DEPARTMENT OF
CIVIL & ENVIRONMENTAL ENGINEERING
COLLEGE OF ENGINEERING UNIVERSITY OF WISCONSIN-MADISON

Madison Water Utility
Quality and Reliability since 1882

Customer Perception of Turbidity caused by Iron and Manganese in Madison, WI

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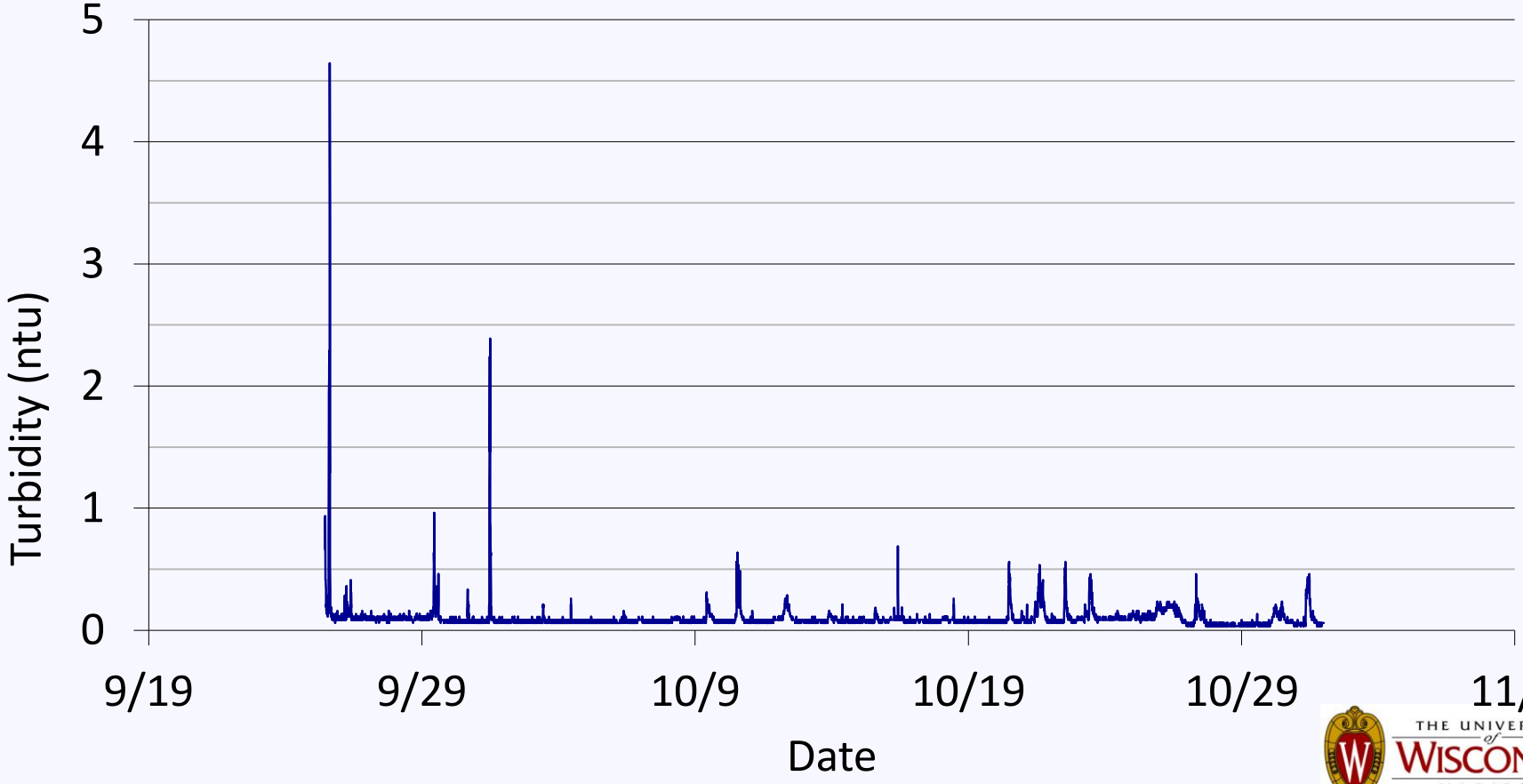
Background

Turbidity Resuspension Model

- Flushing frequencies to control magnitude of turbidity spikes
- Spikes < turbidity goal of 2.5 ntu (Slaats 2003)
- Customer complaints



