ESTABLISHING A RELATIONSHIP BETWEEN TURBIDITY AND TOTAL SUSPENDED SOLIDS – A Student Project

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Real Time Water Quality Monitoring Workshop

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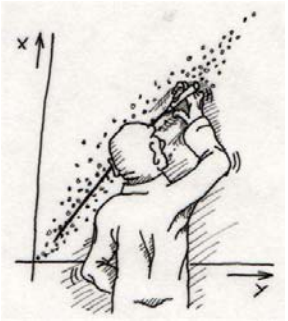
St. John's, NL



Overview

- Overview of Technical Project
- Purpose & Significance
- Types of Sampling
- CCME Aquatic Guidelines and Regulatory Limits for Turbidity and TSS
- Real Time Water Quality Monitoring
- Site and Basin Description
- Statistical analysis for Turbidity-TSS
- Turbidity-TSS Model (Parametric and Non Parametric)
- Real Time TSS Measurement
- Conclusion and Path Forward

Technical Project

- A three semester technical project for the Advanced Diploma Water Quality Program at the Marine Institute (MI) in partnership with the Water Resources Management Division
- Project Requirement
  - Literature Review - Cost Assessment
  - Field Work - Lab Work (MI)
  - Statistical Analysis - Presentation and Report
- Expert opinion and Lab facility was provided by the Marine Institute to analyze grab samples
- Expert opinion and instrumentation was provided by the Water Resources Management Division to measure turbidity in real time

Newfoundland Labrador

MARINE INSTITUTE

Purpose

- Determine the relationship between Turbidity and Total Suspended Solids (TSS) for Leary Brook.
- Develop site specific regression model for TSS using Turbidity as a predictor.
- Apply the model to predict TSS in real time.

Significance

- Turbidity is one of the continuously measured parameters under the Real Time Water Quality Monitoring Program in NL.
- TSS is measured monthly through grab sampling.
- Prediction of TSS would be beneficial for the following reasons:
  - In Newfoundland and Labrador there is a regulatory limit for TSS thus aiding in compliance monitoring efforts.
  - Estimation of TSS in real time would save time, effort and cost required for lab analysis.

Types of Sampling

Grab Sampling:

- Provides a snapshot of water quality at the time the sample was taken.

Continuous/Real Time Sampling:

- Provides a clearer picture of water quality over time.

CCME Aquatic Guidelines for Turbidity

Canadian Water Quality Guidelines for the Protection of Aquatic Life (Total Particulate Matter)

Turbidity in clear flow for short and long periods	Maximum increase of 8 NTUs from background levels (BL's) for a short-term exposure (e.g., 24-h period). Maximum average increase of 2 NTUs from BL's for a longer term exposure (e.g., 30-d period).
Turbidity in high flow (turbid water) for short and long periods	Maximum increase of 8 NTUs from BL's at any one time when BL's are between 8 and 80 NTUs. Should not increase more than 10% of BL's when background is >80 NTUs.

- There is no regulatory limit for turbidity in NL regulations. (Environmental Control Water and Sewage Regulations, 2003)

