Maximizing Value of Abandoned Mine Methane

Global Methane Forum

Toronto, Canada

April 17, 2018

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RUBY CANYON ENGINEERING

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Presentation Outline

- Introduction
- Preparing Underground Workings
- Evaluating AMM Resource
- Estimating Reserves
- Mine Aggregation
- Conclusions

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AMM Pros and Cons

- 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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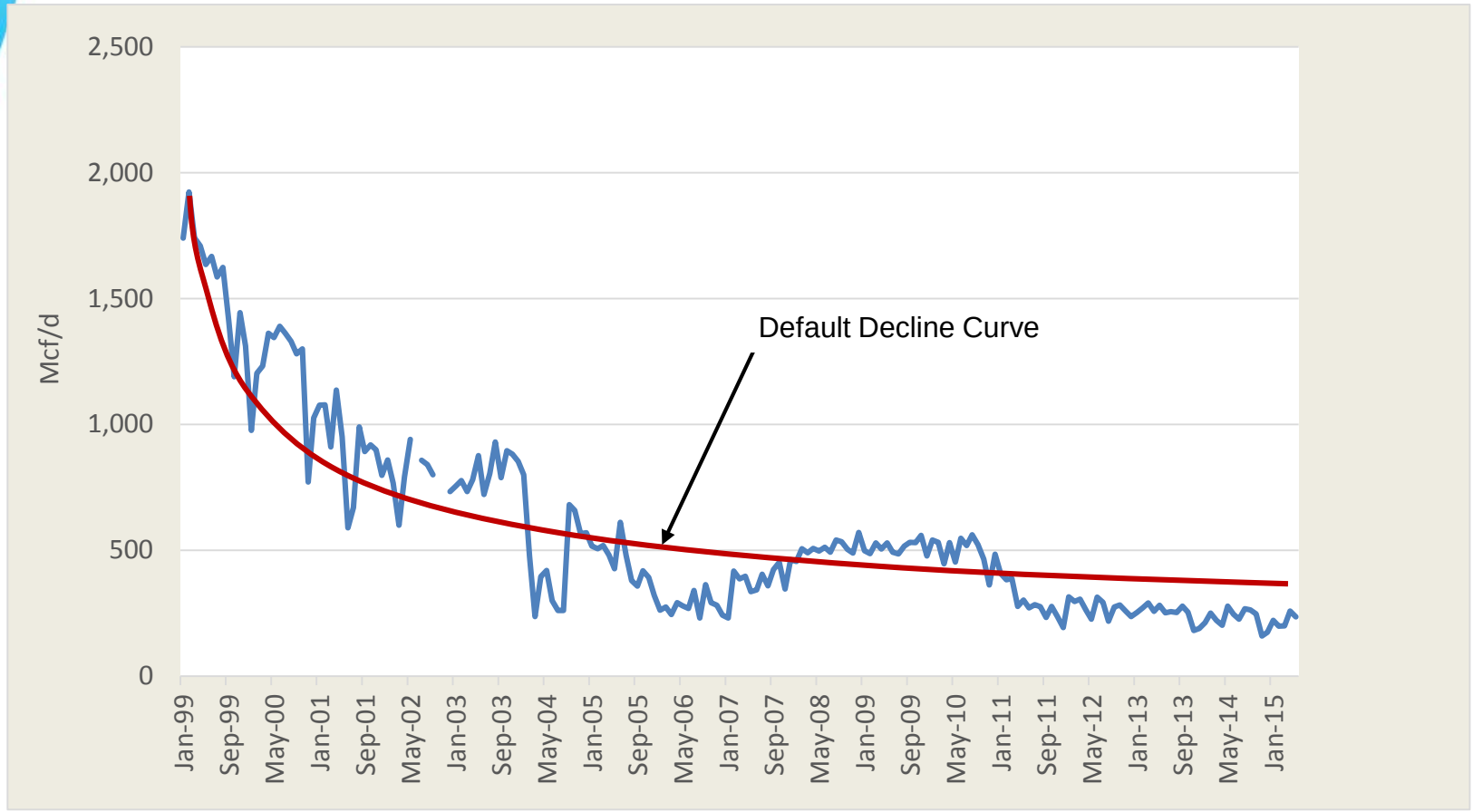
Actual AMM Production vs. Decline Curve Model Forecast



