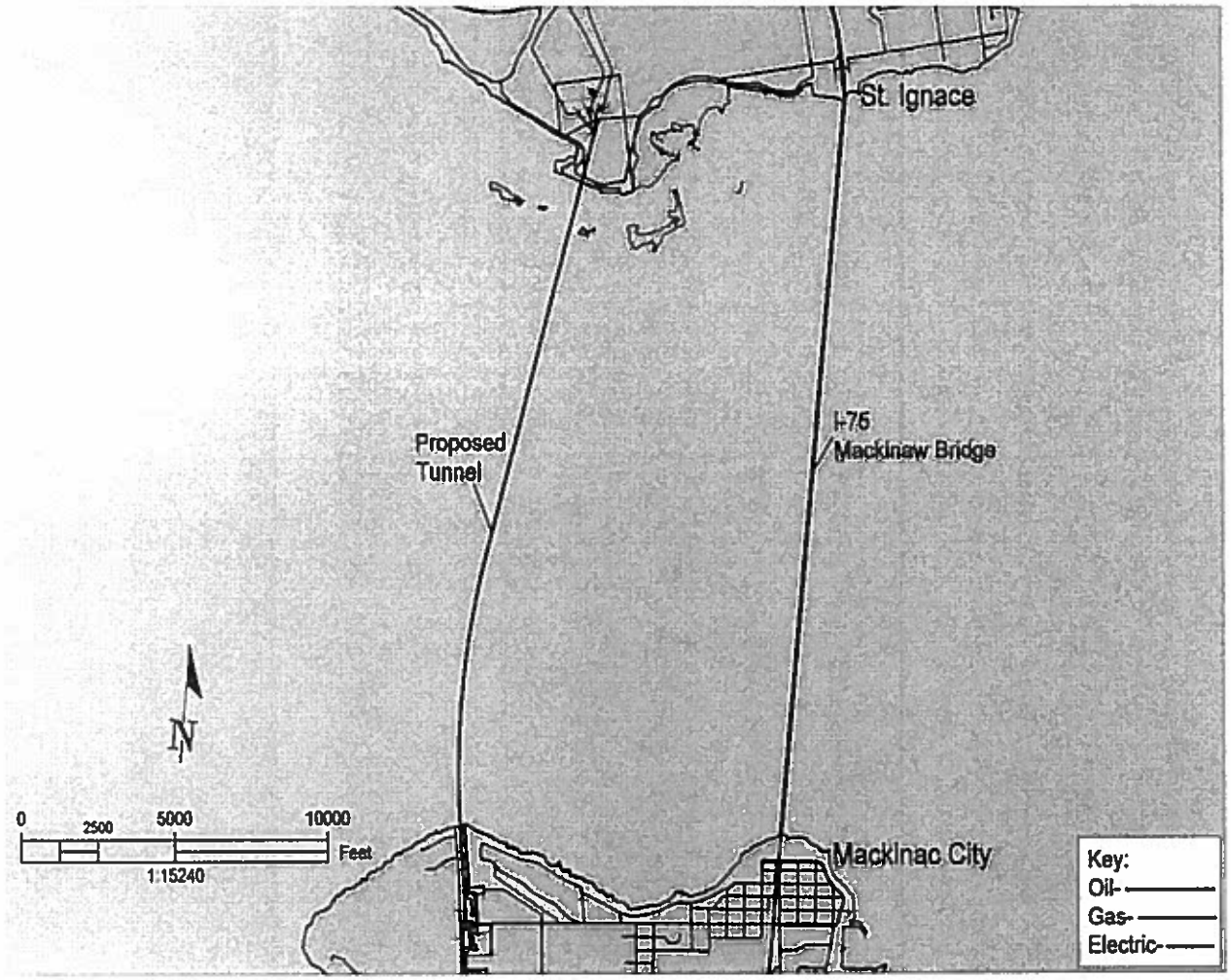
Upper Peninsula Precision

Proposed Tunnel Alignment



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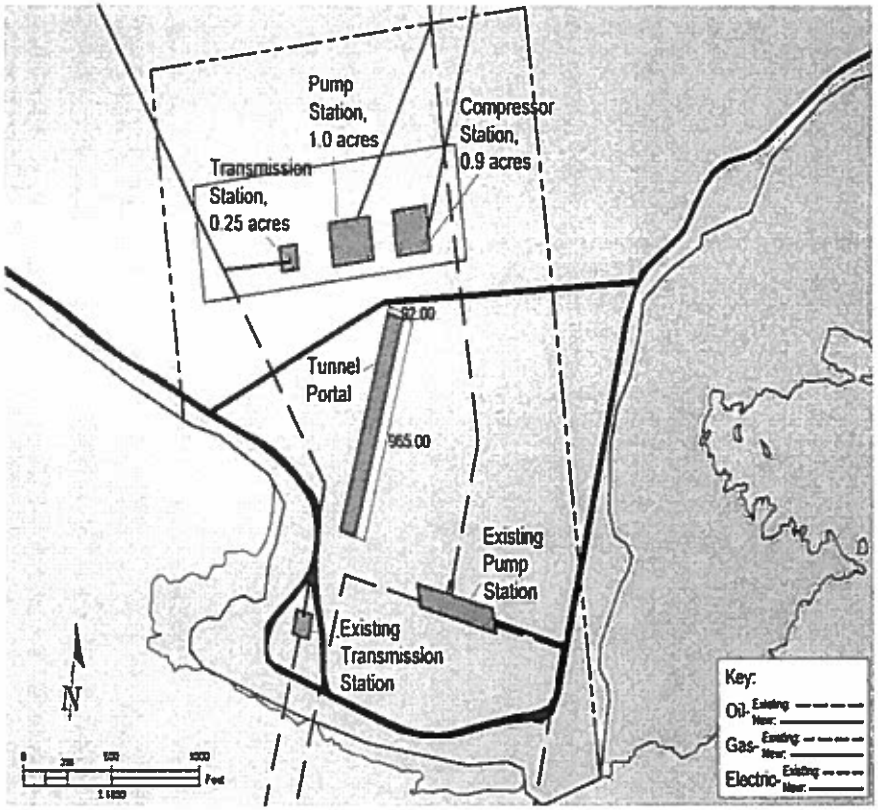
