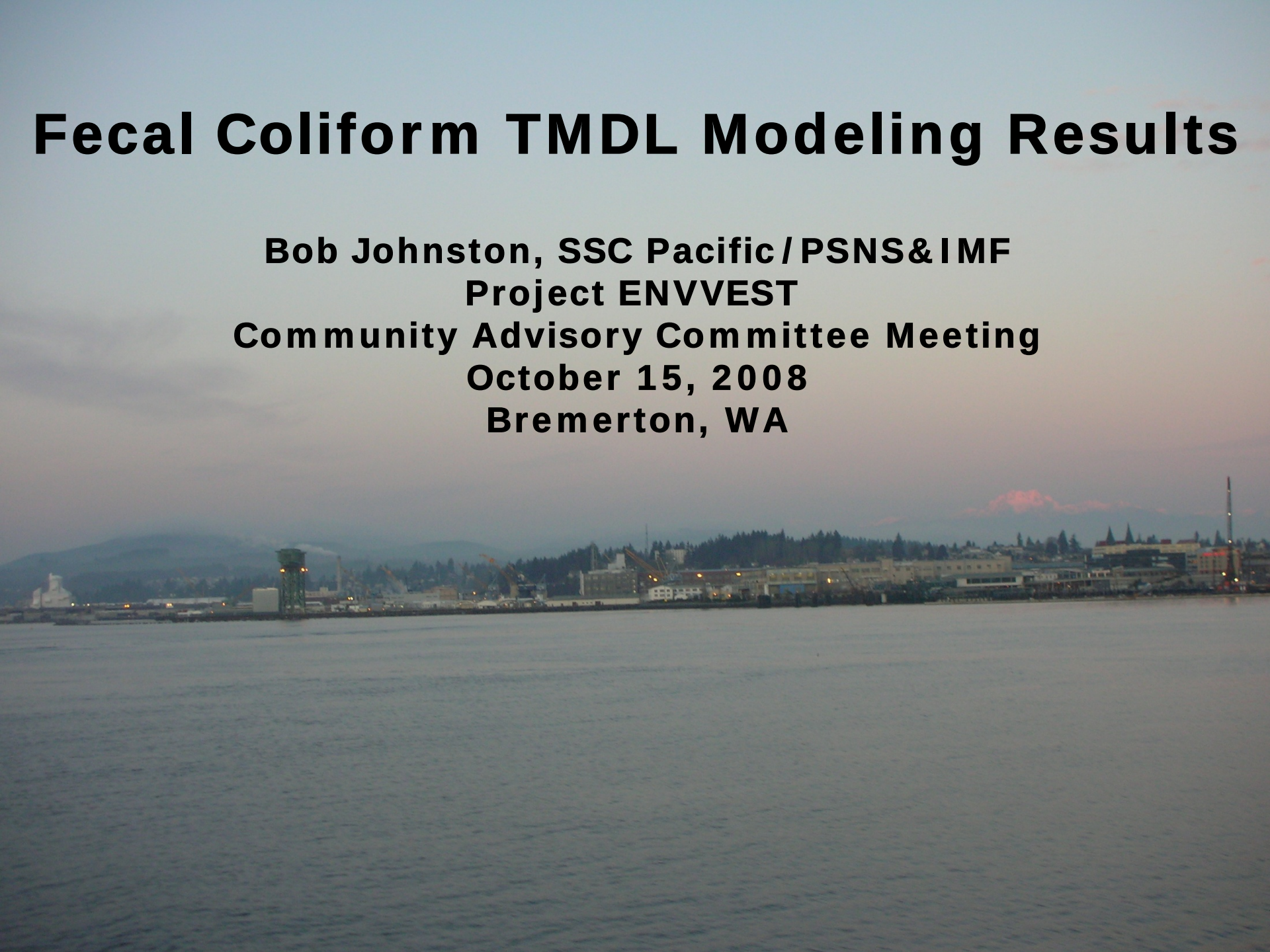
# Fecal Coliform TMDL Modeling Results

**Bob Johnston, SSC Pacific / PSNS&IMF**
**Project ENVVEST**
**Community Advisory Committee Meeting**
**October 15, 2008**
**Bremerton, WA**



# Fecal Coliform TMDL Modeling Results

**Outline:**

**Overview of Modeling (Summary)**

- **Model Evaluation**
  - **How good are the predictions?**
- **Model Sensitivity and Uncertainty**
  - **Future Conditions**

**Simulations for TMDL**

- **Results**
- **Define Targets for TMDL**

**Summary**

# *Beneficial Uses*

**<u>Shellfish Harvest</u>**
**Fishing**
**Contact Recreation**
- **Swimming**
- **Boating**

**Aquatic Life (Fish & Wildlife Habitat)**
**Shoreline Development**
**Commercial & Industrial Activity**
- **Shipping**
- **Marinas**
- **Shipyards**

# State of Washington Water Quality Standards

- Standards developed to protect beneficial uses (Shellfishing)
- Fecal coliform (FC) is used as an indicator of pathogens
- **PART 1**: Average Concentration (Geometric Mean)

  14 colony forming units per 100 ml (cfu/100 ml)

  14 cfu/100 ml (Marine)

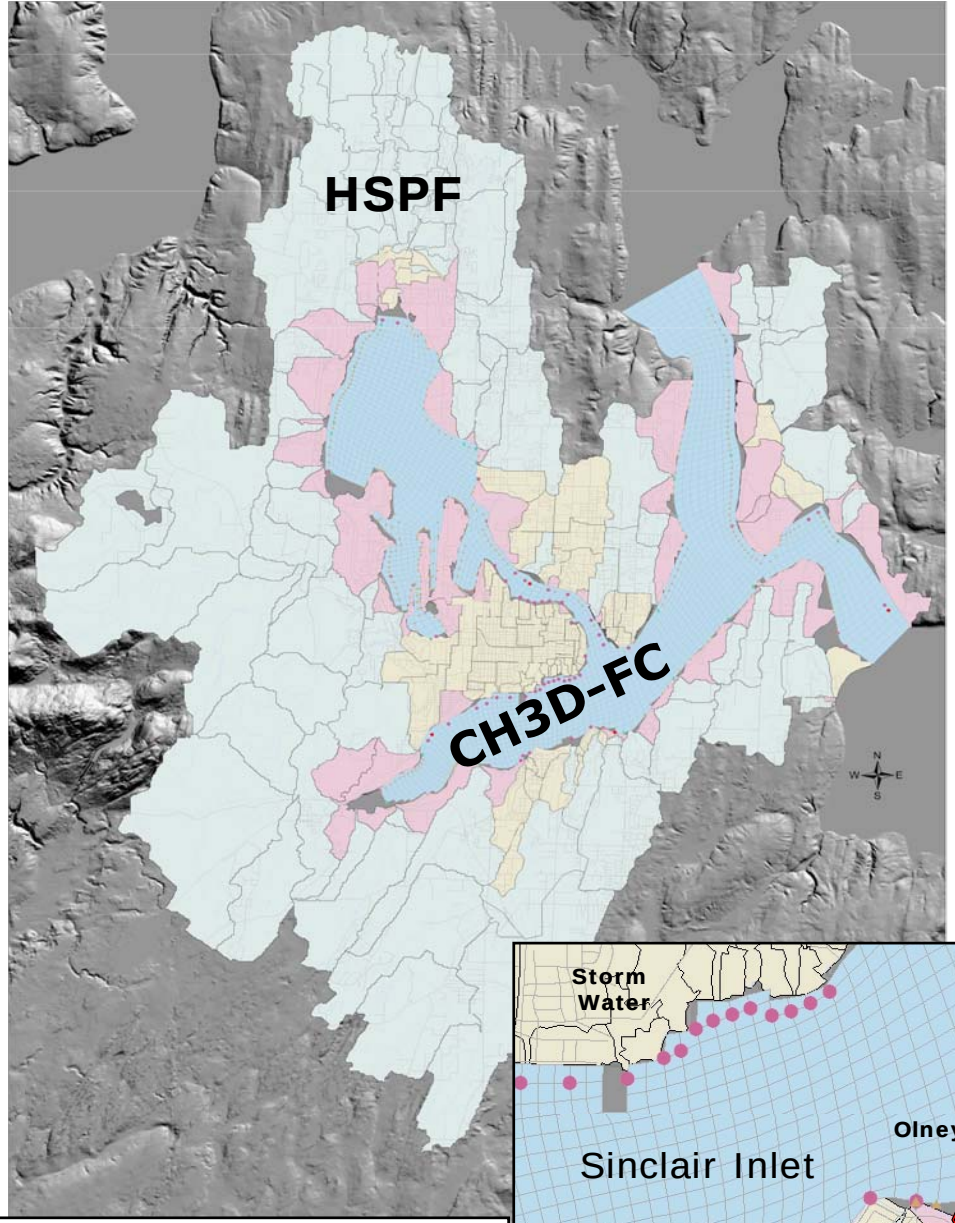
  100 cfu/100 ml (Stream)
- **PART 2**: Spikes

  No more than 10% of the samples can exceed

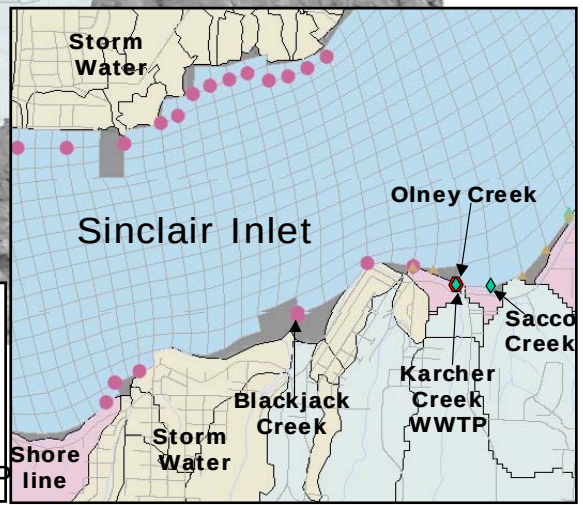
  43 cfu/100 ml (Marine)

  200 cfu/100 ml (Streams)

# Integrated Modeling




Watershed (HSPF) and receiving water (CH3D-FC) models are combined to simulate all inputs.




