Modeling Optimal Congestion Fees within the Ohio River Navigation Investment Model

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Goals of this work

- **Estimate benefits of collecting fees at locks as a non-structural alternative for the Ohio River Mainstem study**
  - **Fixed fee ($/ton) set annually at each lock**
  - **Maximize the National Economic Development (NED) benefits (social optimum)**

Traditional Congestion Fee Analysis

- **Typical non-structural alternative**
- **Compared to construction alternatives**
- **Single lock**
- **“Brute force” optimization**

Congestion fees

- **Short term**
  - **Only during high congestion**
    - **Seasonal, Daily, Hourly**
  - **Goal is to reduce congestion at locks**
    - **spread out the traffic**
    - **Move traffic off system**
  - **Requires modeling individual shipments**
  - **Must estimate the NED cost of changing schedules or moving off the system**

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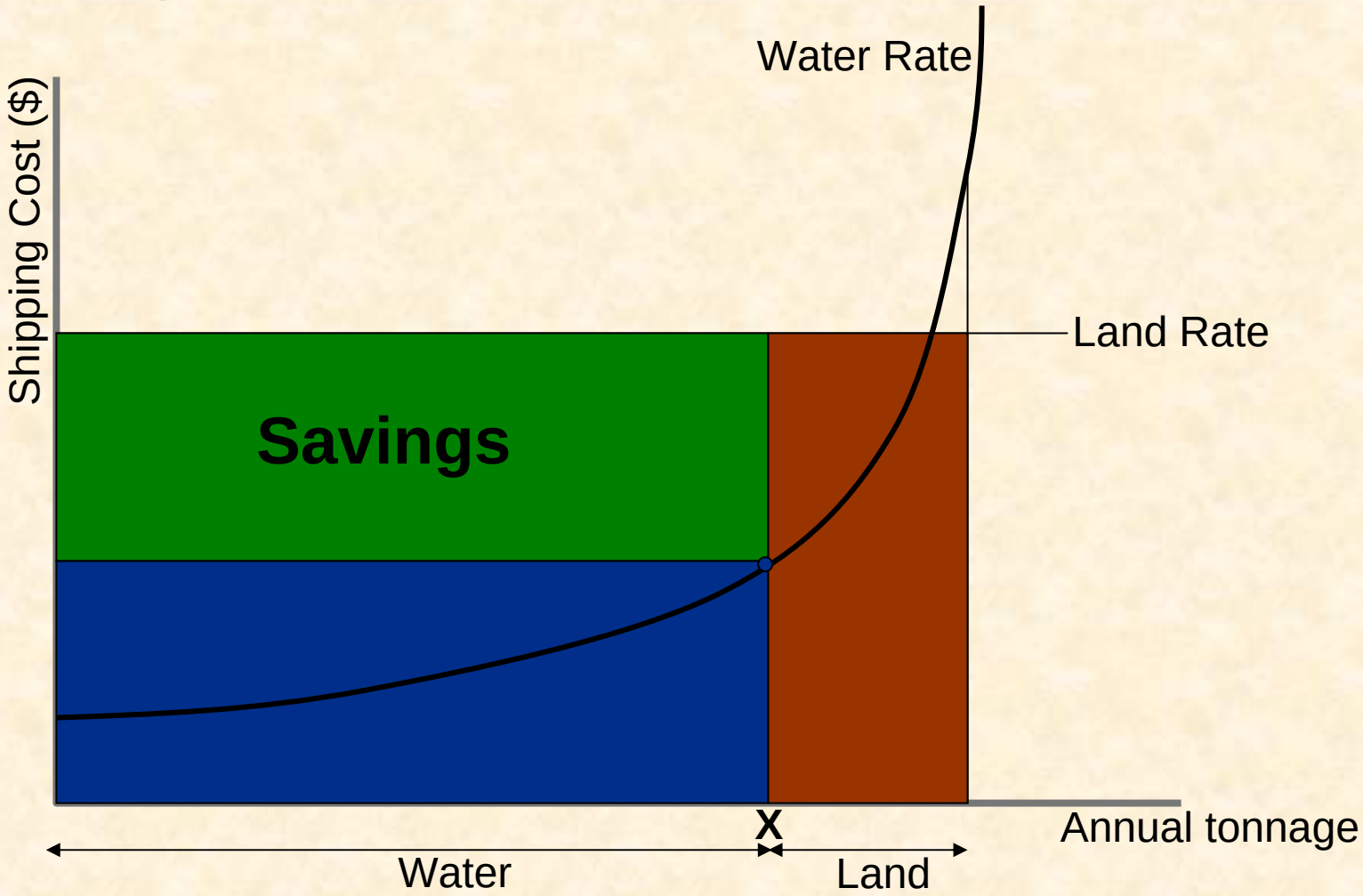
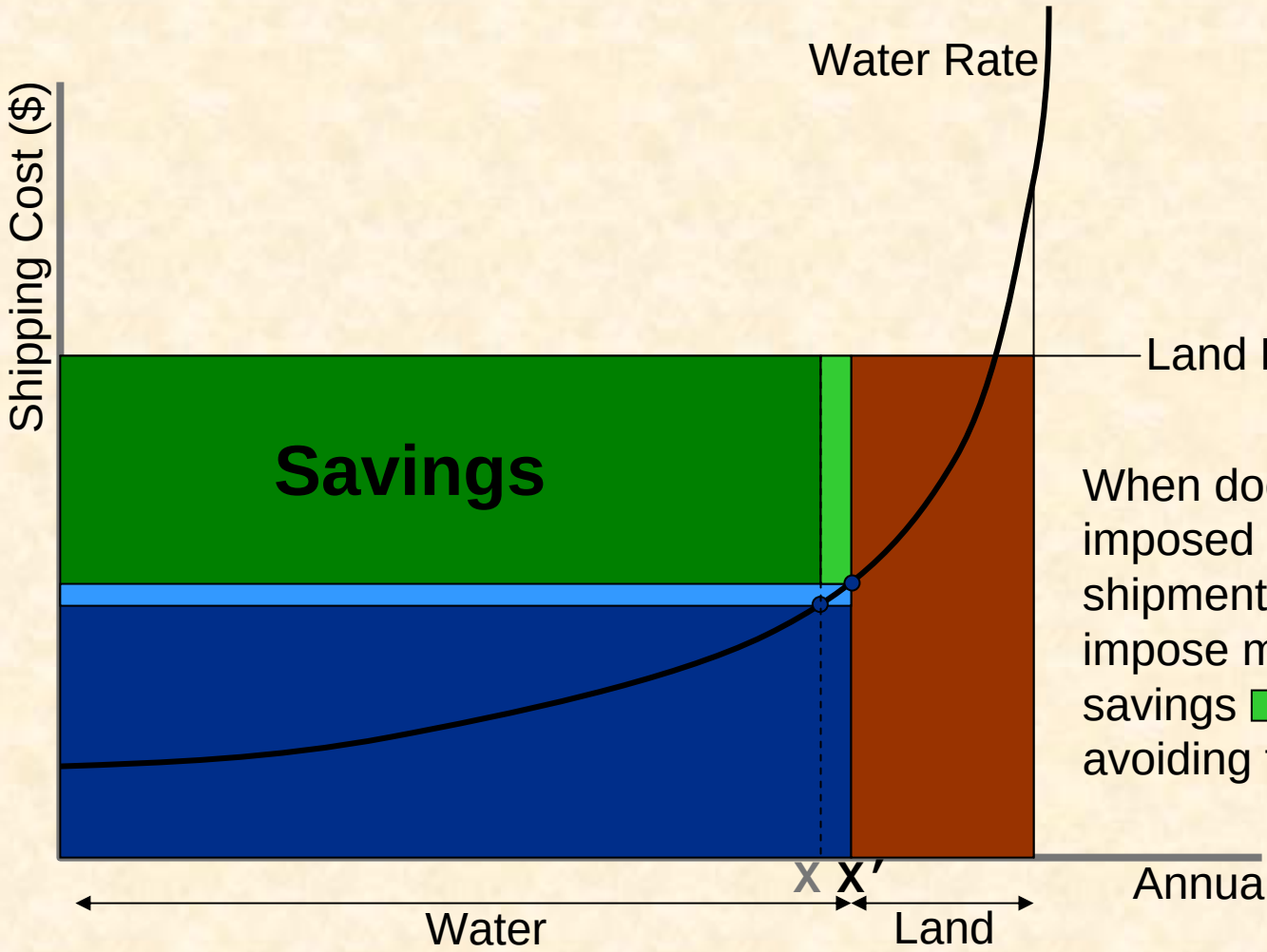
- **Long term**
  - **Annual/multi-year**
  - **Published well ahead**
  - **Goal is to price the use of the waterway to maximize national benefits.**
  - **Must assume shippers have an alternative.**

