Alberta Energy Regulator

AGS ALBERTA GEOLOGICAL SURVEY

Review of Management of Induced Seismicity

Todd Shipman, PhD and Ryan Schultz
Alberta Geological Survey

October 26th, 2018

Risk Management Approach to Induced Seismicity

Establishing the Context:
What are the potential outcomes (negative or positive) of the induced seismicity?

-safety to people and infrastructure, groudwater impacts, social perception/security, economic realities. What can be tolerated by induced earthquakes? Where? Why?

Risk Identification

Where is induced seismicity occurring?

What are the interaction that could lead to induced seismicity? Geologic condition or operations behavior.

What are the best predictors of induced seismicity?

Risk Analysis

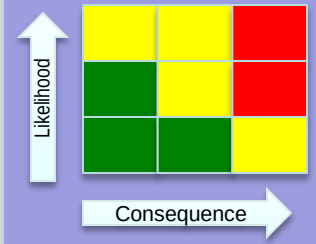
If an geological association, then; What is the regional distribution of susceptibility?

If an operational association, then; What parameter is most associated with triggered events?

How should this be mitigated?

Risk Evaluation

Evaluation of risk with using a heat map, common risk framework, bounded by acceptable risk.



Risk Treatment

Decisions: develop regional strategies for management with allowances/thresholds/avoidance areas

Compliance: monitoring and improved reporting

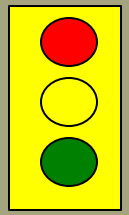
Policy for long term planning.

Risk Treatment

- Process to modify risk. Can involve avoiding the risk, taking or increasing the risk in order to pursue an opportunity; removing the risk source, changing the likelihood; changing the consequences, sharing the risk with another party or parties, and retaining the risk by informed decision

