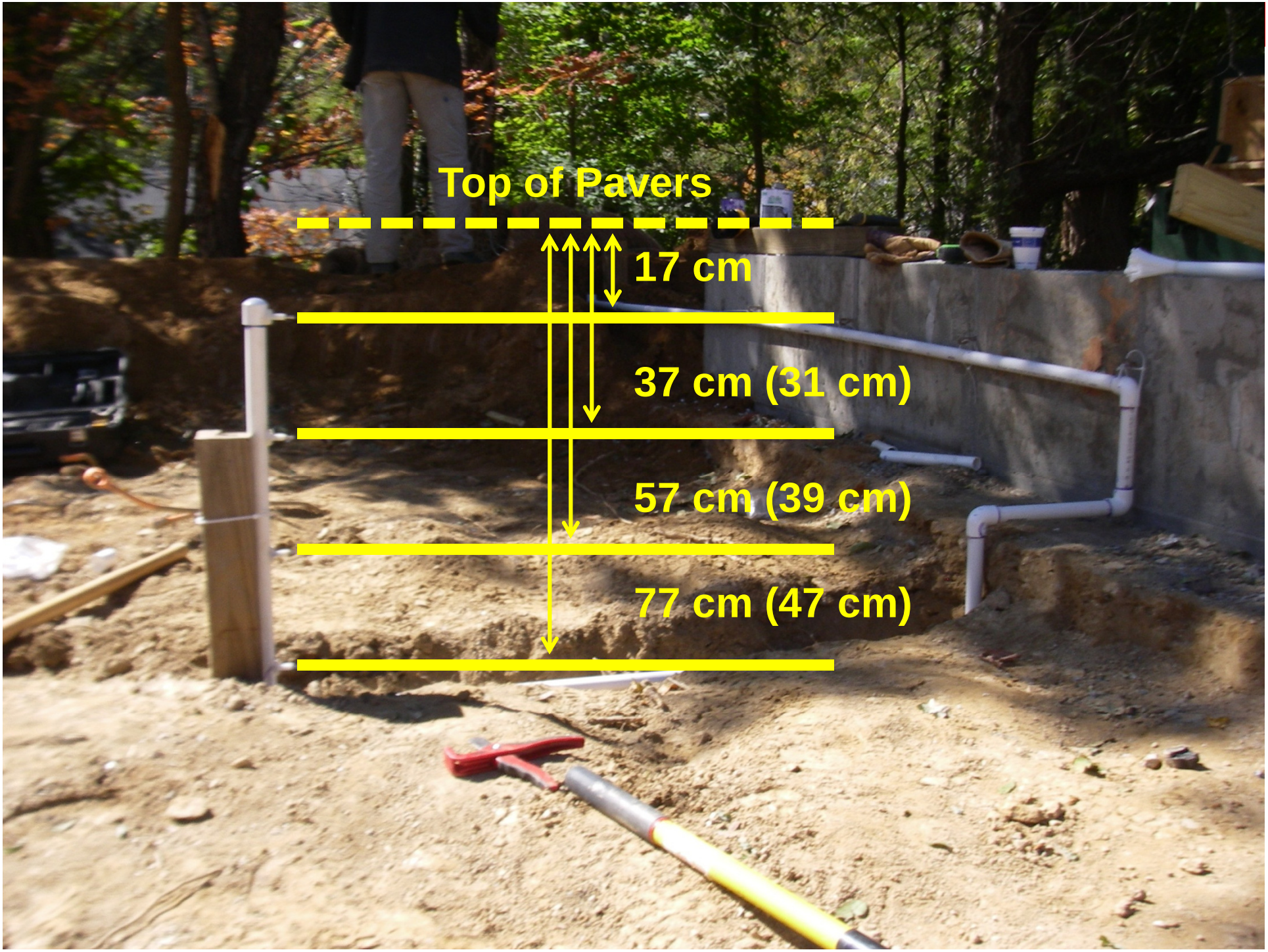
Other Infiltration-based BMPs

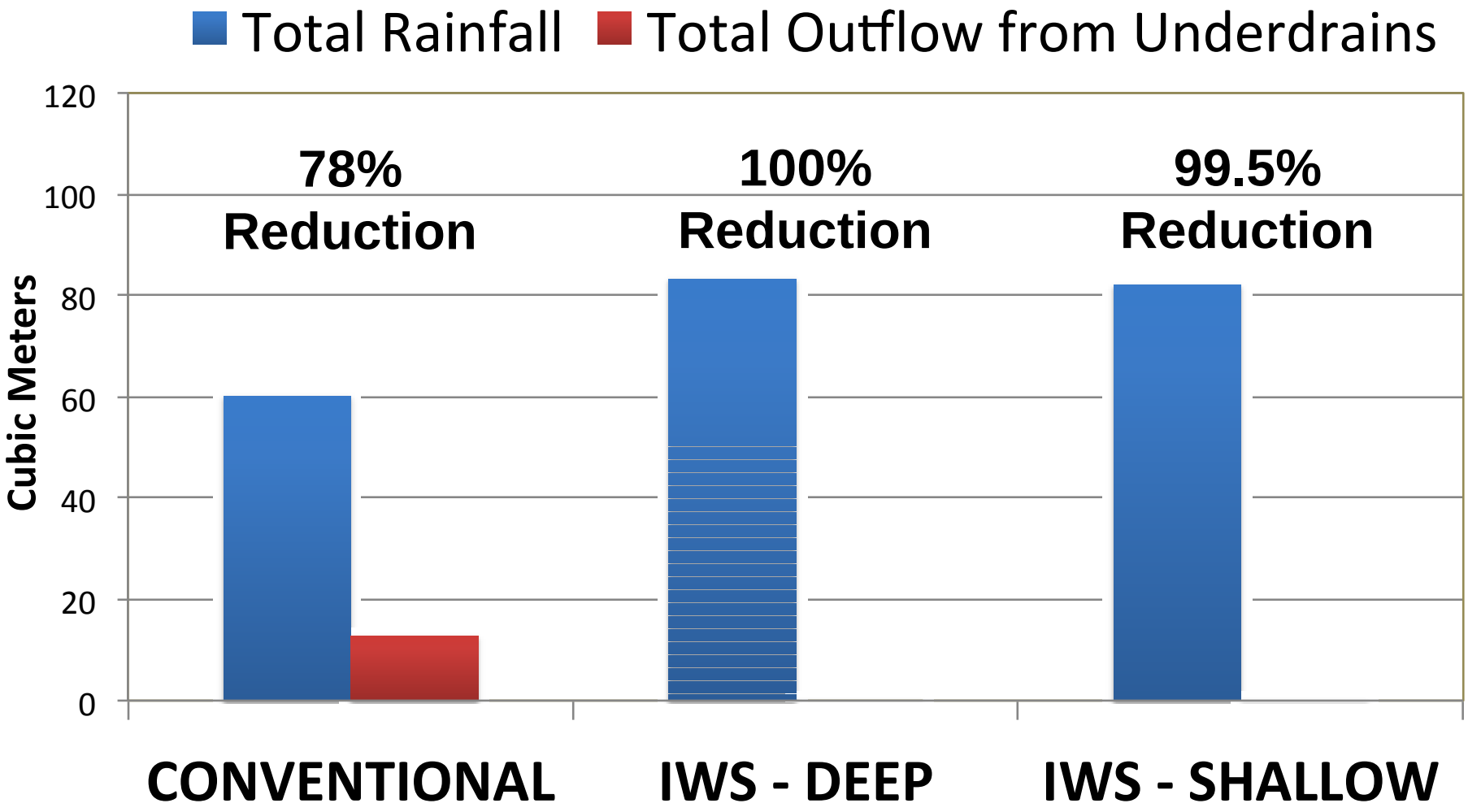