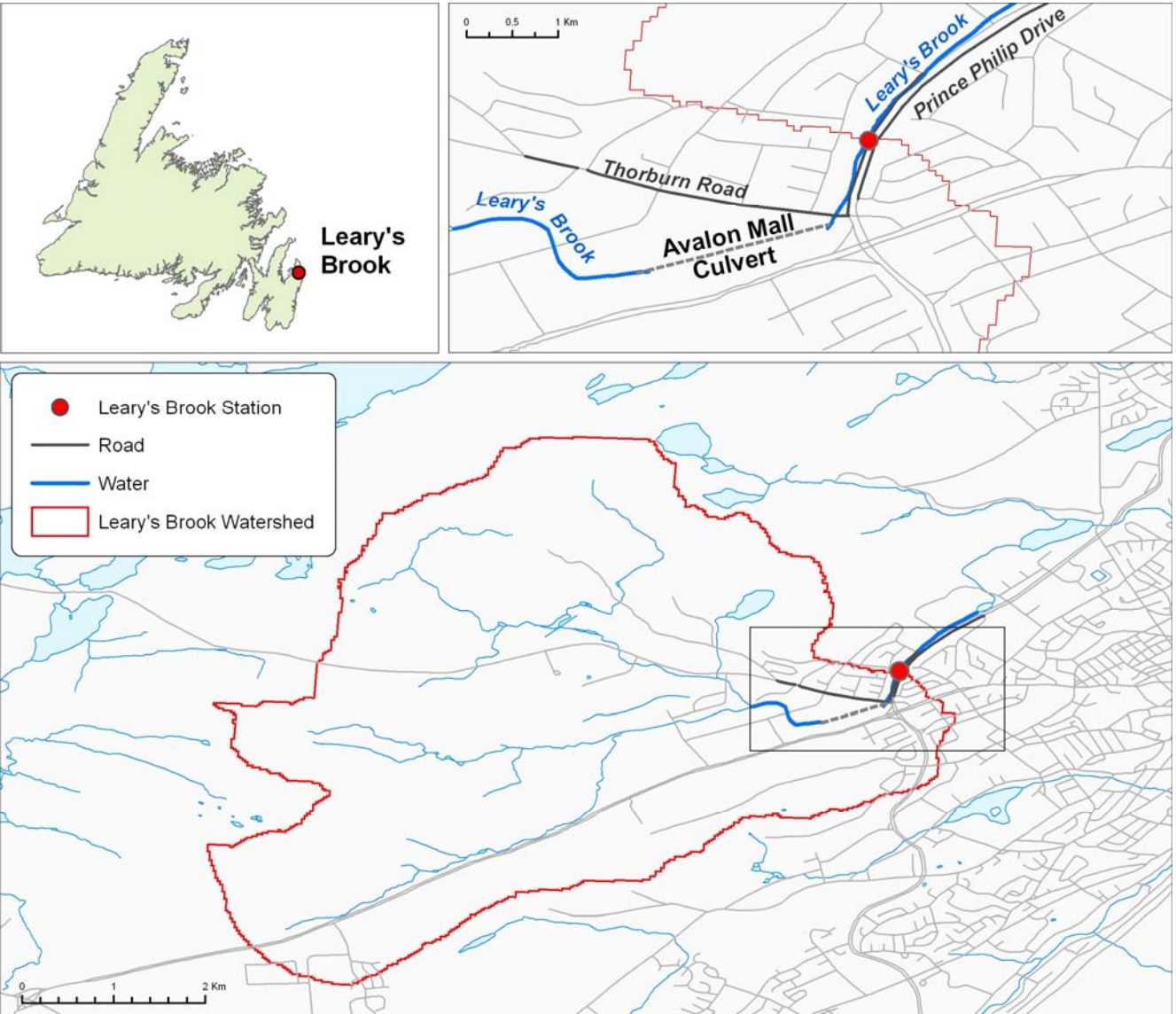
Aquatic Guidelines for TSS

Canadian Water Quality Guidelines for the Protection of Aquatic Life (Total Particulate Matter)

TSS in clear flow for short and long periods	Maximum increase of 25 mg/L from background levels (BL's) for any short-term exposure (e.g., 24-h period). Maximum average increase of 5 mg/L from BL's for longer term exposures (e.g., inputs lasting between 24 hand 30 d).
TSS in high flow for short and long periods	Maximum increase of 25 mg/L from BL's at any time when BL's are between 25 and 250 mg/L Should not increase more than 10% of BL's when background is >250 mg/L

- The regulatory limit for TSS is 30 mg/L in NL regulations. (Environmental Control Water and Sewage Regulations, 2003)

Project Site – Leary Brook



- Located in the vicinity of Avalon Mall and Memorial University.
- Runs in parallel with Prince Phillip Drive crossing Thorburn Road.

Project Site – Leary Brook

- Leary Brook was the first real time water quality monitoring station established in 2001.

Leary Brook Basin Description

- Leary Brook basin is located next to Health Sciences Complex, Avalon Mall and most of The O'Leary Industrial Park.

Leary Brook Basin Description

- Business facilities including construction and engineering, electrical power, materials handling, manufacturing, wholesale and retail industry for food & beverage, recycling, transport and storage, oil and gas facilities are located in these areas.

Turbidity Measurement Using Field Sonde

TSS Measurement Using Grab Samples

Real Time Monitoring Network

Normal Transmission is generally every hour

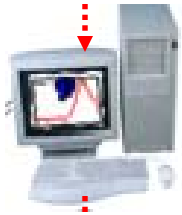
Real-Time Monitoring Station

Real-Time Monitoring Instrument

National Environmental Satellite Data Information System (NESDIS).

Operated by NOAA in Maryland, USA.