Risk Treatment

Reactive

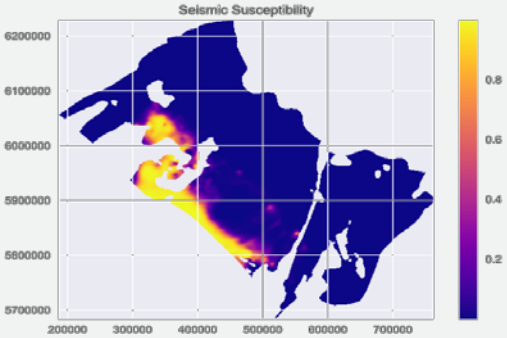


Suspend Operations

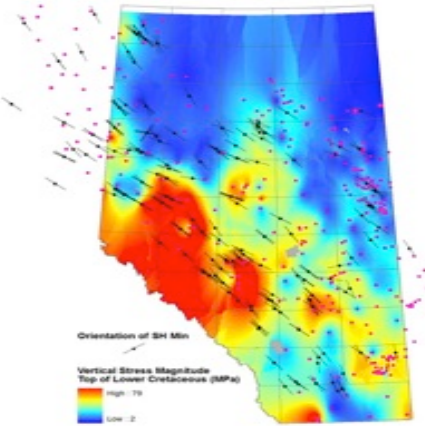
Modify Operations

Normal Operations

Proactive



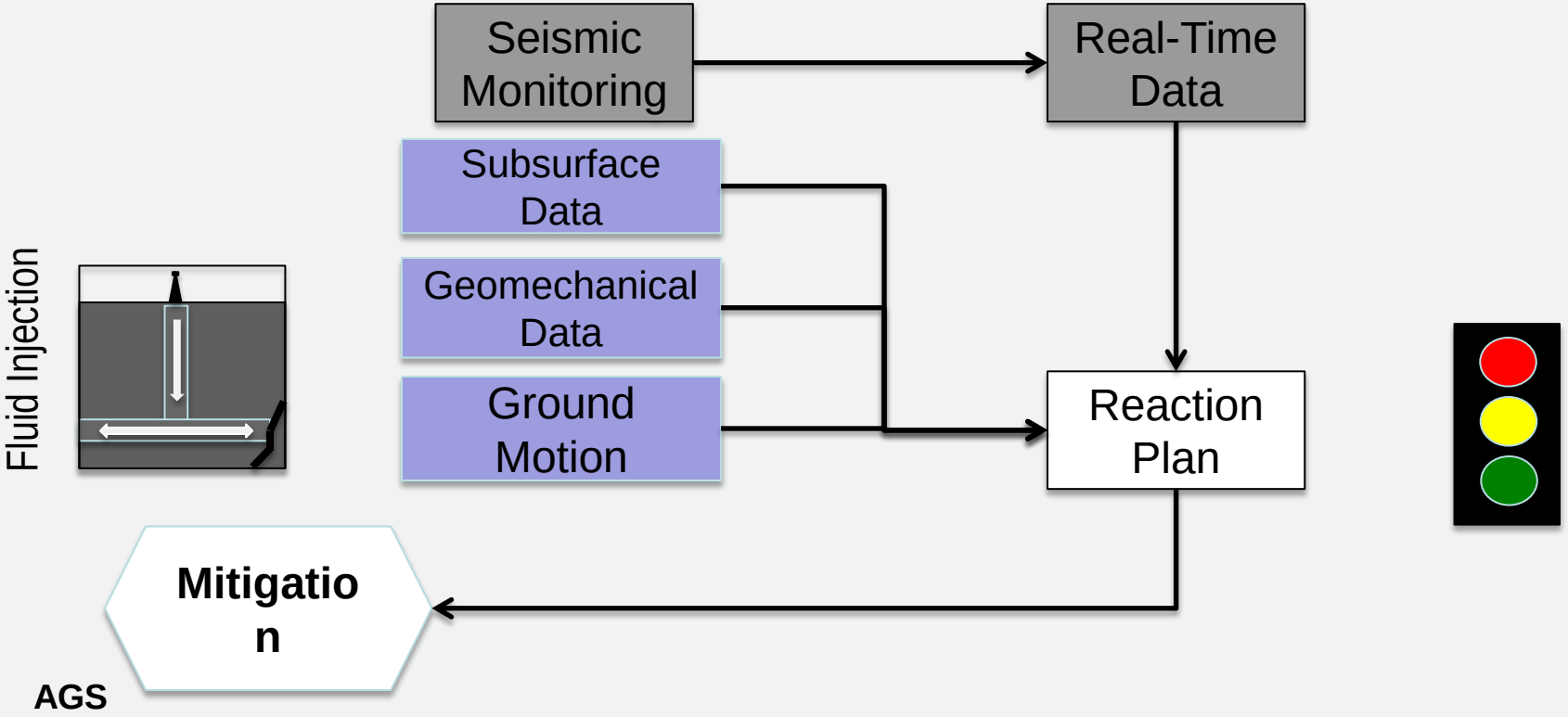
Forecast



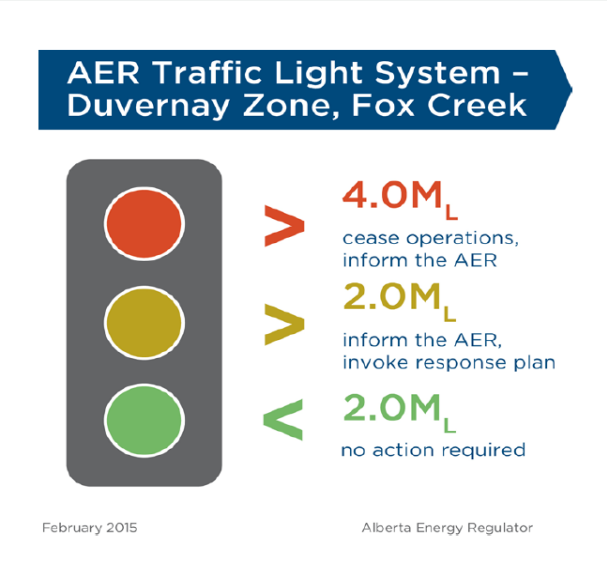
Reactive Risk Treatment

- Risk treatments that allow for non-damaging induced seismic events to occur with a threshold based zone of enforcement
- React to these with mitigation that allows the reduce the risk.