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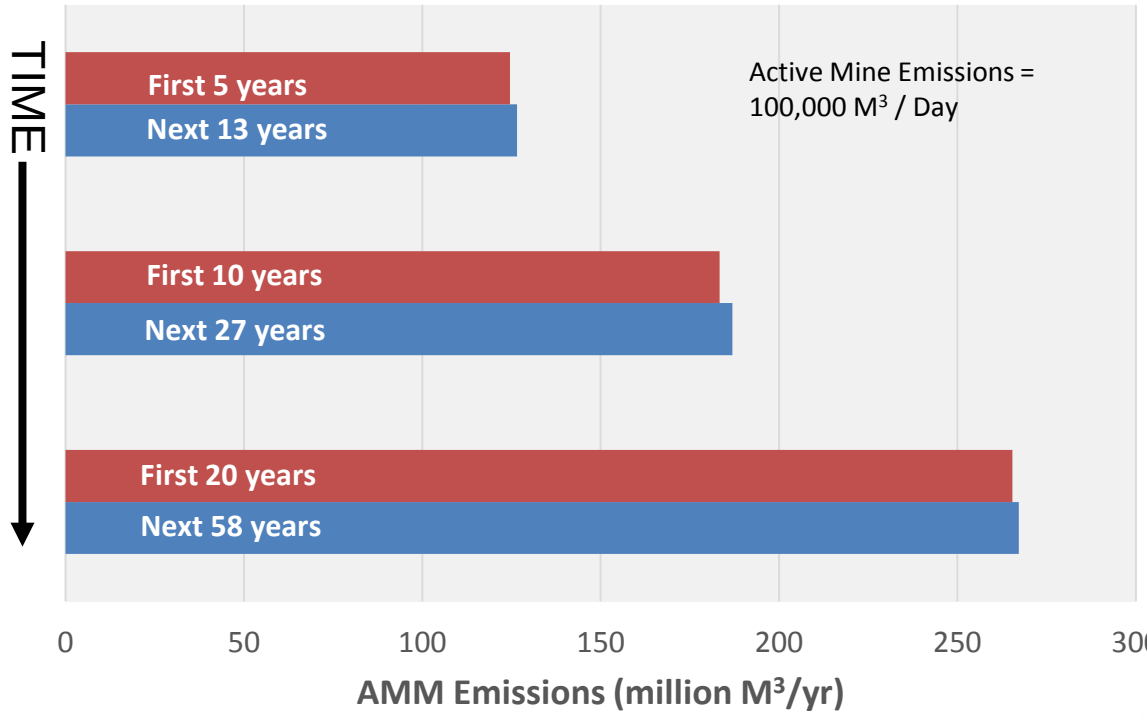
Preparing Coal Mines for AMM Projects

AMM Recovery - Sooner is Better!