Inputs
- Stream
- Storm water
- Shoreline runoff
- Wastewater Treatment Plant (WWTP)

```
Configuration:
 39 Streams
 58 Stormwater Outfalls
 41 Shoreline Drainages
  4 Treatment Plants
---
142 Separate Inputs
```

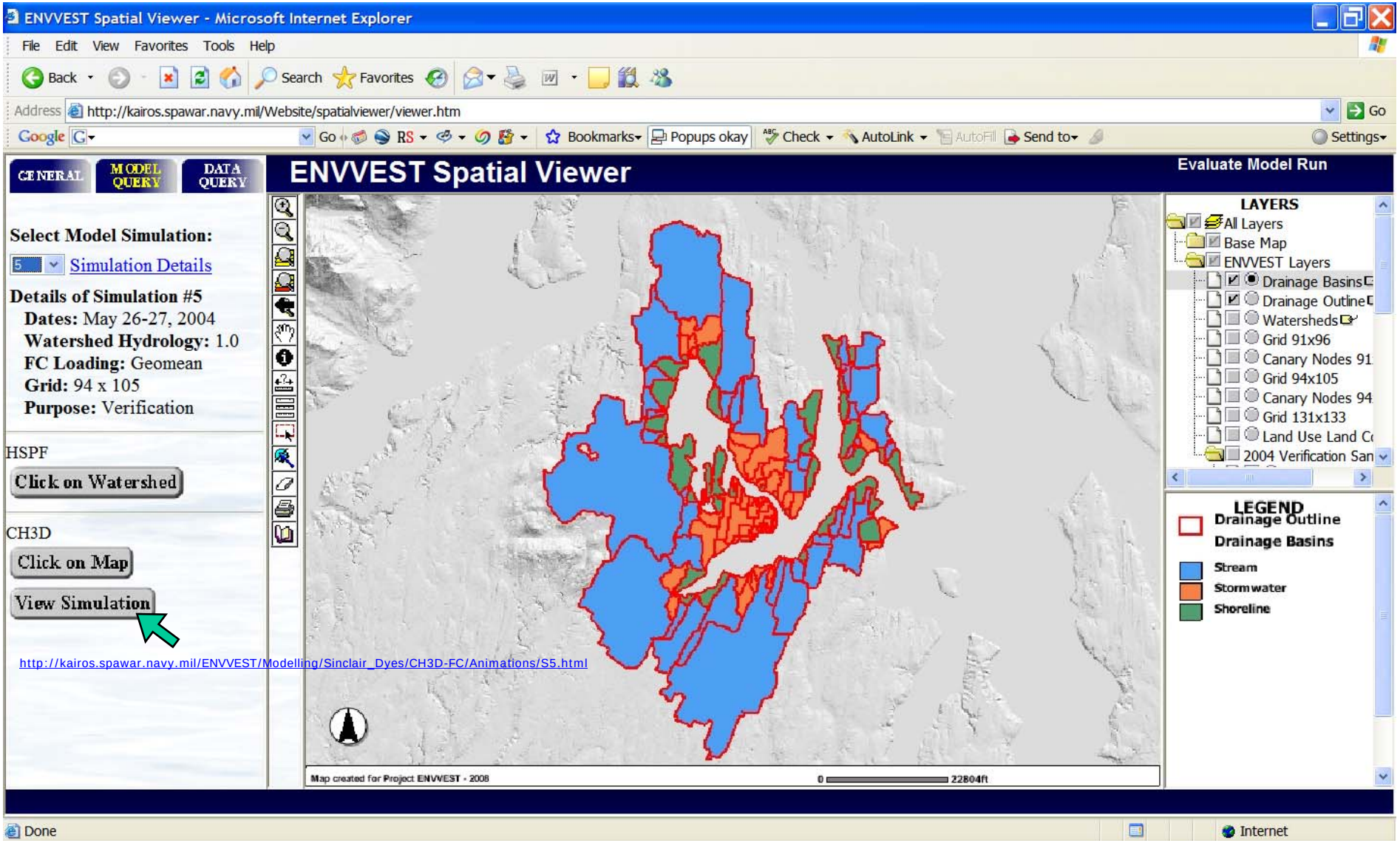
# Simulating Fecal Coliform (FC) Loading

- **Flow Data**
  - Volume of water discharged (cubic feet per second – CFS)
  - Watershed model (HSPF) used to predict flows
  - Measured Flow used for Treatment Plants
- **Concentration Data**
  - FC cfu/100 ml being discharged
  - Empirical Estimates of FC as a function of upstream Land Use/Land Cover
  - Interpolated Measured FC for Treatment Plants
- **Load = Flow x Concentration**
  - FC cfu/day (millions of counts)
- **Inputs Simulated with CH3D-FC**
  - Tides, Currents, FC die-off

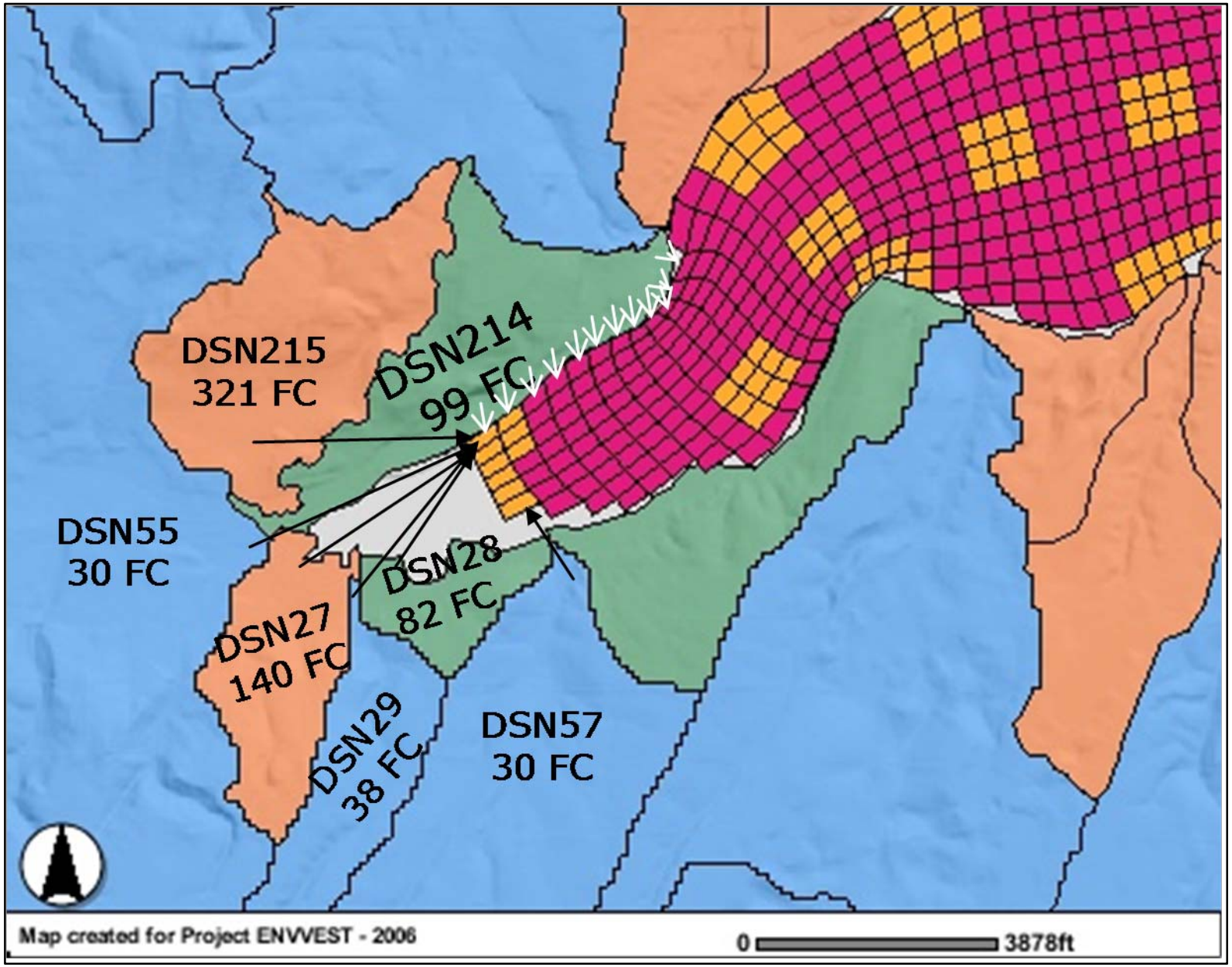
# Example Model Simulation

**Link to ENVVEST Spatial Viewer**

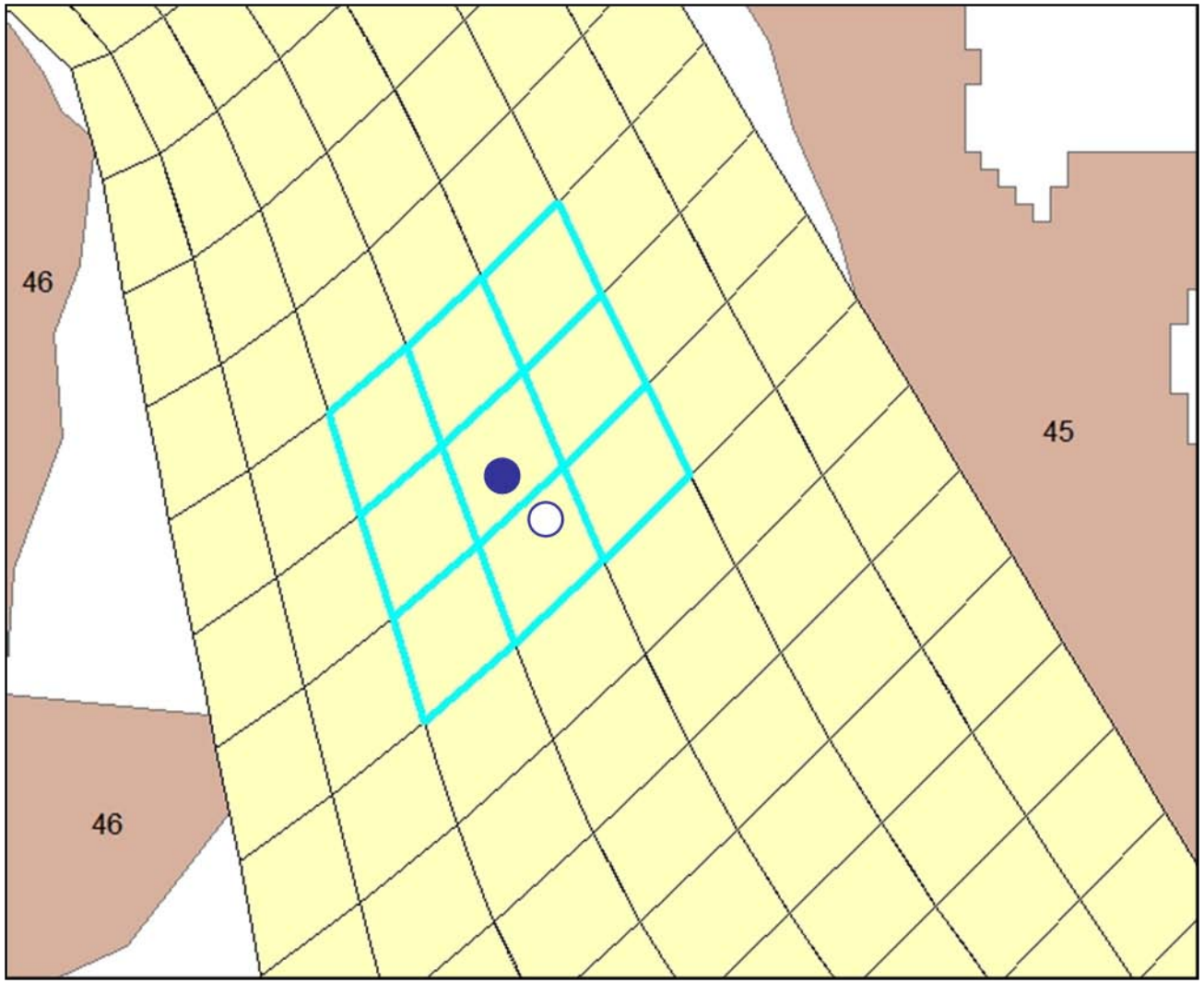
http://kairos.spawar.navy.mil/Website/spatialviewer