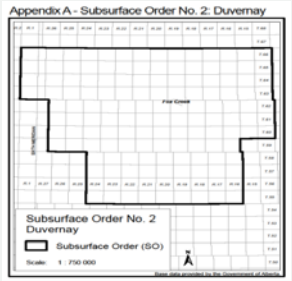
Typical Traffic Light Protocol



Subsurface Order #2, Traffic Light Protocol for Induced Seismicity

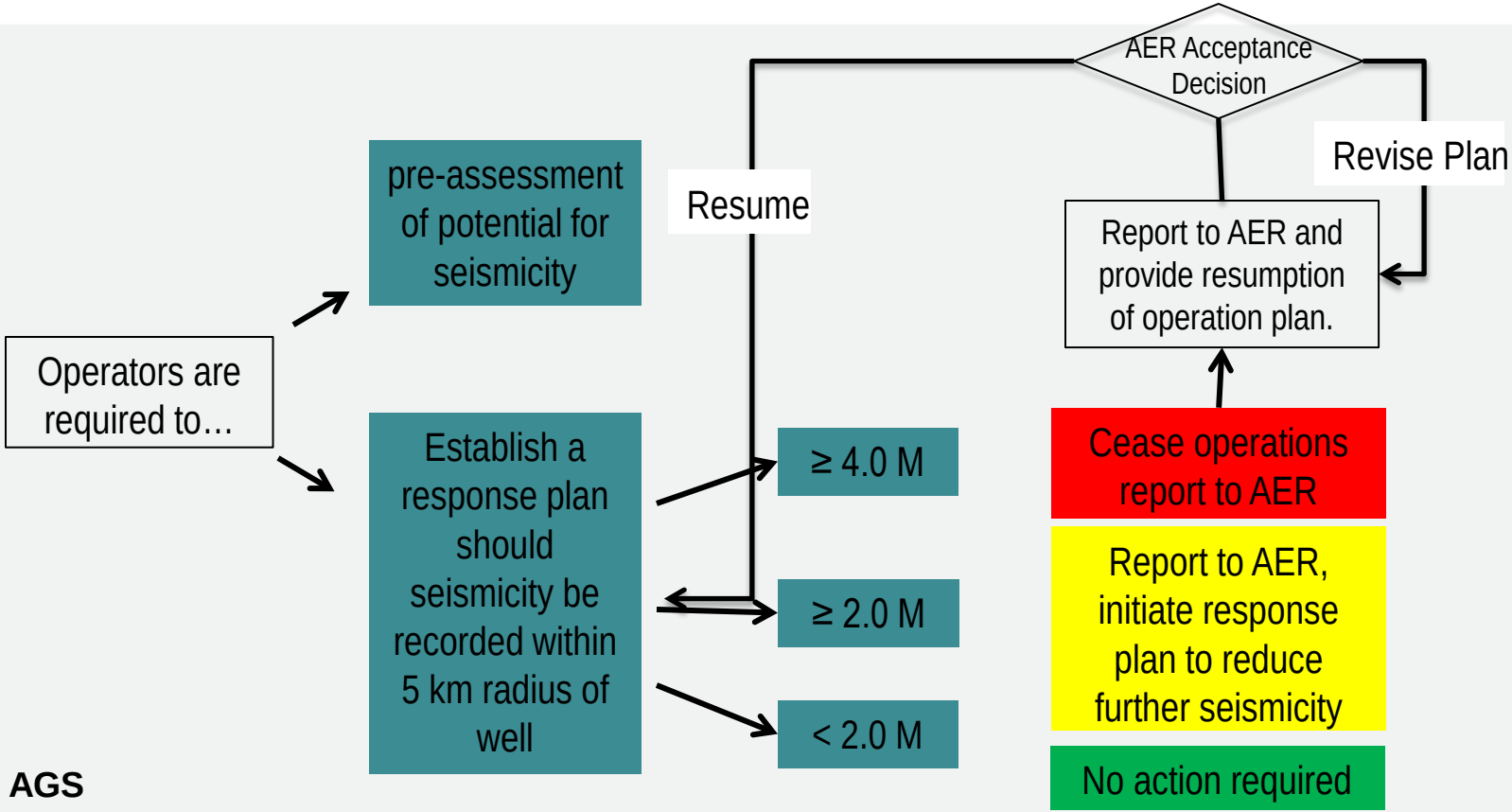


- Issued February 19, 2015
- Applies to hydraulic fracturing operations in Duvernay Zone in Fox Creek area
- Requires an assessment of induced seismicity, a plan to respond to induced seismicity, and seismic monitoring
- Uses a Traffic Light Protocol for response to seismic events