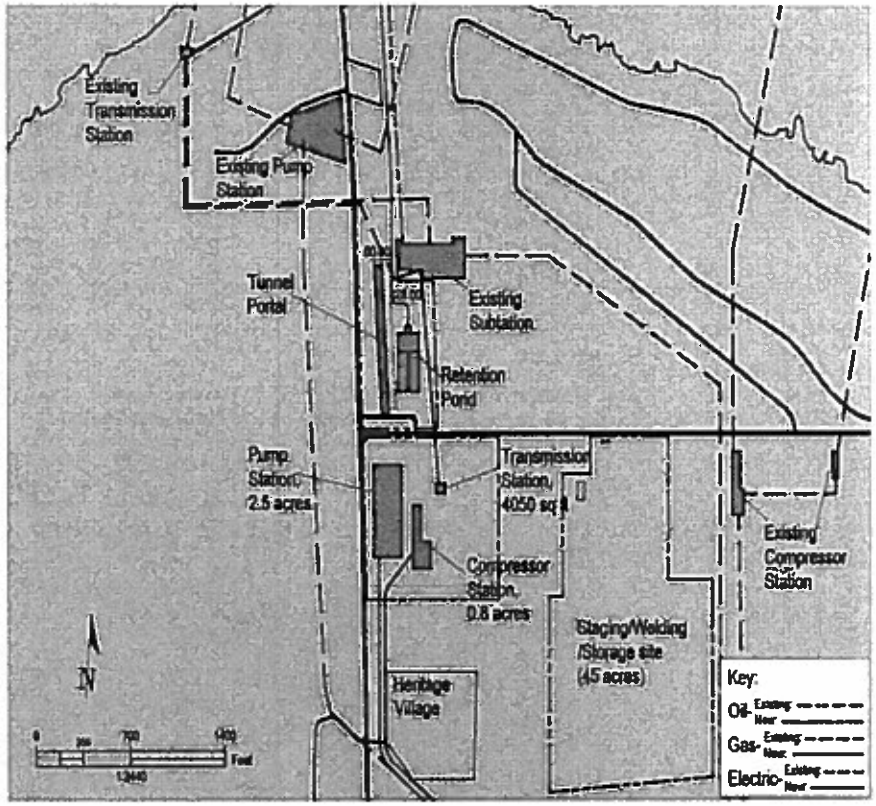
Upper Peninsula Precision

Construction Site Layout



North Site (St. Ignace)



South Site (Mackinac City)