IWS - Shallow
IWS - Deep
Conventional

Ripping the subsoil

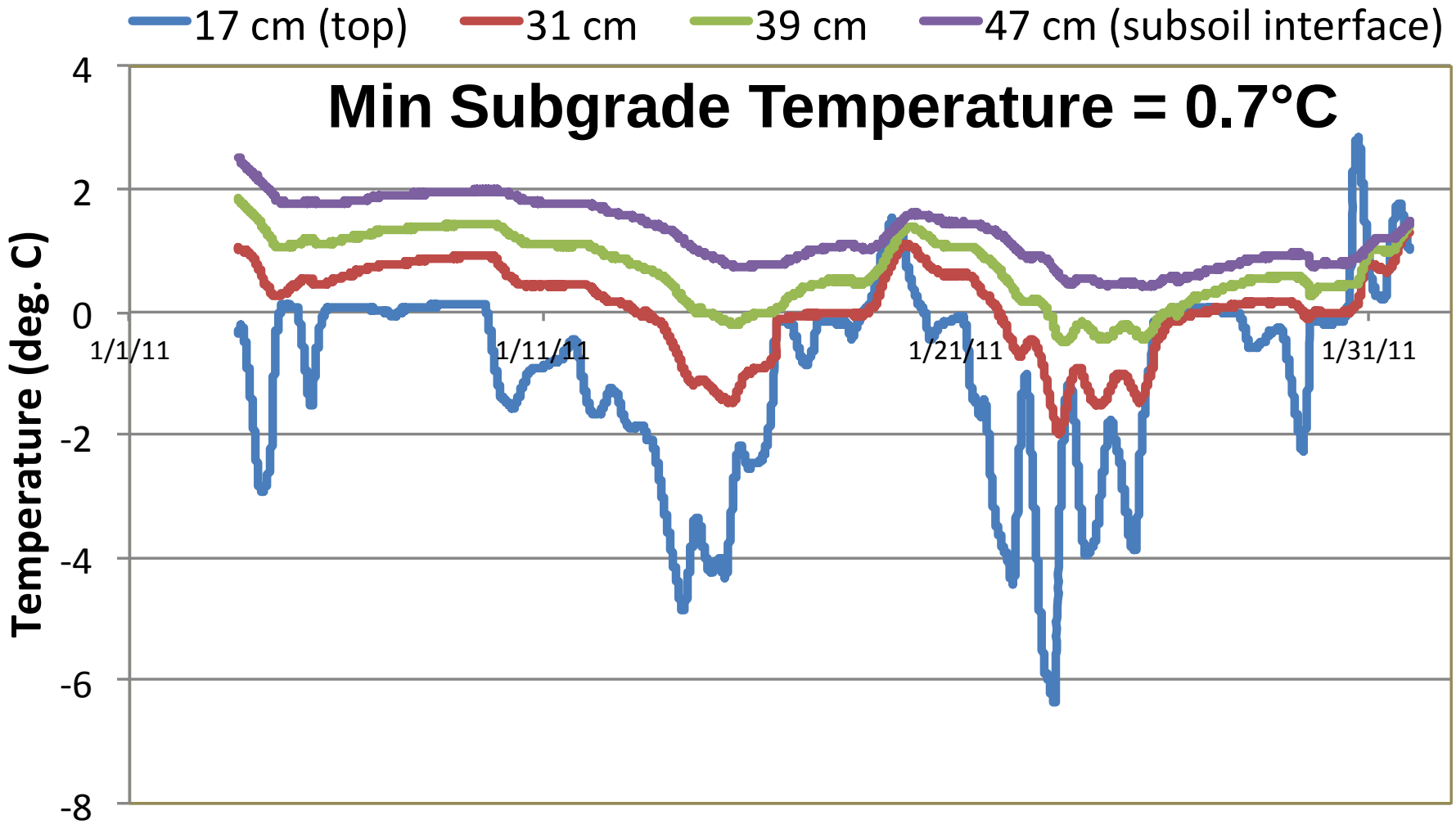
Upturned underdrain


Top of Pavers
17 cm
37 cm (31 cm)
57 cm (39 cm)
77 cm (47 cm)

