Hands on State Point Training Illuminates Clarifier Operation

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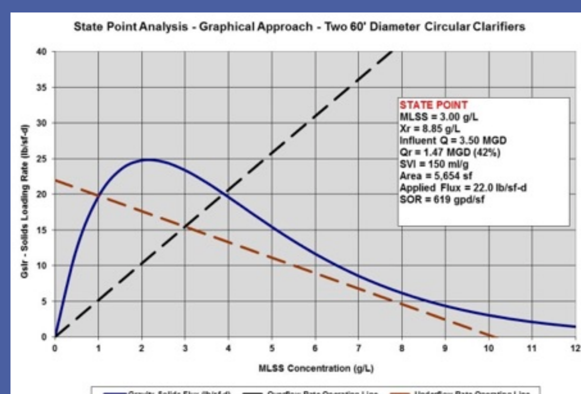

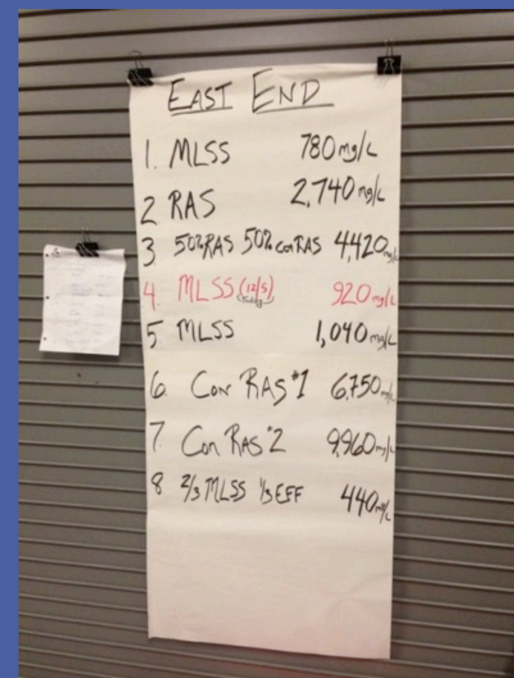

Acknowledgments

- Many individuals and organizations contributed to the concept and delivery of this training:
  - Dick Darling – ME DEP
  - Scott Firmin – Portland Water District (PWD)
  - Leeann Hanson – JETCC
  - Steve Sloan – Portland Water District
  - PWD East End WWTP Staff
  - Al Jellison – City of Bangor
  - Bangor WWTP Staff
  - Numerous operators who served as trainers

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Training Overview

- Hands on training combined with class room instruction
- Step 1 – Conduct a “train the trainer” session
- Step 2 – Conduct training with the assistance of a team of trainers

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Class Agenda

- Review secondary clarifier operating concepts
- Learn how to use the State Point Approach
- Conduct column testing to develop plant-specific data
  - 4 Teams with Trainers

- Illustrate clarifier operating scenarios using Dynamic Modeling
- Review how raw data is used to develop Gravity Flux Curve
- Develop Gravity Flux Curve for the data collected and examine actual operating scenarios