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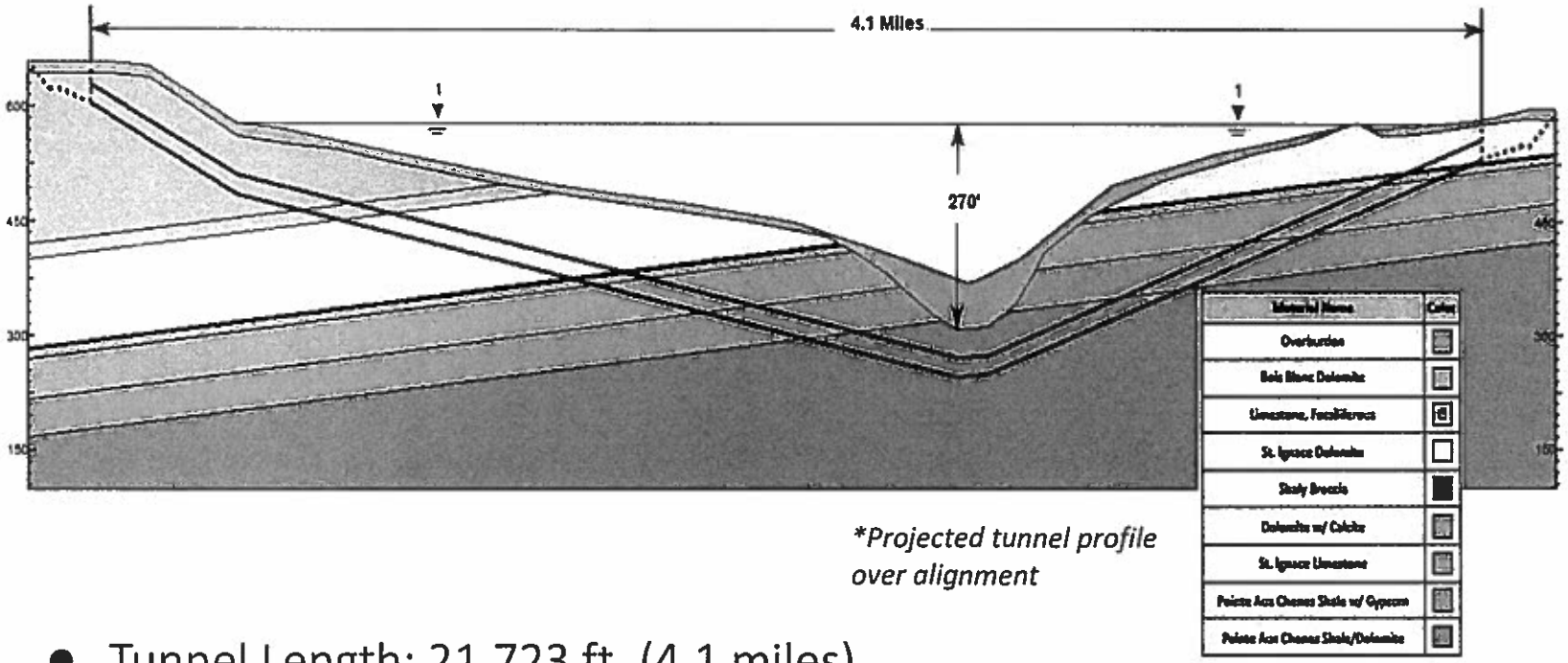
Proposed Tunnel Profile



**Projected tunnel profile over alignment*

- Tunnel Length: 21,723 ft. (4.1 miles)
- Typical grade: 4%
- Estimate 25% to 44% of alignment will require pre-grouting for ground improvement.
- Regional average dip of 55 ft./mi. to the south

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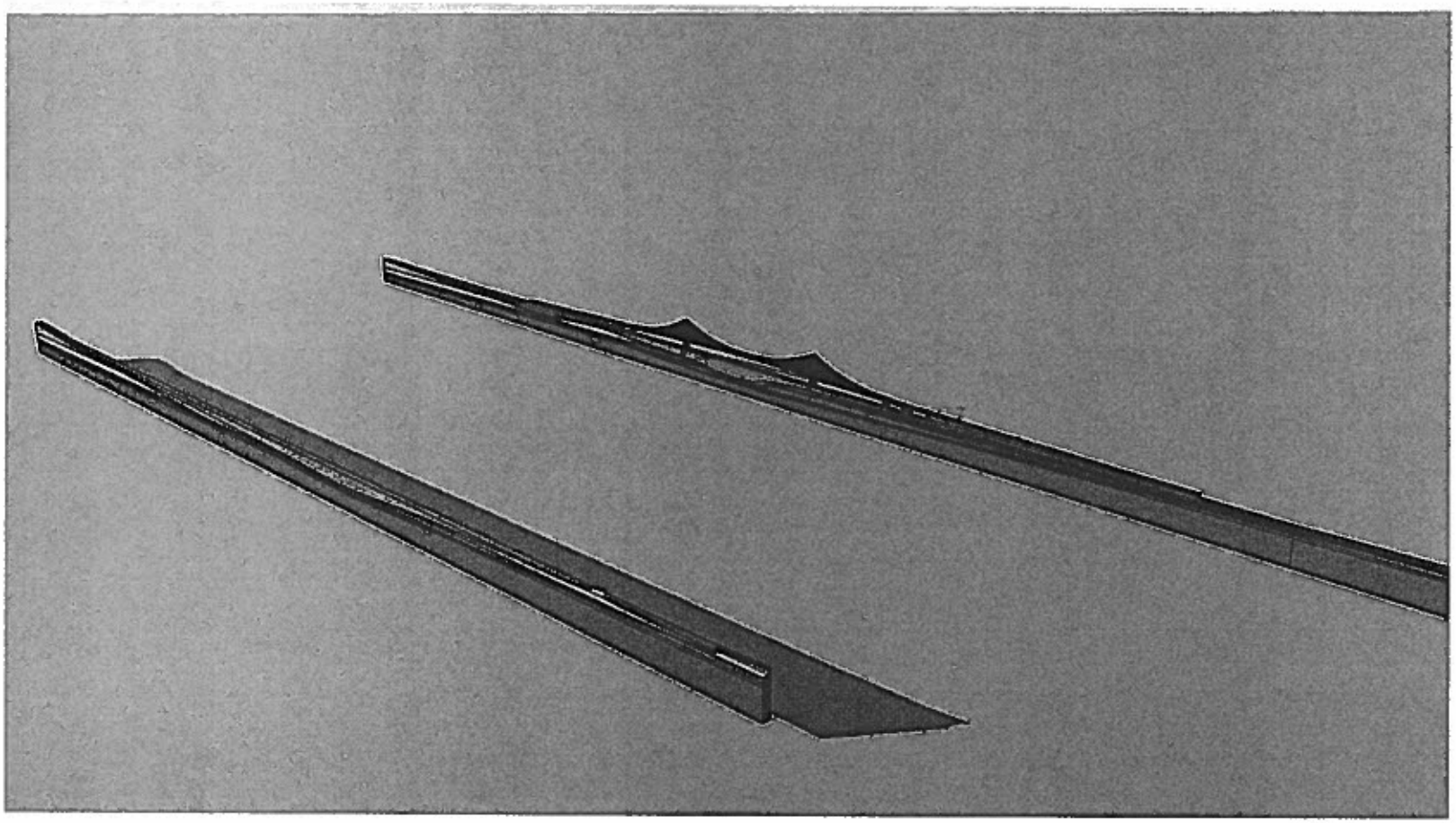
3D Model