Methods

Questionnaire

Sample 1	Extremely uncertain	Very uncertain	Uncertain	Slightly uncertain	Neither uncertain nor certain	Slightly certain	Certain	Very certain	Extremely certain
1. How certain are you that you would wash your colored clothes with this water?	①	①	①	①	①	①	①	①	①
2. How certain are you that you would wash your white clothes with this water?	②	②	②	②	②	②	②	②	②
3. How certain are you that you would bathe yourself with this water?	③	③	③	③	③	③	③	③	③
4. How certain are you that you would bathe an infant with this water?	④	④	④	④	④	④	④	④	④
5. How certain are you that you would cook with this water?	⑤	⑤	⑤	⑤	⑤	⑤	⑤	⑤	⑤
6. How certain are you that you would use this water in baby formula?	⑥	⑥	⑥	⑥	⑥	⑥	⑥	⑥	⑥
7. How certain are you that you would drink this water yourself?	⑦	⑦	⑦	⑦	⑦	⑦	⑦	⑦	⑦
8. How certain are you that you would allow an infant to drink this water?	⑧	⑧	⑧	⑧	⑧	⑧	⑧	⑧	⑧
	Extremely unsafe	Very unsafe	Unsafe	Slightly unsafe	Neither unsafe nor safe	Slightly safe	Safe	Very safe	Extremely safe
9. How safe does this water look?	⑨	⑨	⑨	⑨	⑨	⑨	⑨	⑨	⑨

Questionnaire

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3. How certain are you that you would bathe yourself with this water?	③	③	③	③	③	③	③	③	③
4. How certain are you that you would bathe an infant with this water?	④	④	④	④	④	④	④	④	④
5. How certain are you that you would cook with this water?	⑤	⑤	⑤	⑤	⑤	⑤	⑤	⑤	⑤
6. How certain are you that you would use this water in baby formula?	⑥	⑥	⑥	⑥	⑥	⑥	⑥	⑥	⑥
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8. How certain are you that you would allow an infant to drink this water?	⑧	⑧	⑧	⑧	⑧	⑧	⑧	⑧	⑧
	Extremely unsafe	Very unsafe	Unsafe	Slightly unsafe	Neither unsafe nor safe	Slightly safe	Safe	Very safe	Extremely safe
9. How safe does this water look?	⑨	⑨	⑨	⑨	⑨	⑨	⑨	⑨	⑨

Method of Successive Categories

Extremely uncertain	Very uncertain	Uncertain	Slightly uncertain	Neither uncertain nor certain	Slightly certain	Certain	Very certain	Extremely certain
①	①	①	①	①	①	①	①	①
②	②	②	②	②	②	②	②	②
③	③	③	③	③	③	③	③	③
④	④	④	④	④	④	④	④	④
⑤	⑤	⑤	⑤	⑤	⑤	⑤	⑤	⑤
⑥	⑥	⑥	⑥	⑥	⑥	⑥	⑥	⑥
⑦	⑦	⑦	⑦	⑦	⑦	⑦	⑦	⑦
⑧	⑧	⑧	⑧	⑧	⑧	⑧	⑧	⑧
Extremely unsafe	Very unsafe	Unsafe	Slightly unsafe	Neither unsafe nor safe	Slightly safe	Safe	Very safe	Extremely safe
⑨	⑨	⑨	⑨	⑨	⑨	⑨	⑨	⑨