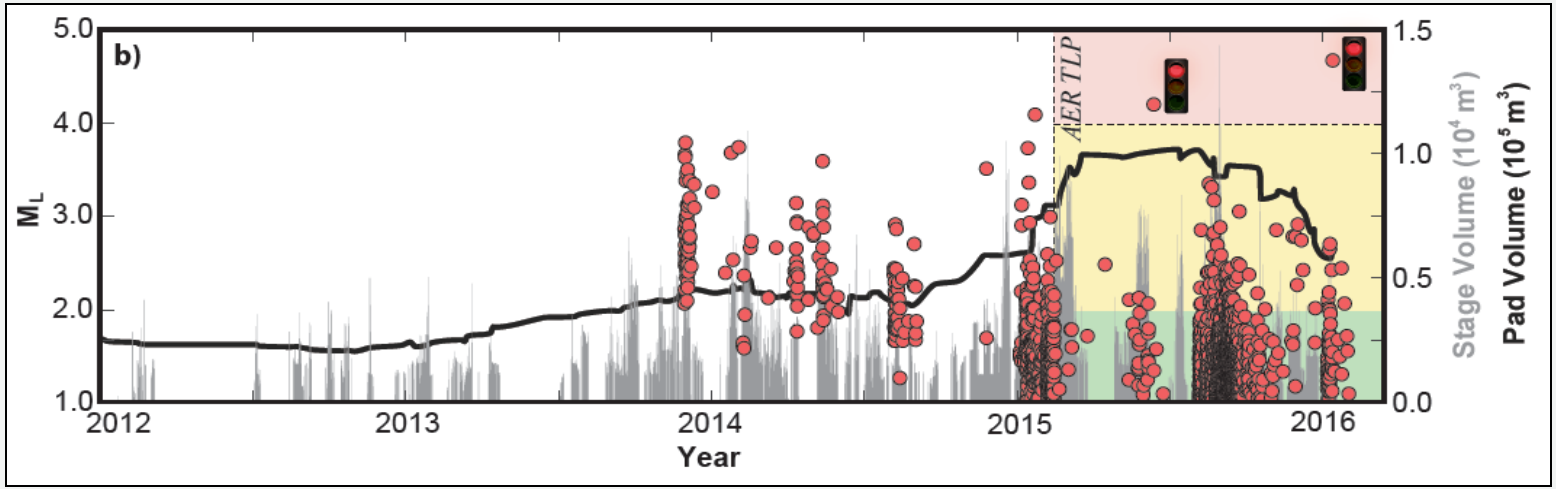
AGS

AER's Subsurface Order No. 2



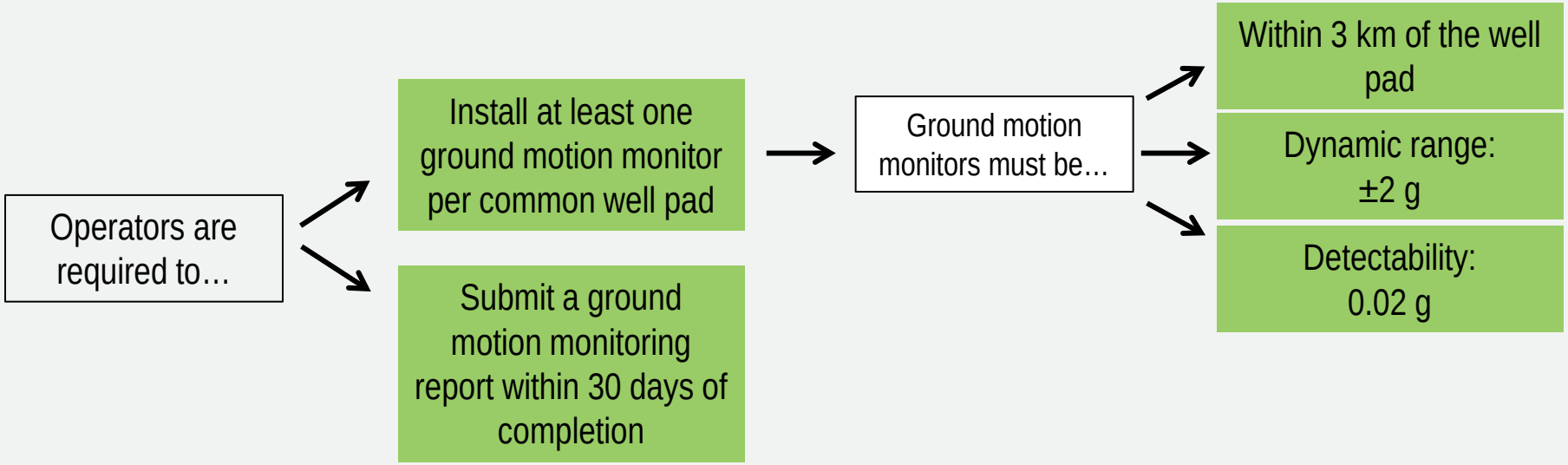
AGS

HF Operations near Fox Creek



After Schultz et al.,2018

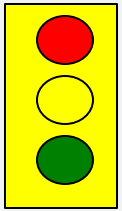
BCOGC's Ground Motion Regulations



AGS

Risk Treatment

Reactive

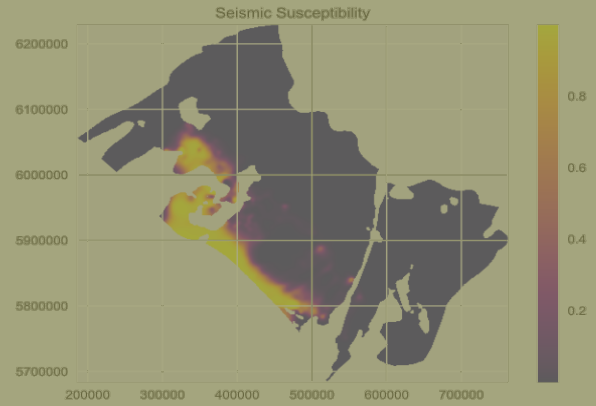


Suspend Operations

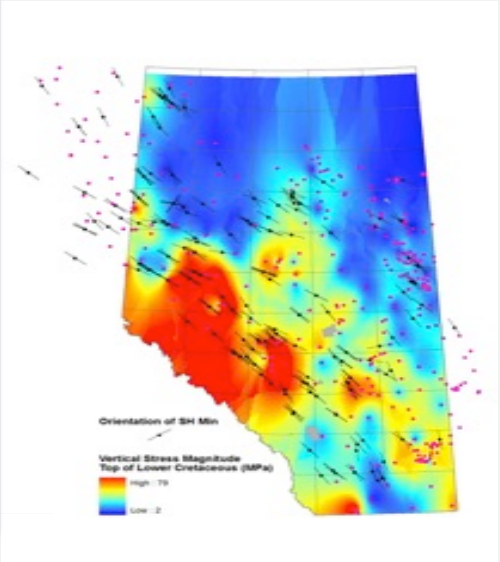
Modify Operations

Normal Operations

Proactive



Forecast



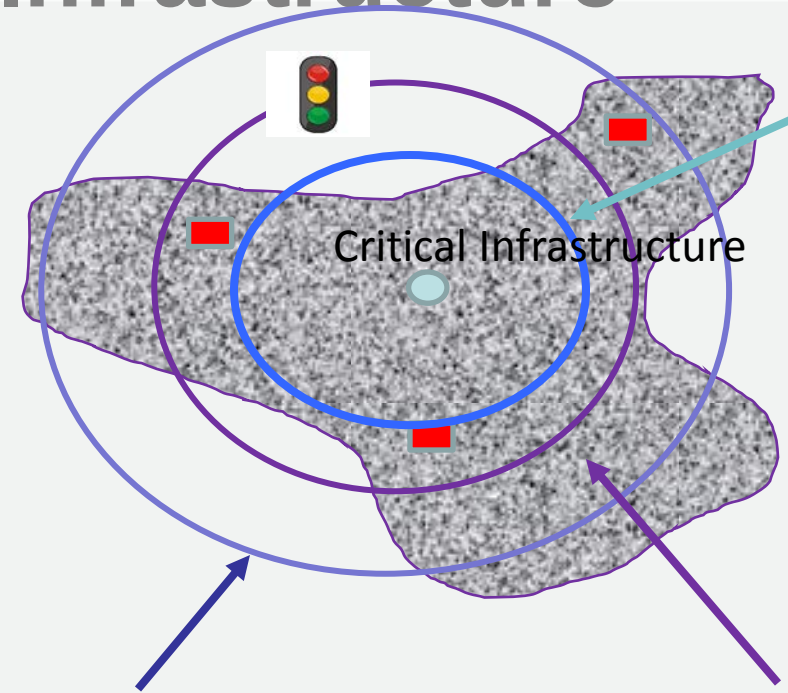
Proactive Risk Treatment

- Risk treatments prevent risky activity through avoidance.
- This includes mitigation of operational behavior, avoidance of susceptible areas, and/or setbacks

What options are there for managing the risk for induced seismicity?