Video created by Horizon Engineering (Team 2)
https://www.youtube.com/watch?v=FPmjHw14e6A

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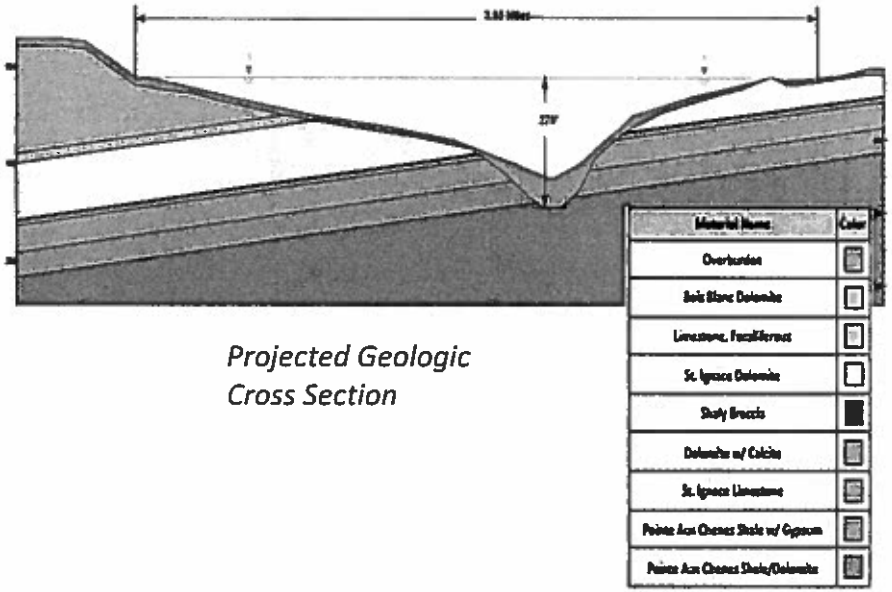
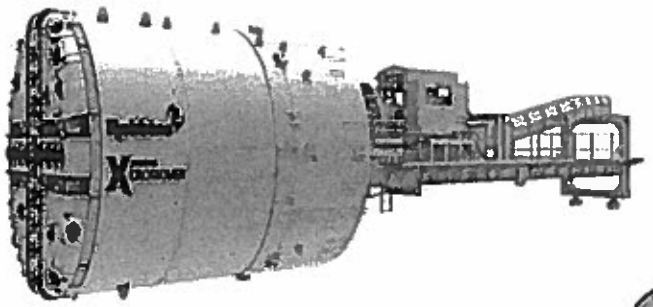
Geology and TBM Selection

- Geologic Risks:
  - Mackinaw City Side:
    - Fractured Bois Blanc dolomite
    - High potential for water inflow, significant grouting required
    - intermittent clay seams
  - St Ignace Side:
    - More competent rock
  - General Risks
    - "Megabreccia" formations –slickensided faults
    - Soft shale – potential for squeezing
    - Unknown depth of scour channel
- Proposed Tunnel Boring Machine:
  - XSE Crossover Series (EPB/Slurry Hybrid)
    - Designed for complex geology
    - Customizable
    - Muck removal and cutterhead adaptability while mining
  - 25 ft. Cutting diameter
  - Advance Rate 35-40 ft. per day



Projected Geologic Cross Section



XSE Crossover Series TBM

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Site Visit March 26, 2018

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Estimated Rock Properties

Rock Layer	Secondary Minerals	Fracture Frequency	Potential for Water Inflow	Expected Tunneling Length
Bois Blanc Dolomite	Calcite, Chert	Heavily Fractured	High Potential	4,057'
St Ignace Dolomite	Calcite	Well-Cemented "Megabreccia" (large blocks), few but persistent joints	Low to moderate Potential	5,252'
Shaly Breccia		Moderately Jointed, fairly cemtented	Moderate Potential	303'
St Ignace Dolomite with Calcite	Calcite	Well-Cemented "Megabreccia" (large blocks), few but persistent joints	Low Potential	696'
St Ignace Limestone/Breccia	Calcite, Limestone		Low Potential	3,772'
Pointe Aux Chenes Shale	Gypsum	Moderately Jointed, moderate to poor cementation	Low to Moderate Potential	3484'
Pointe Aux Chenes Shale/Dolomite	Gypsum			4159'