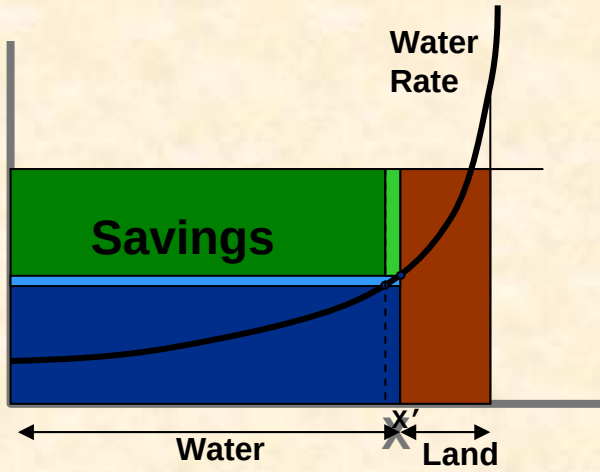
Maximize Savings (social optimum)-simplified



Maximize Savings (social optimum) - simplified



The Math



Maximize Savings

Let f(x)=water rate

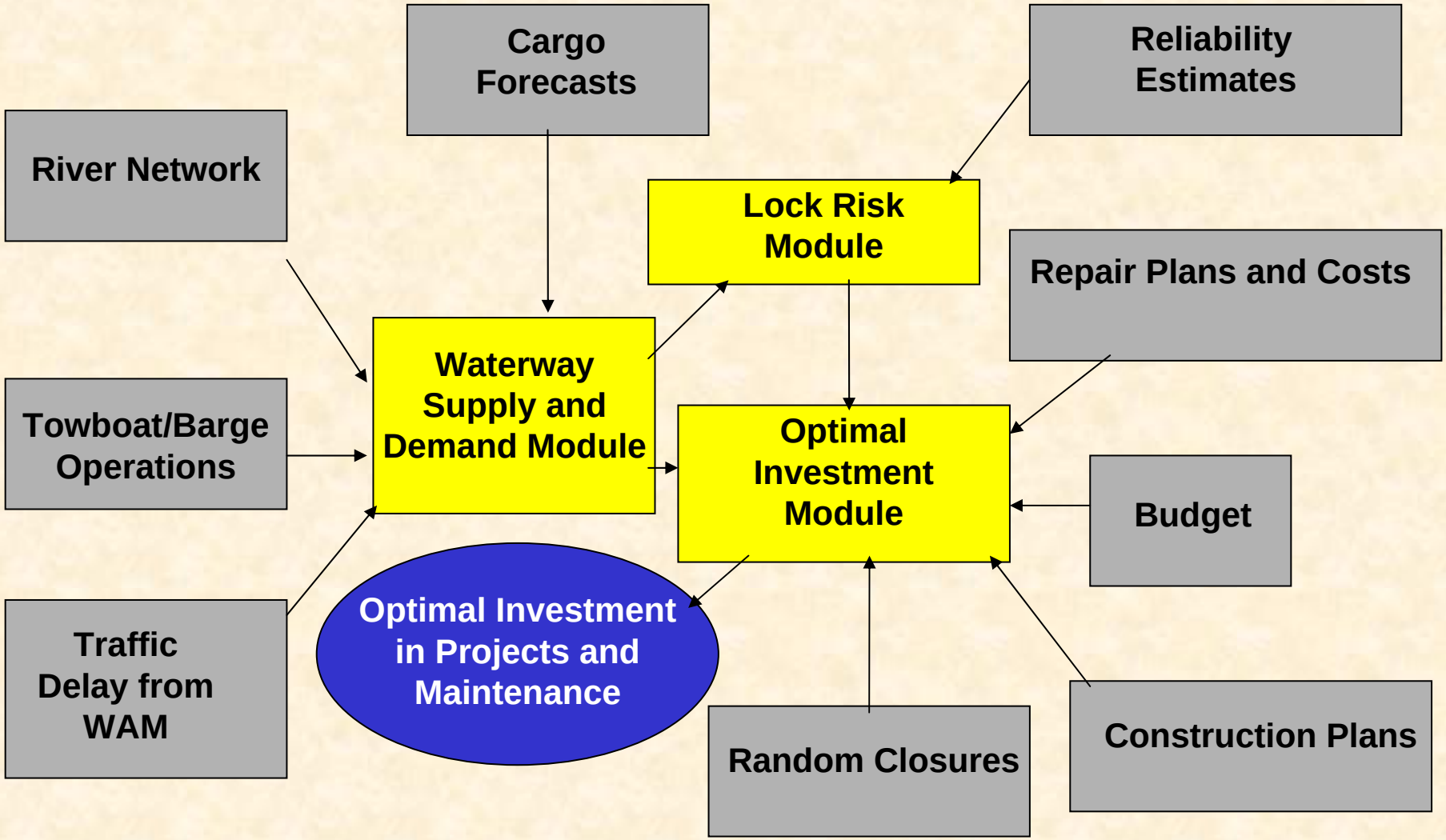
Max [x(R-f(x)]

d/dx [x(R-f(x)]= R-xf'(x)-f(x)