New Graphs every 3 hours



Users access using Web Browser to view graphs

Leary Brook Real Time Data

http://www.env.gov.nl.ca/wrmd/ADRS/v6/Data/NF02ZM0178_Daily.csv - Wi

http://www.env.gov.nl.ca/wrmd/ADRS/v6/Data/NF02ZM0178_Daily.csv

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1	Due to the volume and frequent updating of the data available on this Web					
2	STAT_NUM	WSC_NUM	YMD	NUM_RE	WATER_TEMP	WAT
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4	NF02ZM0178	02ZM020	30/03/2011	194	1.63	
5	NF02ZM0178	02ZM020	31/03/2011	195	2.38	
6	NF02ZM0178	02ZM020	01/04/2011	193	2.92	
7	NF02ZM0178	02ZM020	02/04/2011	199	1.5	
8	NF02ZM0178	02ZM020	03/04/2011	196	1.95	
9	NF02ZM0178	02ZM020	04/04/2011	195	2.14	
10	NF02ZM0178	02ZM020	05/04/2011	195	1.59	
11	NF02ZM0178	02ZM020	06/04/2011	195	2.34	
12	NF02ZM0178	02ZM020	07/04/2011	195	2.13	
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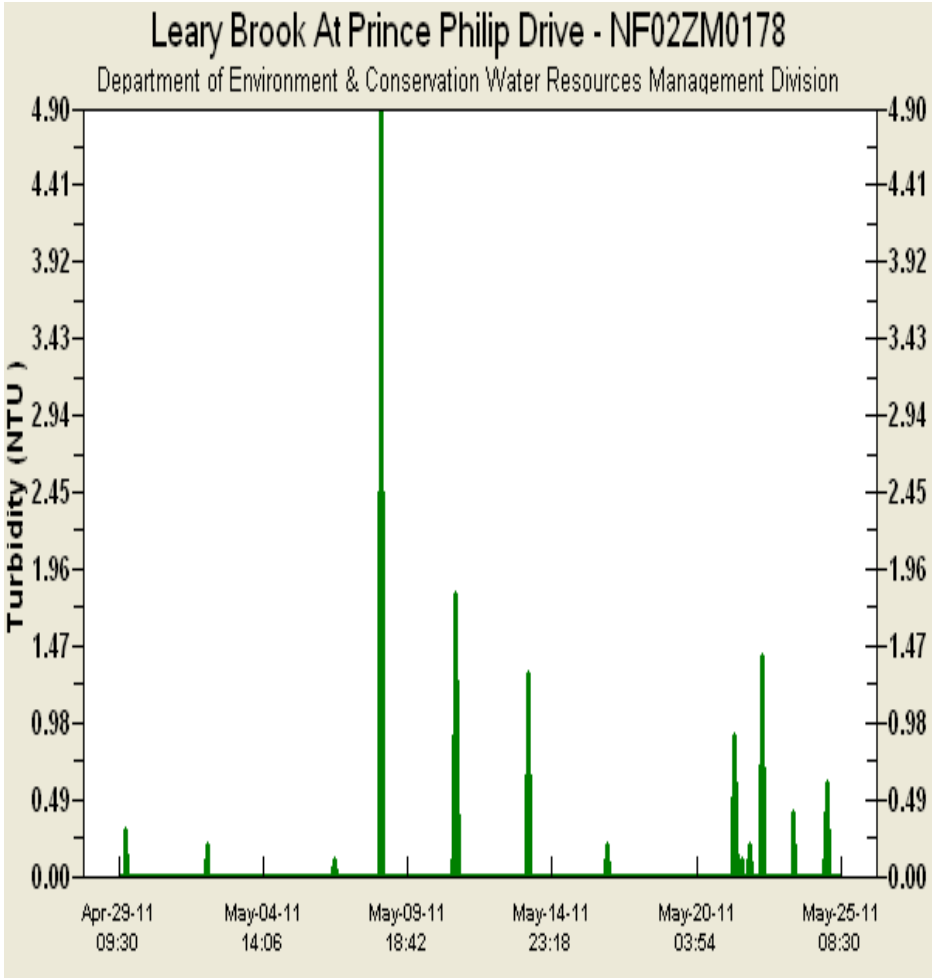


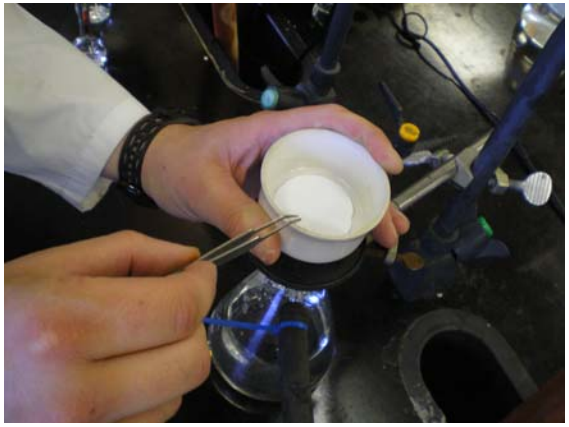
Leary Brook Timeline

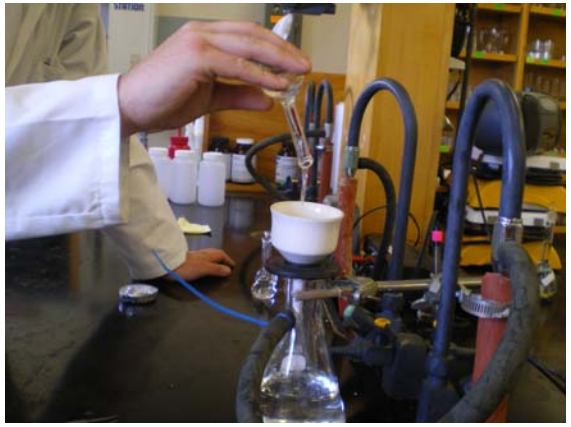
- Timeline for the sampling period:

  January – May 2011

- Obtained from Leary Brook Webcam

TSS Measurement





1. Filter (pore size = 1µm) is soaked in distilled water and dried at 103 ^{0}C. Weights are read and recorded.
2. The filter is placed in a filtering flask.
3. The sample bottle is shaken and poured into the funnel.