- Avoidance
  - Geological susceptibility- effective stress, structures
  - Infrastructure-measured ground motion, distance activity, PSHA, Shake Maps
- Moratorium
  - Activity driven- disposal, conventional extraction, HF
  - Depth driven- prevent all operations near formations that are known to cause IS
  - Location driven- near susceptible areas, such as faults, zone where induced seismicity is more likely

Induced Seismicity Near Critical Infrastructure



Area of restricted oil and gas development

Resources under application

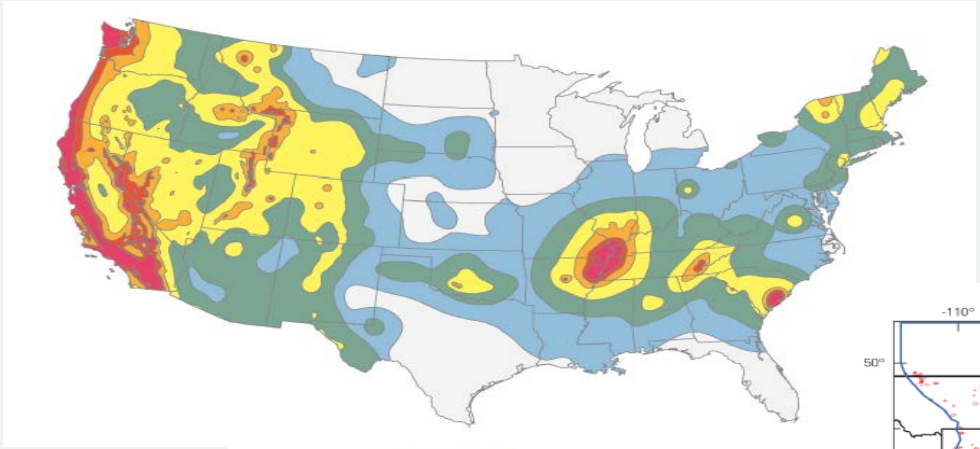
Well

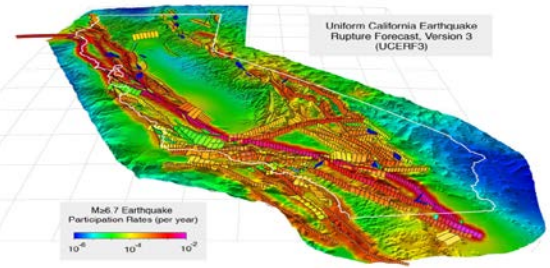
Site-specific mitigation strategy, traffic light, etc. to restrict potentially damaging ground motion from any susceptible play

Radius of monitoring and reporting

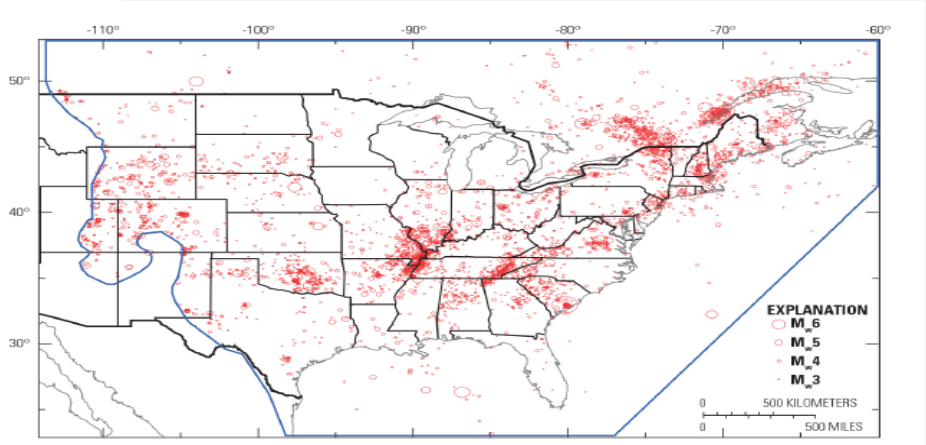
Radius of TLP w/ modifications

Seismic Susceptibility





Are there other underlying geological factors which we can correlate to induced seismicity?

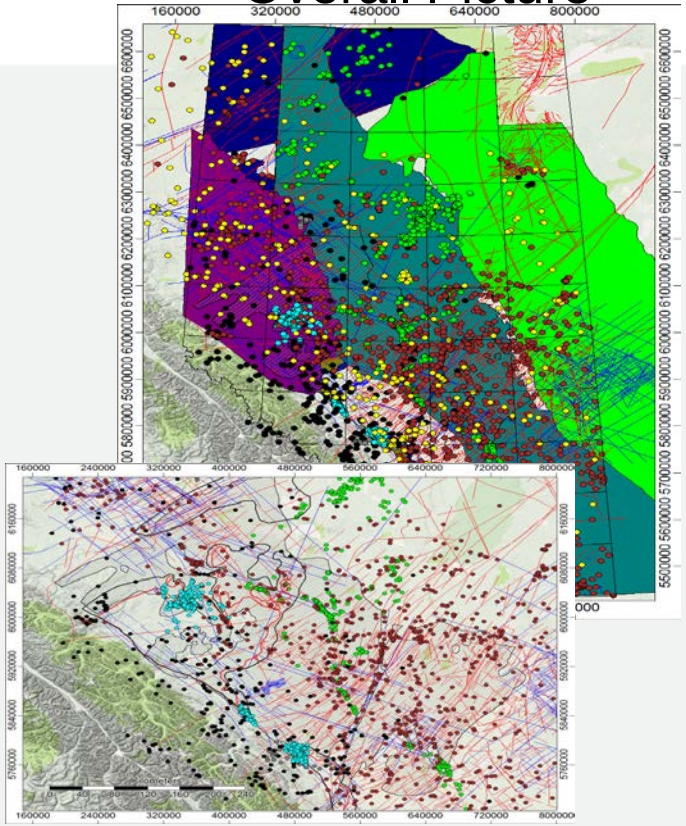


AGS

Geological Predictors

- Faults/Reef Edges
- Formations of Interest, including influence of temp and pressure (present/not present)
- Dolomite occurrence
- Li and Sr concentrations (indication of basement involvement)
- Pressure and Stress data
- Natural earthquake occurrence
- Basement structure

