The Integrated Well Factory

Modeling of Shale Field Developments

Department of Petroleum Engineering

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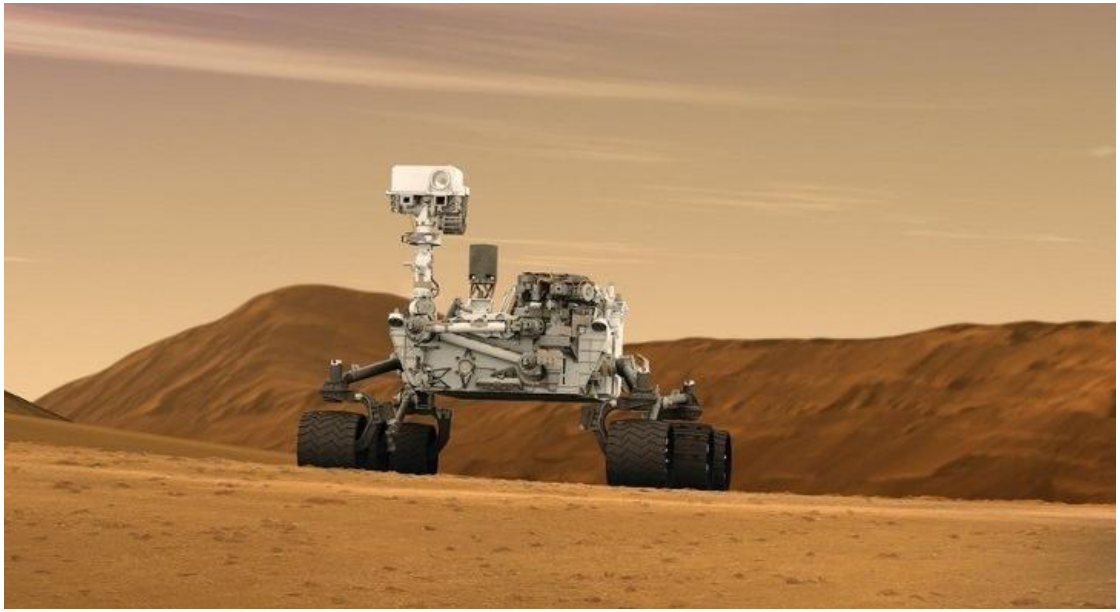
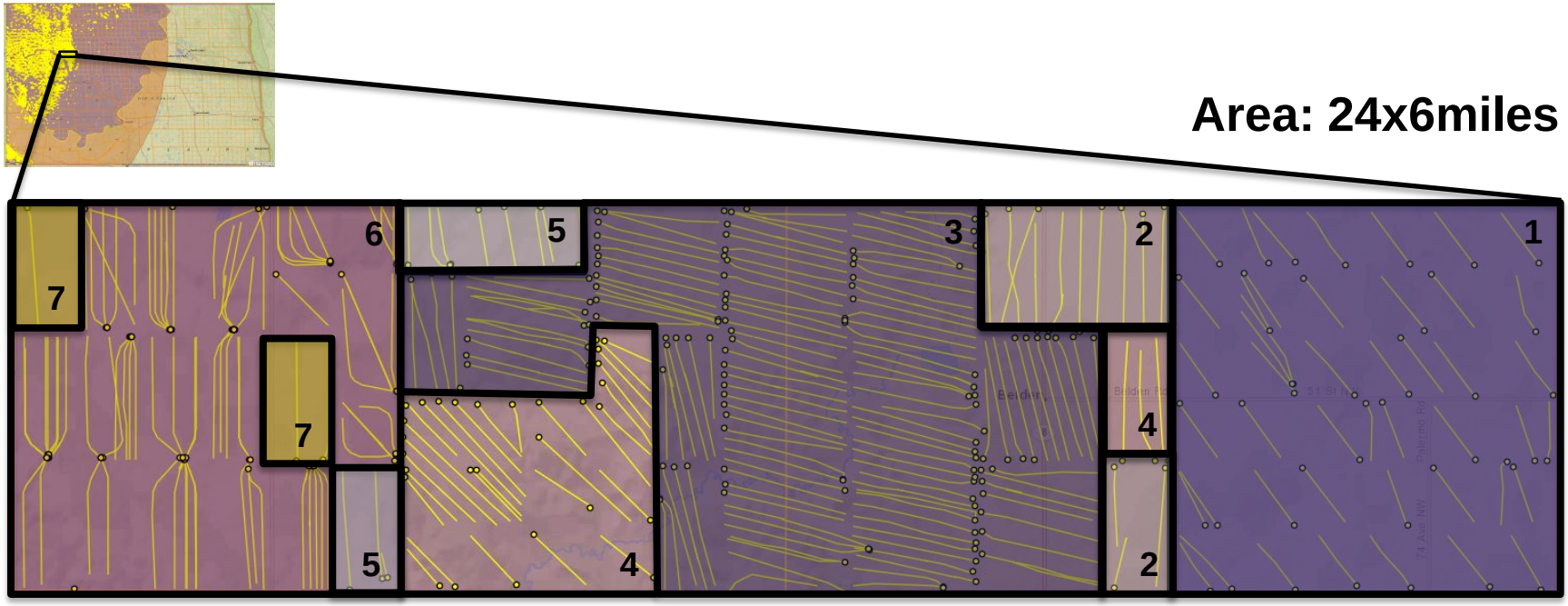
…what if we suppose it is a mission to Mars?