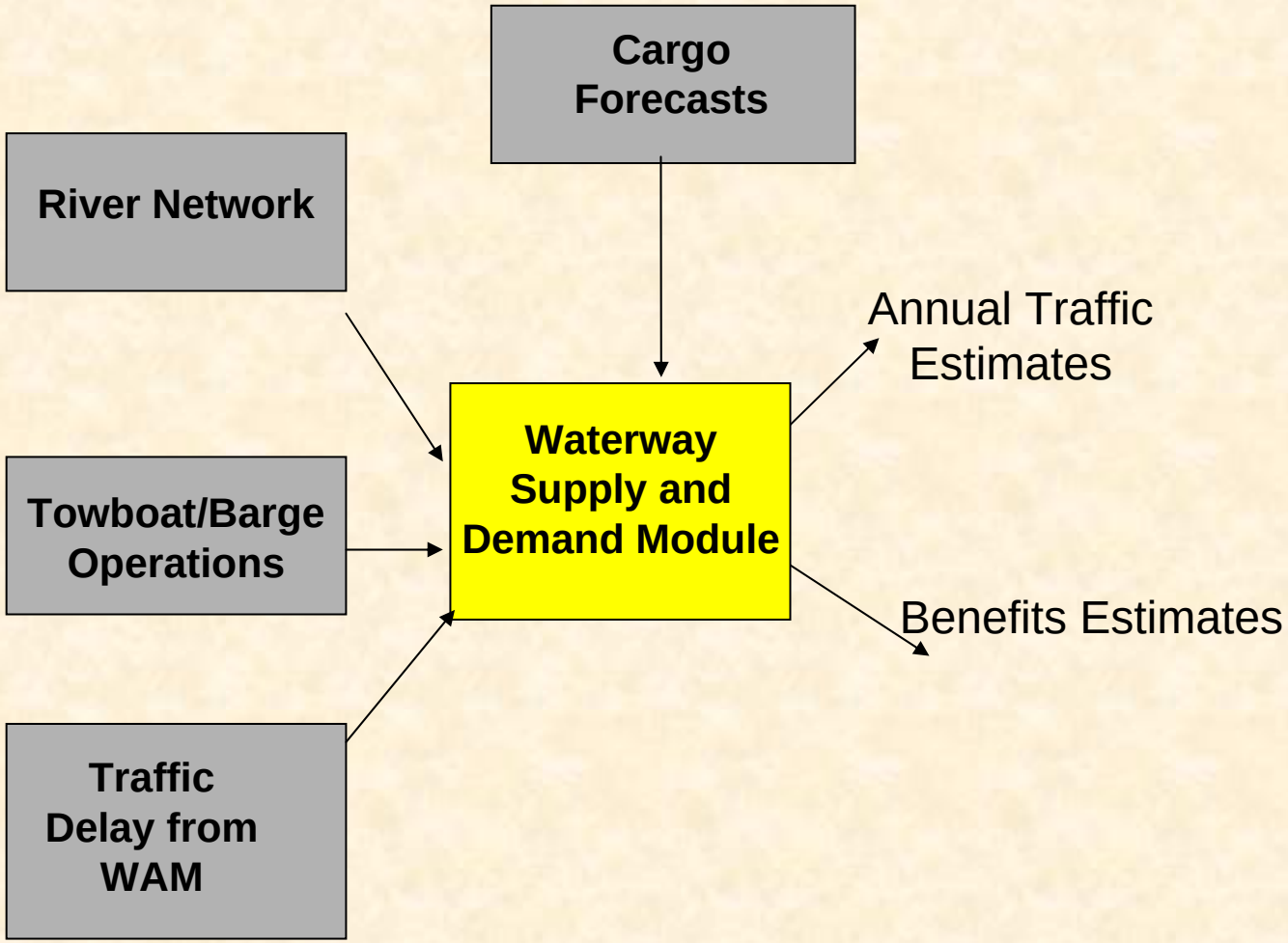
Maximum occurs at

R- f(x)= xf'(x)