Questionnaire

Sample 1	Extremely uncertain	Very uncertain	Uncertain	Slightly uncertain	Neither uncertain nor certain	Slightly certain	Certain	Very certain	Extremely certain
1. How certain are you that you would wash your colored clothes with this water?	①	①	①	①	①	①	①	①	①
2. How certain are you that you would wash your white clothes with this water?	②	②	②	②	②	②	②	②	②
3. How certain are you that you would bathe yourself with this water?	③	③	③	③	③	③	③	③	③
4. How certain are you that you would bathe an infant with this water?	④	④	④	④	④	④	④	④	④
5. How certain are you that you would cook with this water?	⑤	⑤	⑤	⑤	⑤	⑤	⑤	⑤	⑤
6. How certain are you that you would use this water in baby formula?	⑥	⑥	⑥	⑥	⑥	⑥	⑥	⑥	⑥
7. How certain are you that you would drink this water yourself?	⑦	⑦	⑦	⑦	⑦	⑦	⑦	⑦	⑦
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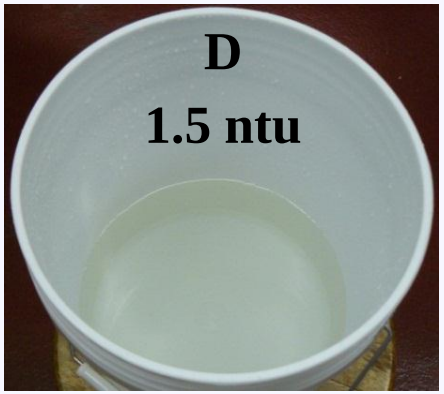
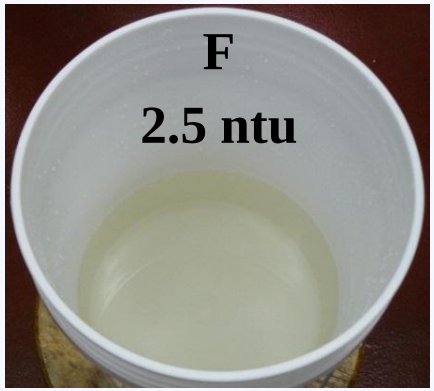
	Extremely unsafe	Very unsafe	Unsafe	Slightly unsafe	Neither unsafe nor safe	Slightly safe	Safe	Very safe	Extremely safe
9. How safe does this water look?	⑨	⑨	⑨	⑨	⑨	⑨	⑨	⑨	⑨