What if there is no room for trial and error?

Data Analysis



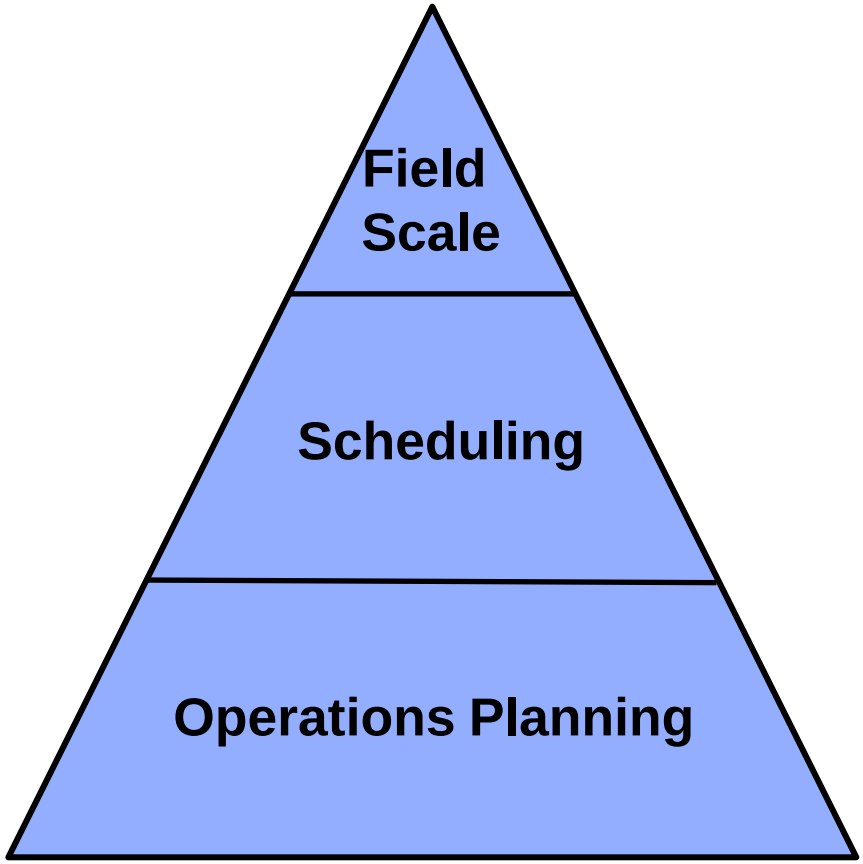
Company	Period	Wells	Pads	1 Well/Pad	2-4 Wells/Pad	>4 Wells/Pad	Lateral [m]	Well Spacing [m]
1	2008-2010	45	44	44	1		1,600	>500
3	2008-2012	13	13	13			3,200	400-600
2	2008-2013	131	121	113	8		3,200	500
5	2008-2012	28	28	28			1,600-3,200	300
4	2009-2011	10	8	6	2		1,500	200 (600)
6	2009-2013	68	23	7	11	5	3,200	125-500
7	2010-2013	3	3	3			3,200	(800)

GOAL

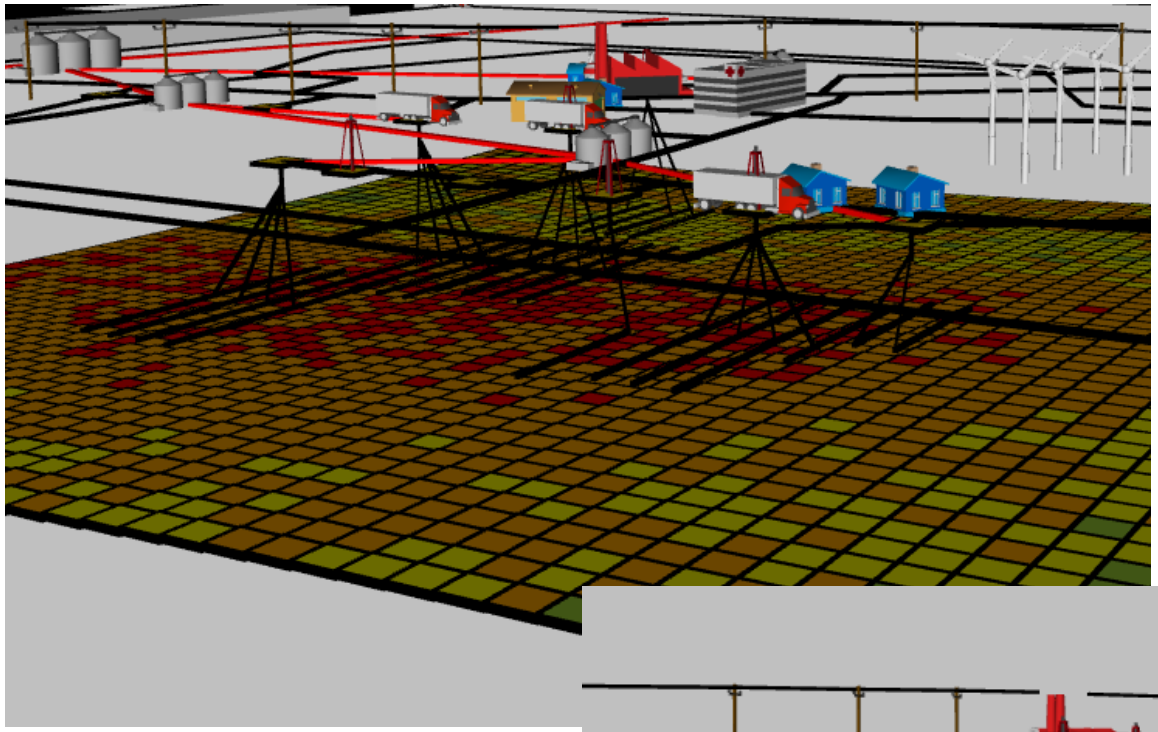
Large scale field modeling:

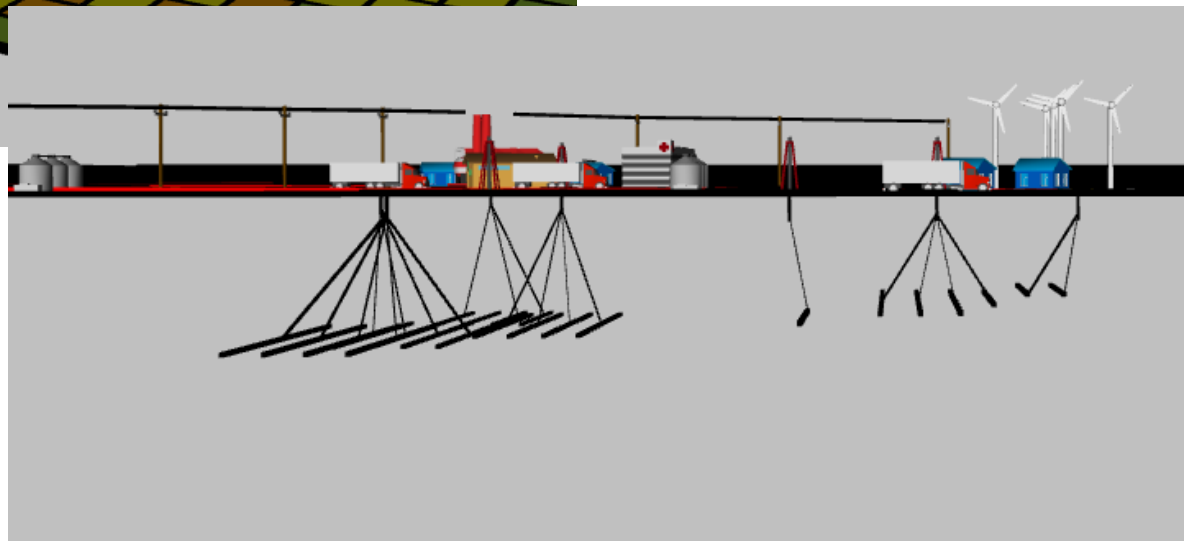
- Strategy testing
- Impact of technology
- Well scheduling and pace of development planning
- Public acceptance
- …

Model and Optimization Hierarchy



Full Field Model





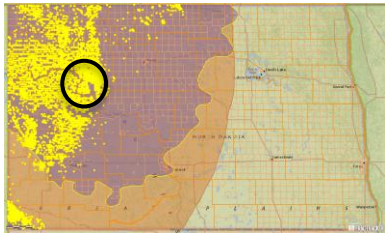
Scheduling Goals

Define right sequence of wells given specific boundary conditions:

- Permitting
- Lease hold expiration
- Production facility capacity
- Rig move distances
- …

