Optimizing Abandoned Mine Methane Projects

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RUBY CANYON ENGINEERING

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Presentation Outline

- Number of Abandoned Mines
- Advantages & Disadvantages of AMM Projects
- Evaluating AMM Resource
- Preparing Underground Workings

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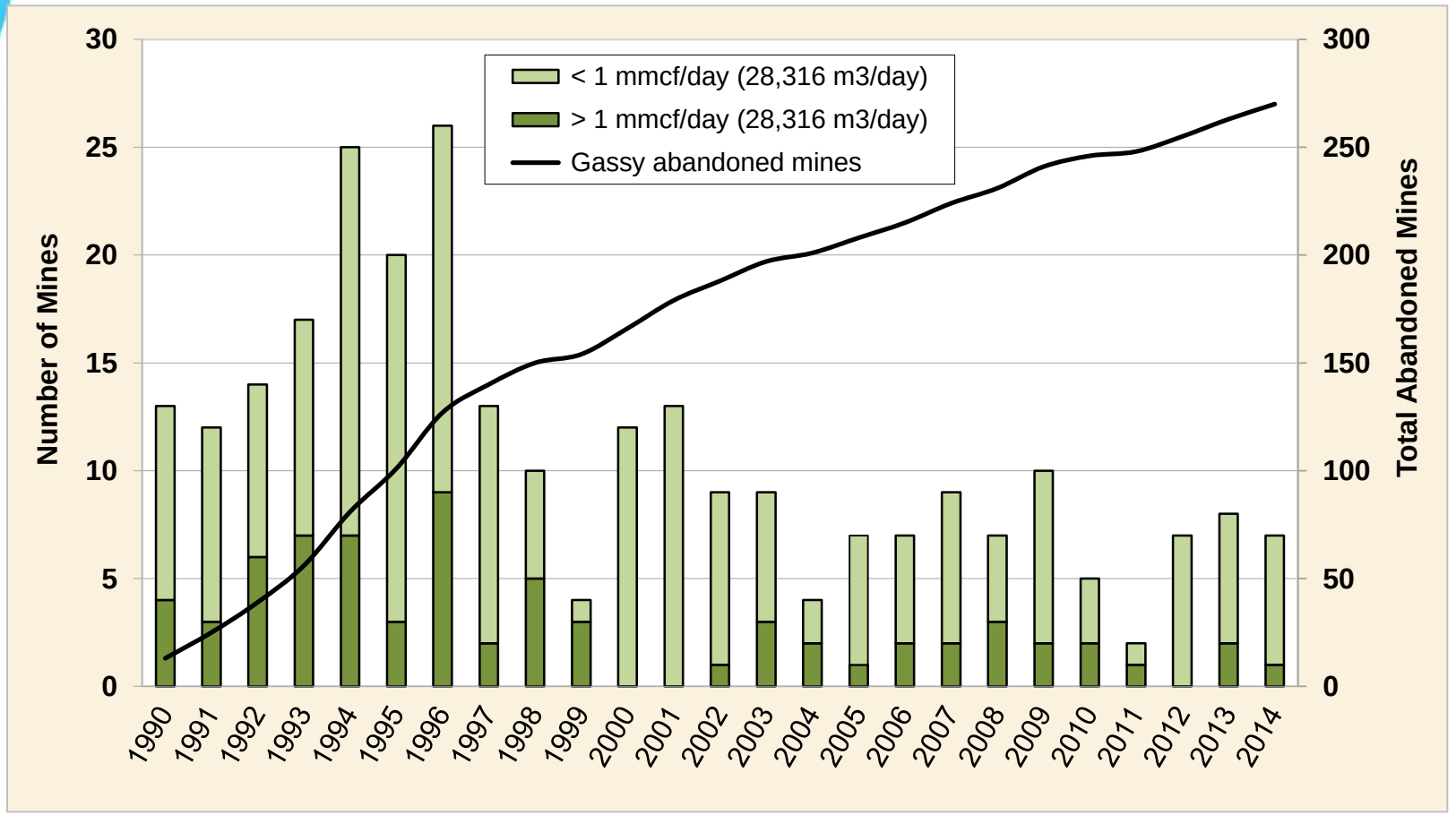
Number of Abandoned Coal Mines in the U.S.



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Future AMM Projects

Annual Abandoned Mine Rate in U.S.