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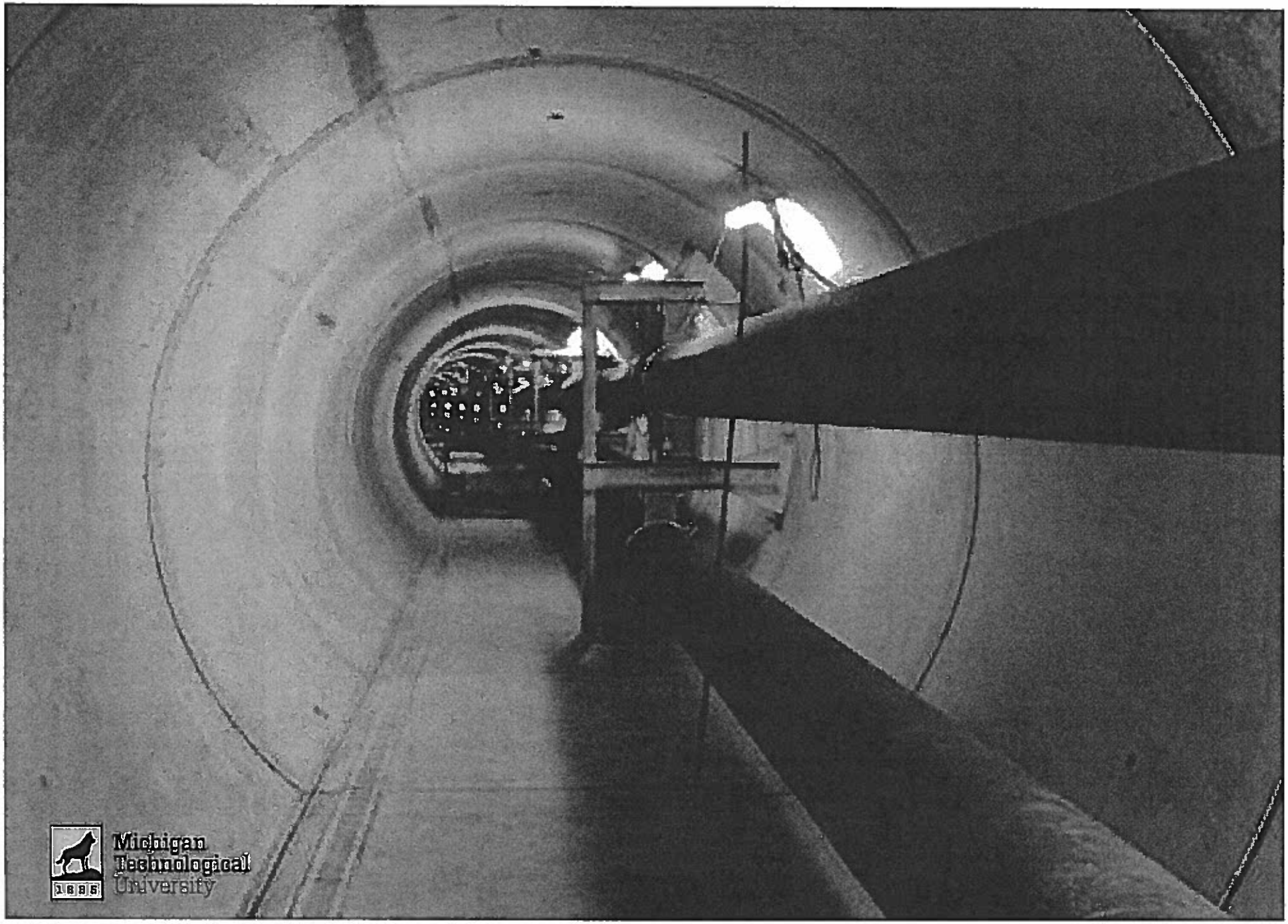
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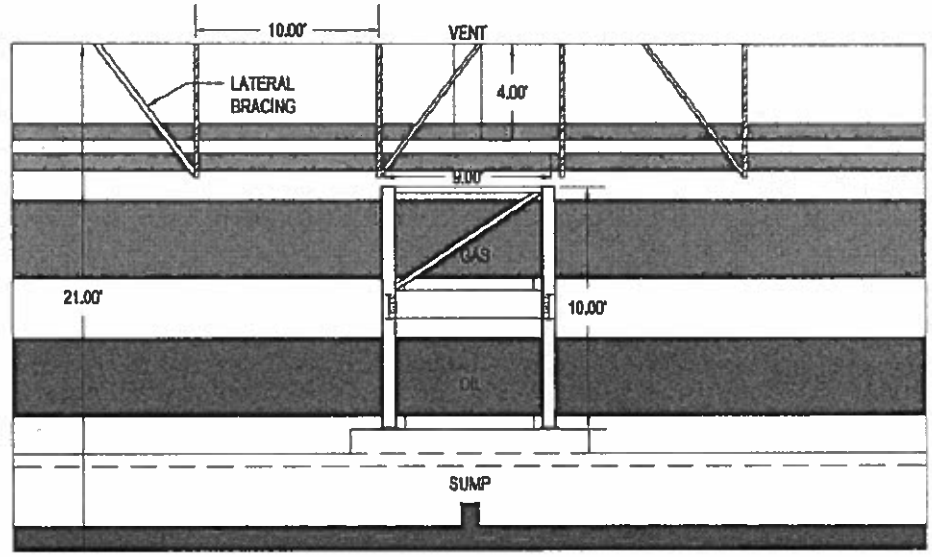
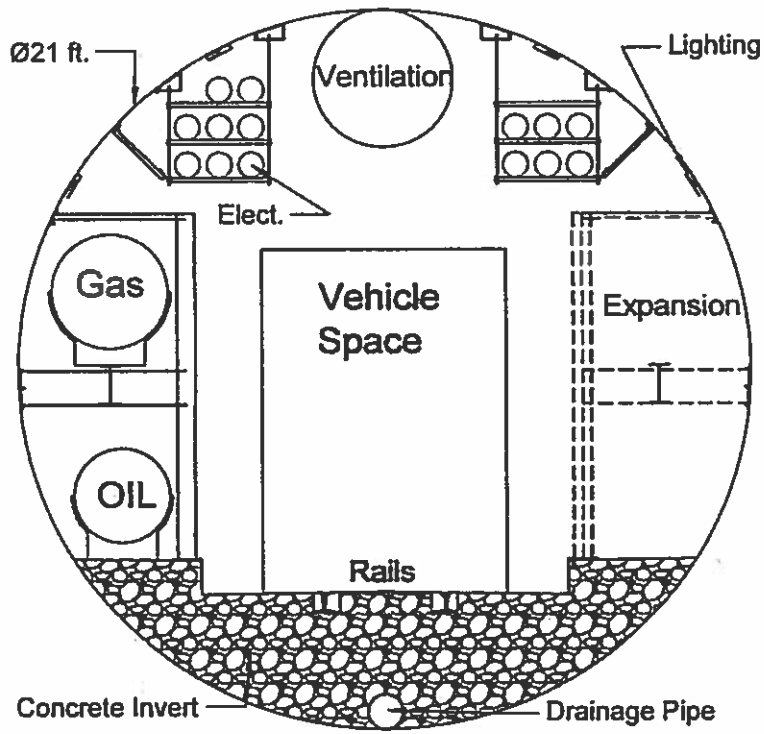
Proposed Design