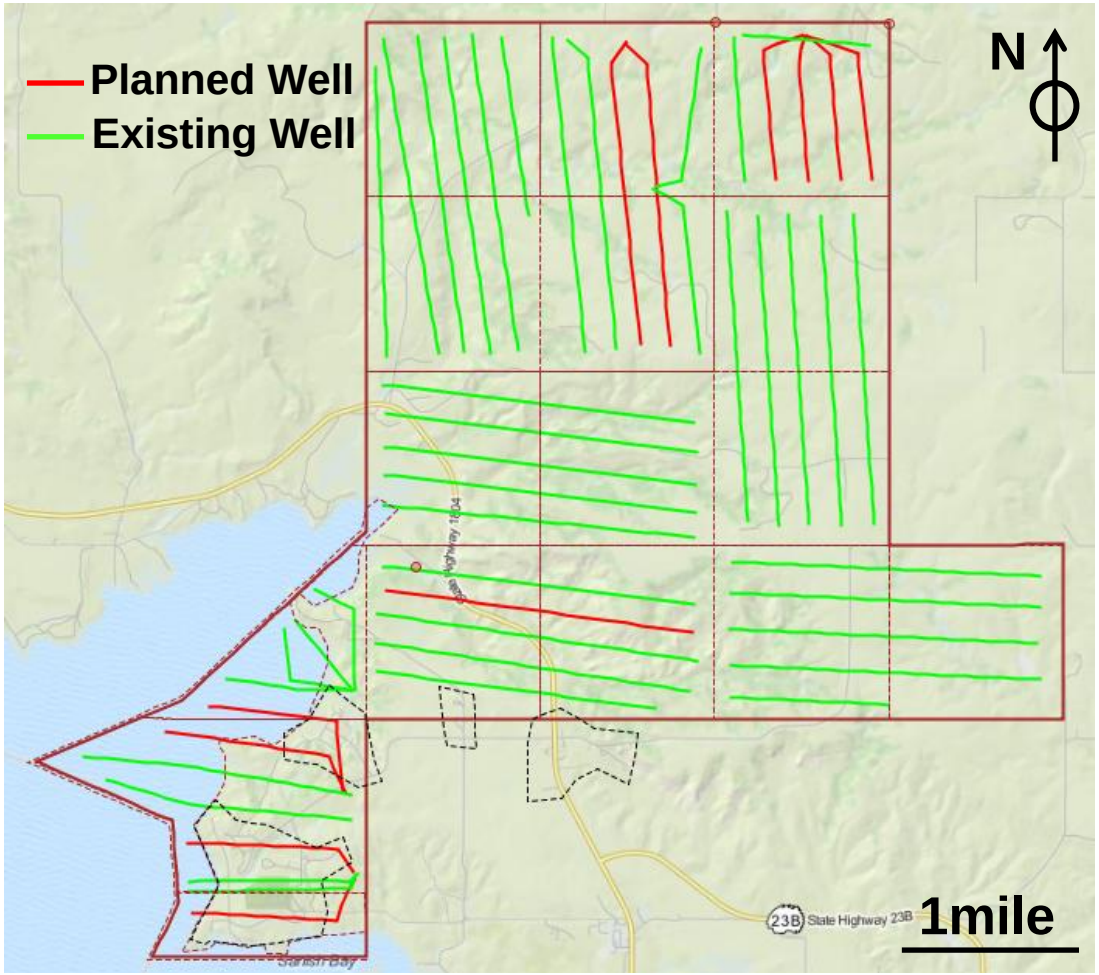
Well Scheduling

North Dakota



Boundary Conditions:

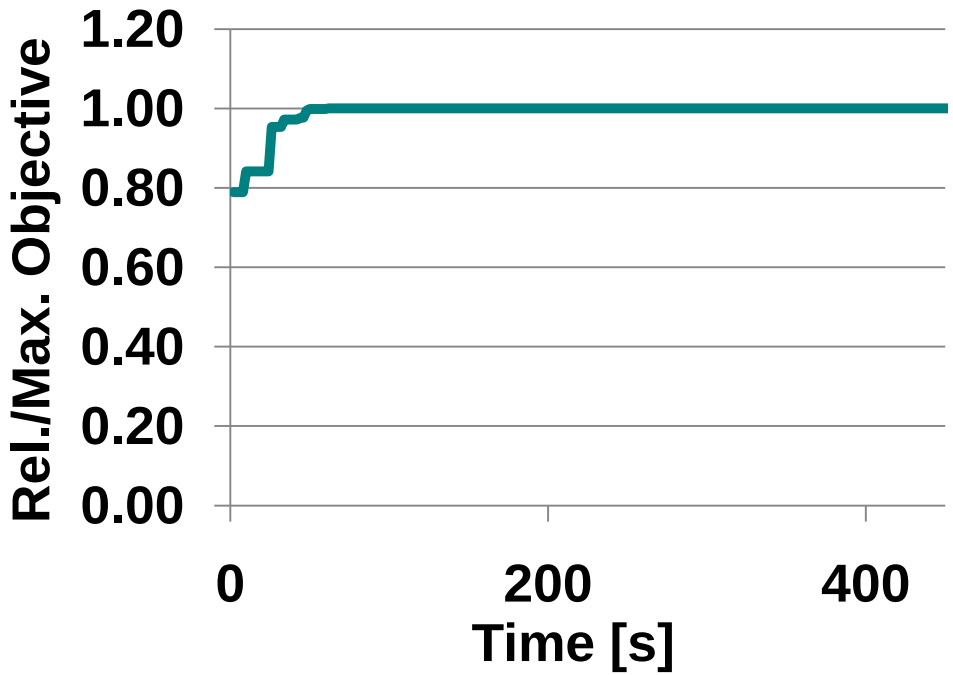
- Permits
- Lease Expiration
- Rig Move Distance
- Location of Facilities



Scheduling Optimzation

Problem: What is the optimal sequence and strategy to drill those wells?