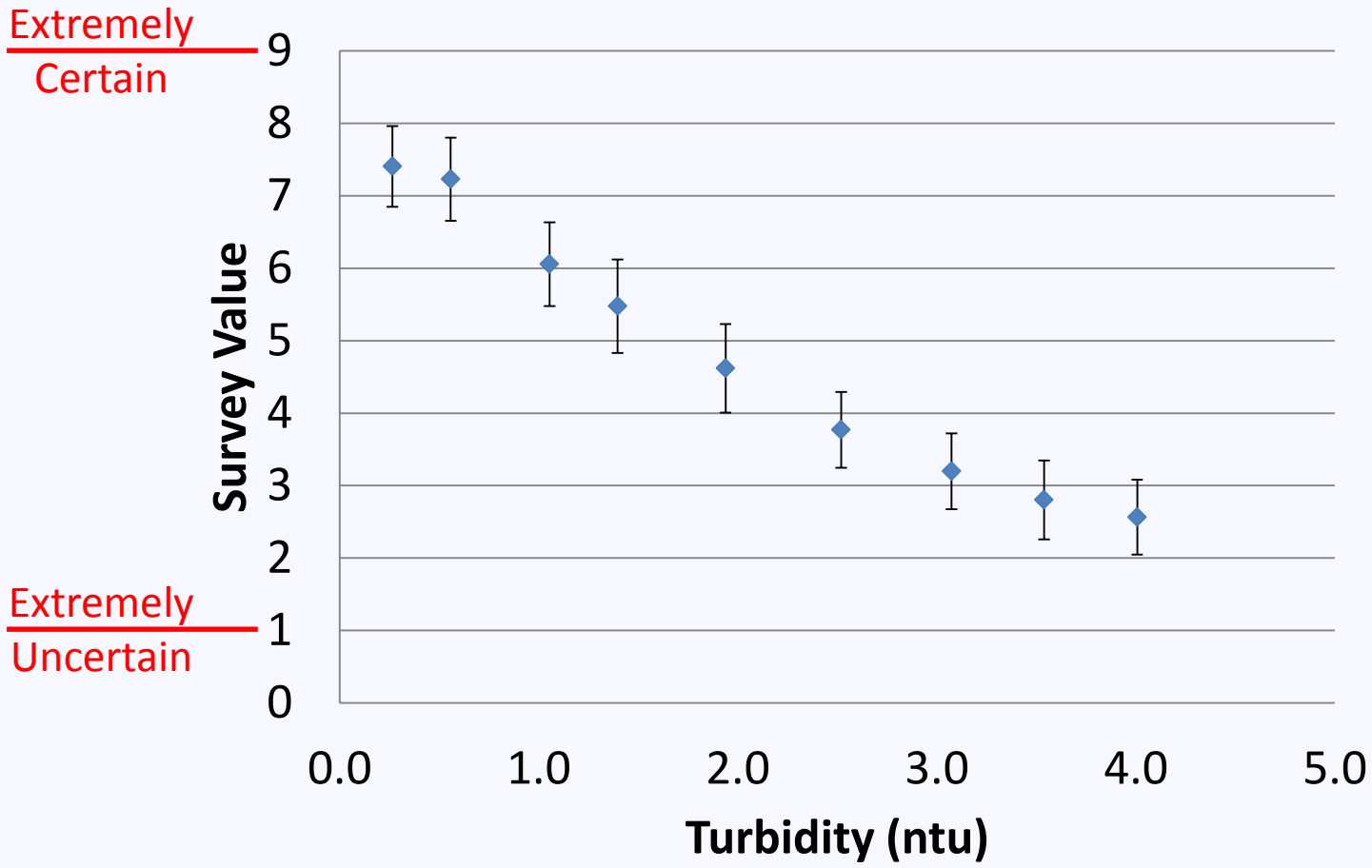
Turbidity of Samples





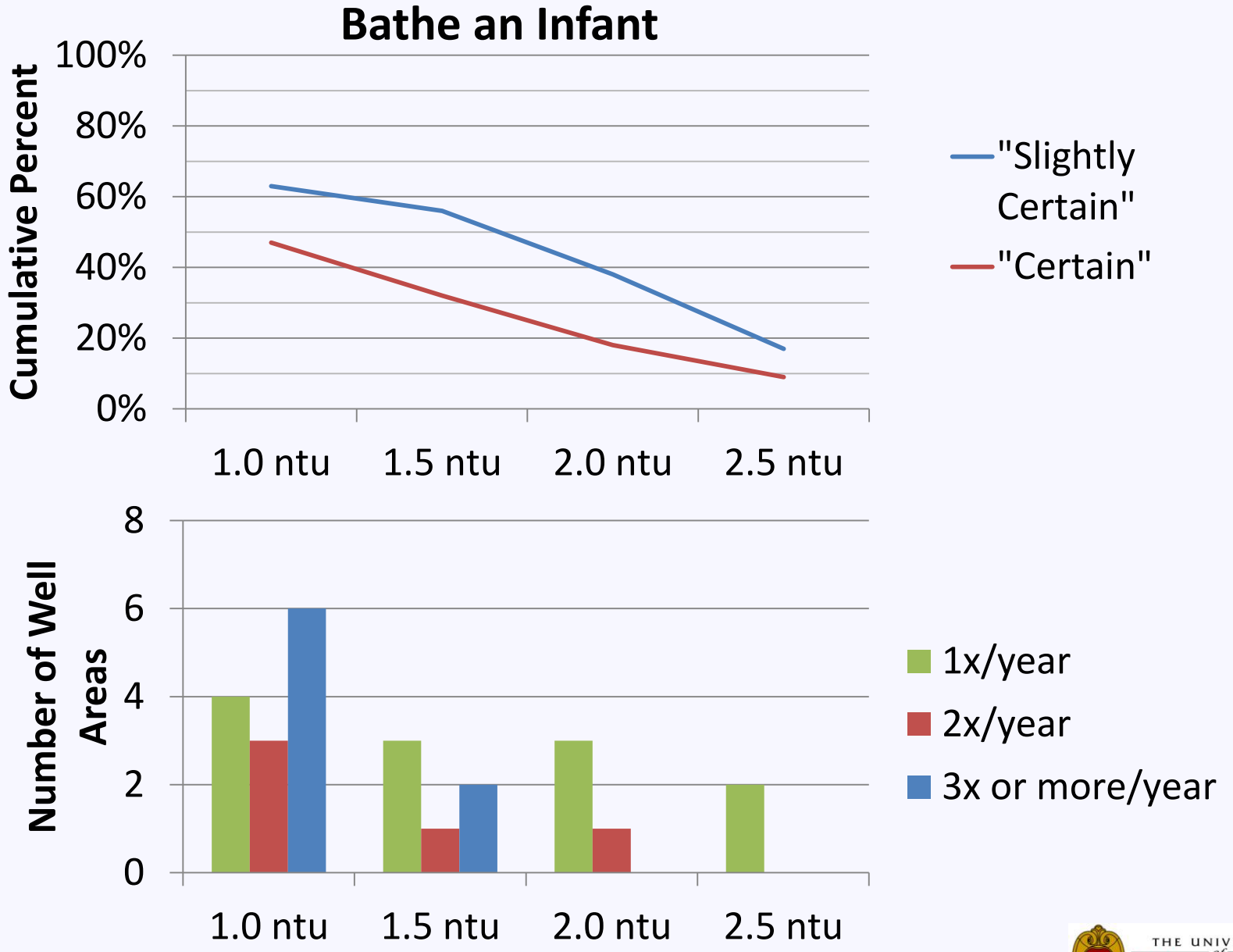
Results

Survey Results



1. How certain are you that you would bathe an infant with this water?

Survey Results and Pumping Frequencies



Conclusions and Recommendations

Conclusions & Recommendations

- 86% of participants at least “slightly certain” would bathe infant at typical turbidity levels (≤ 0.5 ntu)
- Statistical analysis