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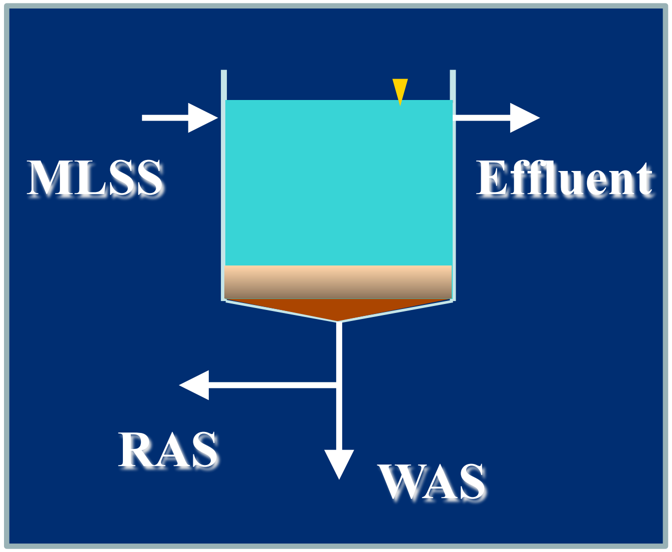
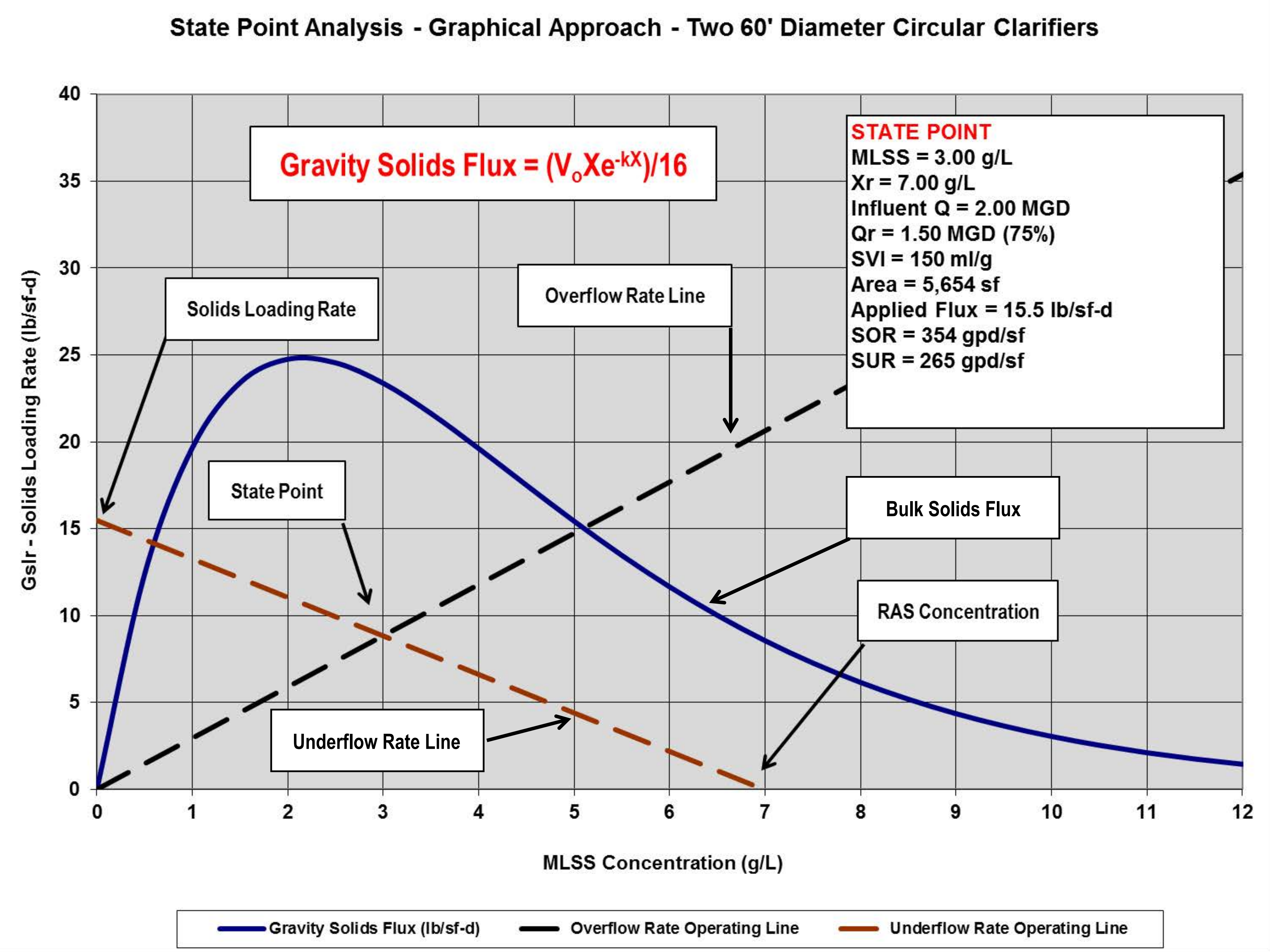
What is State Point Analysis?