Strategy	+	-
New pads	Less directional work	More pipelines
Batch drilling	Less rig mob/demob	Deferred production

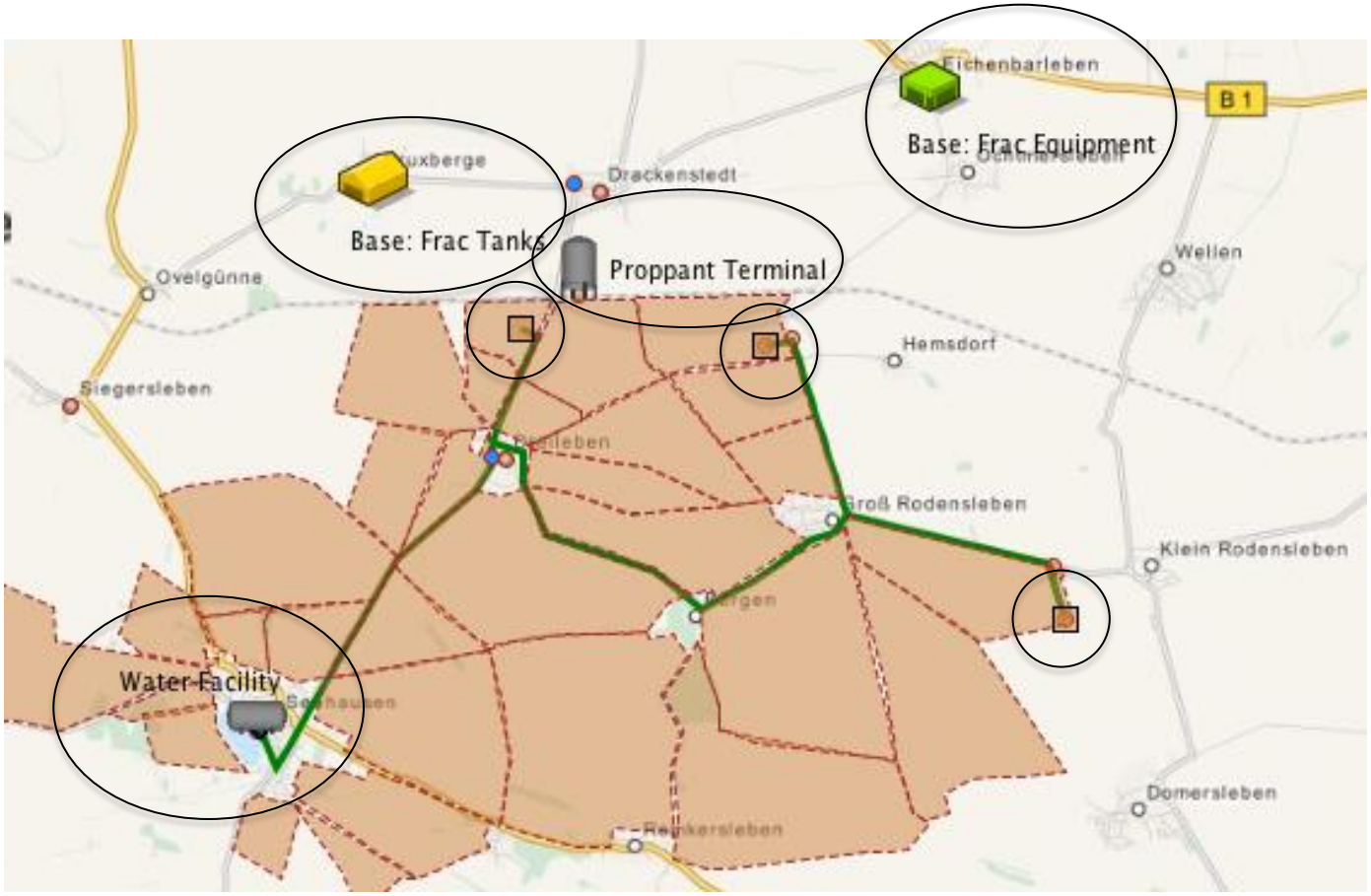


NPV…Net Present Value

Operations Planning Goals

- Water hauling vs. pumping
- Operating Limits (truck moving restrictions 10pm-6am)
- Public buildings
- Equipment requirements
- Water requirements vs. availability (e.g. seasonal)
- Design & # of water “facilities”
- …