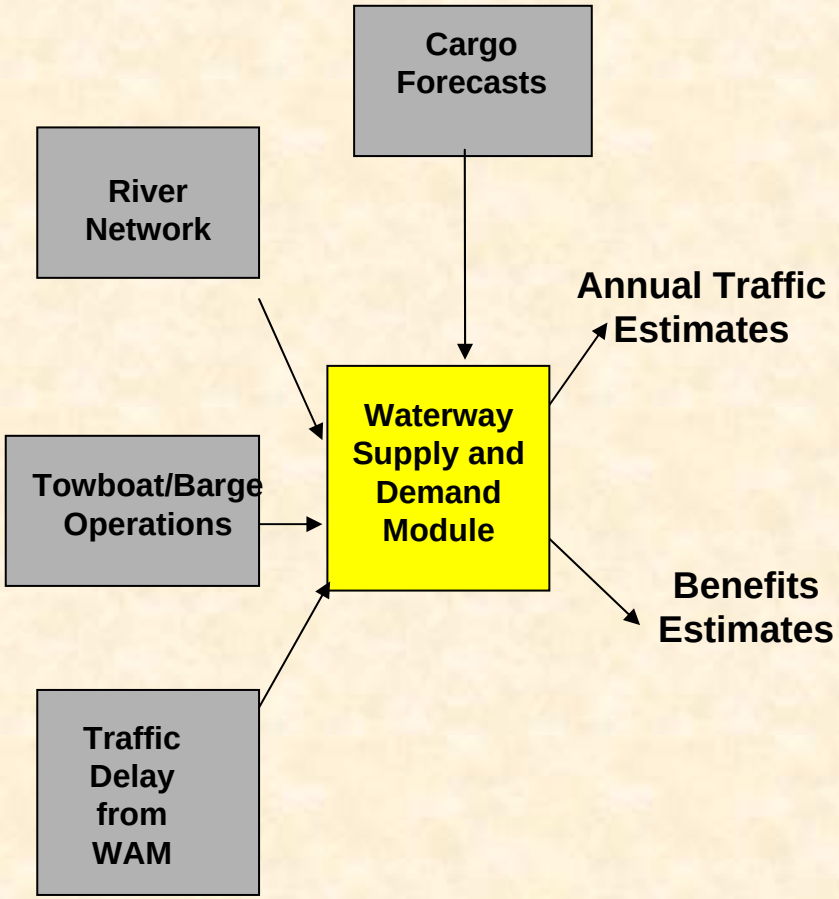
The ORNIM System



The ORNIM System—Equilibrium Process

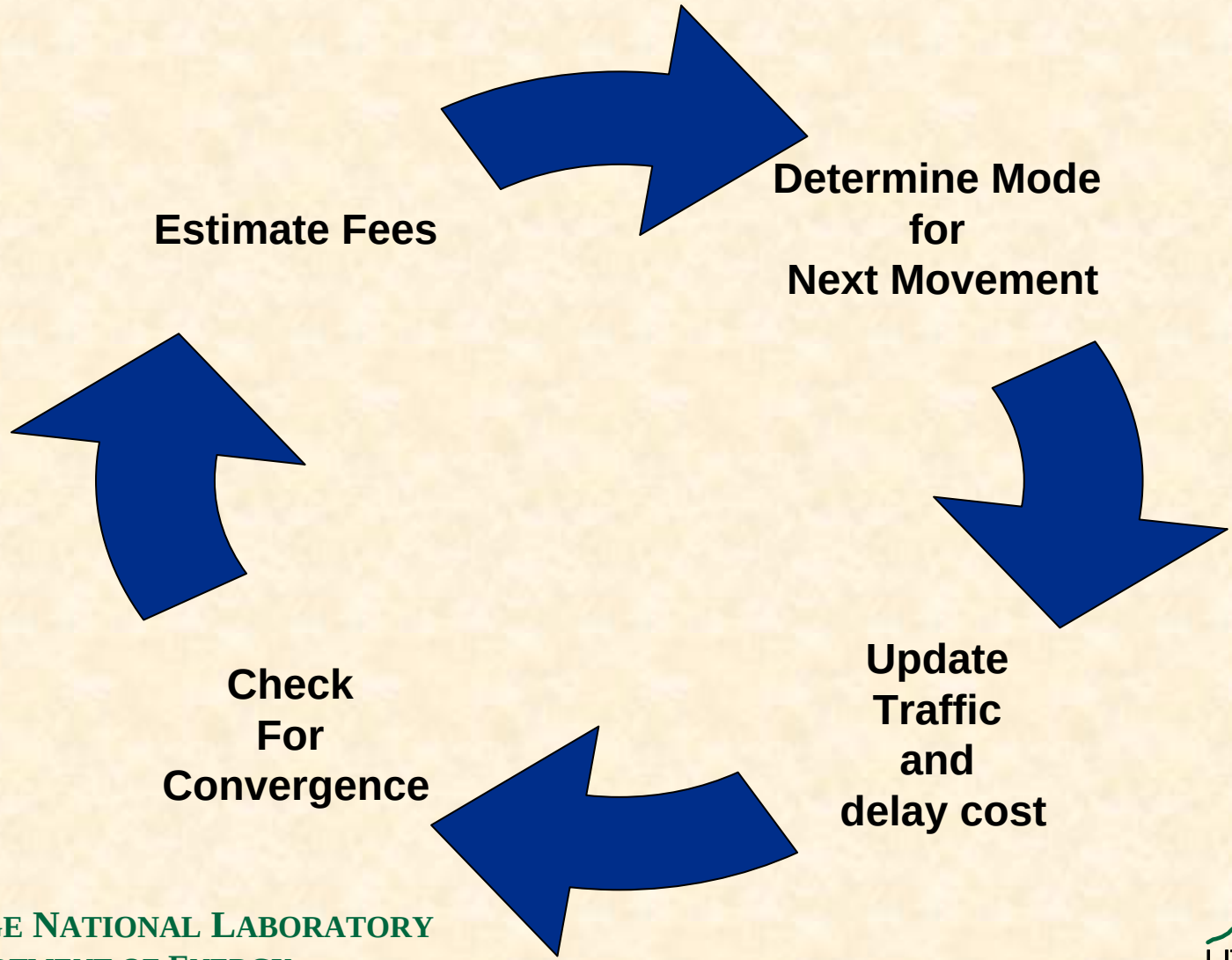


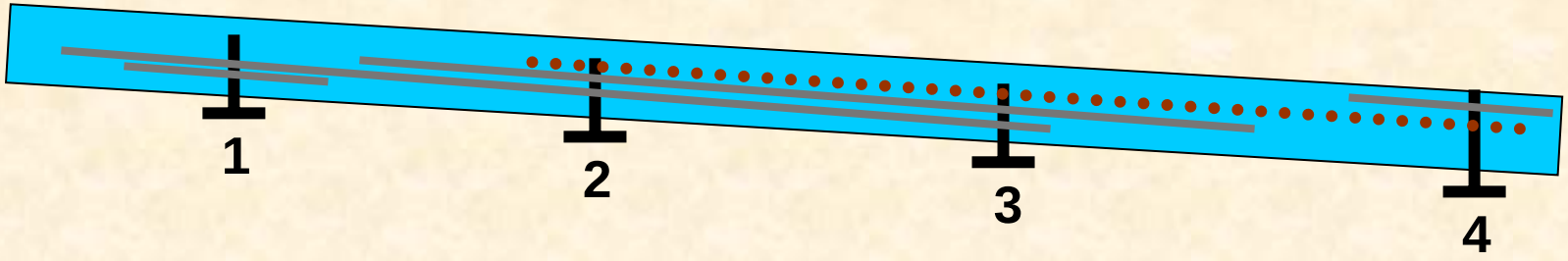
The ORNIM model is a few steps closer to reality.



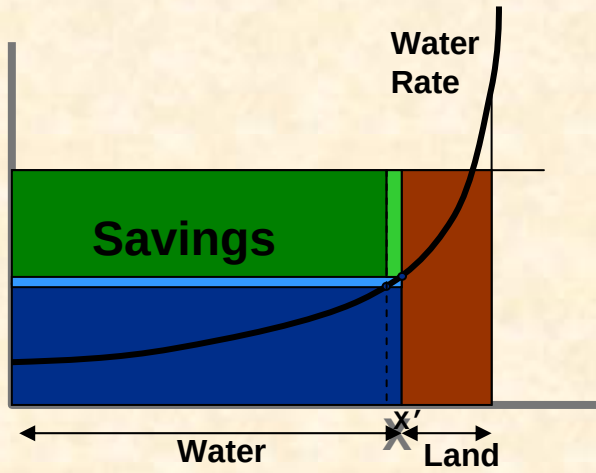
- **Network of 56 unique locks**
- **31,000 unique movements**
  - **Origin/destination**
  - **commodity**
  - **Alternative (Land) rate**
  - **Delay cost ($/hour)**
- **70 year horizon**
- **Multiple forecasts and investment plans**

The estimation of fees has been integrated into the equilibrium process.