- **State Point Analysis:**
- Graphical solids mass balance of the secondary clarifiers
- Dependent on:
  - Physical facilities
  - Influent flow
  - Sludge settling characteristics
- Can be used to determine:
  - Allowable MLSS to the clarifiers
  - Minimum RAS rate
  - The capacity of the clarifiers




State Point Analysis - Graphical Approach - Two 60' Diameter Circular Clarifiers
Gravity Solids Flux = (VoXe-kX)/16
STATE POINT
MLSS = 3.00 g/L
Xr = 7.00 g/L
Influent Q = 2.00 MGD
Qr = 1.50 MGD (75%)
SVI = 150 ml/g
Area = 5,654 sf
Applied Flux = 15.5 lb/sf-d
SOR = 354 gpd/sf
SUR = 265 gpd/sf
Solids Loading Rate
Overflow Rate Line
State Point
Bulk Solids Flux
RAS Concentration
Underflow Rate Line
GsIr - Solids Loading Rate (lb/sf-d)
MLSS Concentration (g/L)
0
5
10
15
20
25
30
35
40
0
1
2
3
4
5
6
7
8
9
10
11
12
Gravity Solids Flux (lb/sf-d)
Overflow Rate Operating Line
Underflow Rate Operating Line

Gravity Flux Equation

Gravity Solids Flux = $(V_o X e^{-kX})/16$

- Vo = Initial Settling Velocity (ft/day)
- X = MLSS Concentration (g/L)
- e = Exponential Function
- k = empirical settling parameter (L/g)

The Gravity Solids Flux defines the zone settling rate in the clarifier

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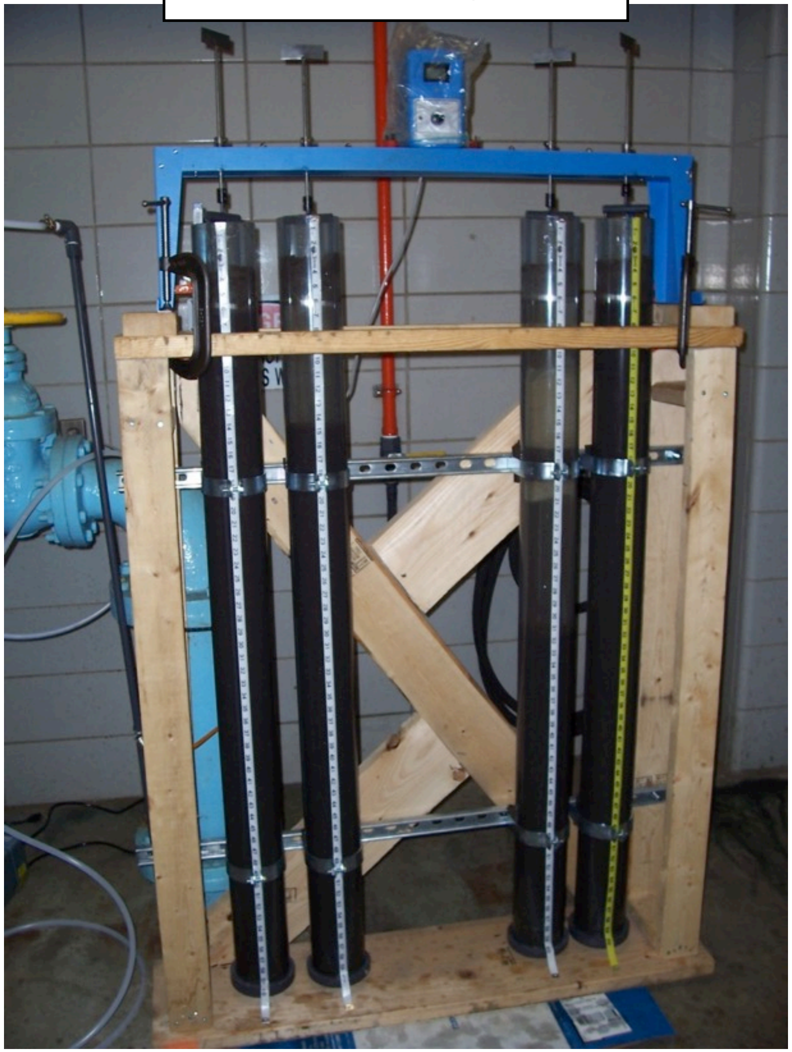
Test Equipment

4 Column Arrangement



Single Column Arrangement
For JETCC Class

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Test Procedure

- Measure MLSS and SVI
- Create sample dilutions from 1,000 – 10,000 mg/L
- Thoroughly mix sample
- Pour sample into column using funnel
- Start timer when fill completed
- **Mix column contents**
- Measure interface level at 1 minute intervals
  - Low MLSS concentrations will settle faster
  - High MLSS concentrations will settle slower