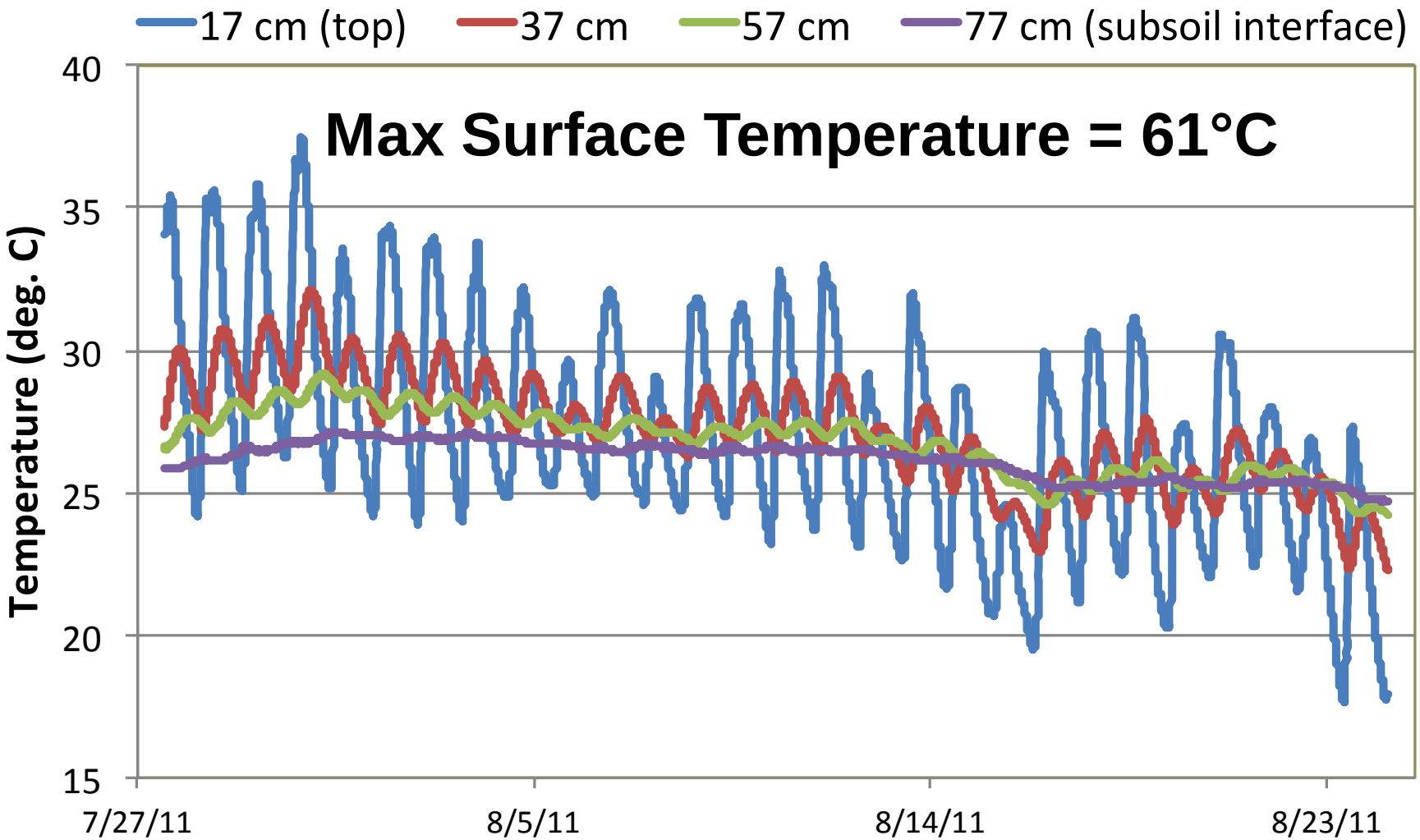
Hydrology


Total Rainfall
Total Outflow from Underdrains
Cubic Meters
120
100
80
60
40
20
0
78% Reduction
100% Reduction
99.5% Reduction
CONVENTIONAL
IWS - DEEP
IWS - SHALLOW