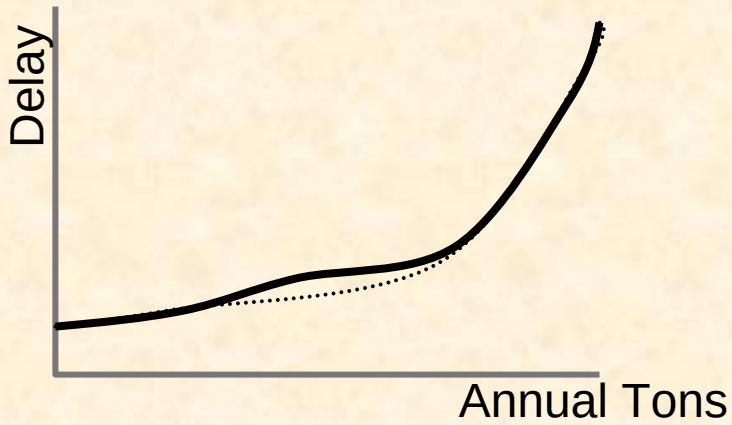


		MOVEMENTS				
LOCK	DELAY SLOPE	1	2	3	4	5
		x_1	x_2	x_3	x_4	x_5
1	d_1	c_1	c_2			
2	d_2		c_2	c_3	c_4	
3	d_3		c_2	c_3	c_4	
4	d_4				c_4	c_5