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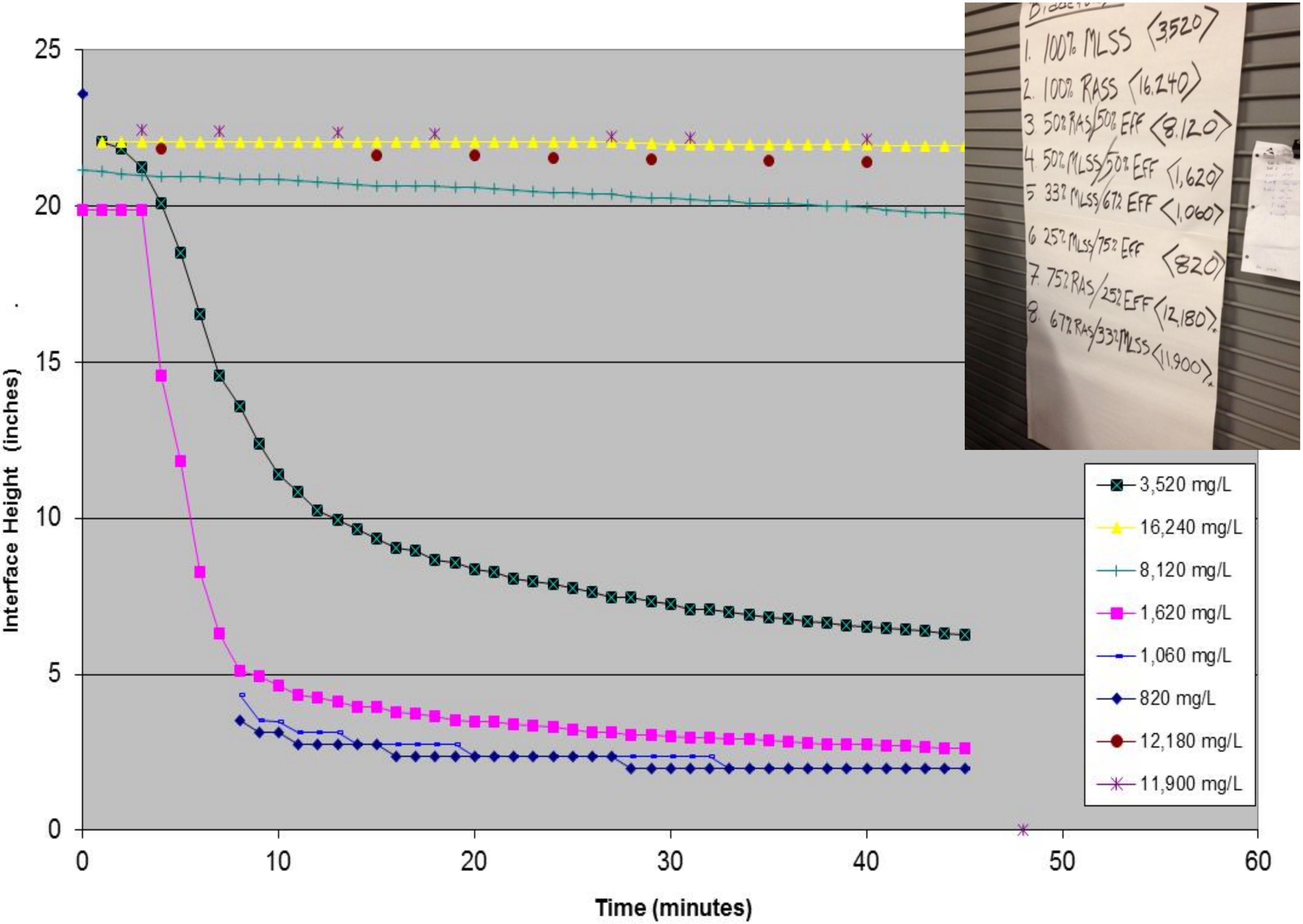
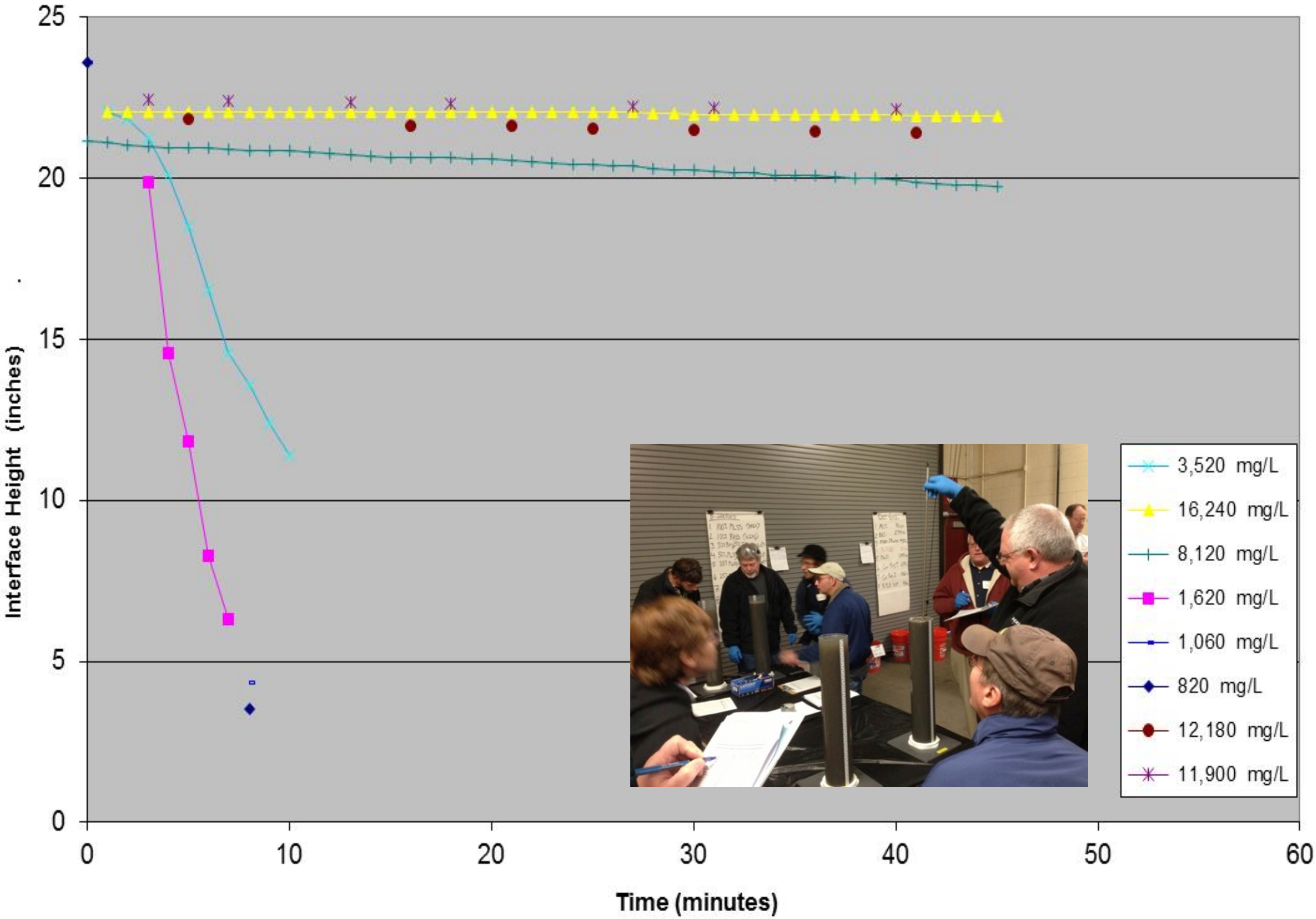