Years	Gassy UG Mines Abandoned	Mines >1mmcf/d (28.3 m3/day)
1990 – 1999	11	5
2000 – 2009	7	2
2010 - 2014	5	1

Questions:

How do you evaluate the resource?

What are some best practices when preparing to close a mine?

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AMM v. CMM Projects

What are the differences?

- AMM flows decline over time
- No mine ventilation air to compete with
- AMM infrastructure smaller than CMM
- AMM gas ownership issues
- Sealing integrity of mine vents & pipes
- No mining company involvement
- High and consistent quality

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Evaluating AMM Resources

- Screening Criteria & Model Inputs
  - Mine size; greater than ~1,000 acres
  - Closure date; more recent is better
  - Specific emissions; over ~200 scf/ton mined (6.2 m^3/tonne)
  - Mining method; longwall is best
  - Location; market for energy
  - Ownership; surface and mineral

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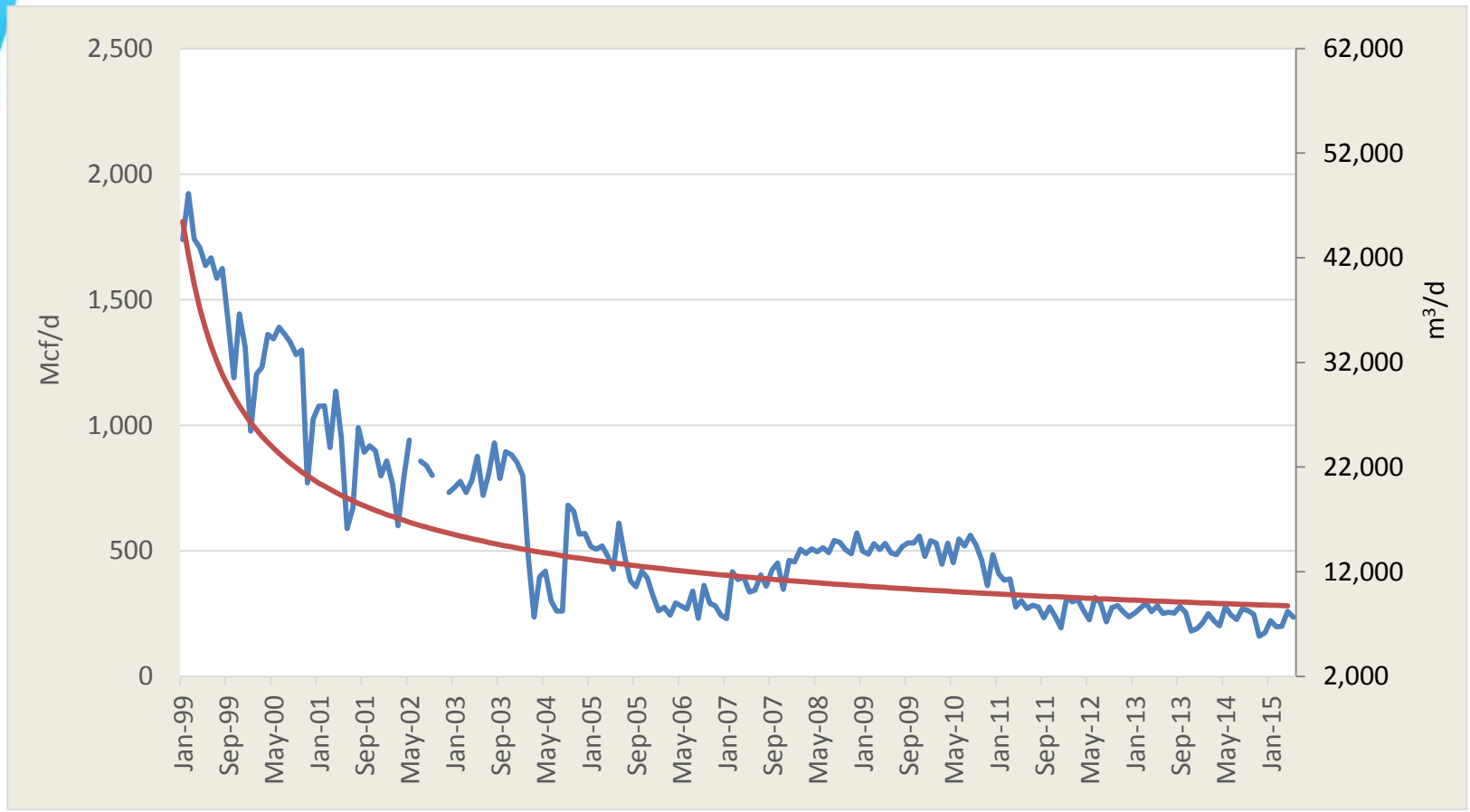
Actual AMM Production vs. Decline Curve Model Forecast