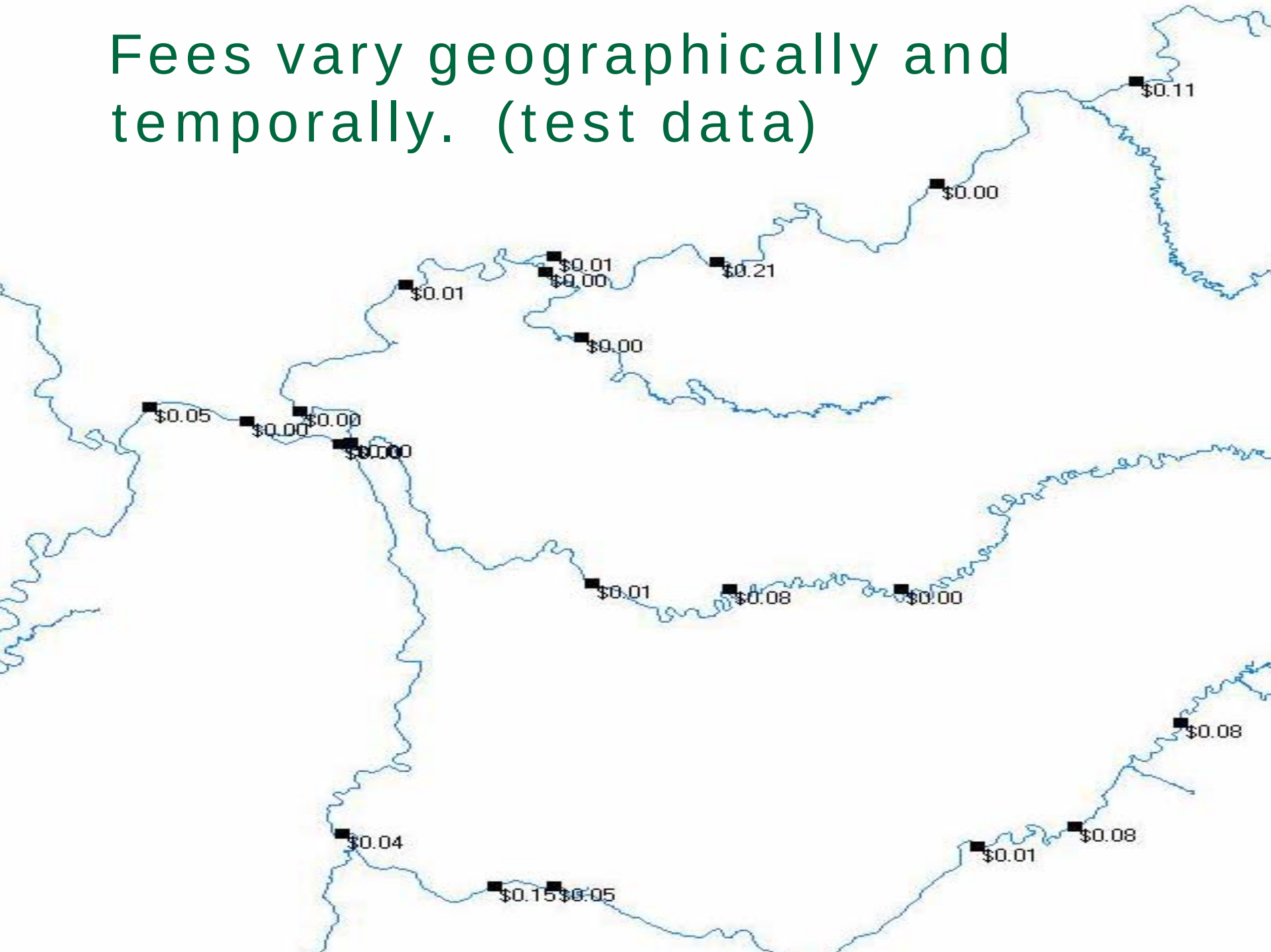


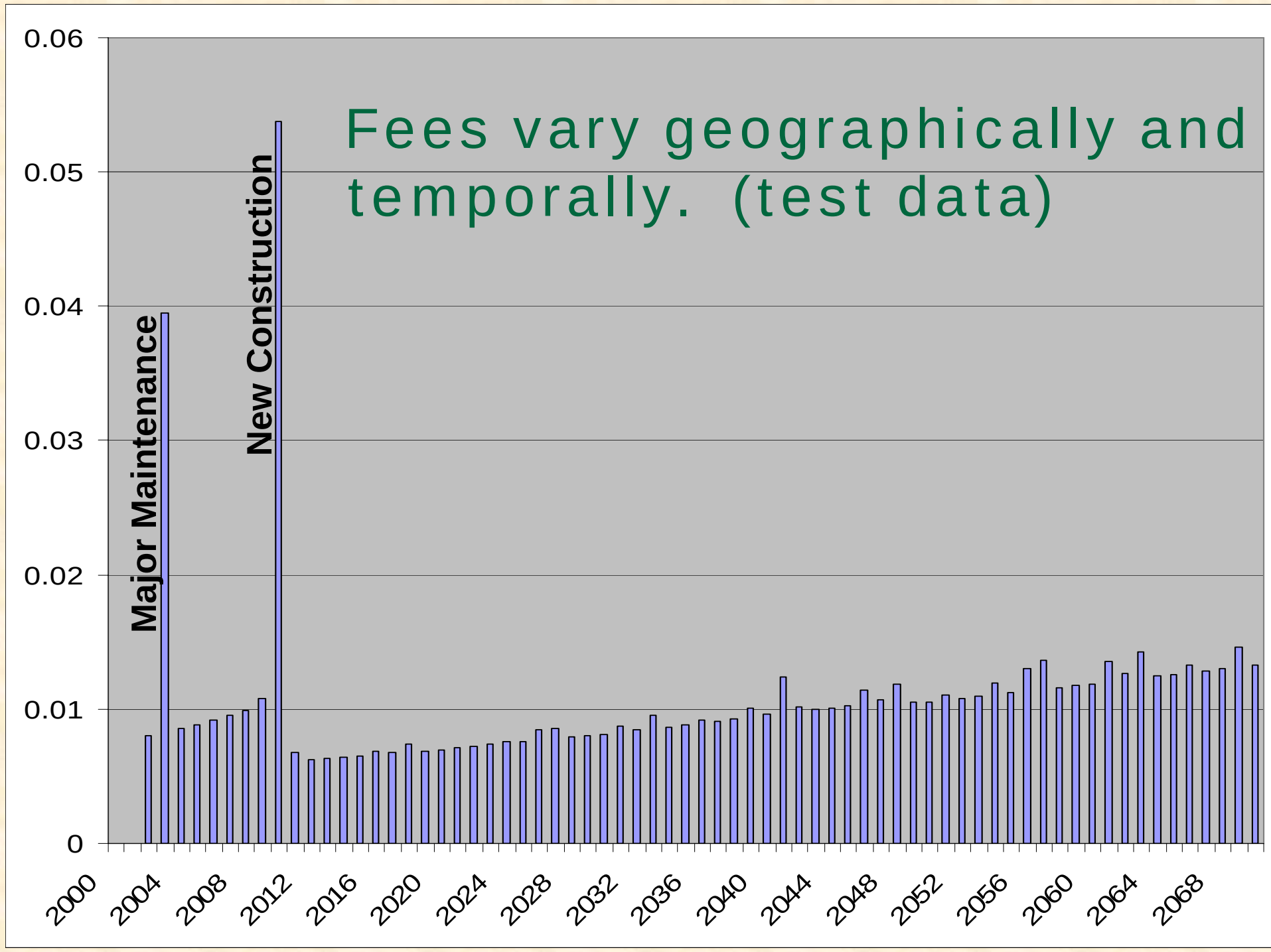
Convergence

- **Converges quickly for most cases**
- **Can be problematic for non-convex delay curves—probably need to "smooth" the simulation results at these rare points.**



Fees vary geographically and temporally. (test data)




Fees vary geographically and temporally. (test data)
Major Maintenance
New Construction
0.06
0.05
0.04
0.03
0.02
0.01
0
2000
2004
2008
2012
2016
2020
2024
2028
2032
2036
2040
2044
2048
2052
2056
2060
2064
2068

Benefits of estimating fees at all locks

- **Fulfills the goal of a "system" study**
- **Estimates an upper bound on the potential benefits of fees.**
- **Fees indicate a relative value of capacity at each lock in each year (given a forecast and investment plan).**