- 21 foot inside diameter
- Tunnel Features:
  - Maintenance and Emergency Vehicle Space
  - Rail and rubber tire access
  - Allows for Utility Expansion
  - Provision for emergency spill control and collection
  - Ventilation and fire suppression
- Cross Section Considerations:
  - Large pipelines on rack supports
  - Electrical in hangers
  - Embedded rails
  - Spill control and storm drainage in invert
  - Life support utilities
    - Lighting
    - Ventilation
    - Communication system



Longitudinal Cross Section



Cross Section

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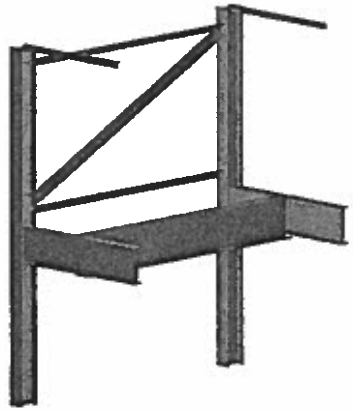
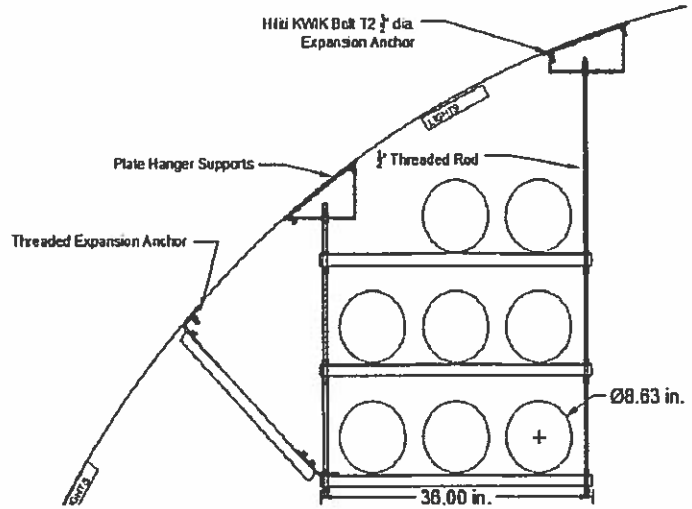
Design Details

- Utility Racks:
  - 10ft tall x 9ft depth
  - Length accommodates calculated thermal expansion in pipeline
  - Max load induced is 46kips
- Utility Hangers:
  - Trapeze Uni-strut system
    - Threaded rod connector
  - Custom hanger supports design to eliminate wall curvature
  - Lateral support
    - Uni-strut seismic product
- Transportation:
  - Rail Cars
    - Battery powered
    - Standard metal wheels with hill assist systems
    - Construction cars slightly different than final
  - Rail infrastructure
    - Narrow gauge
    - Embedded rail
    - Groove Girder Rails
    - Construction rail system for construction requirements