  - Significant factors
    - Question
    - Turbidity ↑ Certainty/Perceived safety ↓
    - Women had a higher level of certainty compared to men
  - Insignificant factors
    - Well area, age, household income, repetition
    - Education level and number of children living in the household
- Recommendation for practice
  - Target turbidity of 1.5 ntu for turbidity spikes

Acknowledgements

- Professor Greg Harrington
- Katie Richardson
- Madison Water Utility
  - Al Larson
  - Joe Grande
  - Shayne Santi
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- Professor Dan Noguera
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  - John Stevenson
  - Dr. Jennifer Dykema
- Previous Graduate Students
  - Ryan Holzem
  - Brian Scott

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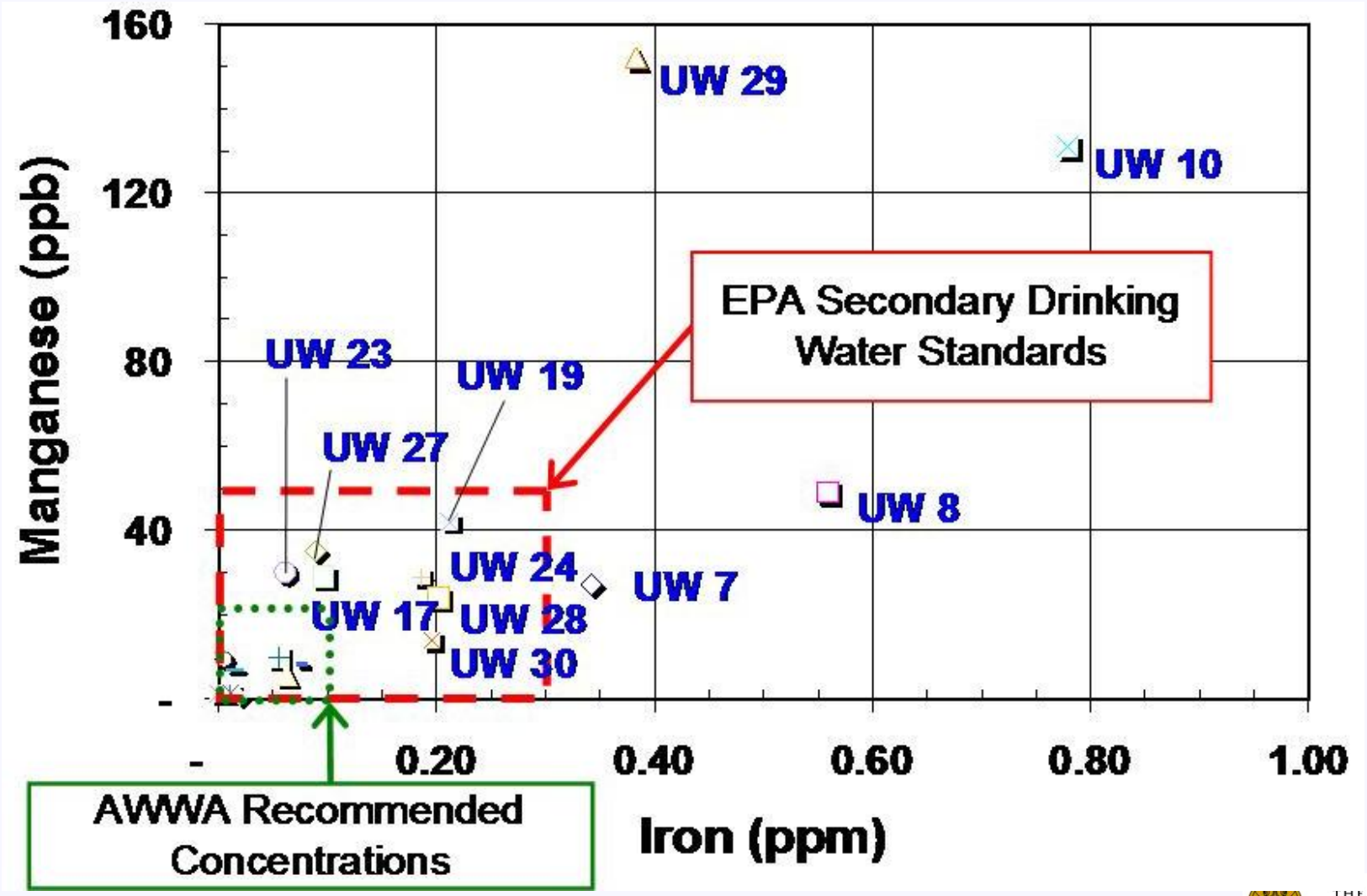
Any Questions?