# Linkage Between Watershed and Inlet

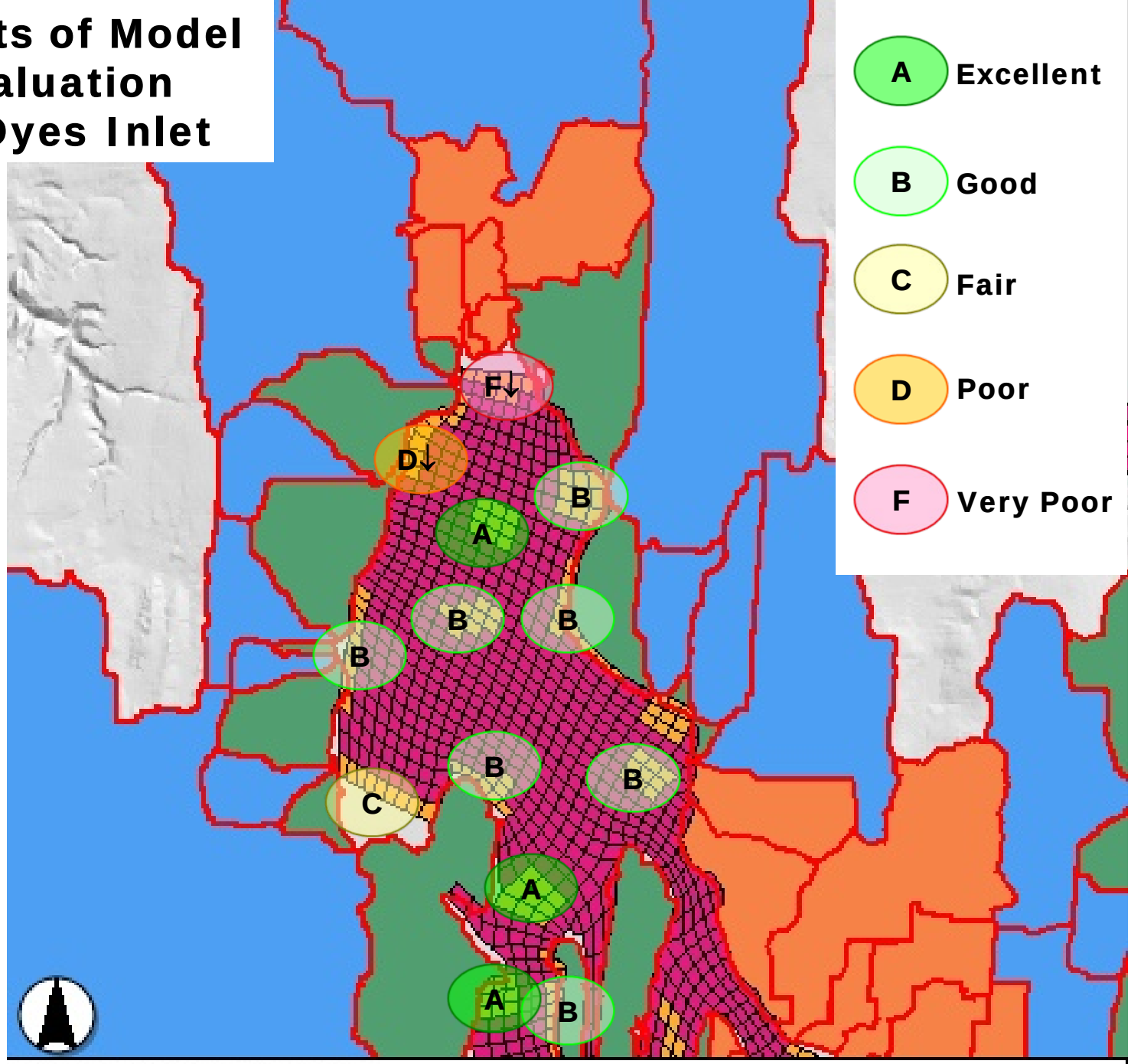


# Canary Nodes

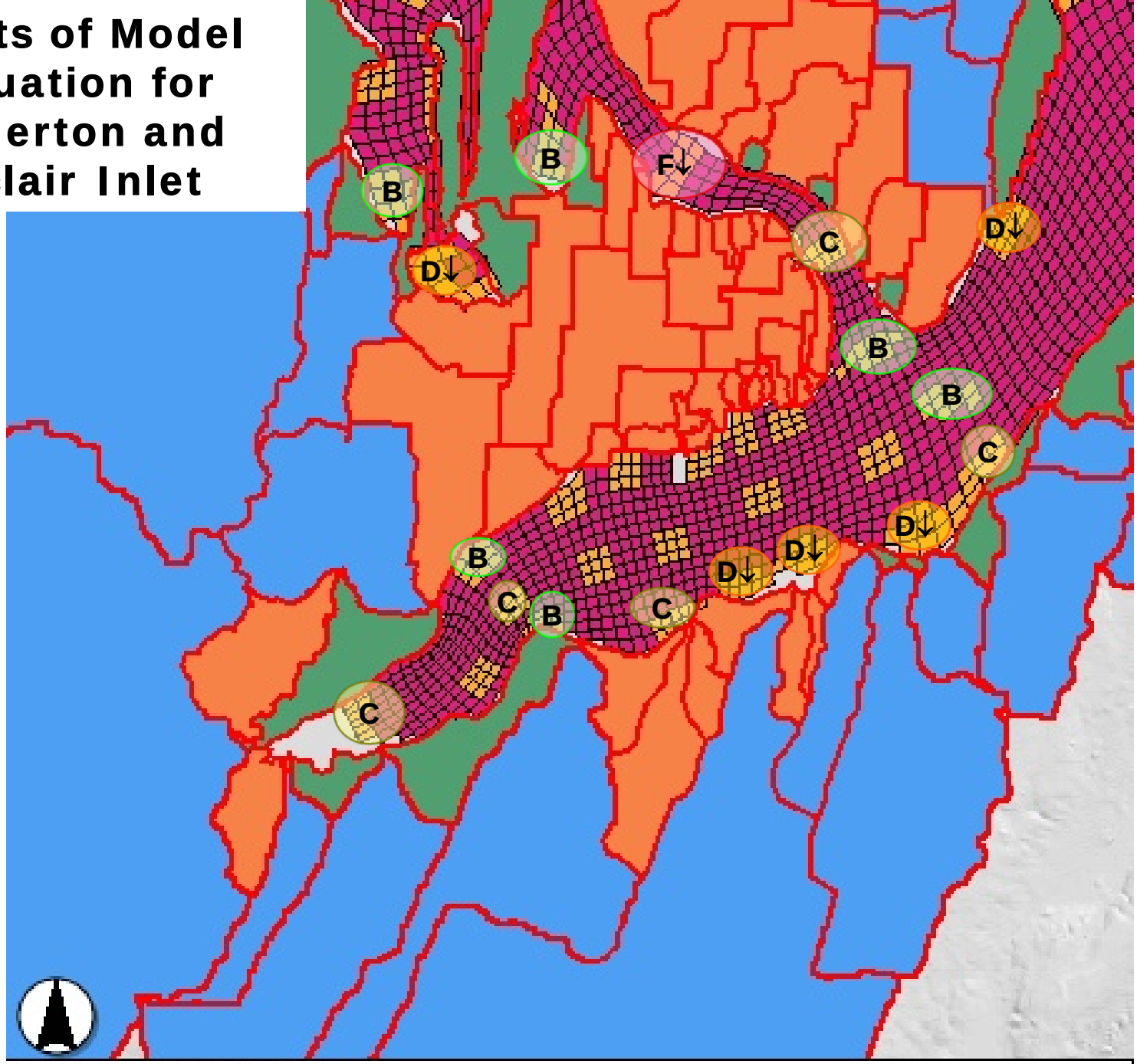


# Canary Nodes Continued

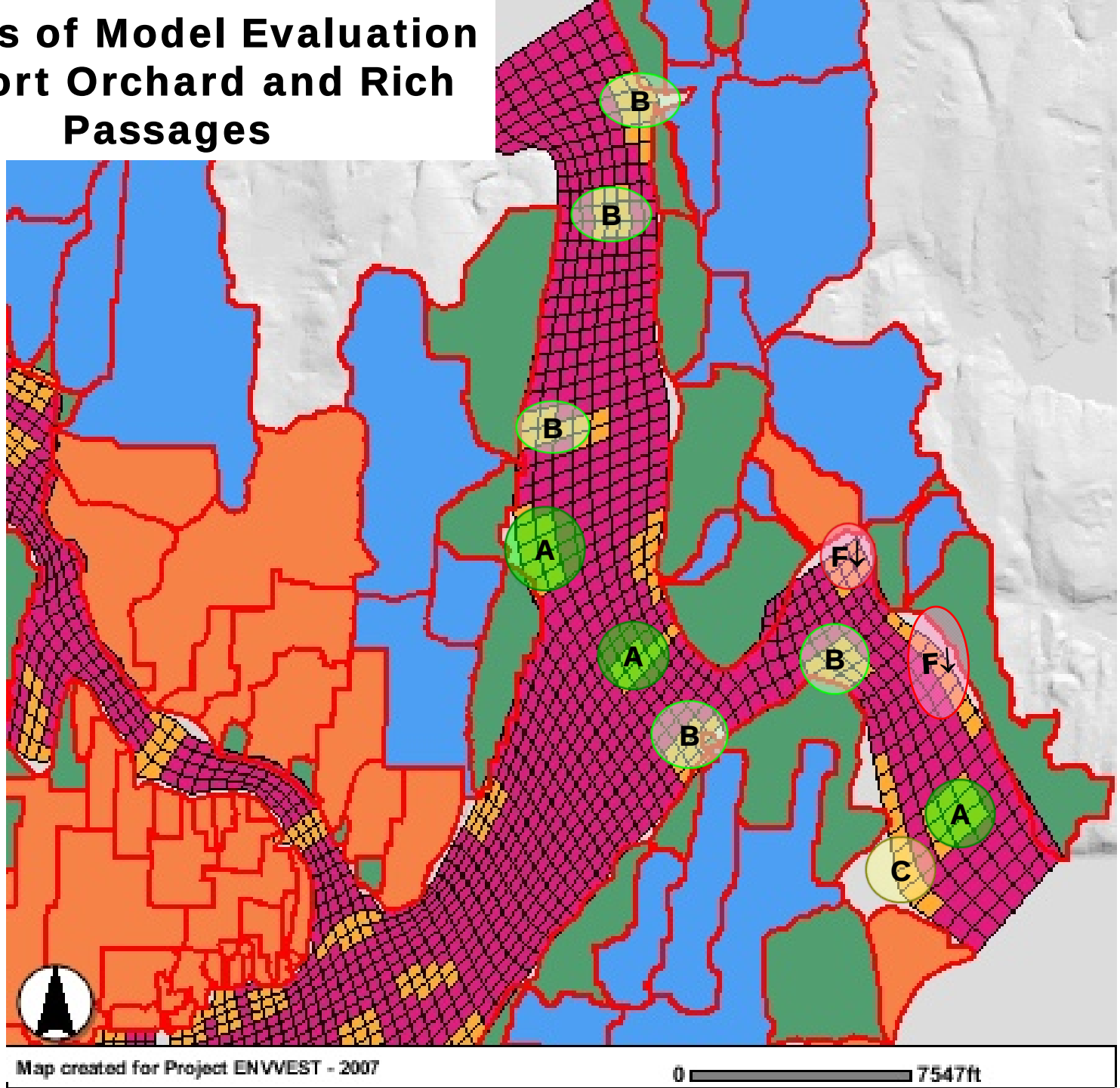
# Results of Model Evaluation for Dyes Inlet



# Results of Model Evaluation for Bremerton and Sinclair Inlet



# Results of Model Evaluation for Port Orchard and Rich Passages



# How Good Are the Model Predictions?

- **FC loading predicted by upstream land use/land cover and runoff from watershed**
  - √ **Yes – High degree of confidence with Good to Excellent agreement with observed data for most watersheds, however tendency to under predict loads in certain areas**
- **CH3D-FC simulates FC concentrations in the Inlets**