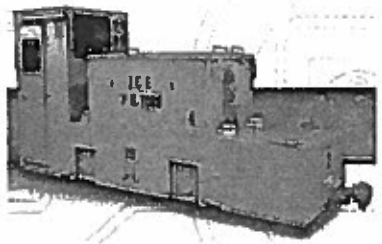


Oil and Gas Pipeline Rack



Elect. Utility Hanger

Typ. Hanger Support



Rail Locomotive

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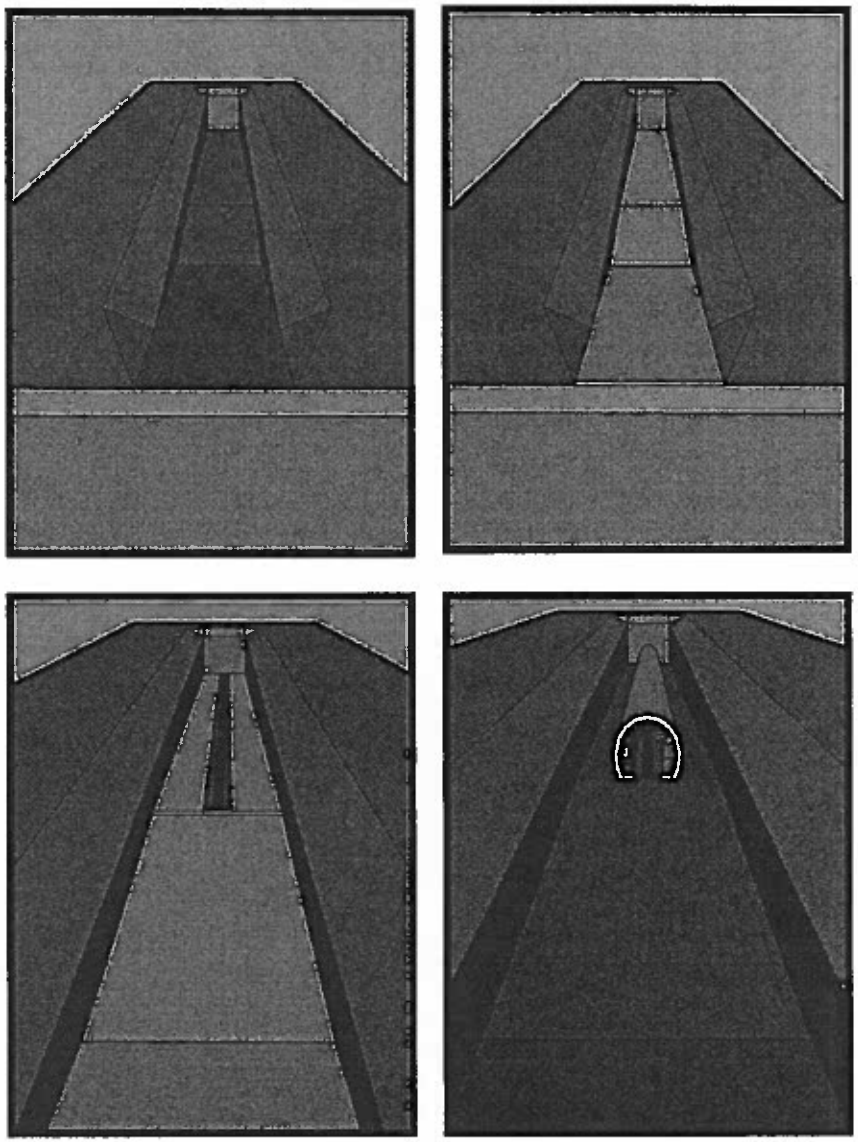
Portal Design

- Ramped portal necessary to reach desired depth to begin boring
- Mackinaw City and St. Ignace portals differ only in depth to bedrock
- Construction sequence:
  - Blast and excavate
  - Install support of excavation and erosion control
  - Place concrete construction slabs
  - Complete TBM assembly, tunnel boring, and disassembly
  - Install topping slab and embed service rails
  - Install precast sections over connecting tunnel
  - Backfill portal and install maintenance facility