TSS Measurement

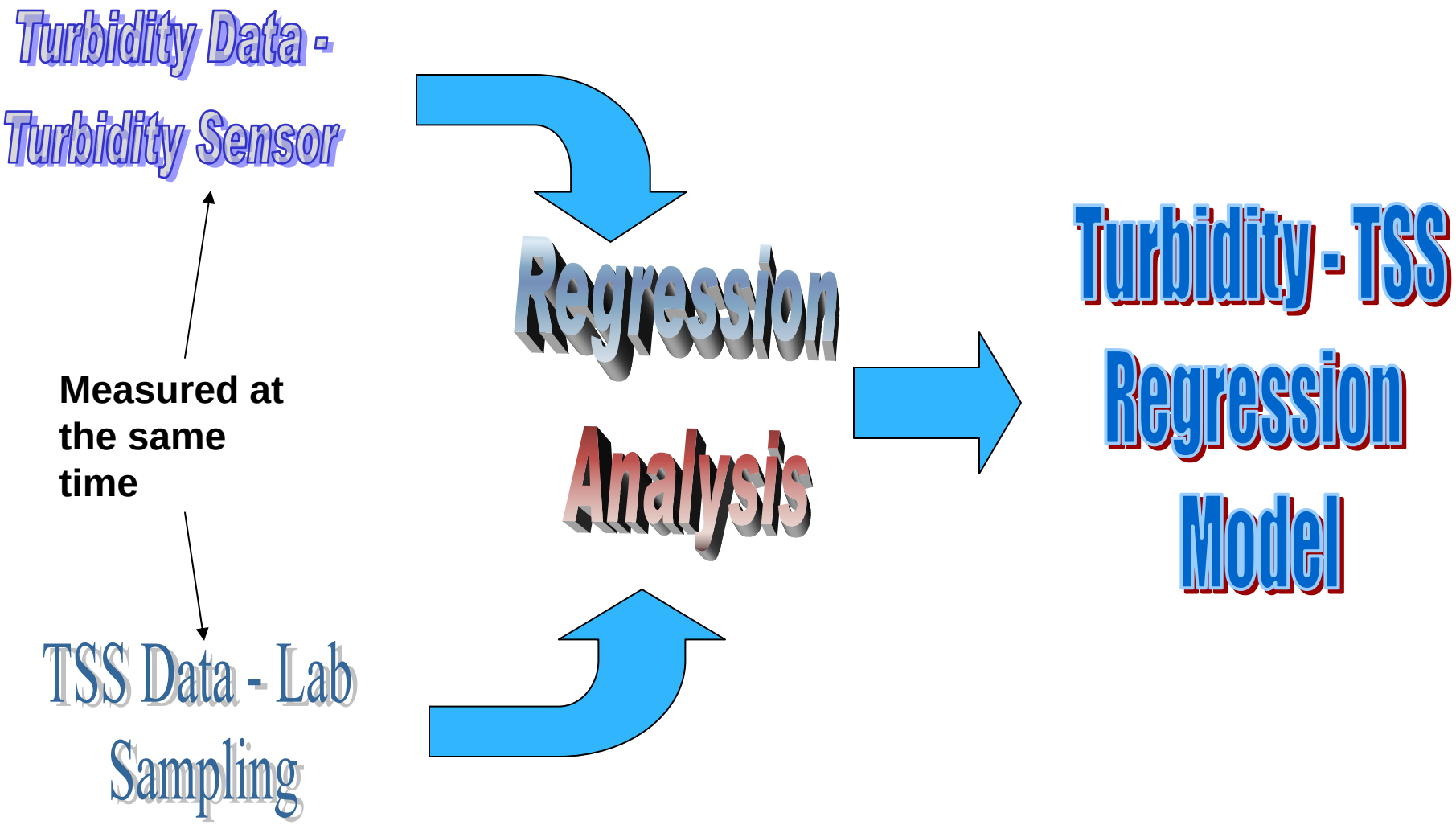
4. The filter is dried at 103^0 - 105^0C, cooled at room temperature and re-weighed.

5. TSS is calculated using the following:

$$[(A-B)*1000]/C$$

Where
A = End weight of the filter
B = Beginning weight of the filter
C = Volume of water