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Evaluating AMM Resources

- Pressure Testing
  - Using the void volume from the model, determine the expected pressure response relative to the volume of gas produced (gas law)
  - Drill borehole into roadway or use pre-existing borehole
  - Continuously monitor the static pressure of the borehole together with the barometric pressure

Evaluating AMM Resources

- Flow Testing & Pressure Buildup
  - Using a portable testing rig with a flare and blower can produce the gas at either constant rate or pressure
  - Continuously monitor gas rate, methane content and upstream pressure
  - Shut-in well, and let pressure stabilize at a predetermined volume recovered.
  - Compare actual pressure to expected pressure from model

Evaluating AMM Resources

Photo courtesy of Perennial Energy

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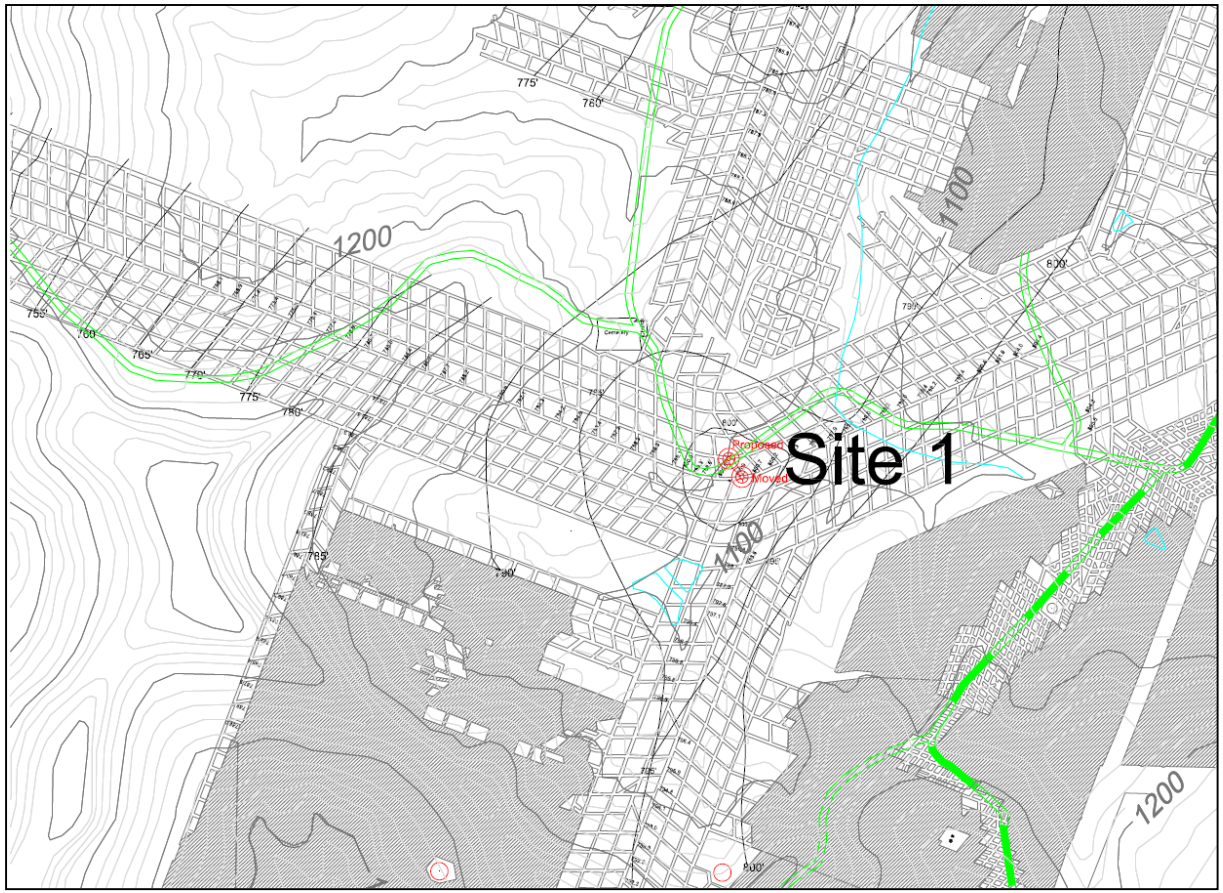
Evaluating AMM Resources