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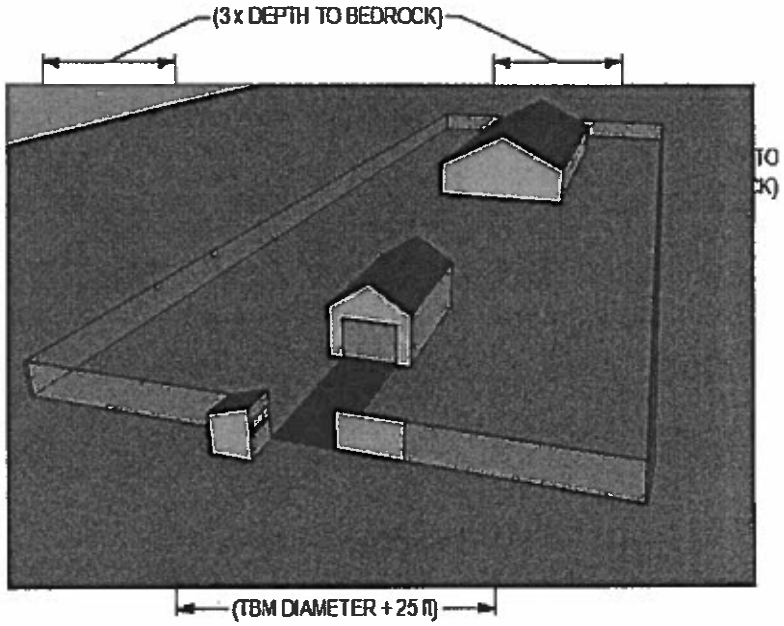
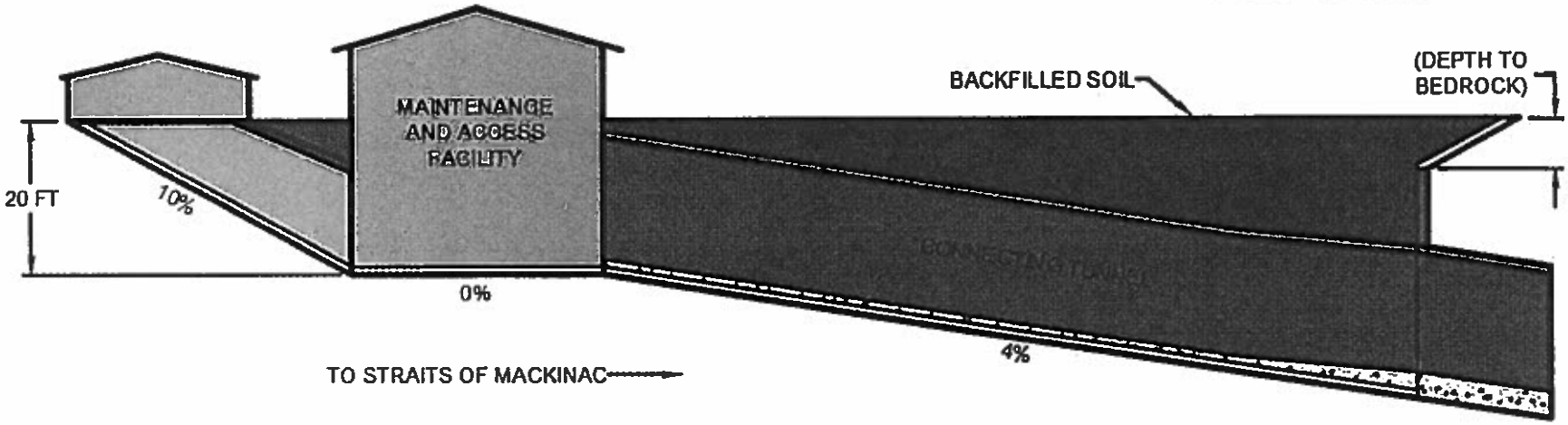
Portal Configuration

- Portal provides
  - Enough width for TBM assembly and disassembly
  - Sufficient rock depth over TBM to avoid stability problems during initial boring
  - Location for maintenance building





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Concept Construction Cost Estimate

Mackinac Straits Utility Tunnel Concept Construction Cost Estimate		
Portal Construction	$	35,849,000
Tunnel Construction	$	380,145,000
Headhouse and Systems Construction	$	5,889,000
Overall Contingency - 35%	$	147,659,000
Grand Total:	**$**	**569,542,000**

Note: Does not include: -Preconstruction Engineering & Planning
- Owner Management
- Overhead & Profit

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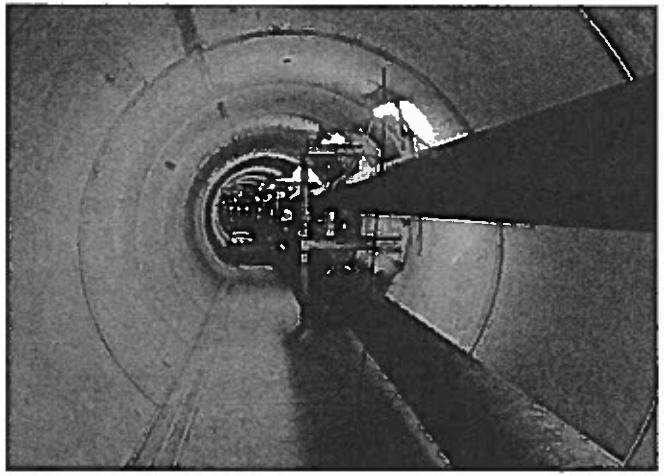
Concept Schedule

- **Preconstruction Engineering & Planning: 792 Days**
  - → Preliminary Engineering and Land acquisition: 200 days
  - → Geotechnical investigation: 130 days (concurrent)
  - → Engineering and design: 322 days
  - → Contract procurement: 270 days
- **Portal Construction: 265 Days**
  - → Dewatering, site preparation: 65 days
  - → Earth support and excavation: 200 days
- **Tunnel Construction: 1345 Days**
  - → TBM procurement: 270 days
  - → Tunnel mining: 550 days
  - → Interior and systems installation: 525 days
- **Surface Headhouse & Site Civil: 208 Days**
  - → Prefabricated building: 102 days each



Total: 7 Years

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Next Steps

1. **Develop Comprehensive Utility Management Strategy for the Straits**
2. **Geotechnical Investigation in the Straits – (*This Defines Cost*)**
3. **Advance Conceptual Design**
   - Develop Tunnel Safety Features and Spill Prevention Plan
   - Develop utility implementation plan
4. **Business Model – Public or Private?**
5. **Contracting Model**

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Contact Information

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