Regression Model



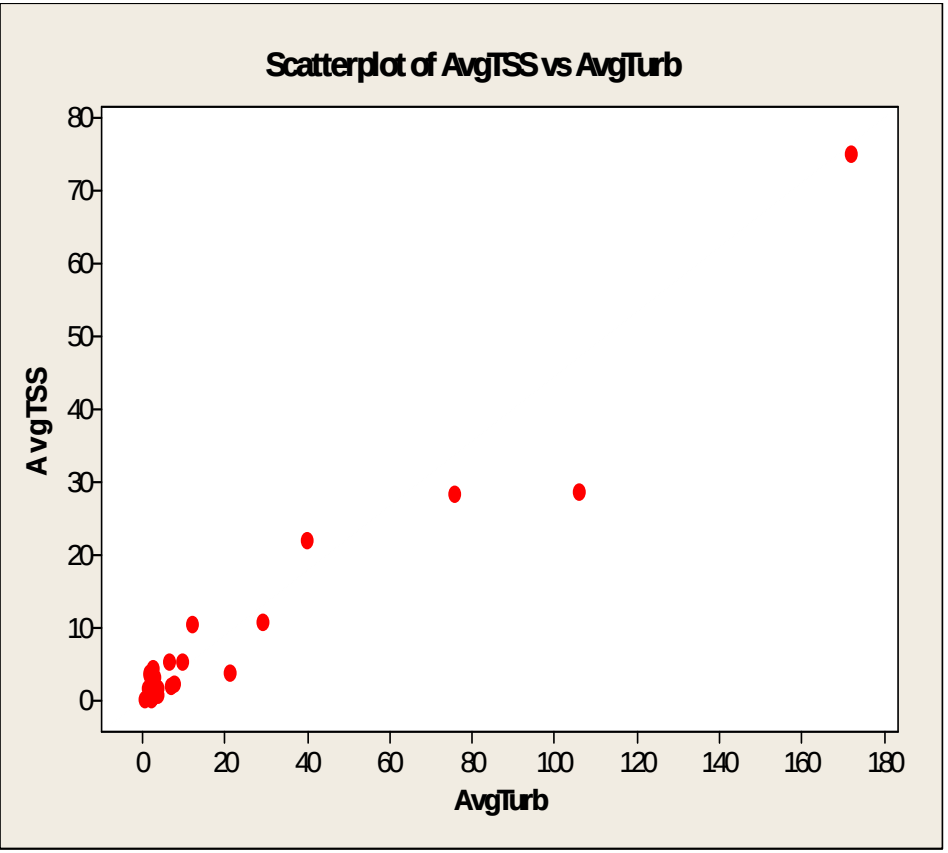
Statistical Analysis

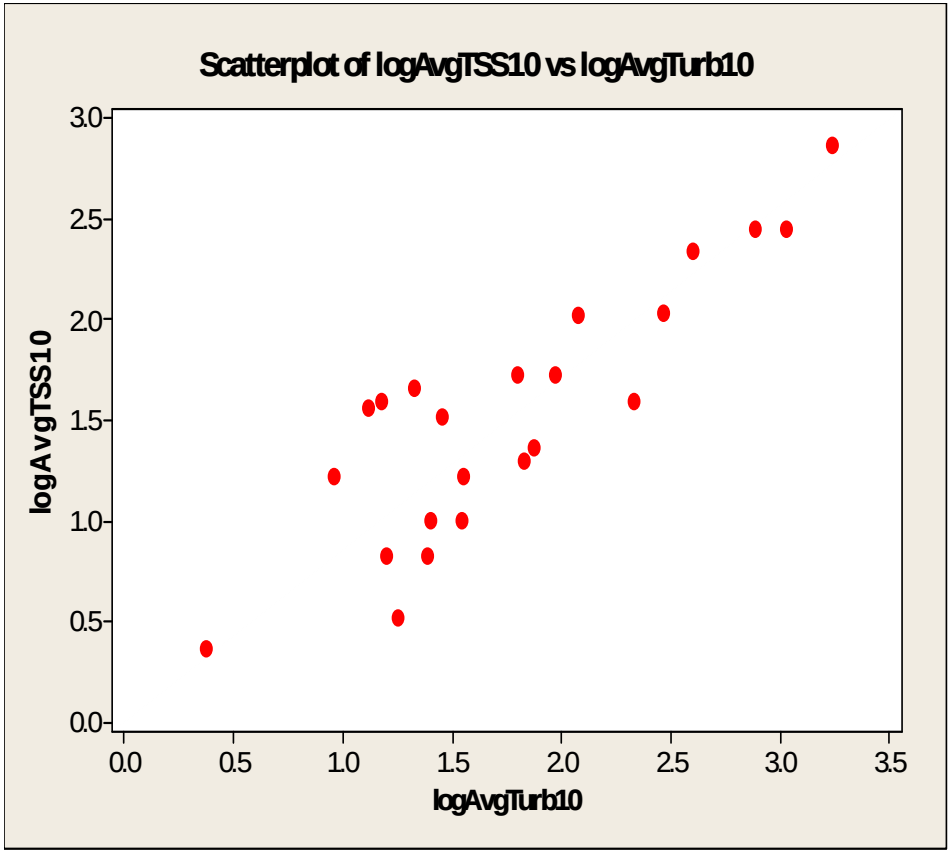
- 23 TSS samples (in triplets).
- Average TSS using triplicate samples.
- Average turbidity for corresponding TSS samples.
- Anderson Darling (Normality test), Box Plot (Outlier test) and Scatter Plot for all data.
- Log Transformation of sample values.
- Model TSS using Ordinary Least Square regression and Kendall Theil Robust Line.

Normality and Outlier check for Turbidity and TSS

Parameter	AD Normality Test		Box-Plot (Outlier Detection)
	Normal/ Non Normal	P-value	Present/ Absent
Turbidity	Non Normal	<0.005	Present
TSS	Non Normal	<0.005	Present
Log (10 *Turb)	Normal	0.295	Absent
Log (10 * TSS)	Normal	0.884	Absent