- Results
  - A comparison of the *pressure change vs gas volume recovered* will provide an indication of the volume of the void in contact with the wellbore
  - Modify model to conform to test results
  - Once the test is completed, allow the pressure to build over time to determine the recharge rate of the gas desorbed from the coal

Evaluating Old Mine Maps & Coal Contours



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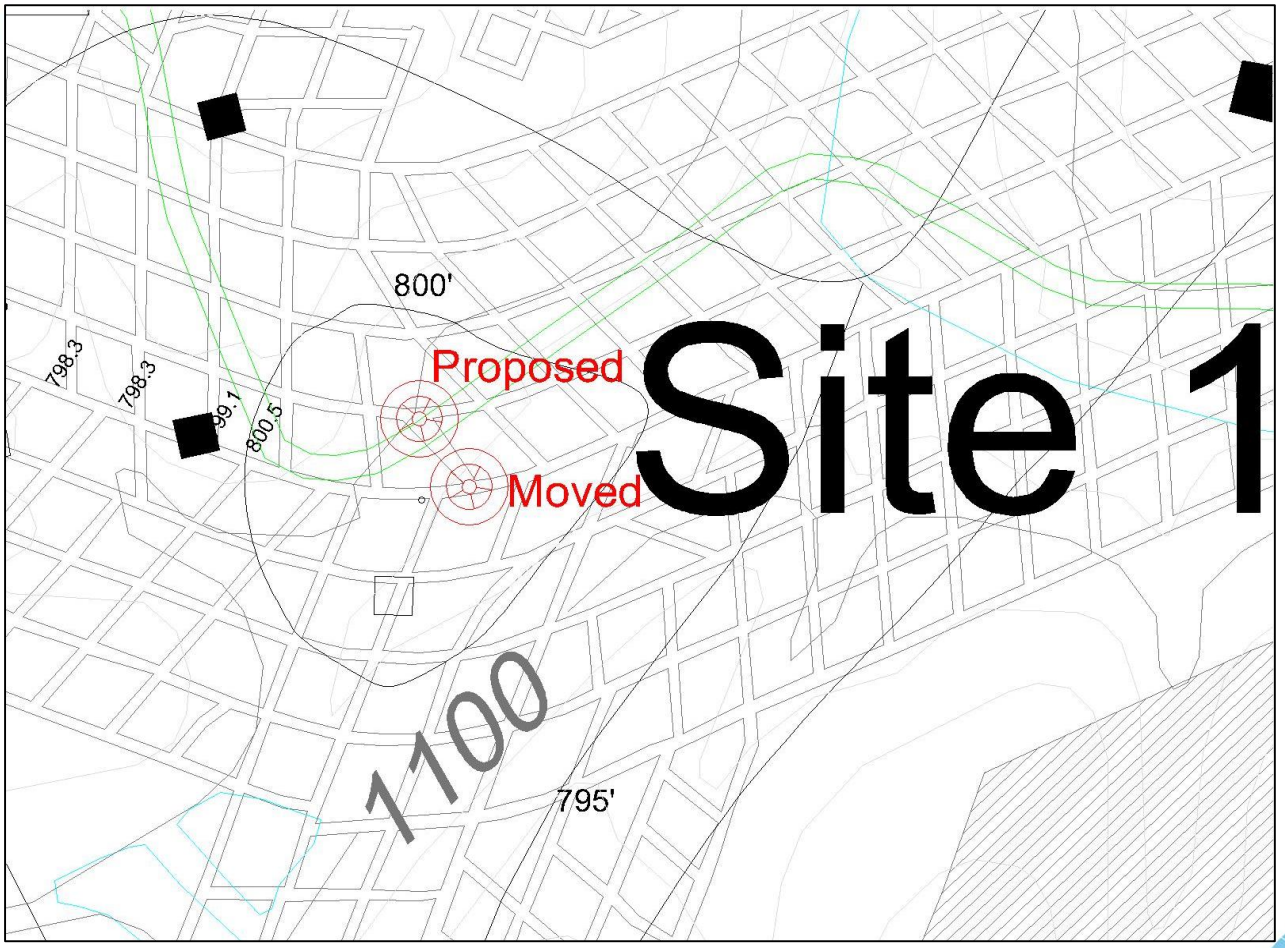
Evaluating Coal Contours & Surface Topography