  - √ **Yes – High degree of confidence with Good to Excellent agreement with observed data for marine waters, however tendency to under predict FC concentrations in certain nearshore areas**

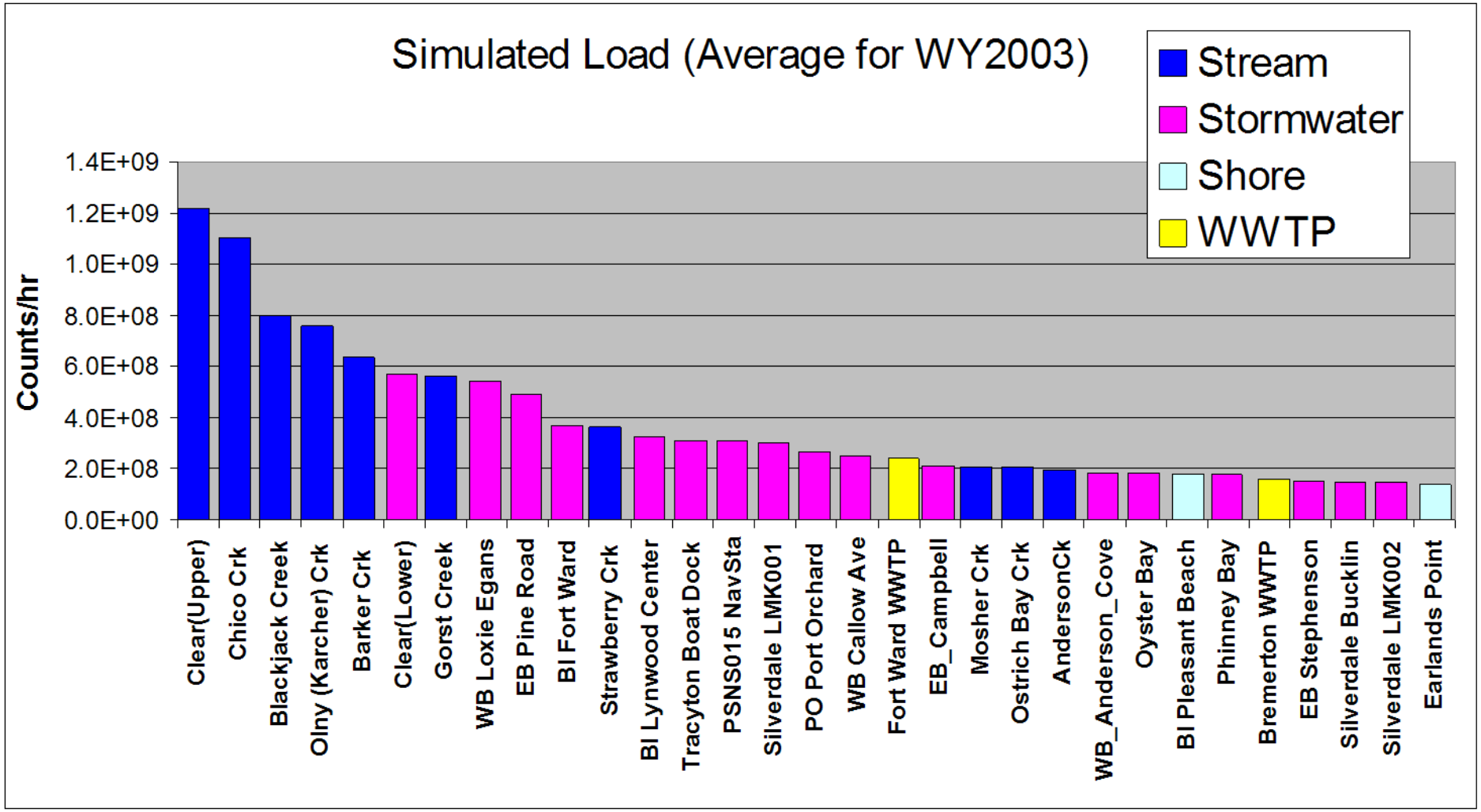
**Nearshore Areas Under Predicted**

- **Clear/Strawberry**
- **Oyster Bay**
- **Dee Creek**
- **Port Orchard waterfront**
- **South Bainbridge Island**

# Model Limitations

- **Indirectly accounts for:**
  - **Failed septic systems**
  - **Upland Waterfowl and Wildlife**
- **Inputs do not include:**
  - **Marinas**
  - **Broken pipes**
  - **CSO Events**
  - **Nearshore waterfowl and marine mammals**
  - **Sediment resuspension and regeneration of bacteria spores**
  - **Other unknown sources**

# Top 30 Loads from Watershed



# Uncertainty

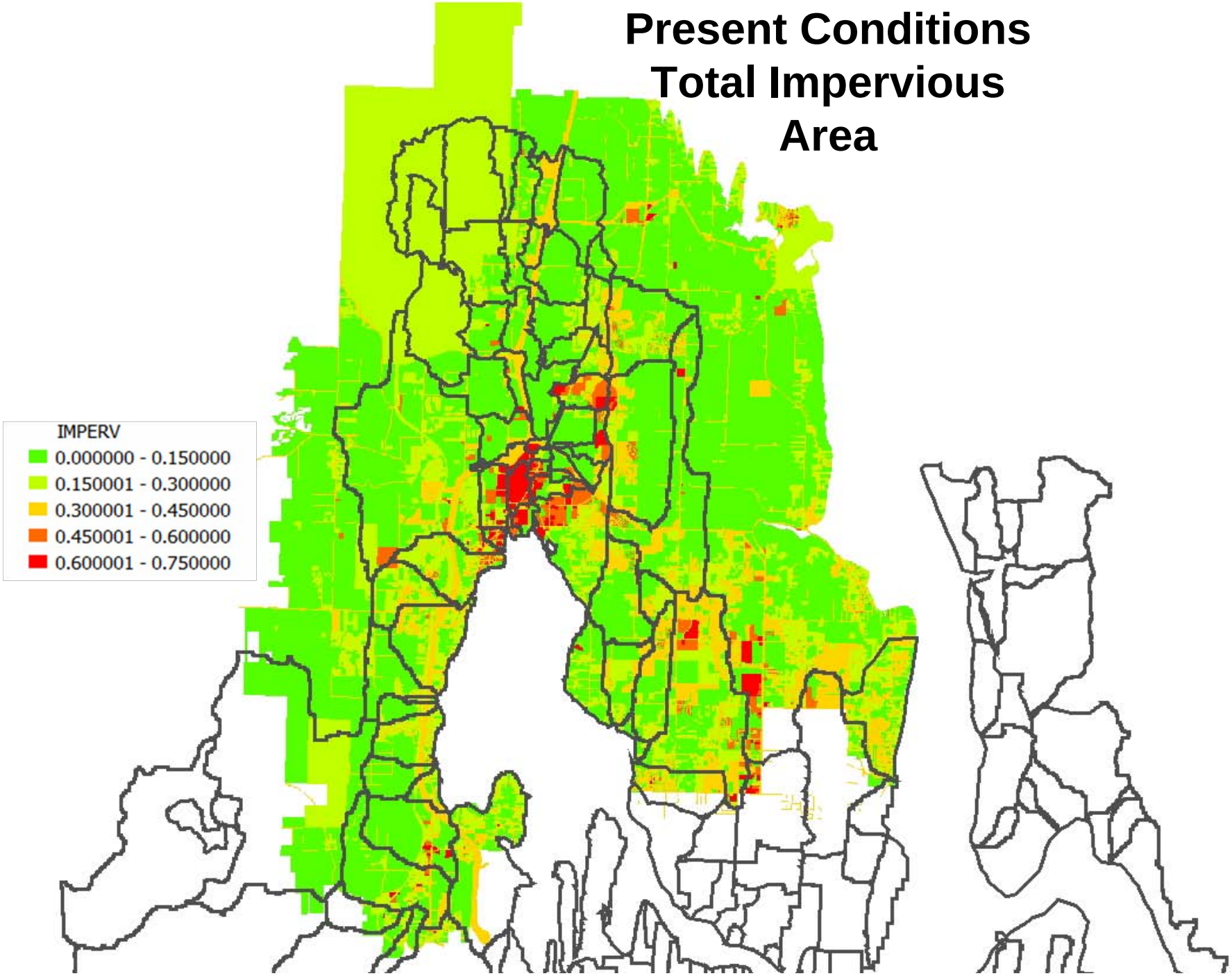
**"*We don't know enough about how the present leads to the future*" – Gregory Bateson**