Supplementary Information

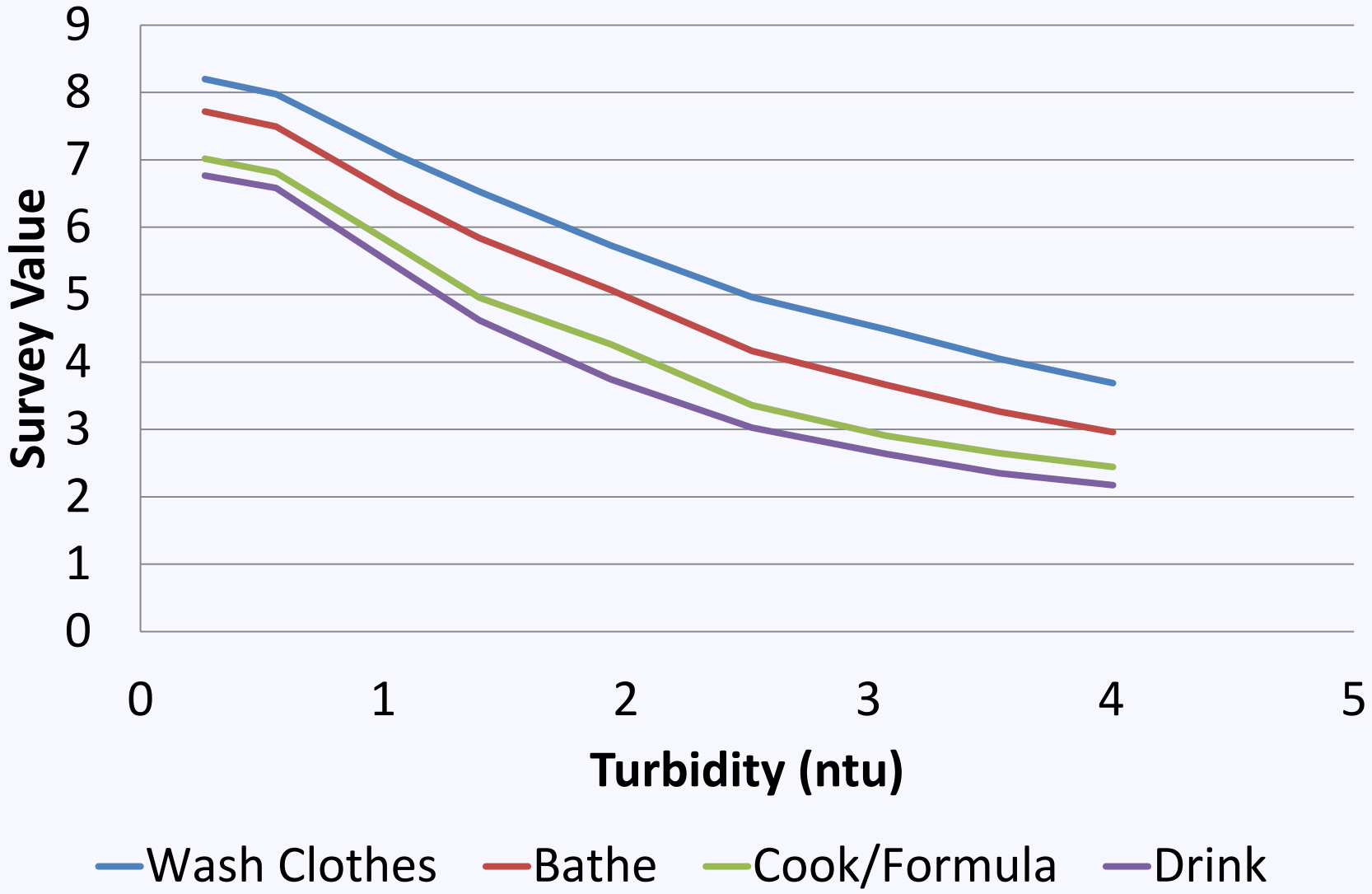
Raw Water Characteristics



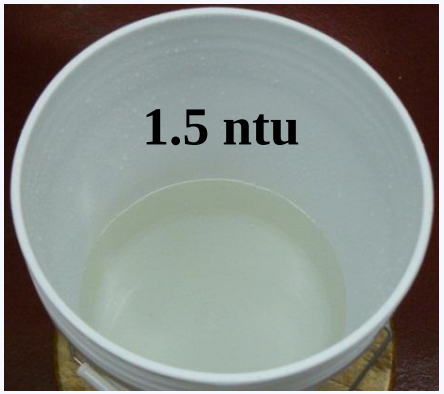
What led to research on customer perception?

- Need to answer question of what turbidity level is acceptable to **Madison** residents
- Slaat design problems
  - Participant bias
  - Experimental design
- Piriou chlorine study
  - French vs. Americans
  - Trained FPA vs. untrained