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Overlay Surface Features to View Potential Drill Sites

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Preparing Underground Workings at Active Mines

- Installing gas piping underground
- Accessing sealed mining districts
- Using the mine roadways as conduit for methane flow
- Verify integrity of surface seals to prevent atmospheric air intrusion

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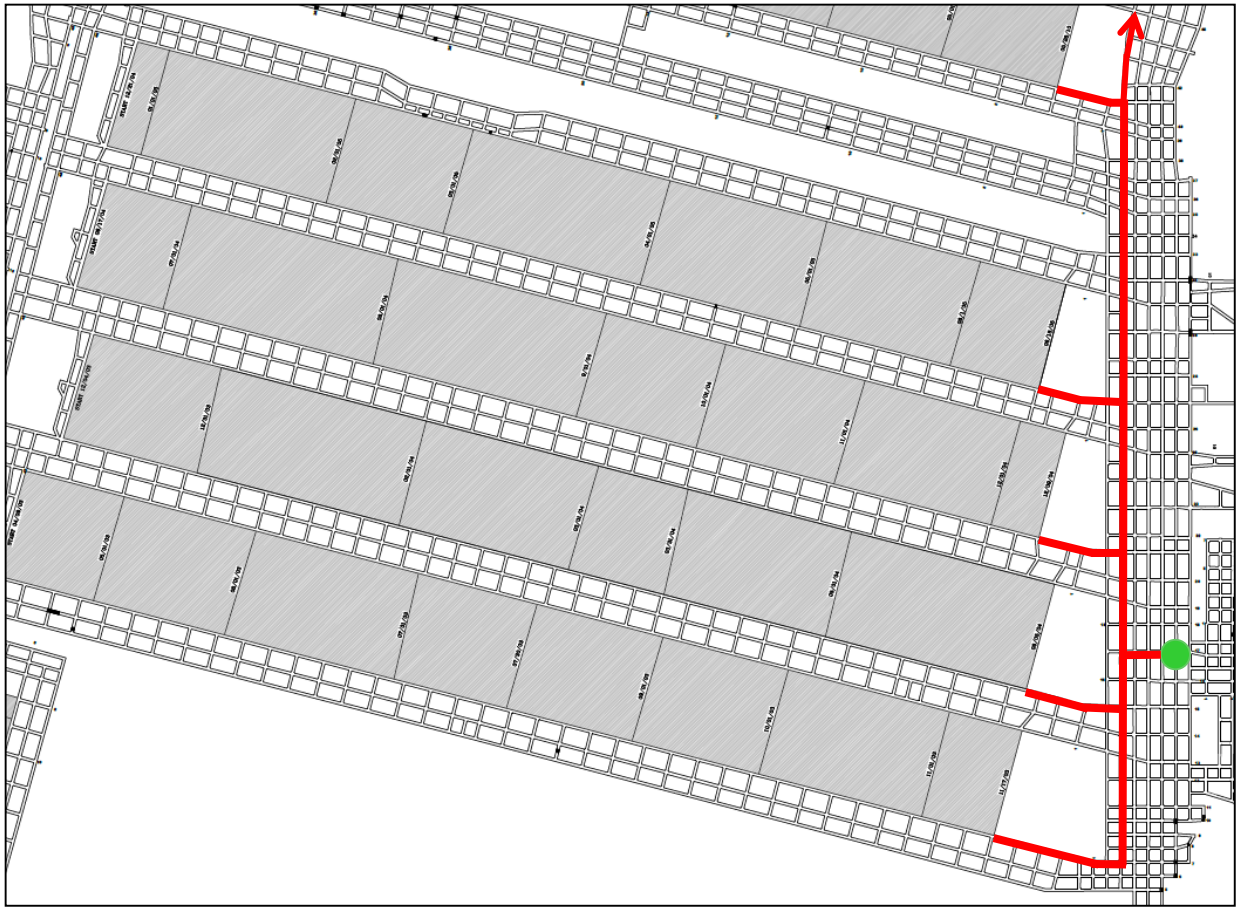
Installing Underground Pipes to Access Sealed Areas