- Future Conditions
- Kitsap County Watershed Planning for Northern Dyes Inlet (Alternative Futures Land Use)
  - Current Conditions
  - Conservative Growth Scenario
  - **Expansive Growth Scenario**
- Land use coverage based on county parcel map

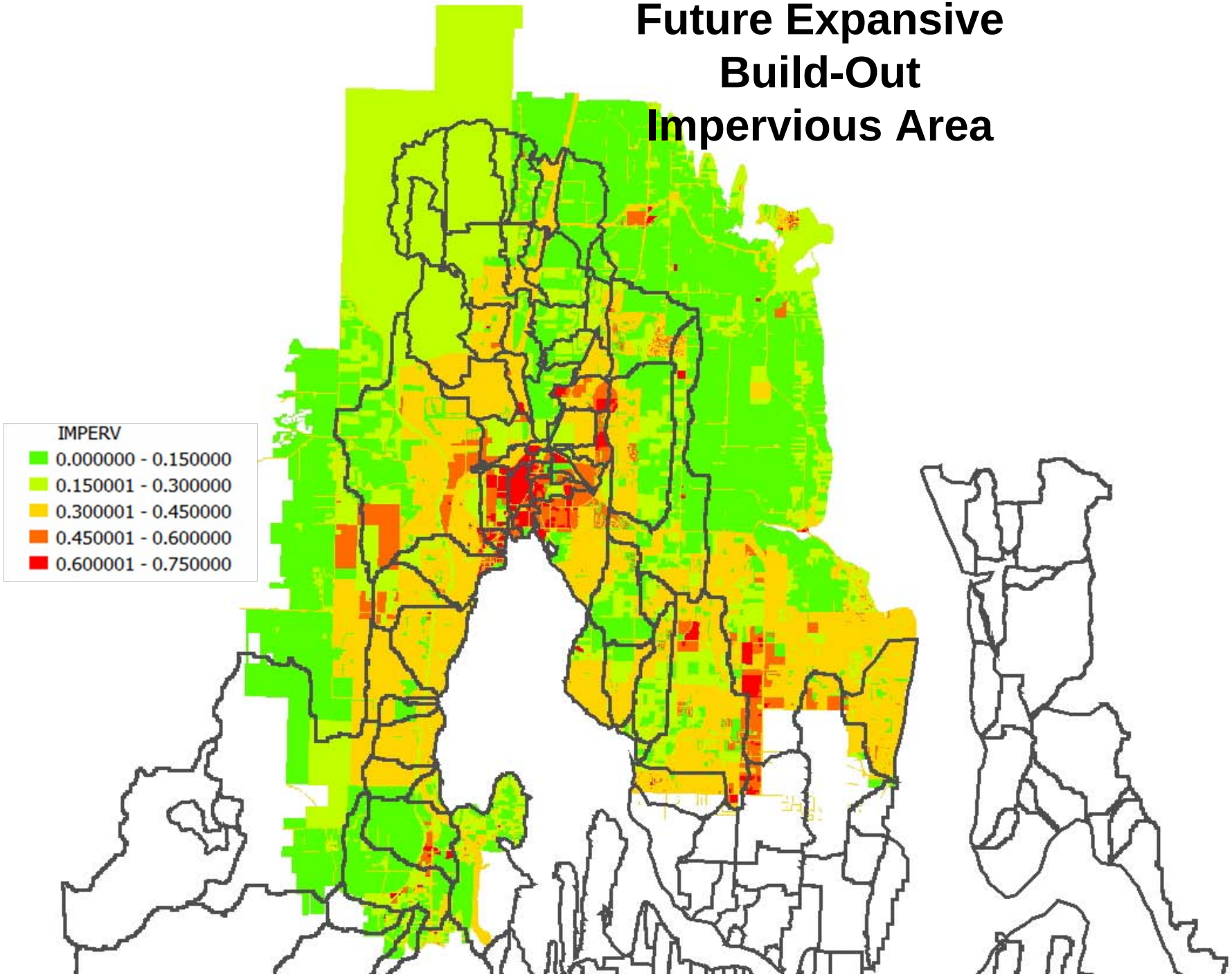
# Future Simulation

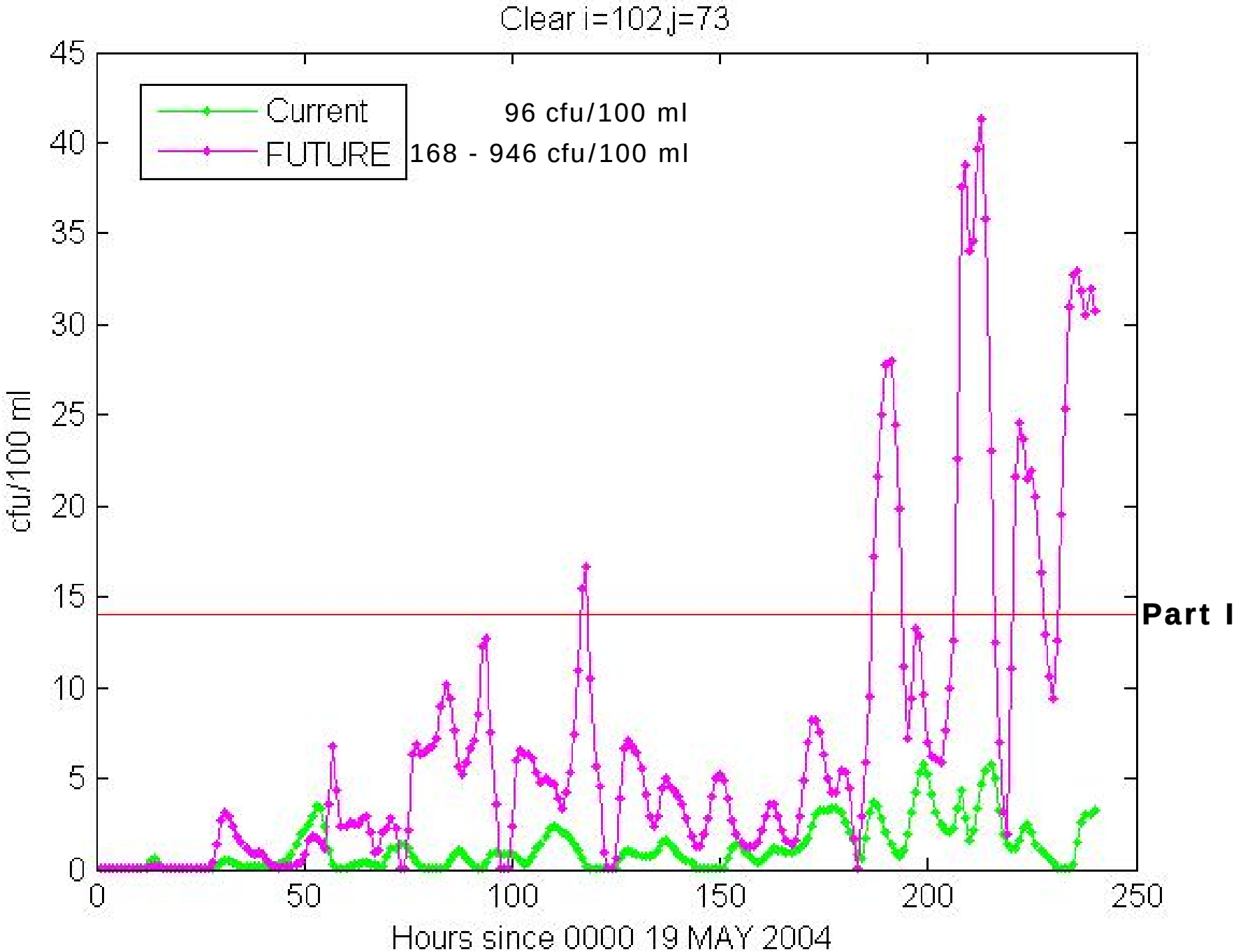
- Update land use and cover to match future buildout
- Model changes in flow
- Estimate FC input based on the change in land use and land cover
- Simulate storm event for May 26-27, 2004 under future conditions
- Future buildout was only applied to Northern Dyes Inlet

# Present Conditions Total Impervious Area



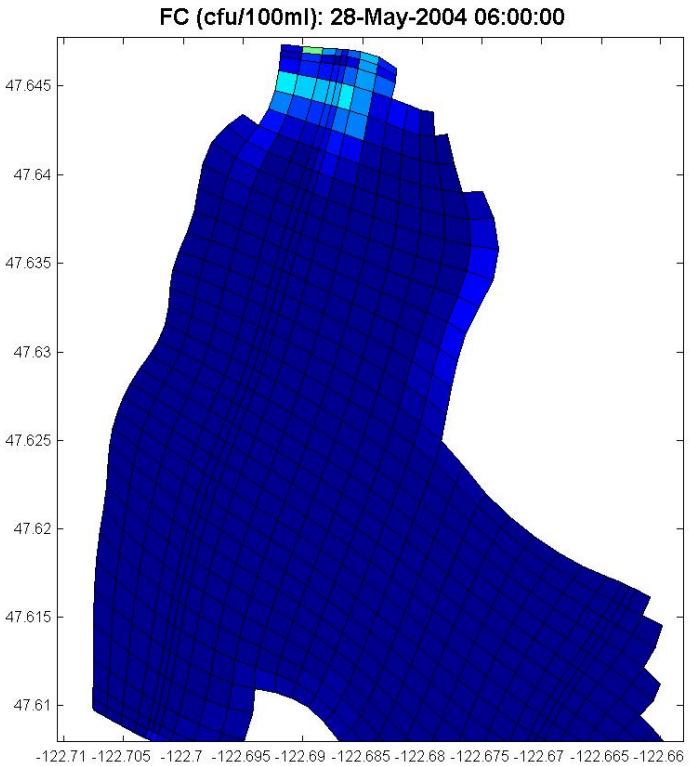
# Future Expansive Build-Out Impervious Area