Overall Picture

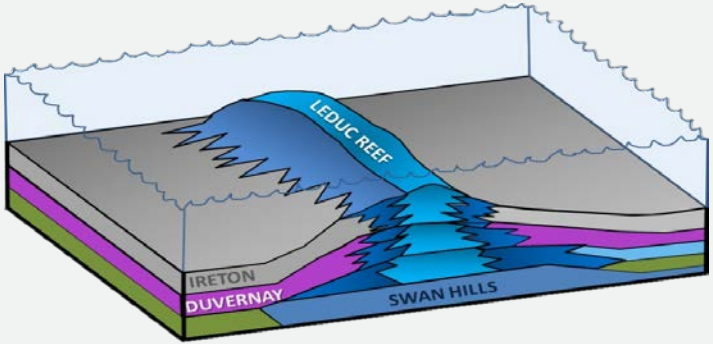


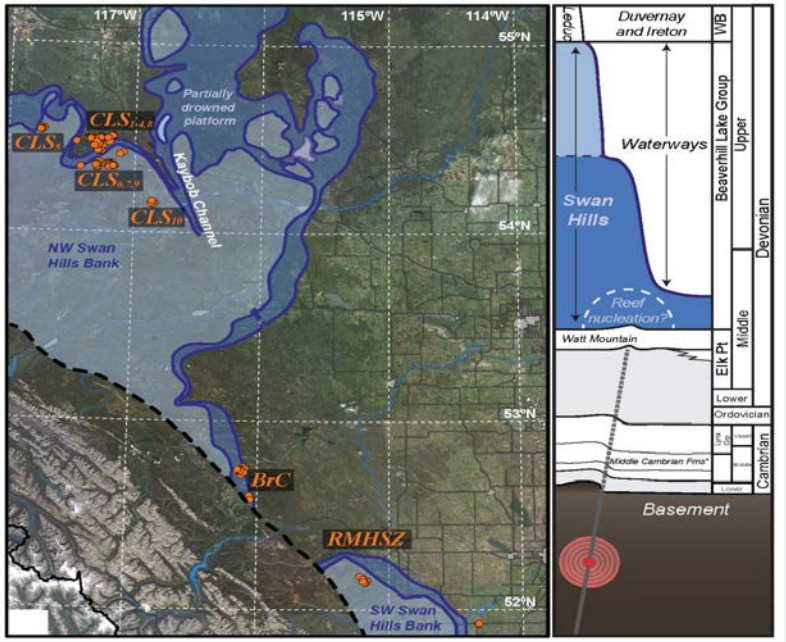
Duvernay Formation

AGS

Geospatial Association

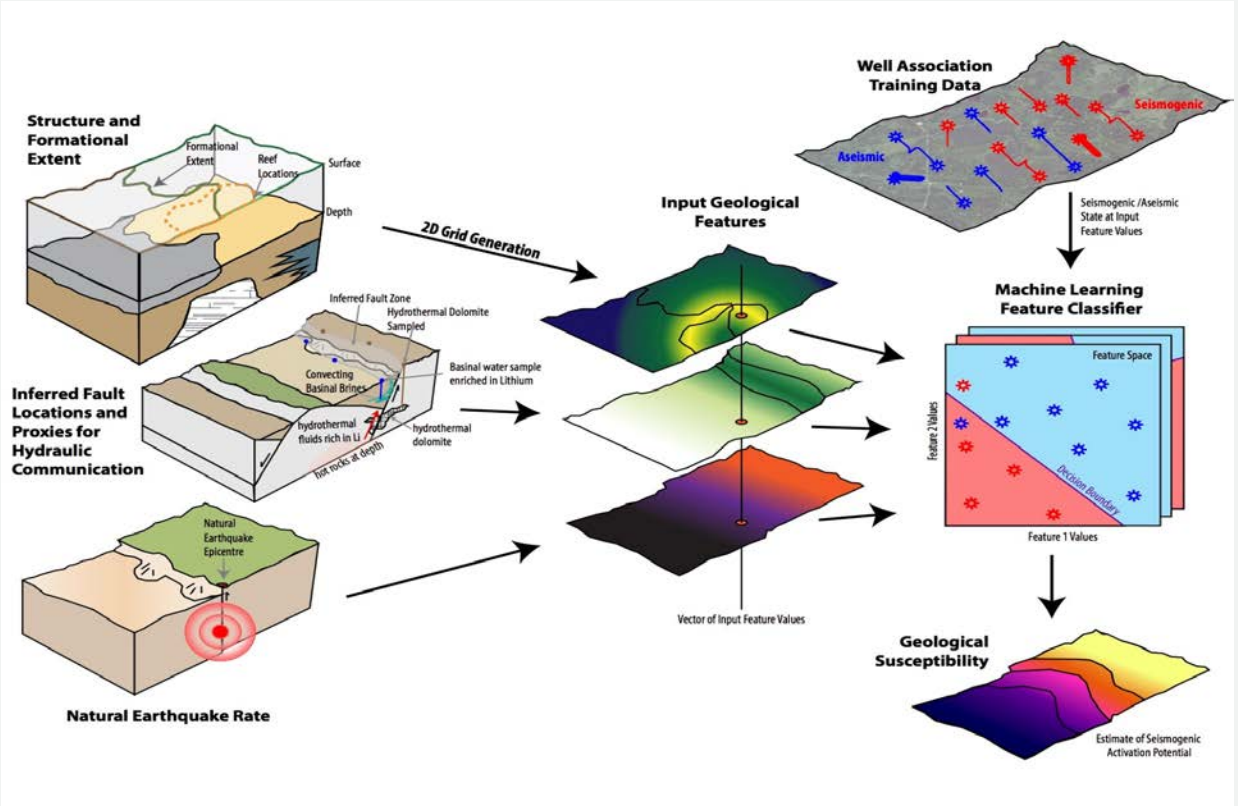
Geological features may be used to infer areas with faults that could be prone to reactivation; seismic events near Fox Creek and central Alberta follow a trend along an ancient fossil reef (Schultz et al., 2016)