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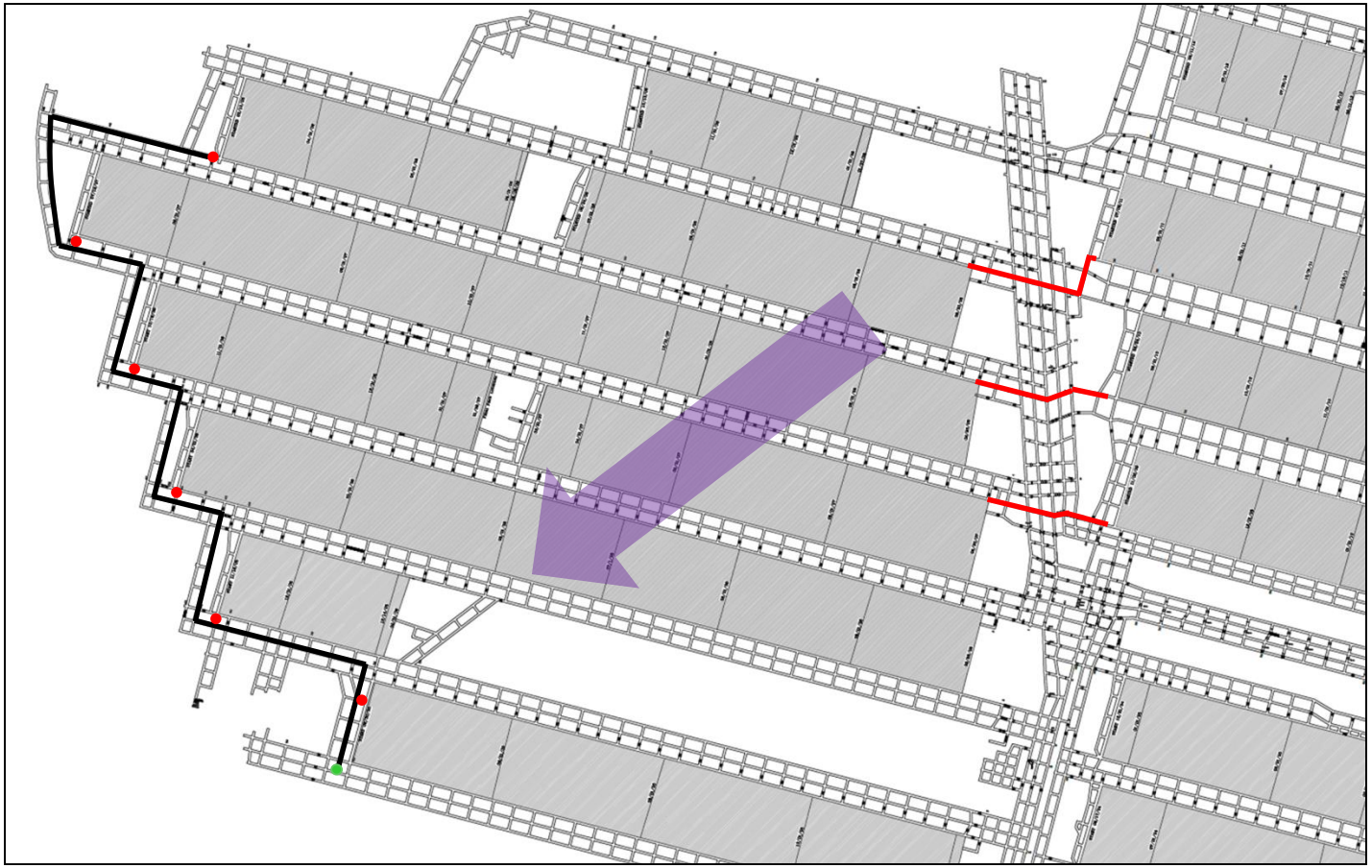
Accessing Sealed Areas Using Mine Roadways



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Conclusions

- AMM projects offer a different set of opportunities and challenges
- Performing a proper resource evaluation to adequately size the project
- Integrity of mine seals at the surface can limit suction pressure and methane production
- Importance of preparing an active mine for methane extraction at the time of closure

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Thank you!

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