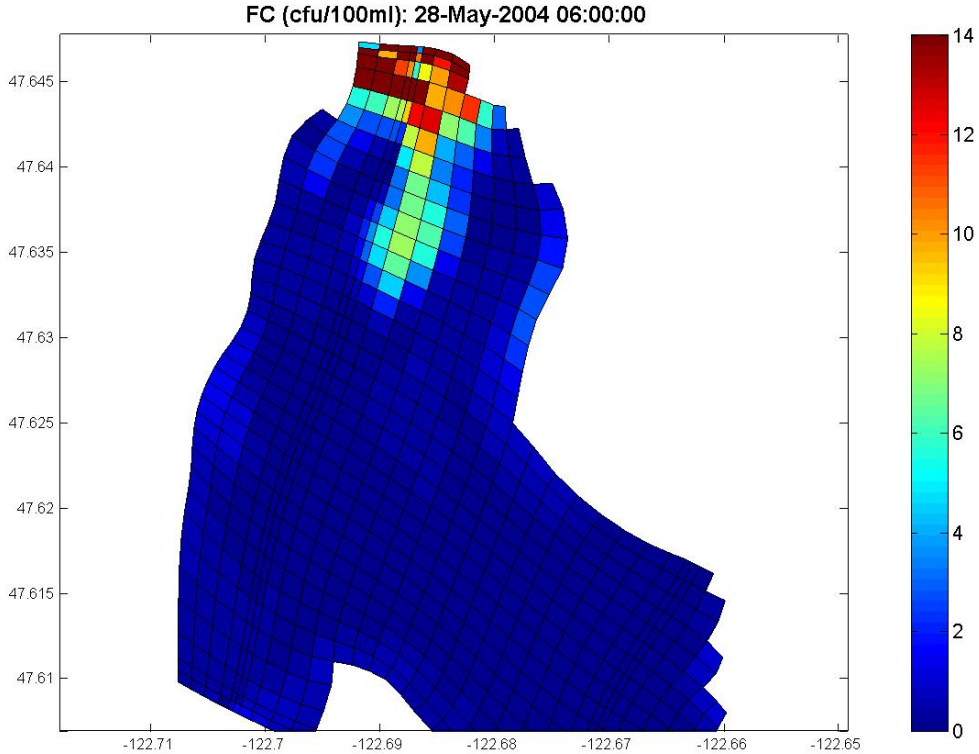

Clear i=102,j=73
Current
FUTURE
96 cfu/100 ml
168 - 946 cfu/100 ml
Part I
cfu/100 ml
Hours since 0000 19 MAY 2004
0
5
10
15
20
25
30
35
40
45
0
50
100
150
200
250

# Current and Future Build Out

## Current Conditions




## Future Expansive Build Out




Link to Future Simulation Scenario

http://kairos.spawar.navy.mil/ENVVEST/Modelling/Sinclair_Dyes/CH3D-FC/Animations/S19.html

# Future Conditions

- **Effect of Future Build Out on FC Loading**

  **Low confidence because future is unknown**

  **Expanded Build Out would likely increase the frequency, magnitude, extent, and duration of FC levels exceeding water quality standards through out the watershed**

- **Likely that any actions that effectively eliminate or reduce current problems would also be effective in addressing future problems**

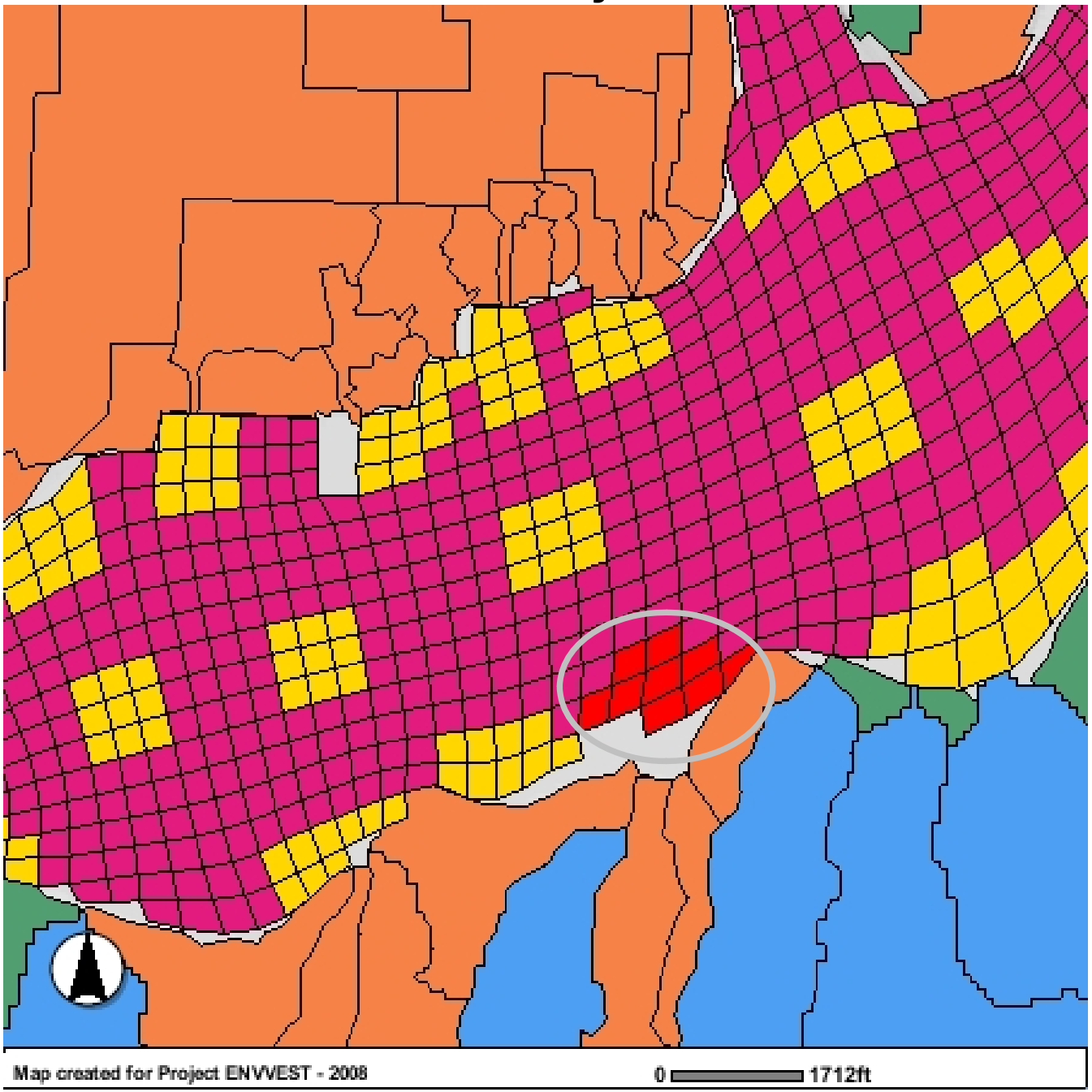
# TMDL Results

- **Observed Data**
  Data Collected during WY2003
  Geomean and 90$^{th}$ Percentile
- **Actual Conditions (Critical Conditions)**
  30-day moving average of daily maximum
  Average of grids within canary nodes
- **100/200 TMDL Simulation (Part I)**
  Streams and Stormwater set to 100 cfu/100 ml
  Treatment Plants set to 200 cfu/100 ml
  Compared to 14 cfu/100 ml (Geometric Mean)
- **200/400 TMDL Simulation (Part II)**
  Streams and Stormwater set to 200 cfu/100 ml
  Treatment Plants set to 400 cfu/100 ml
  Compared to 43 cfu/100 ml (90$^{th}$ Percentile)

# Canary Nodes that Exceeded Standards

| Canary Node | % Reduction Needed to Meet Standard | | | |
|---|---|---|---|---|
| | OBSERVED | SIMULATED | | |
| | | Actual | TMDL 100/200 | TMDL 200/400 |
| 01-Dyes-Barker-Cr | | | | 8.40% |
| 03-Dyes-Clear-Cr | 69.30% | 15.20% | | 9.9% - 30.6% |
| 33-PWN-AnCov-PineR | 37.50% | | | |
| 35-RPass-FortWard | 35.3% - 84.5% | | | |
| 36-RPass-LynnwoodC | 80.7% - 84.5% | | | |
| 43-Sin-Gorst-Cr | | 24.70% | 14.7% - 77.0% | 14.6% - 78.5% |
| 49-Sin-SNO3-PTOW | | | 8.6% - 45.1% | 0.2% - 37.3% |
| 50-SinPO-BlackJ | 40.4% - 55.1% | 4.10% | 1.9% - 49.7 | 14.9% - 47.4% |
| 51-SinPO-KarcherC | 15.00% | | | |