- AMM Emissions Forecast Using Decline Curve Estimate



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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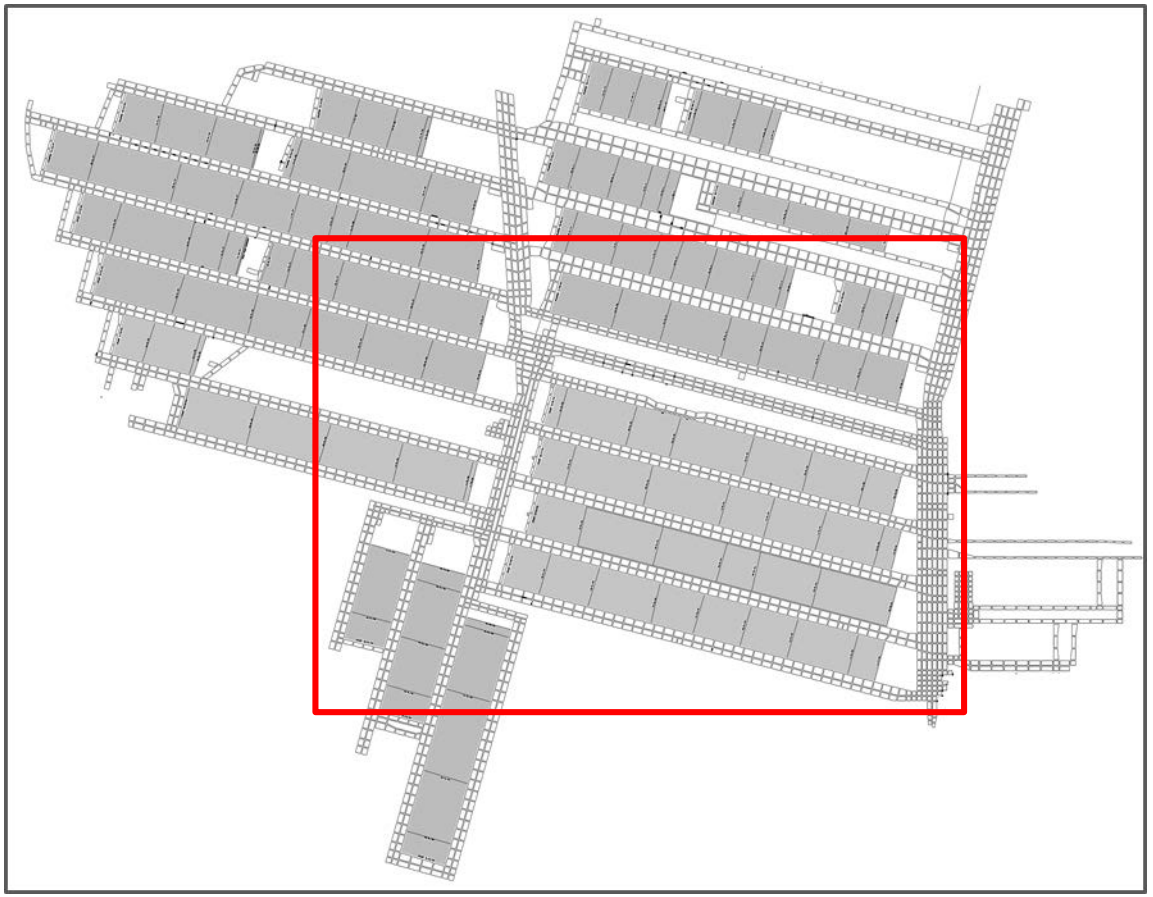
Installing Underground Pipes to Access Sealed Areas