Profile Temperature - Winter



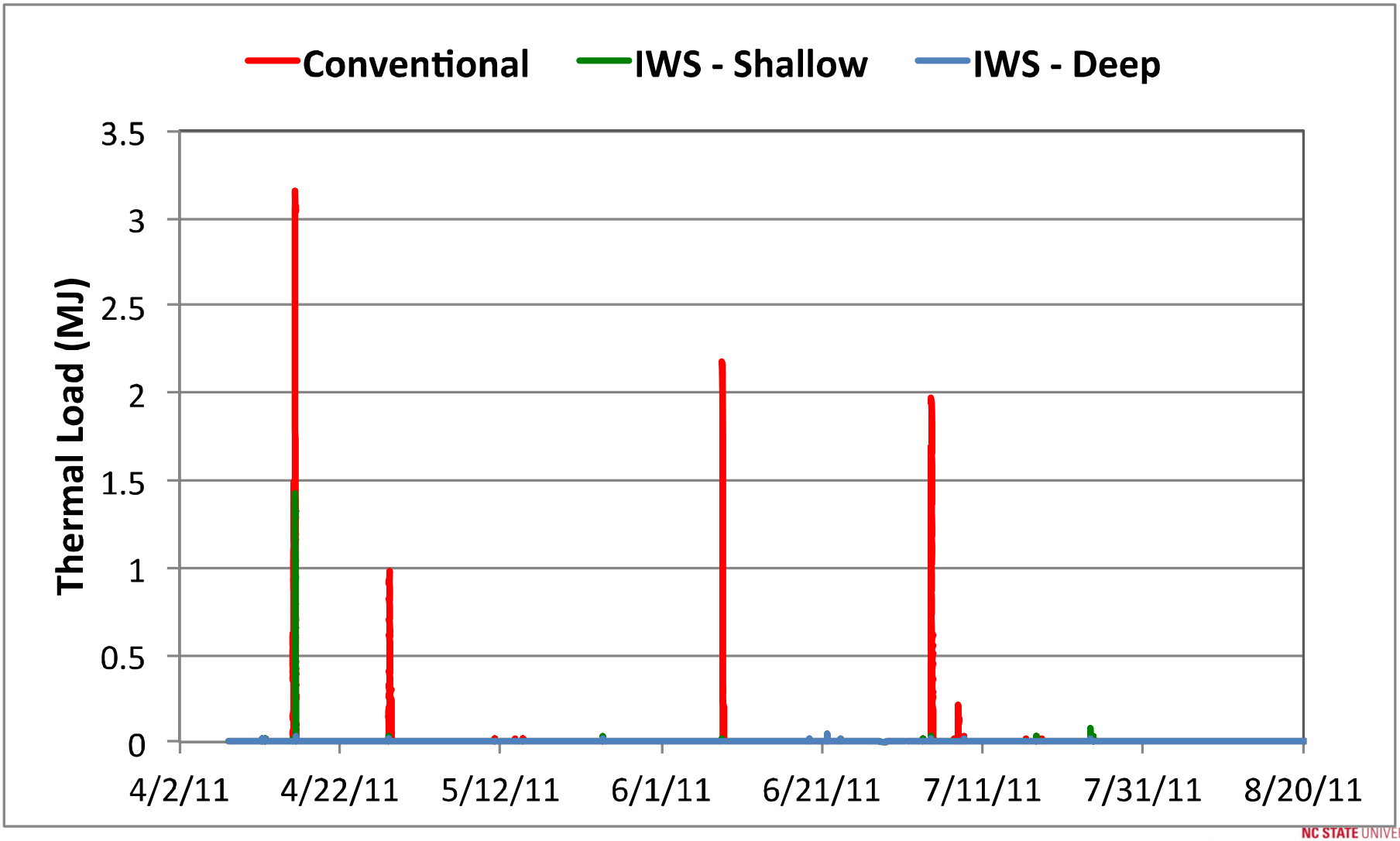
Profile Temperature - Summer



Effluent Temperature

Monitoring Location	Mean Outflow Temp.	Median Outflow Temp.	Max. Outflow Temp.
Conventional	20.1°C (68°F)	22.8°C (73°F)	27.8°C (82°F)
IWS – Deep	N/A	N/A	N/A
IWS – Shallow	14.4°C (58°F)	14.6°C (58°F)	14.8°C (59°F)

Thermal Export



Thermal Export

Source	Thermal Load
Conventional	1092 MJ **(<16% of Imperv.)**
IWS – Deep	0 MJ **(0% of Conventional)**
IWS – Shallow	25 MJ **(2% of Conventional)**
Hypothetical Impervious Lot (5% abstraction, 21°C runoff)	6900 MJ

6000 4000 2000 0

Megajoules

Summary

- Hydrologic mitigation?

  YES! 78-100% retention

- Temperature mitigation?

  Initial cooling effect

- Thermal load reduction?

  YES! >84% reduction

- Conventional vs. IWS?