AGS

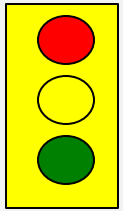
Susceptibility Modeling



AGS

Risk Treatment

Reactive

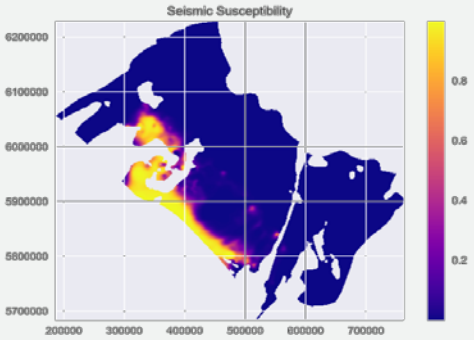


Suspend Operations

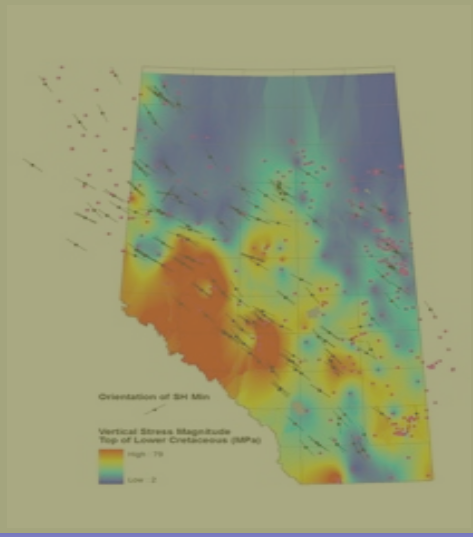
Modify Operations

Normal Operations

Proactive



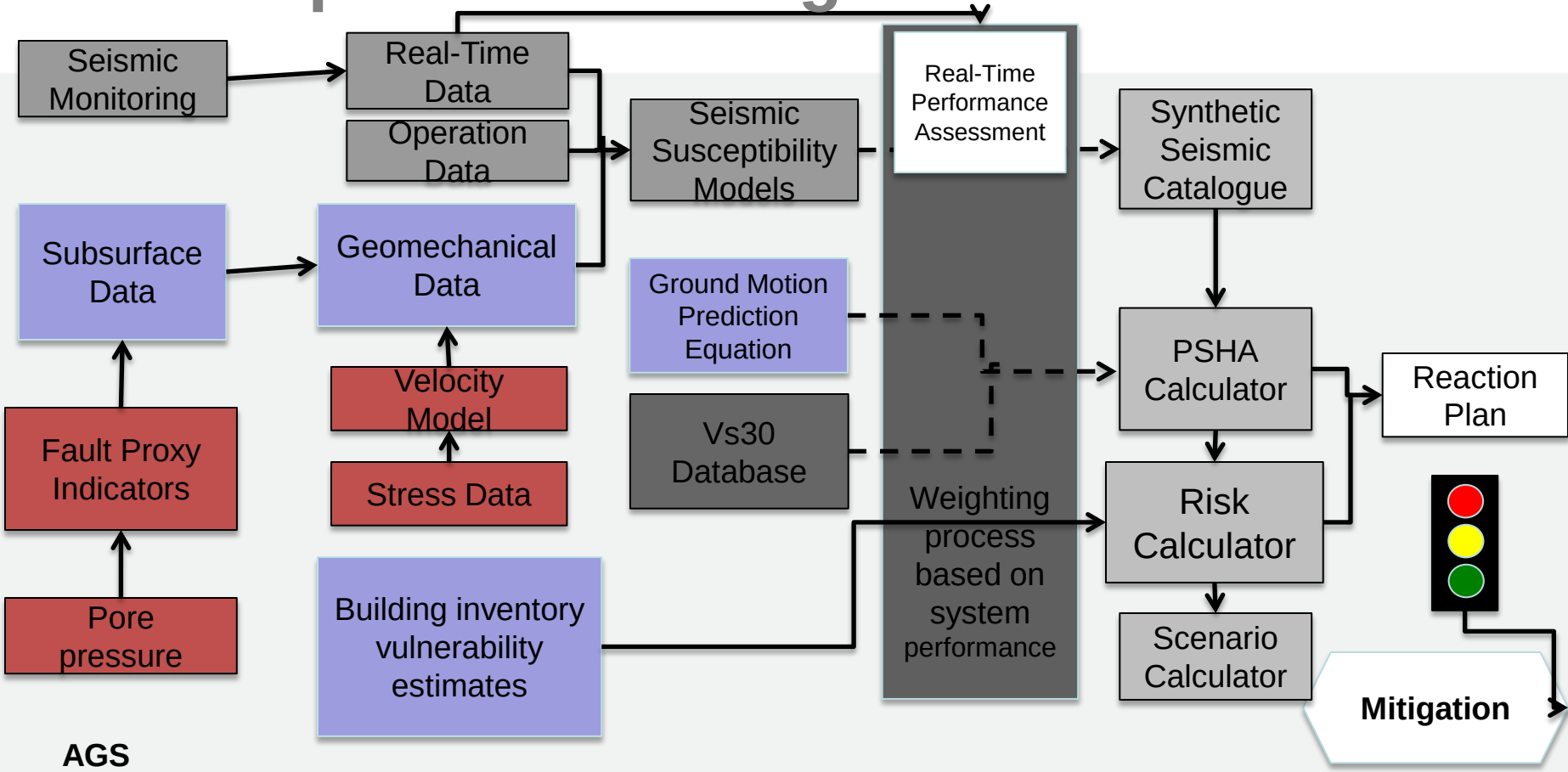
Forecast



Forecasted Risk Treatment

- Risk treatments that forecast the risk in order to mitigate it.
- This is a combination of a reactive and proactive treatment, which allows for activity in high risk areas and reacts to change in risk in order to avoid any damaging induced seismicity

Adaptive Traffic Light Protocol



Risk Management Approach to Induced Seismicity

Establishing the Context:
What are the potential outcomes (negative or positive) of the induced seismicity?