Scatter plot for original and log transformed Turbidity-TSS



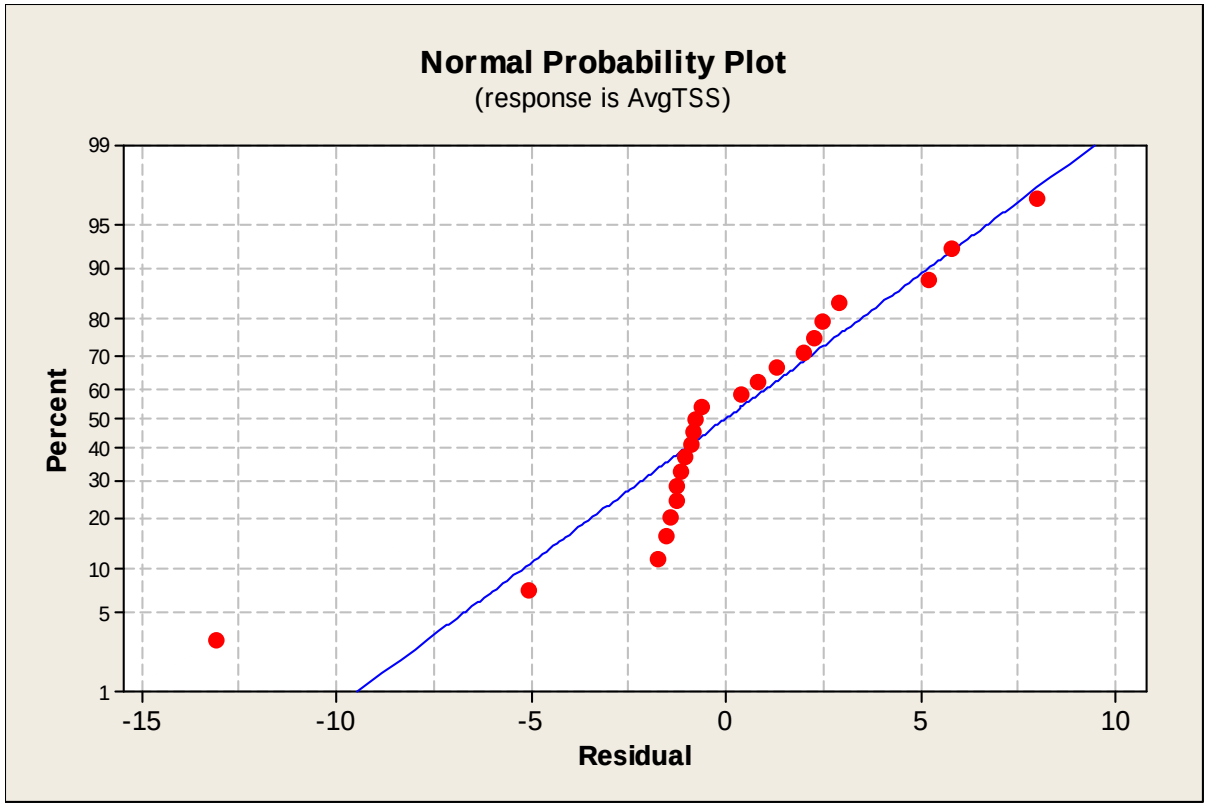


Ordinary Least Square Regression Model (Original Data)

Computed Variable	**TSS (mg/L)**
Range	0.23 – 75.17
Regression Model	**AvgTSS = 0.943 + 0.385 *AvgTurb**
R-Sq(adj)	93.7%
P-value	0.000
Standard Deviation	4.15799
No. of Samples	23

Residual Plot for Normality (Original Data)

- Residual for original values were non normal and hence violates the assumption for regression model.