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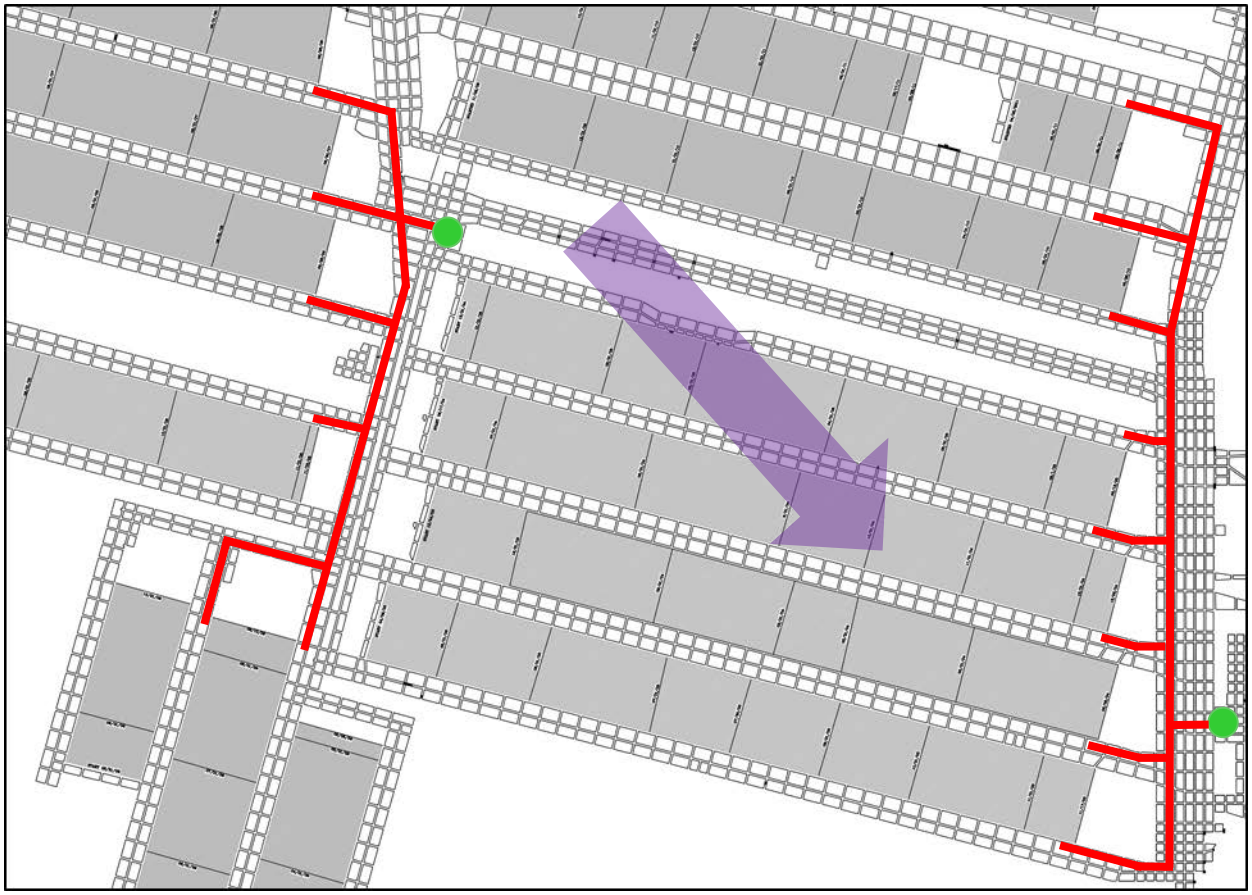

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Accessing Sealed Areas Using Mine Roadways