-safety to people and infrastructure, groudwater impacts, social perception/security, economic realities. What can be tolerated by induced earthquakes? Where? Why?

Risk Identification

Where is induced seismicity occurring?

What are the interaction that could lead to induced seismicity? Geologic condition or operations behavior.

What are the best predictors of induced seismicity?

Risk Analysis

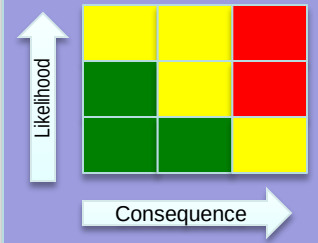
If an geological association, then; What is the regional distribution of susceptibility?

If an operational association, then; What parameter is most associated with triggered events?

How should this be mitigated?

Risk Evaluation

Evaluation of risk with using a heat map, common risk framework, bounded by acceptable risk.



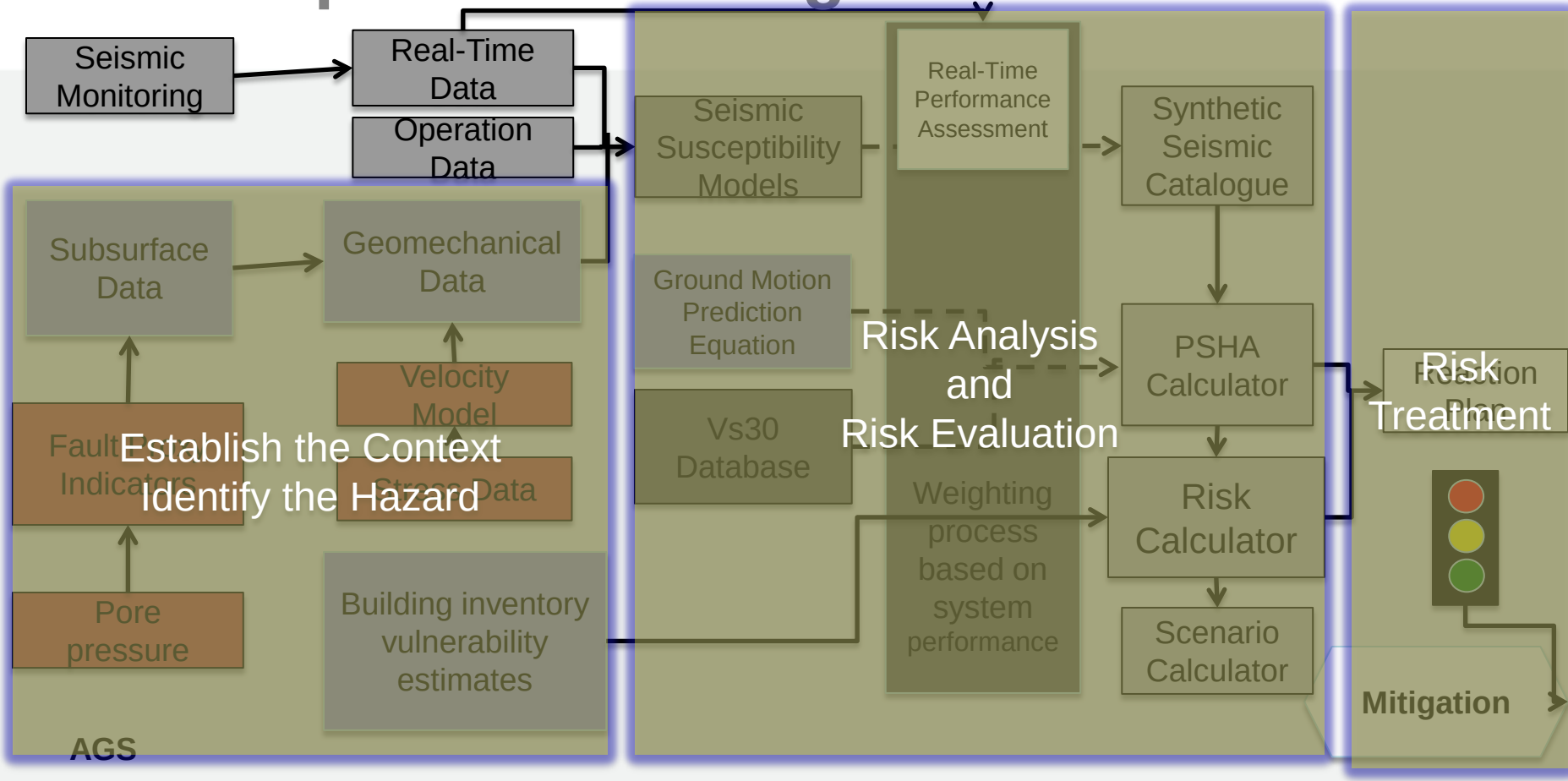
Risk Treatment

Decisions: develop regional strategies for management with allowances/thresholds/avoidance areas

Compliance: monitoring and improved reporting

Policy for long term planning.

Adaptive Traffic Light Protocol



Questions?

Thank you