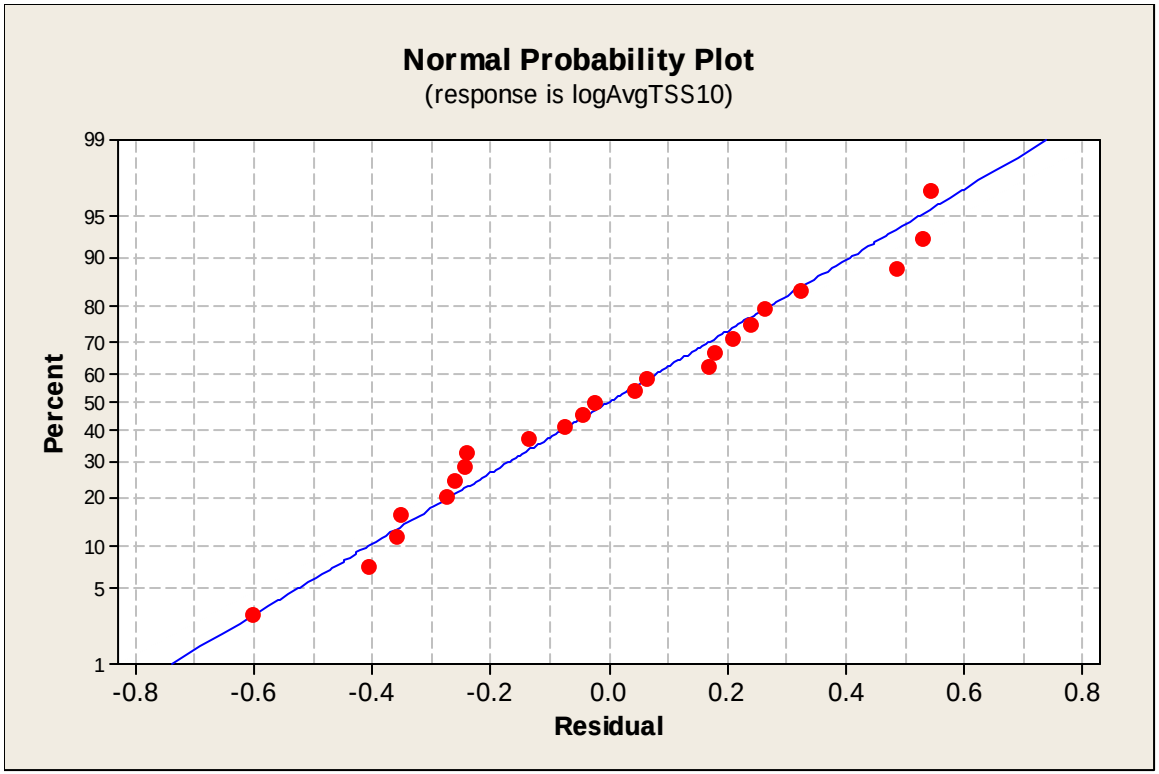


Ordinary Least Square Regression Model (Log Transform)

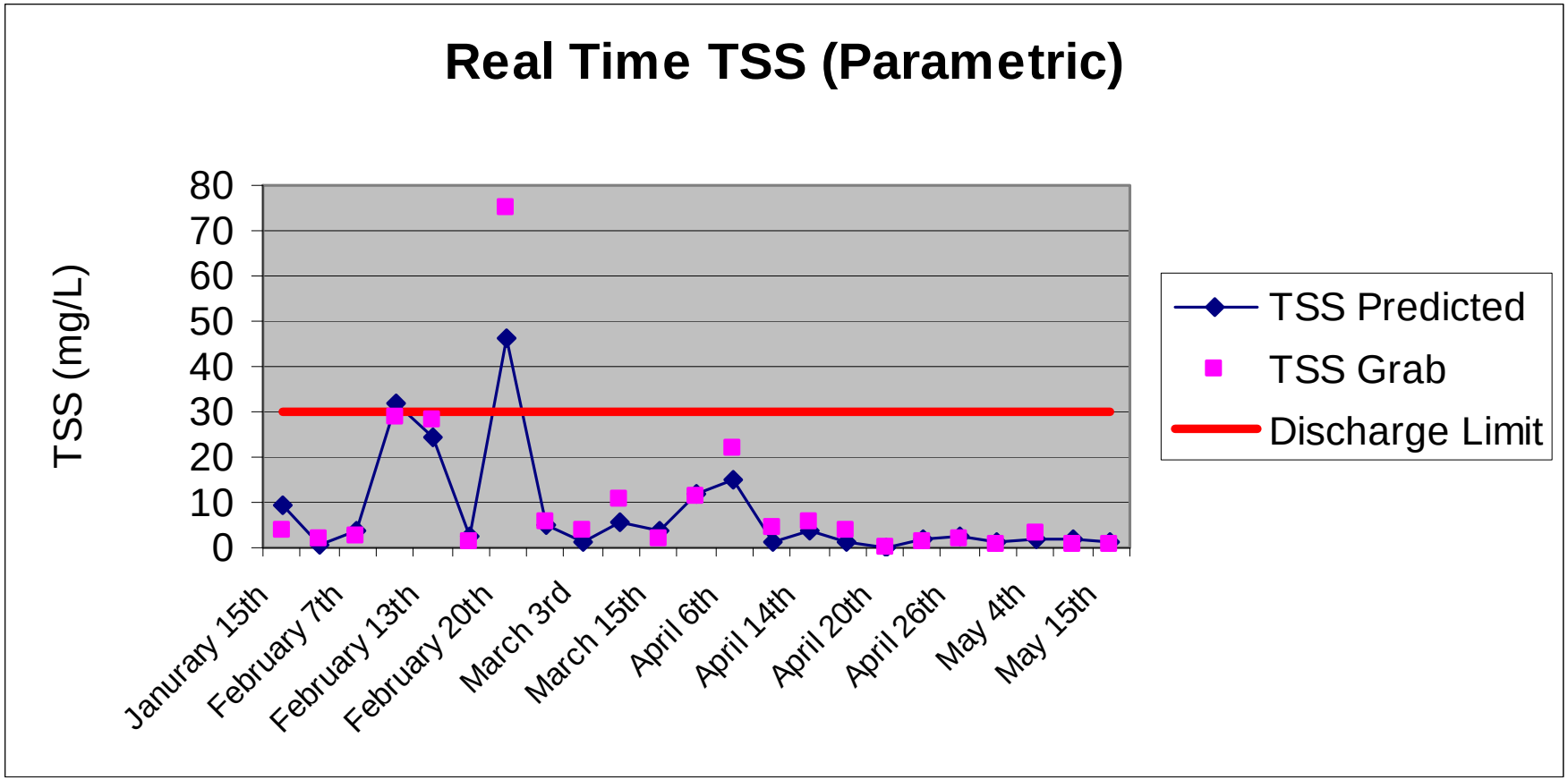
Computed Variable	TSS (mg/L)
Range	0.37– 3.24
Regression Model	**AvgTSS = [10^{0.16 + 0.775 * log (10 *AvgTurb)}]/10**
R-Sq(adj)	74.1%
P-value	0.000
Standard Deviation	0.325
No. of Samples	23

Residual Plot for Normality (Log Transform)

- Residual for log transformed values were normal and hence fits assumption for regression model.