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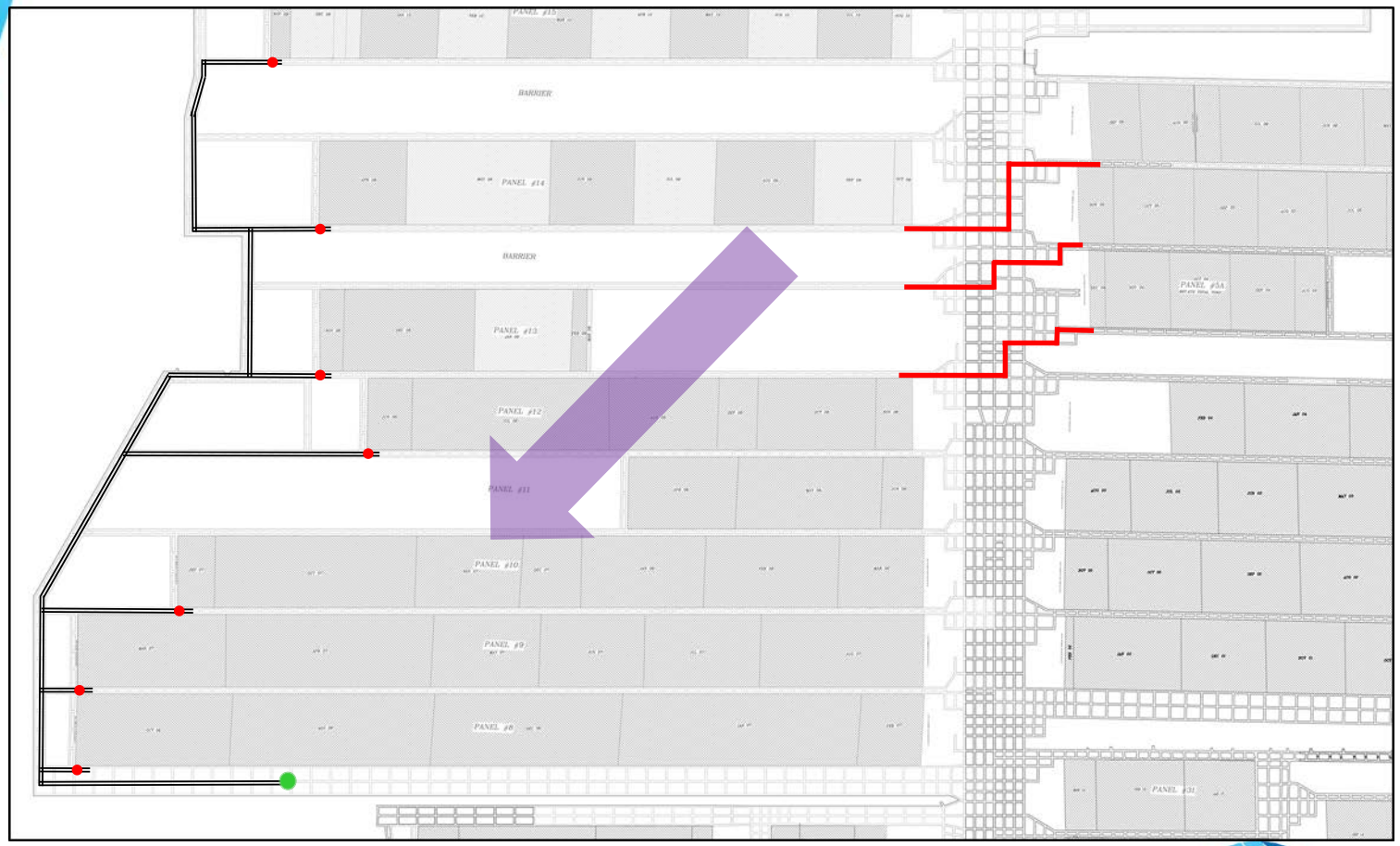
Accessing Sealed Areas Using Mine Roadways



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Evaluating AMM Resources

- Pressure Testing
  - Estimate the void volume using mine maps and coal production records.
  - Continuously monitor the static pressure of a borehole/well and barometric pressure
- Flow Testing & Pressure Buildup
  - Continuously monitor gas flow rate, methane content and upstream pressure
  - Shut-in well, let pressure stabilize at a predetermined volume recovered
  - Compare actual P to expected P from void model

Evaluating AMM Resources

Photo courtesy of Perennial Energy

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Estimating Reserves

- Analyzing Results
  - A comparison of the *pressure change vs gas volume recovered* will provide an indication of the methane volume in contact with the wellbore
  - Repeat procedure for additional wells (if applicable)
  - Test data can be compared to a generic decline curve that was used in the original resource assessment

Estimating Reserves

- Forecasting Production
  - Initial Forecast - Recalibrate model to conform to flow test results
  - Follow-up Forecast - Apply a best fit decline function to the actual production data
  - Project decline function into future years
  - Repeat model recalibration every one or two years