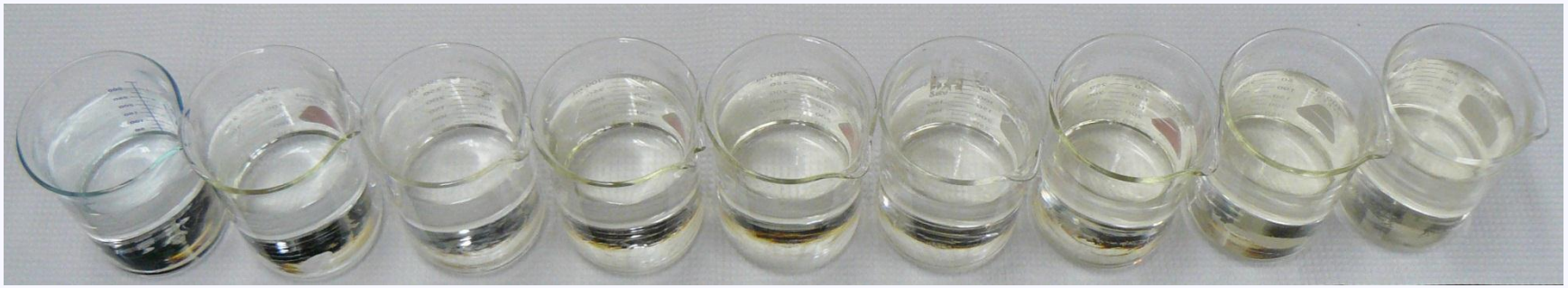
Survey Results



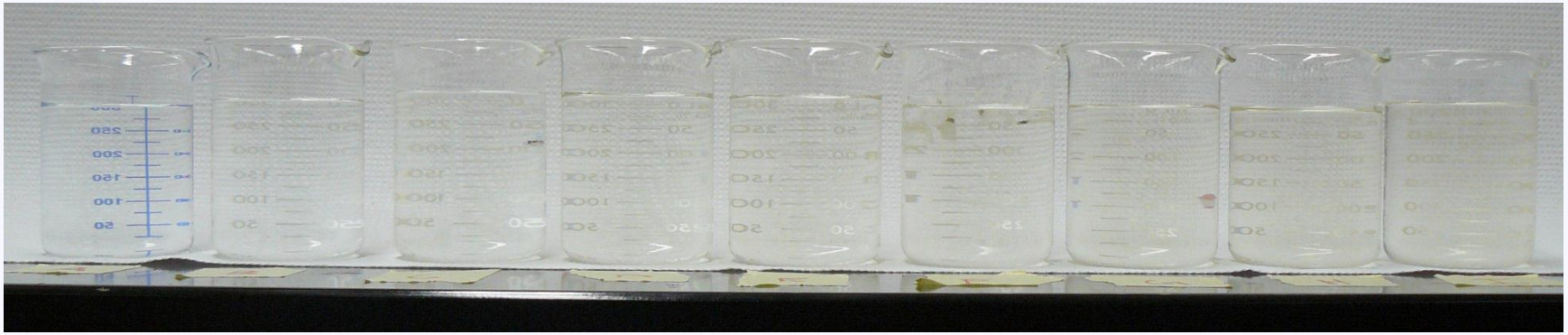
Focusing on Bathing Question



Focusing on Bathing Question



0.2 ntu 0.5 ntu 1.0 ntu 1.5 ntu 2.0 ntu 2.5 ntu 3.0 ntu 3.5 ntu 4.0 ntu



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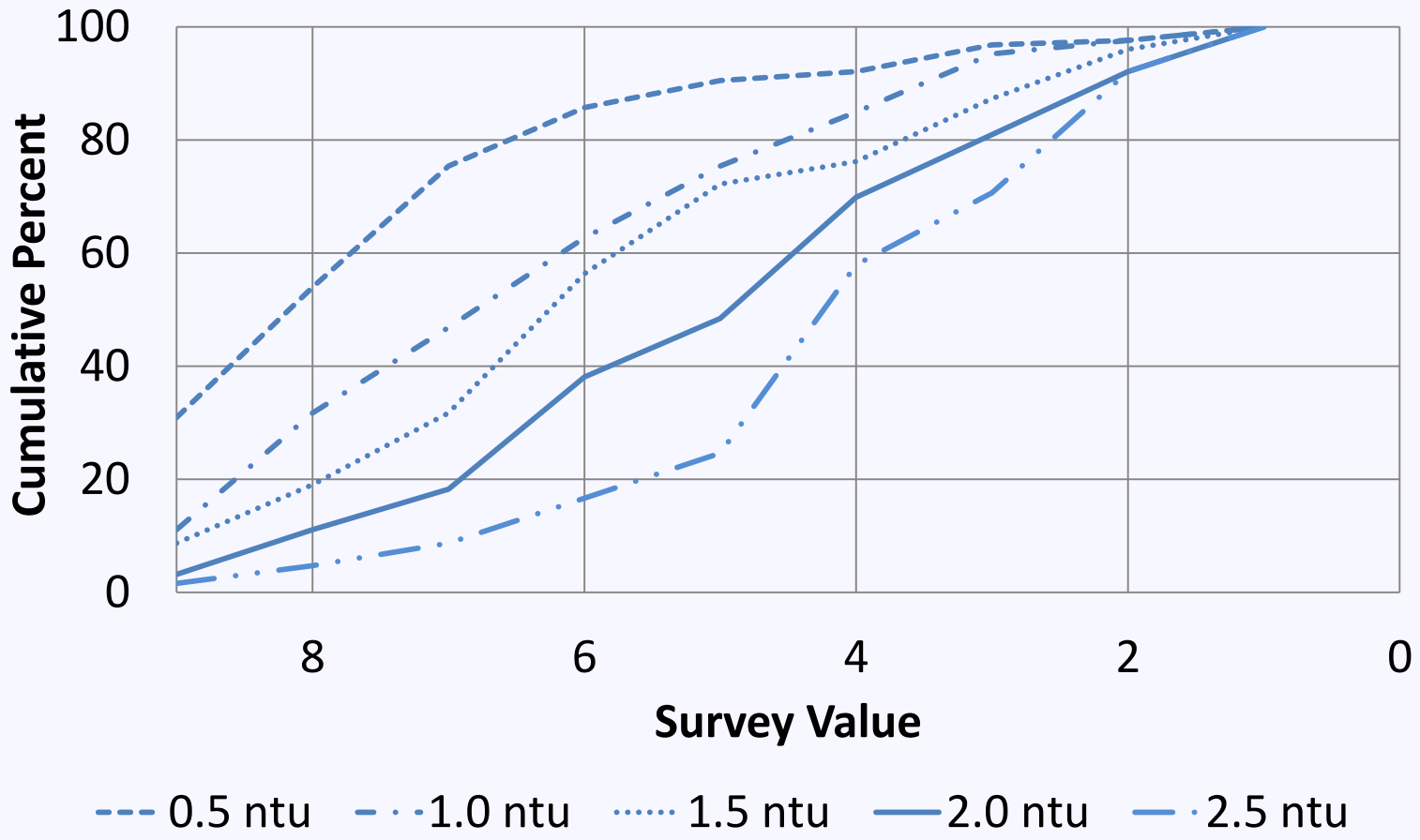

1. How certain are you that you would bathe an infant with this water?