Logistics Model



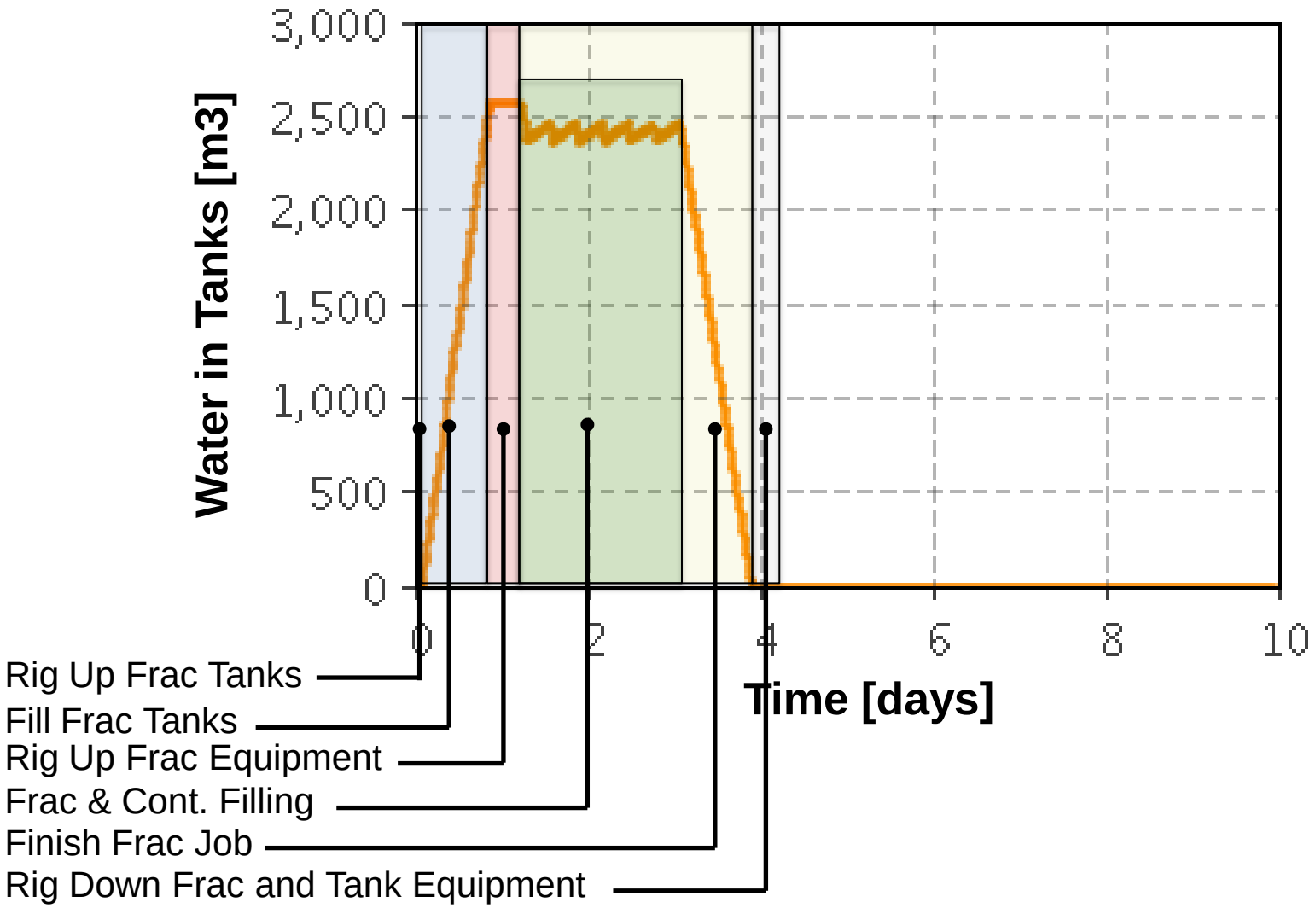
Service & Rental:
Frac Equipment
Frac Tanks