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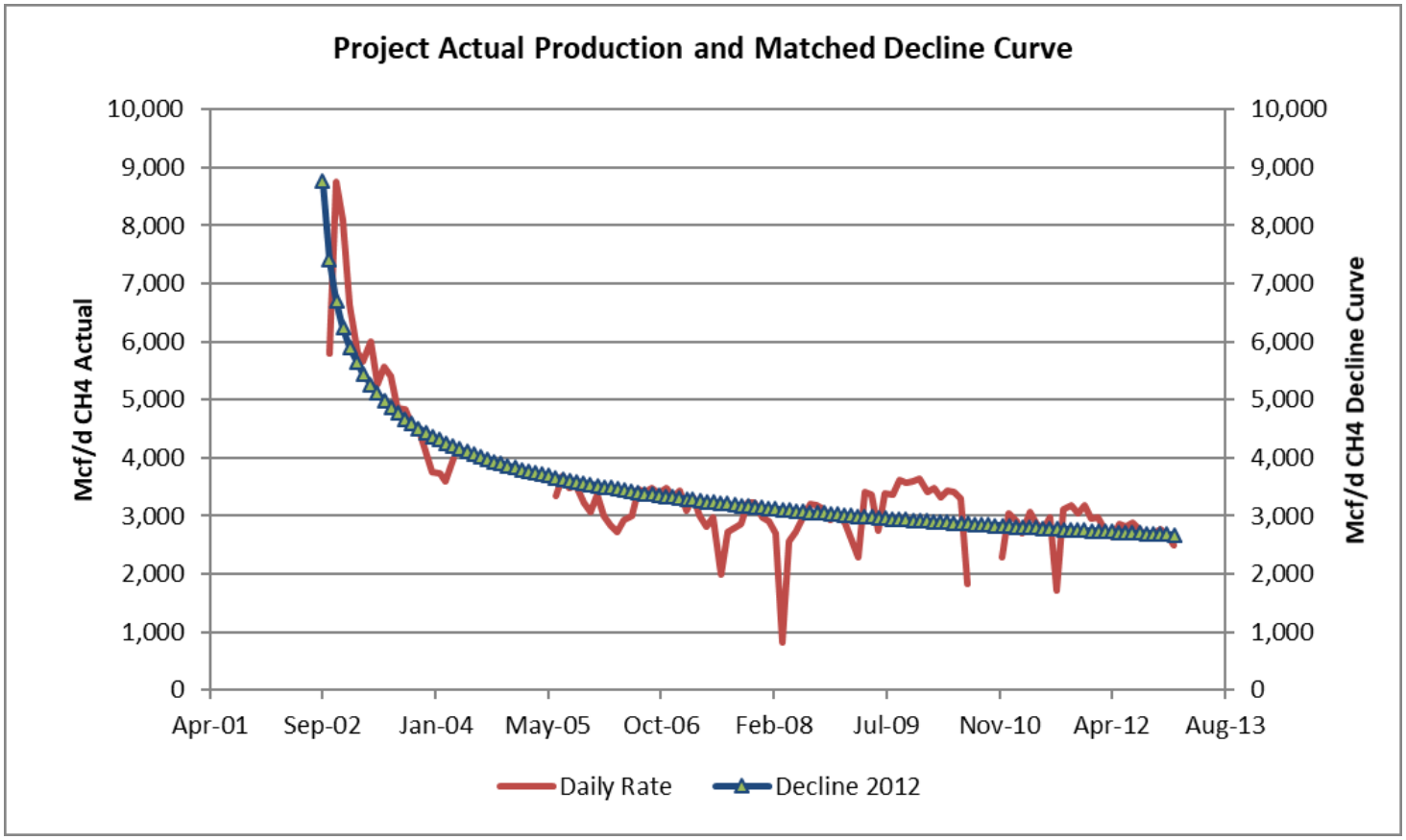
Estimating Reserves



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Aggregating Abandoned Mines in the U.S.