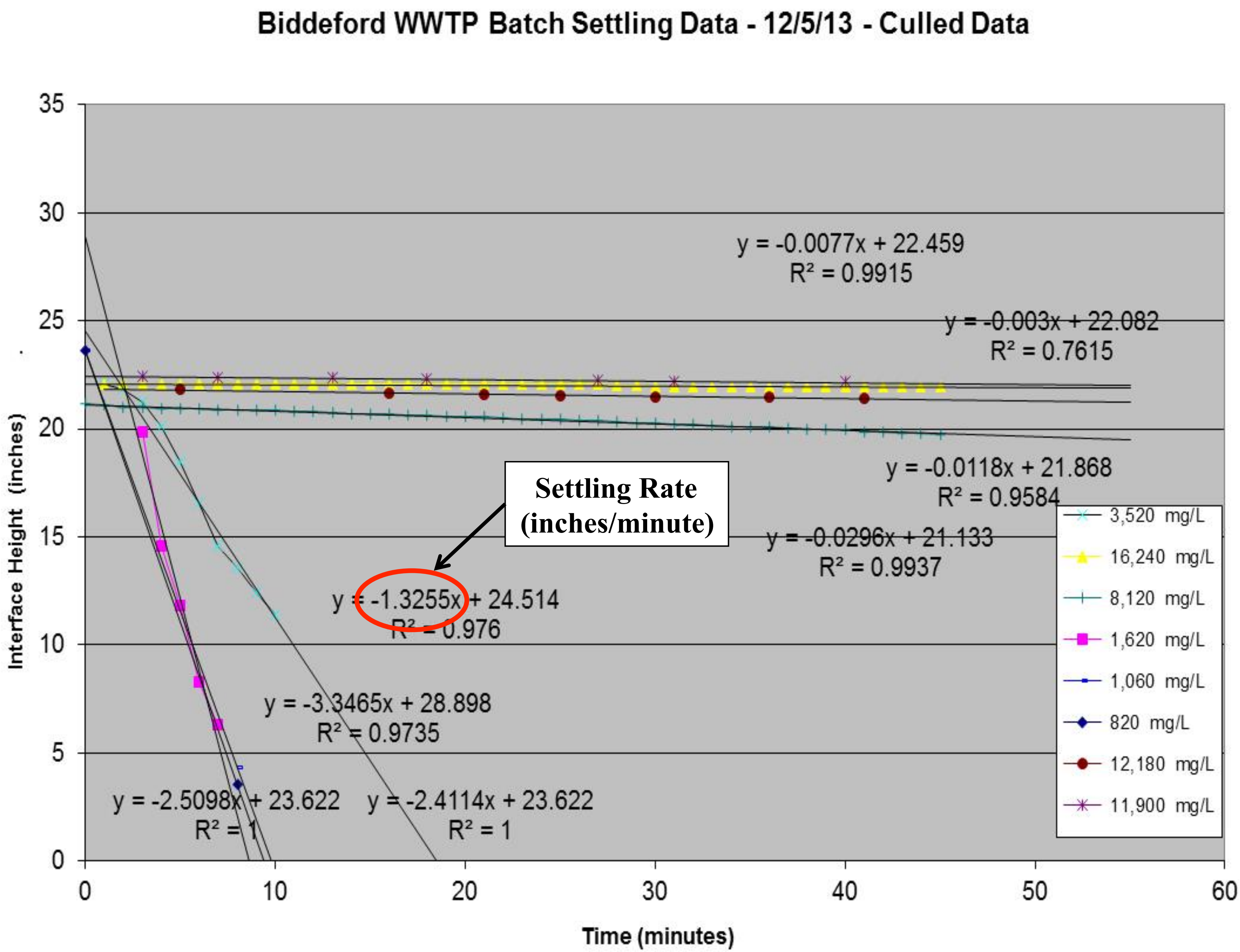
Biddeford WWTP Batch Settling Tests - 12/5/2013 - Raw Data