Rail Terminal:
Proppant Terminal

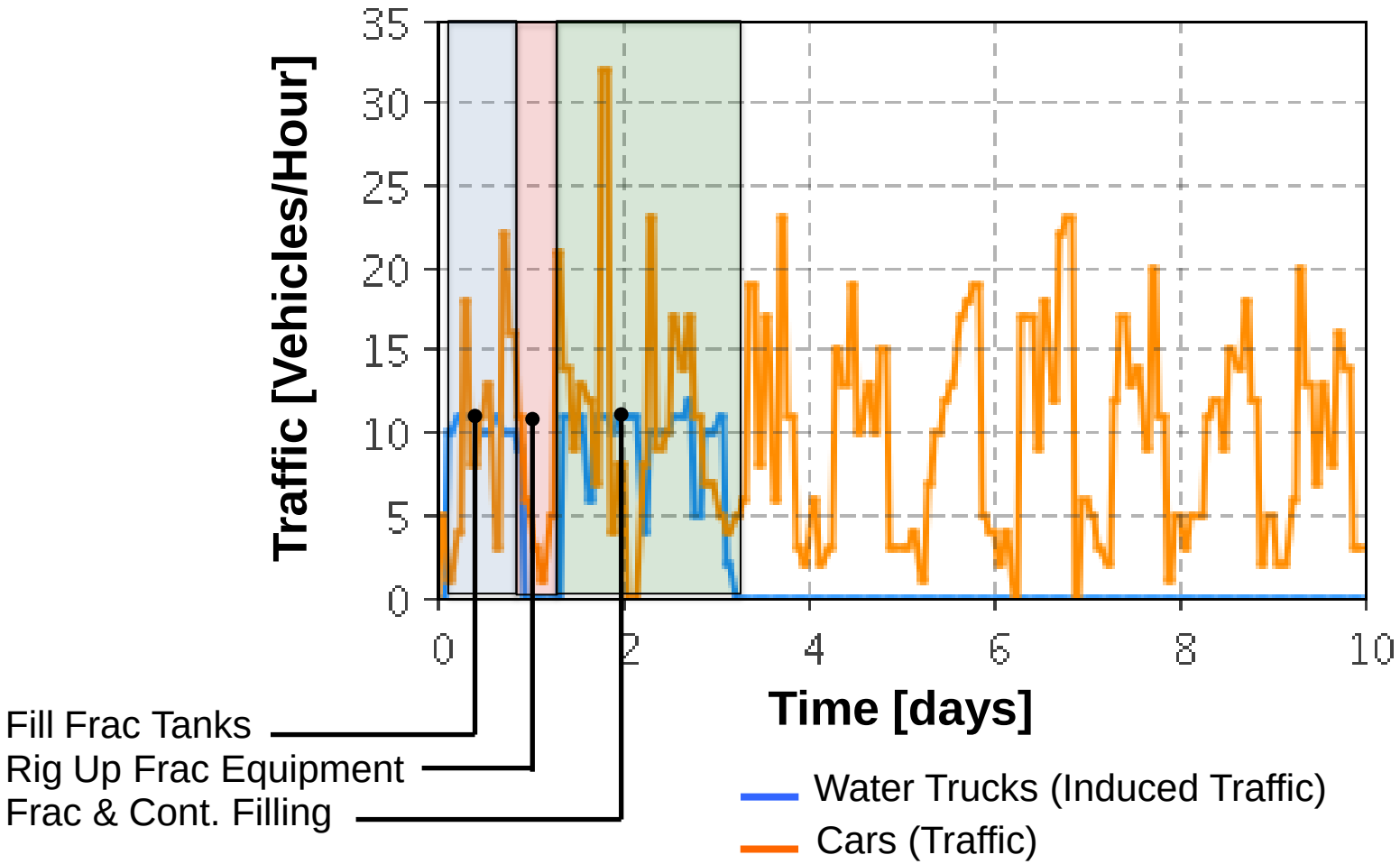
Water:
Water Withdrawal Facility

Location:
Pad

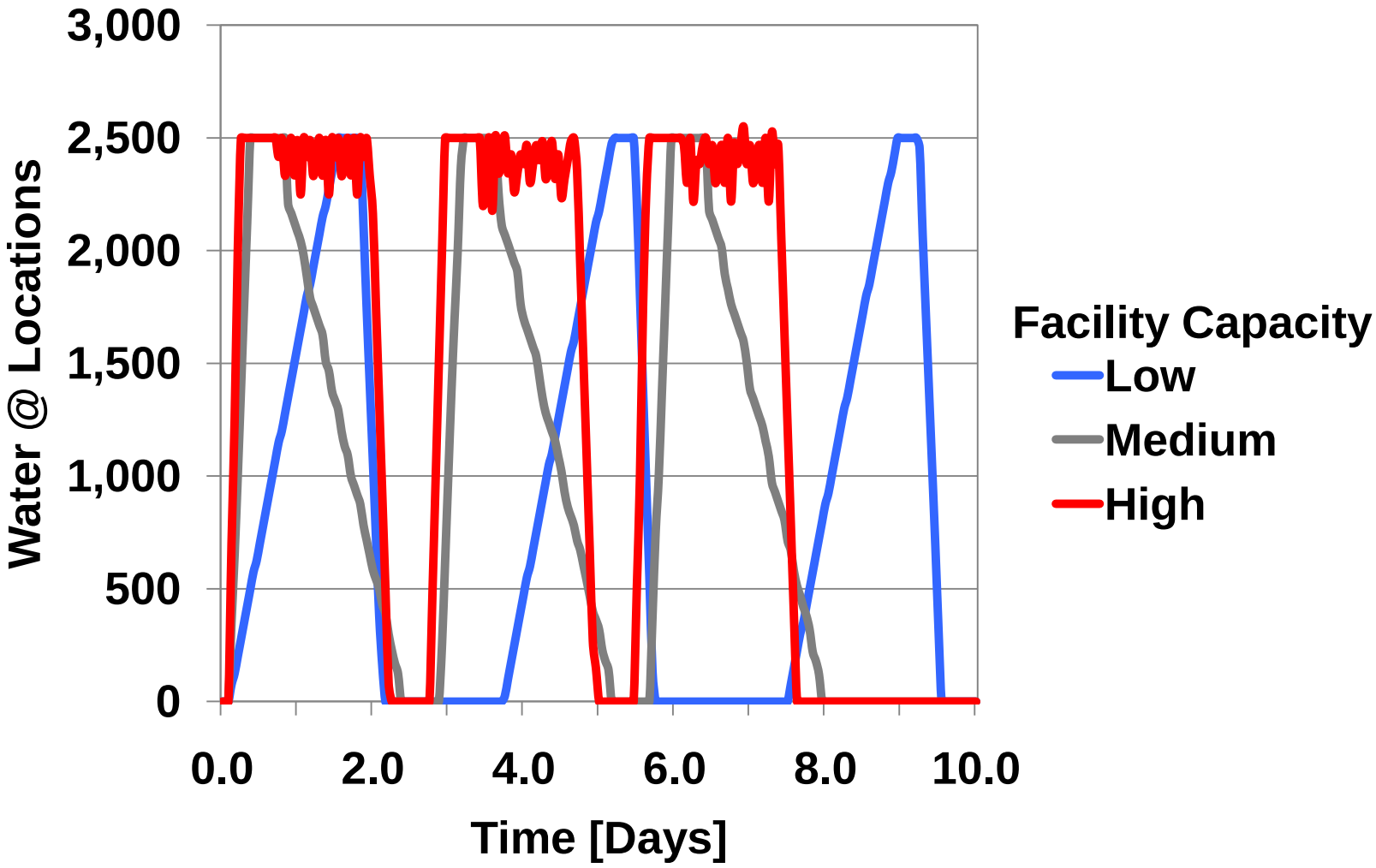
Frac Job Modeling

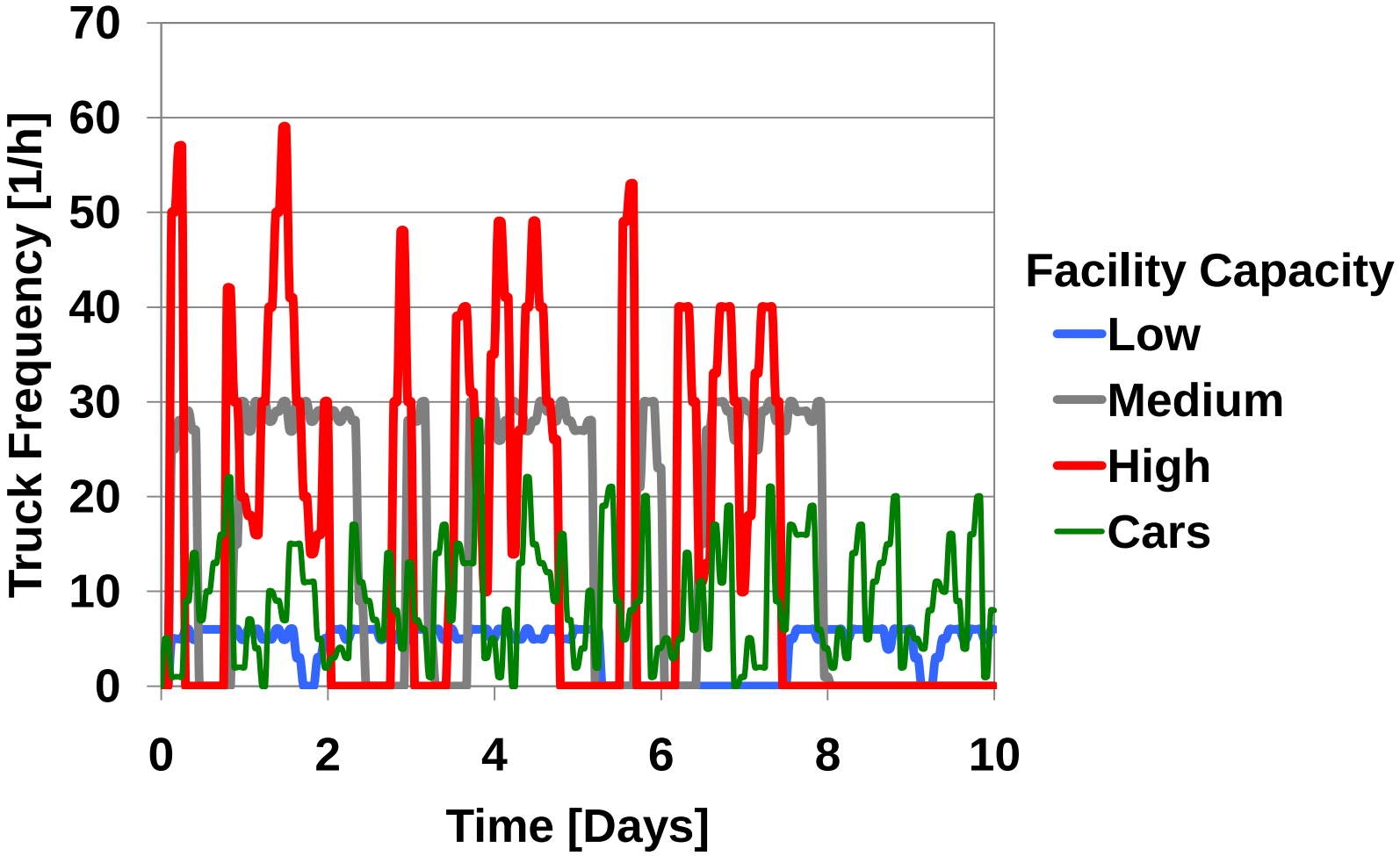


Induced Traffic



Water Facility Design




Truck Frequency [1/h]
70
60
50
40
30
20
10
0
0
2
4
6
8
10
Time [Days]
Facility Capacity
Low
Medium
High
Cars

Traffic Maps

— Low Induced Traffic Frequency Low @ before/after Frac Job

— High Induced Traffic Frequency Low @ Frac Job

Conclusion

- Capture various aspects of a development life-cycle
- Test strategies at various levels
- Combination of subsurface (geo-models) & surface (GIS)
- Create risk maps
- Study impact of technology, surface requirements,
- Induced traffic, seasonal effects, etc.

Outlook

- Calibrate model to real world examples
- Include field “sensor” data for real time field monitoring and optimization
- Further model develop
- Implement smarter algorithms

Thank you!