- Total AMM Projects –
  - 19 AMM projects at 45 mines
- Aggregated Projects –
  - 3 AMM projects group 3-5 mines into a single project
  - 1 AMM project aggregates methane from 14 mines
  - 3 AMM projects are combined with existing CMM projects

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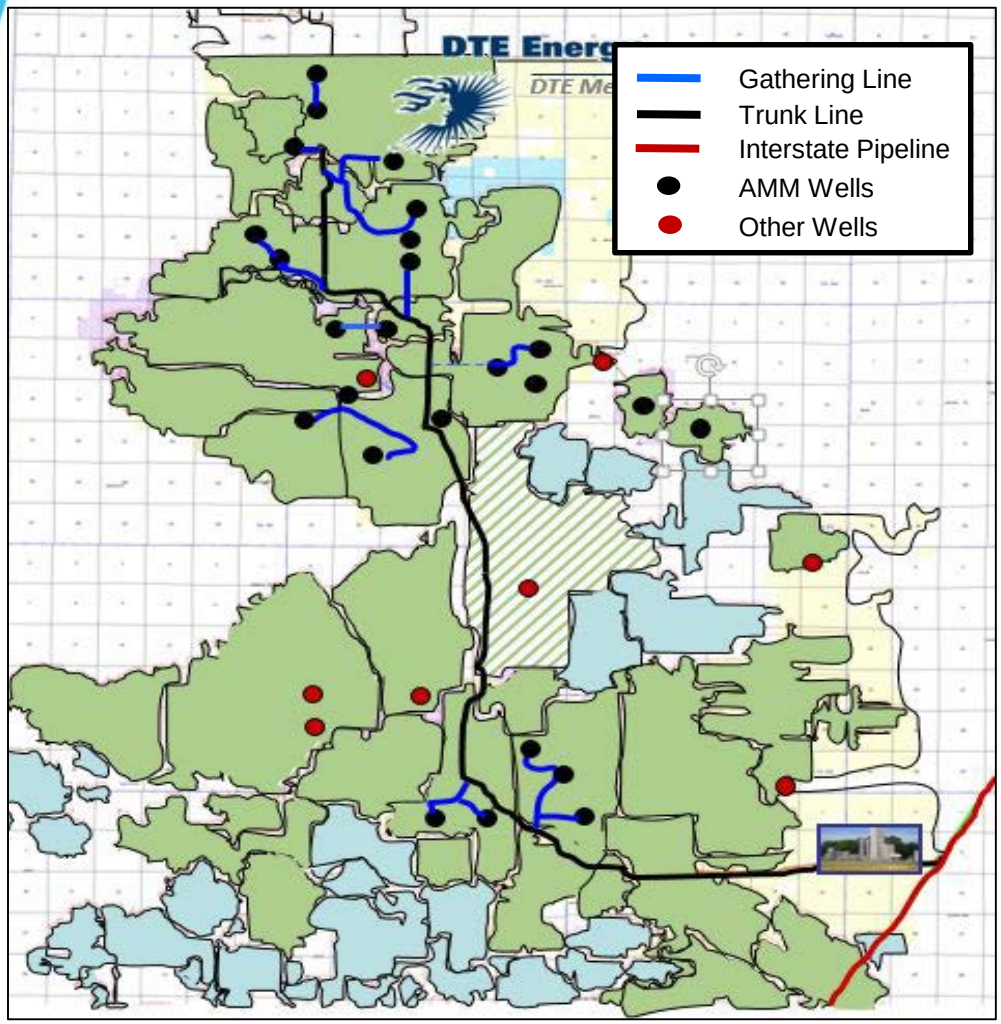
Example AMM Project – Illinois, U.S.



- 14 mines
- 31 wells
- 70% CH_4
- 34,000 hectares
- 11 field stations
- 85 mM^3/day

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Technical Barriers

- Uncertainty in methane resource
- Geological conditions
- Water flooding
- Compartmentalization
- Adequate piping and seals upon closure
- Suction pressure
- Remote locations with limited access

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Conclusions

- AMM projects offer a different set of opportunities and challenges
- Perform a proper resource evaluation to adequately size the project
- Preparing an active mine for methane extraction at the time of closure
- Important to update reserves model

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Thank you!

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