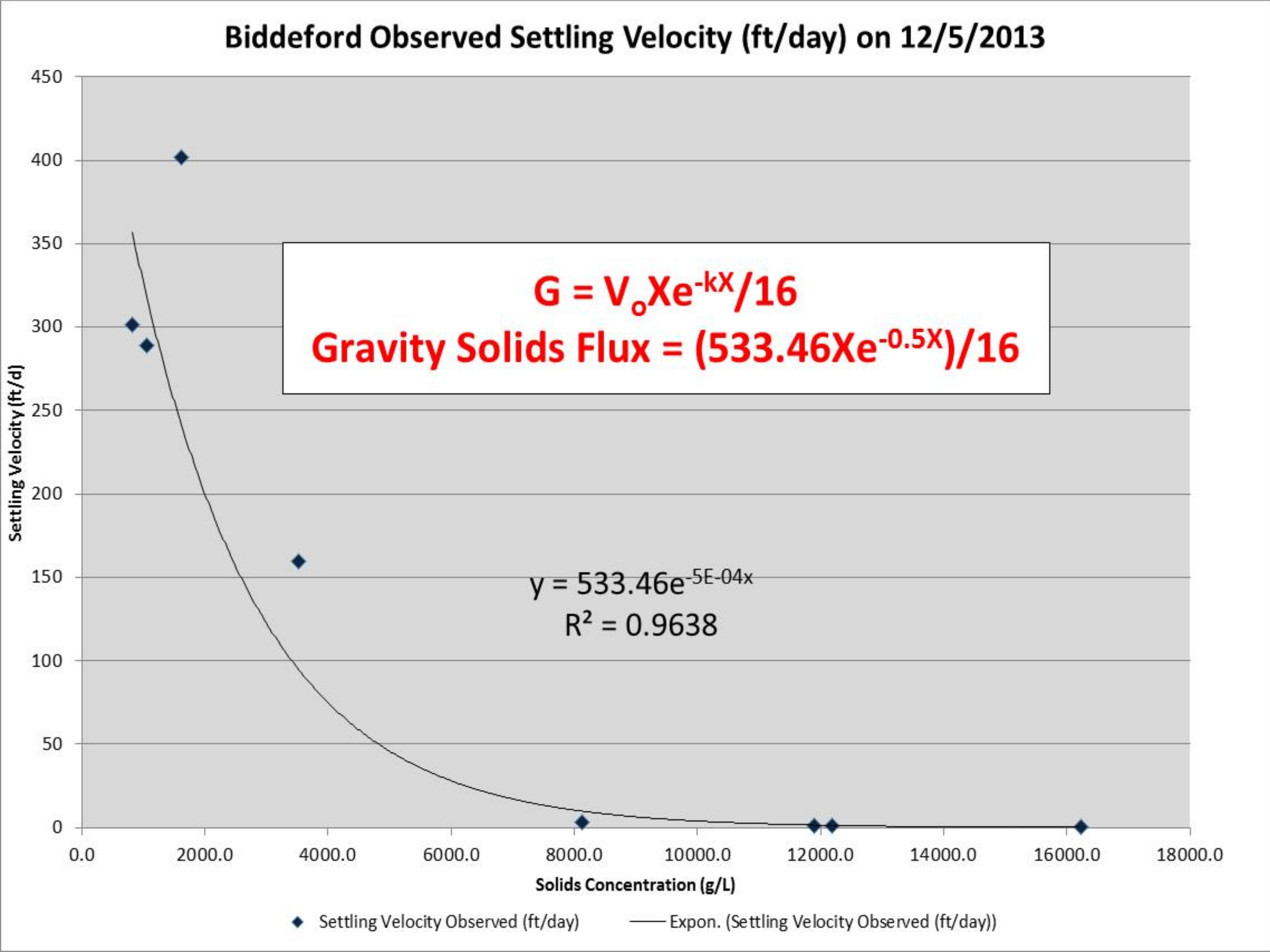


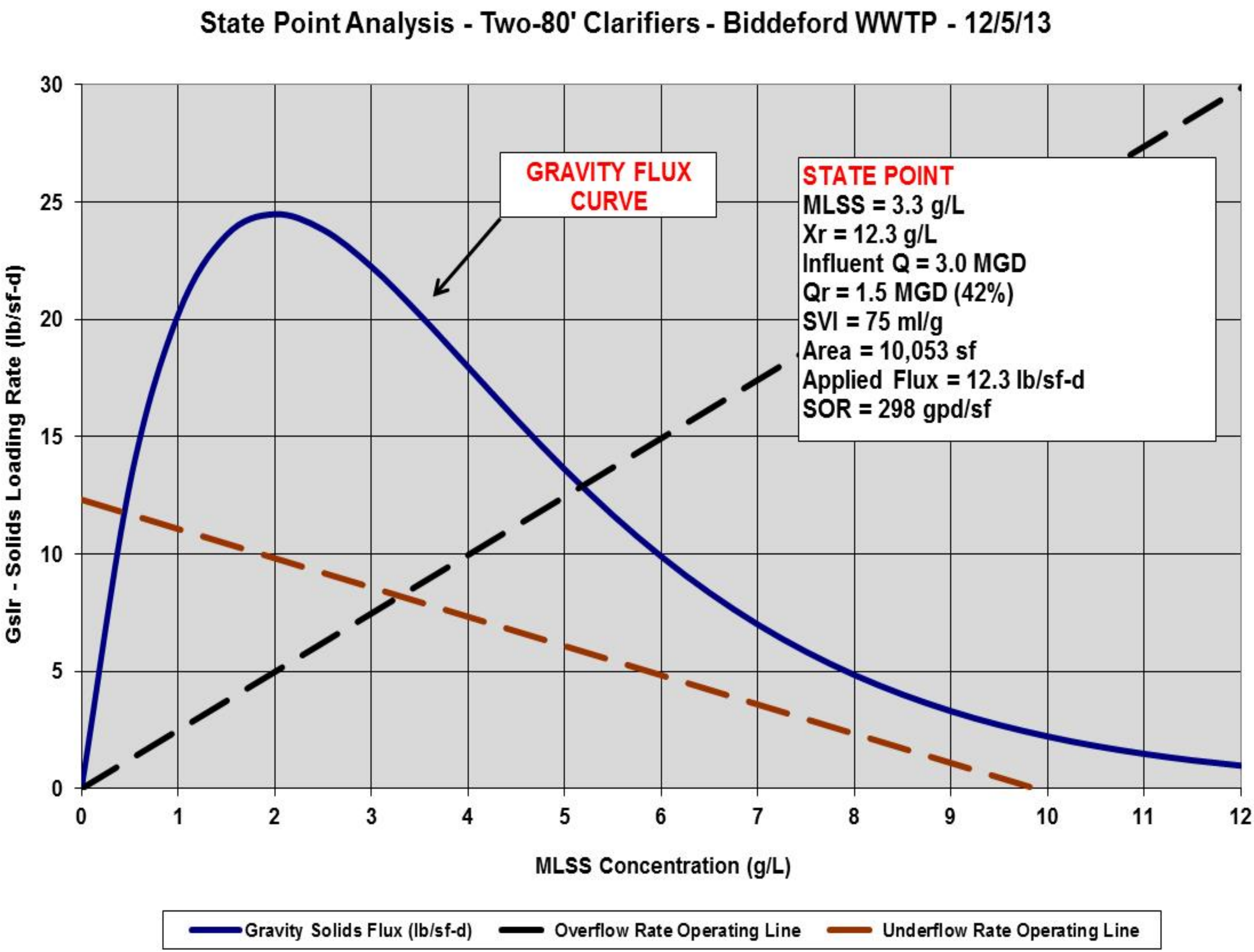
Biddeford WWTP Batch Settling Data - 12/5/13 - Culled Data