# Sinclair: Blackjack Creek



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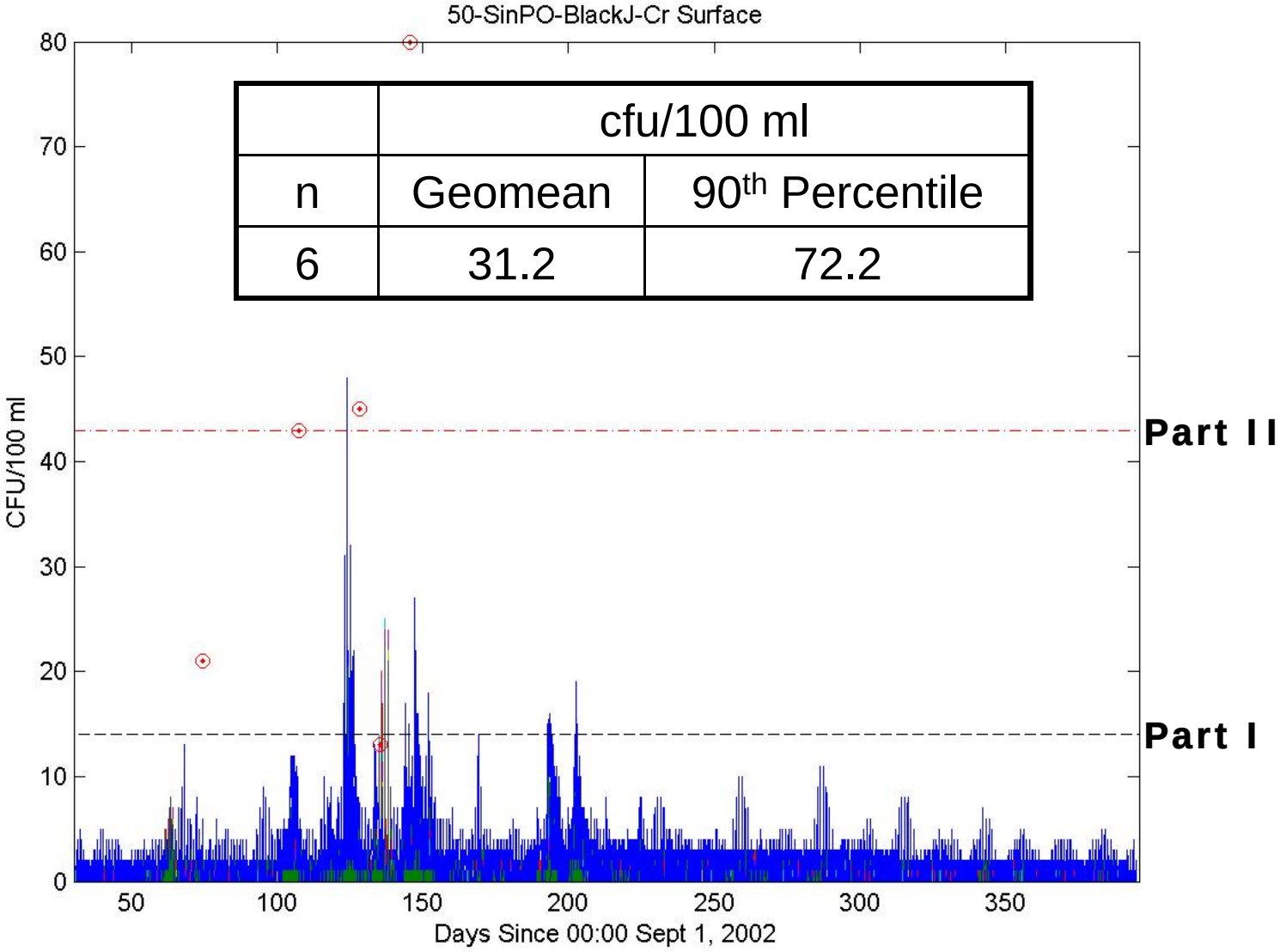
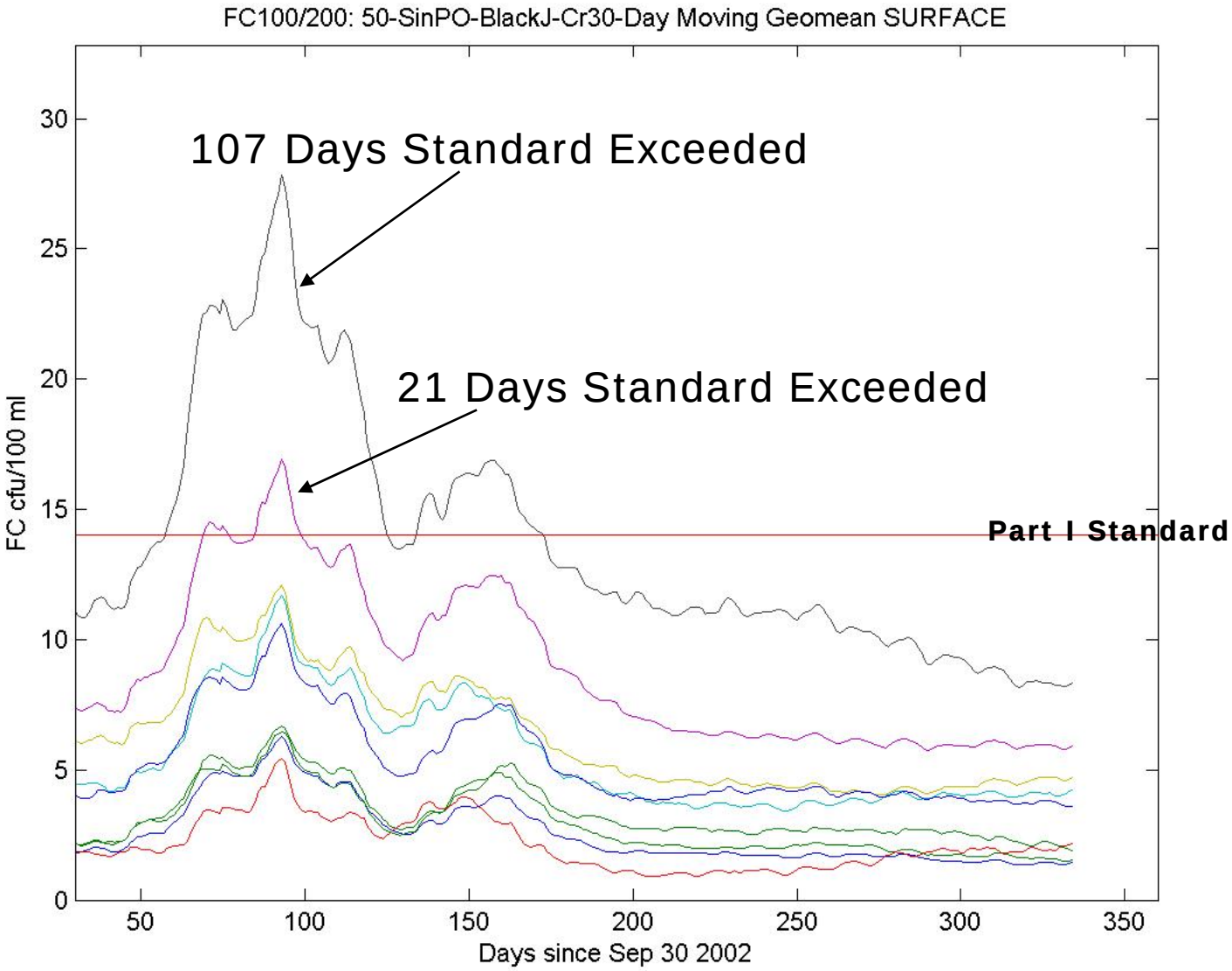
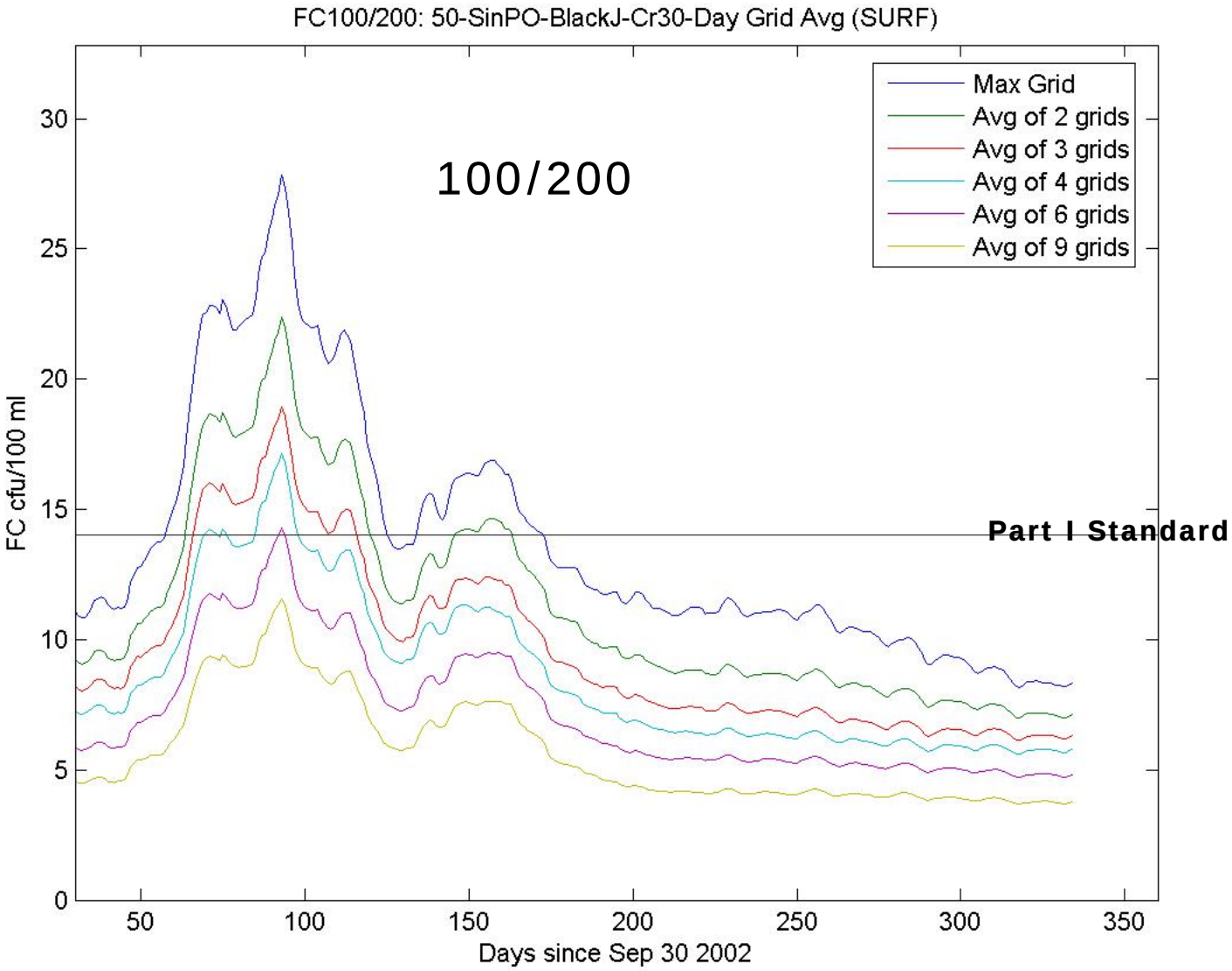



| | cfu/100 ml | |
|---|---|---|
| n | Geomean | 90th Percentile |
| 6 | 31.2 | 72.2 |