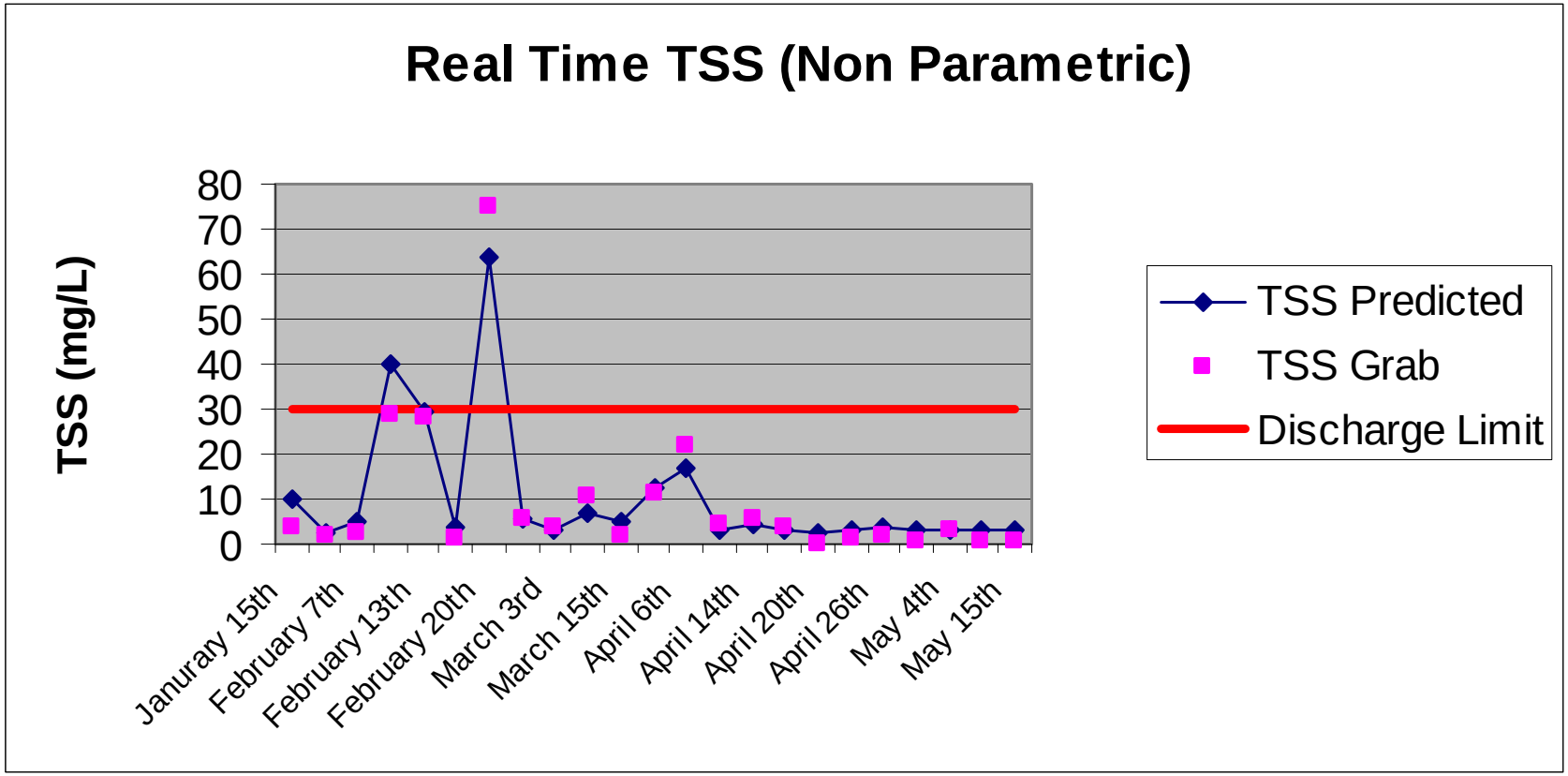
Real Time Graph for TSS and comparison to grab samples (OLS)



Kendall Theil Robust Line (Non Parametric)

Computed Variable	TSS (mg/L)
Range	0.23 – 75.17
Kendall Theil Line	**AvgTSS = 2.412 + 0.3564 *AvgTurb**
Median Deviation	-1.7123
Median Absolute Deviation	2.3014
Root Mean Square Error	4.424
Confidence Interval (95%)	0.2636 – 0.4396

Real Time Graph for TSS and comparison to grab samples (KTRL)



Conclusion

- Increased variation in sample measurement provides clearer picture of sample matrix and leads to a better model.
- Enable industry partners to meet regulatory limits using real time TSS estimates.
- TSS can be predicted in real time using turbidity as an indicator parameter.

Path Forward

- Estimation of Turbidity-TSS models at select industry stations (using TSS grab sample data from accredited laboratory).
- Estimation of ionic concentration using specific conductance as a predictor.
- Model for less than detection limit values.
- Site specific Real Time Water Quality Index Calculator using surrogate parameter measurement.

QUESTIONS

Don’t forget the Web Camera is back there...

...make it look like we are working hard!

ACKNOWLEDGEMENT

- **Marine Institute:**
  - **Rob Trenholm, Mary Pippy, Geoff Whiteway**
- **Water Resources Management Division:**
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