Biddeford WWTP Batch Settling Data - 12/5/13 - Culled Data
Interface Height (inches)
Time (minutes)
35
30
25
20
15
10
5
0
0
10
20
30
40
50
60
y = -0.0077x + 22.459
R² = 0.9915
y = -0.003x + 22.082
R² = 0.7615
y = -0.0118x + 21.868
R² = 0.9584
y = -0.0296x + 21.133
R² = 0.9937
Settling Rate (inches/minute)
y = -1.3255x + 24.514
R² = 0.976
y = -3.3465x + 28.898
R² = 0.9735
y = -2.5098x + 23.622
R² = 1
y = -2.4114x + 23.622
R² = 1
3,520 mg/L
16,240 mg/L
8,120 mg/L
1,620 mg/L
1,060 mg/L
820 mg/L
12,180 mg/L
11,900 mg/L


Biddeford Observed Settling Velocity (ft/day) on 12/5/2013
G = VoXe-kX/16
Gravity Solids Flux = (533.46Xe-0.5X)/16
y = 533.46e-5E-04x
R² = 0.9638
Settling Velocity (ft/d)
Solids Concentration (g/L)
450
400
350
300
250
200
150
100
50
0
0.0
2000.0
4000.0
6000.0
8000.0
10000.0
12000.0
14000.0
16000.0
18000.0
Settling Velocity Observed (ft/day)
Expon. (Settling Velocity Observed (ft/day))


State Point Analysis - Two-80' Clarifiers - Biddeford WWTP - 12/5/13
GRAVITY FLUX CURVE
STATE POINT
MLSS = 3.3 g/L
Xr = 12.3 g/L
Influent Q = 3.0 MGD
Qr = 1.5 MGD (42%)
SVI = 75 ml/g
Area = 10,053 sf
Applied Flux = 12.3 lb/sf-d
SOR = 298 gpd/sf
Gslr - Solids Loading Rate (lb/sf-d)
MLSS Concentration (g/L)
0
5
10
15
20
25
30
0
1
2
3
4
5
6
7
8
9
10
11
12
Gravity Solids Flux (lb/sf-d)
Overflow Rate Operating Line
Underflow Rate Operating Line

Conclusions

- Hands on aspect of the course significantly helped participants:
  - Grasp both theory and math of approach
  - Understand how solids loading rate can be a limiting factor in clarifier operation
- Use of trainers significantly helped students by providing continuous input and feedback during testing
- Limitations of small, unstirred columns was evident

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Thanks to all the Coordinators
Plant Staff
Trainers
Participants

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