# Blackjack Cr. – 30 day moving average of daily max 100/200 Geomean



# Blackjack Cr. – 30 day moving average of daily max Averaged by Grids

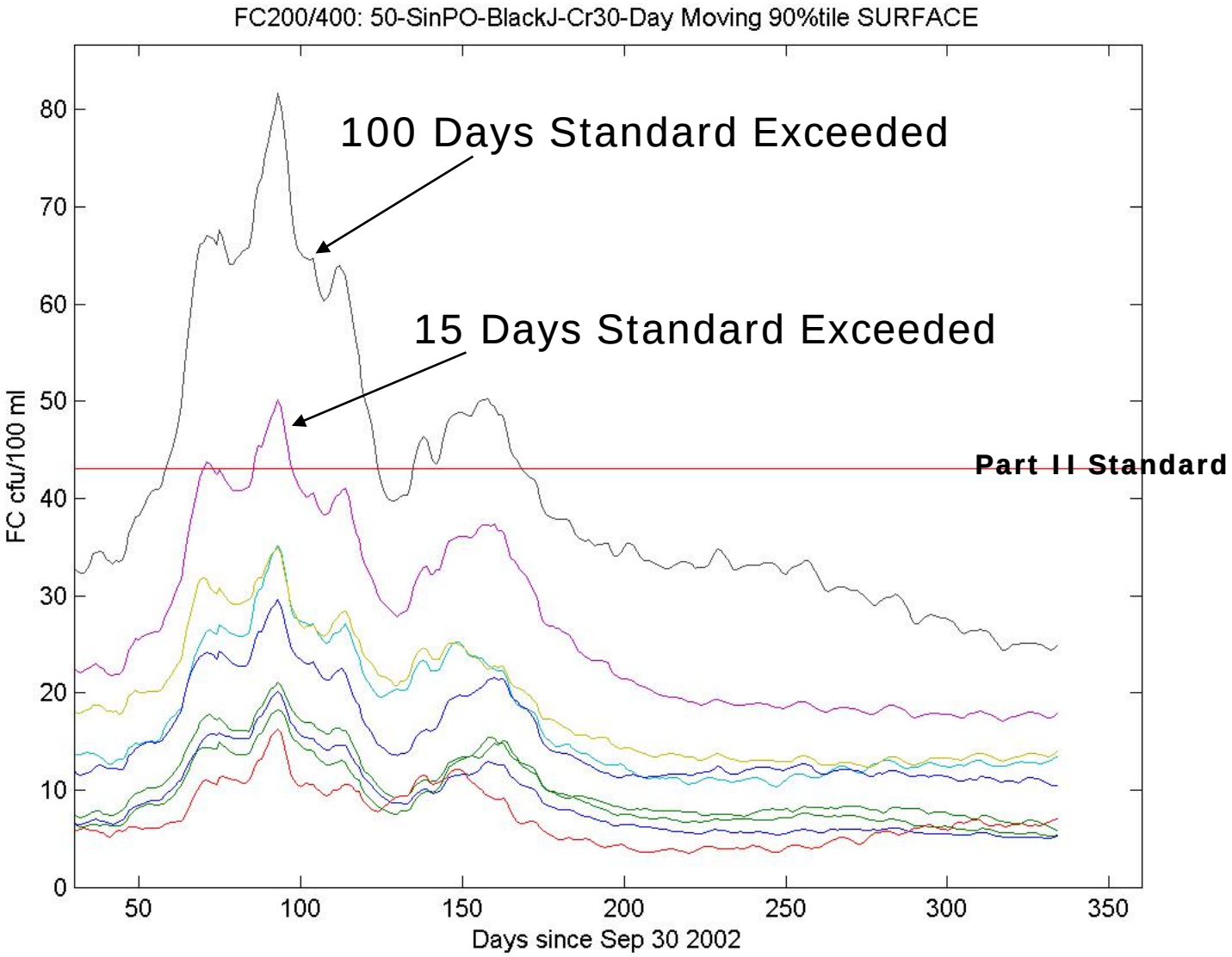


# Reduction Required (Part I)

| | Average of highest 1/2/3/4/6/9 grid cells 30-Day Moving GeoMean of Daily Max | | | | 50-SinPO-BlackJ-Cr | |
|---|---|---|---|---|---|---|
| | Average | | Maximum | | Reduction Needed | |
| | surface | depth-avg | surface | depth-avg | Average | Maximum |
| max grid | 13.4 | 13.4 | 27.8 | 27.8 | Meets Standard | 49.7% |
| avg of 2 girds | 11.0 | 11.0 | 22.4 | 22.4 | | 37.4% |
| avg of 3 girds | 9.4 | 9.4 | 19.0 | 19.0 | | 26.1% |
| avg of 4 girds | 8.4 | 8.4 | 17.1 | 17.1 | | 18.3% |
| avg of 6 girds | 7.0 | 7.0 | 14.3 | 14.3 | | 1.9% |
| avg of 9 girds | 5.5 | 5.2 | 11.6 | 10.6 | | OK |

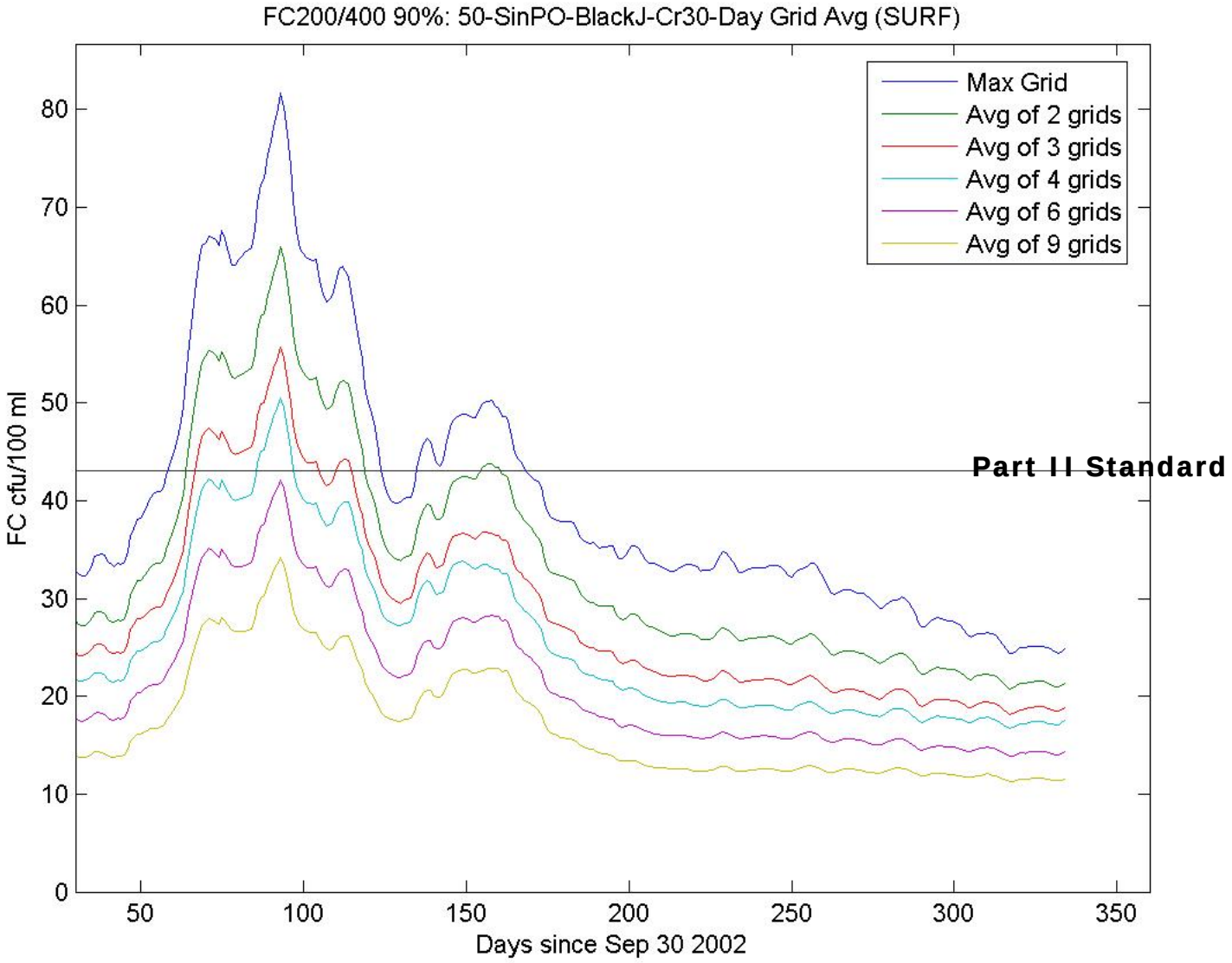
Target Reduction Needed to Meet Part I of Standard: 37.4%

# Blackjack Cr. – 30 day moving average of daily max 200/400 90th Percentile



# Blackjack Cr. – 30 day moving average of daily max

200/400 90th%



# Reduction Required (Part II)

| | Average of highest 1/2/3/4/6/9 grid cells 30-Day Moving 90th% of Daily Max | | | | 50-SinPO-BlackJ-Cr | |
|---|---|---|---|---|---|---|
| | Average | | Maximum | | Reduction Required | |
| | surface | depth-avg | surface | depth-avg | Average | Maximum |
| max grid | 39.8 | 39.8 | 81.7 | 81.7 | Meets Standard | 47.4% |
| avg of 2 girds | 32.9 | 32.9 | 65.9 | 65.9 | | 34.8% |
| avg of 3 girds | 28.1 | 28.1 | 55.6 | 55.6 | | 22.7% |
| avg of 4 girds | 25.2 | 25.2 | 50.5 | 50.5 | | 14.9% |
| avg of 6 girds | 20.9 | 20.9 | 42.1 | 41.7 | | OK |
| avg of 9 girds | 16.7 | 15.4 | 34.2 | 31.2 | | OK |

Target Reduction Needed to Meet Part II of Standard: 34.8%

Target Reduction Needed to Meet Part I of Standard: **37.4%**

# Summary of TMDL Targets for Marine Waters

| Canary Node | % Reduction Needed to Meet Standard | | | | TMDL Target Reduction |
|---|---|---|---|---|---|
| | OBSERVED | SIMULATED | | | |
| | | Actual | TMDL 100/200 | TMDL 200/400 | |
| 01-Dyes-Barker-Cr | | | | 8.40% | |
| 03-Dyes-Clear-Cr | 69.30% | 15.20% | | 9.9% - 30.6% | 27% |
| 33-PWN-AnCov-PineR | 37.50% | | | | |
| 35-RPass-FortWard | 35.3% - 84.5% | | | | |
| 36-RPass-LynnwoodC | 80.7% - 84.5% | | | | |
| 43-Sin-Gorst-Cr | | 24.70% | 14.7% - 77.0% | 14.6% - 78.5% | 75% |
| 49-Sin-SNO3-PTOW | | | 8.6% - 45.1% | 0.2% - 37.3% | |
| 50-SinPO-BlackJ | 40.4% - 55.1% | 4.10% | 1.9% - 49.7 | 14.9% - 47.4% | 37% |
| 51-SinPO-KarcherC | 15.00% | | | | |

# Conclusions

**Model Evaluation**

**– How good are the predictions?**

- **Very High Confidence that the model is able to simulate watershed scale FC loading, fate, and transport in the Inlets**
- **Predictions are Acceptable within limitations and areas under predicted by model were identified**

**Model Sensitivity and Uncertainty**

**– What are the most important factors?**

- **FC Loading Concentration**
- **FC Die Off and Dispersion**

**Simulations for TMDL**

- **– Model can be used to define TMDL targets**

# Acknowledgements

**More info on the CD!**

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