IWS has substantial impact on hydro/thermal export

Summary

- Shallow vs. Deep IWS:

  Shallow is sufficient (depends on subsoils & thermal goals)

- Other important points:
  - Retrofits: be selective
  - Consider solar radiation
  - Maintain your SCMs!

Can LS – VFSs Improve Thermal Loads?

Winston et al., 2011

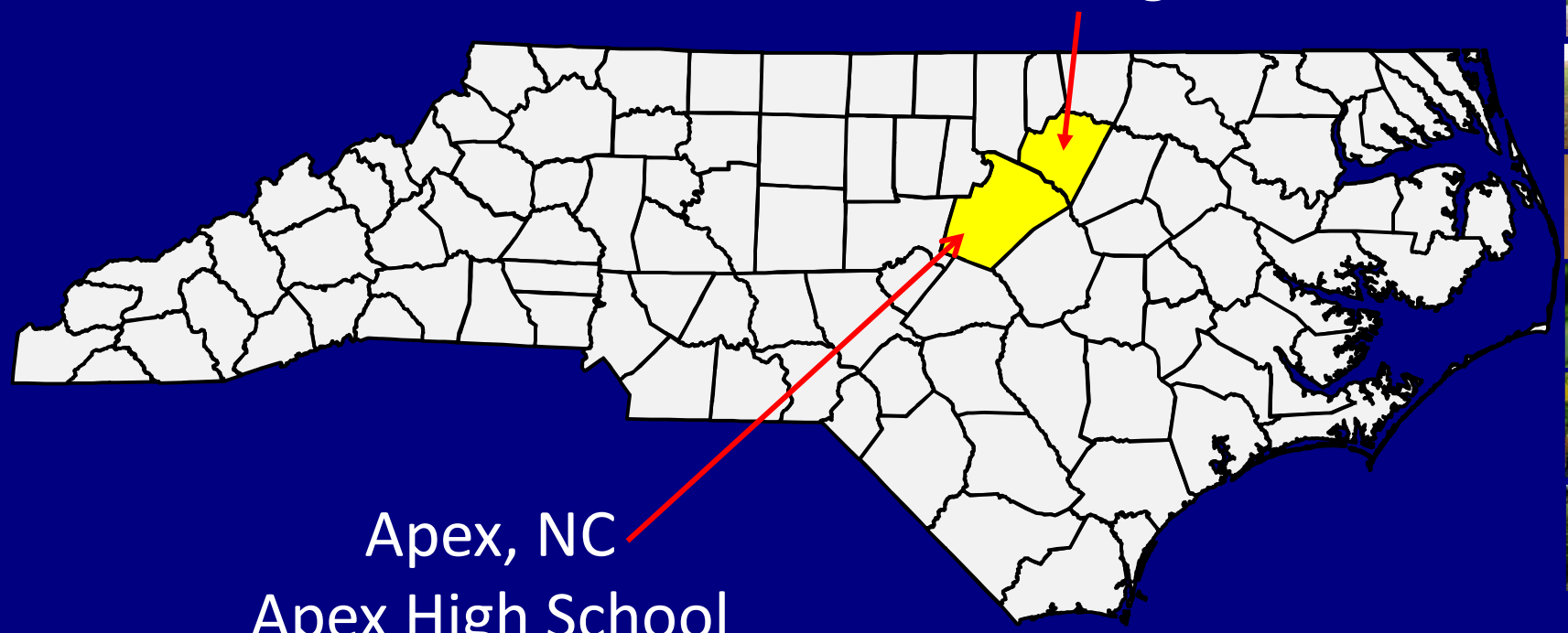
Round 2

Two level spreaders examined for thermal load reduction in Summers of 2008 and 2009.

Site Locations

Note: This study was conducted outside NC's Trout Region.

Louisburg, NC
Franklin County Emergency Management



Apex, NC
Apex High School

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Watershed Characteristics

Louisburg

- Drainage Area:
  0.98 acres
- Percent Impervious:
  75%
- Soil Type:
  Wedowee Sandy Loam
  PSA – Sandy Loam
- Buffer Slope:
  6%

Apex

- Drainage Area:
  1.04 acres
- Percent Impervious:
  89%
- Soil Type:
  Creedmoor Sandy Loam
  PSA - Loam
- Buffer Slope:
  4%

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Site Layout

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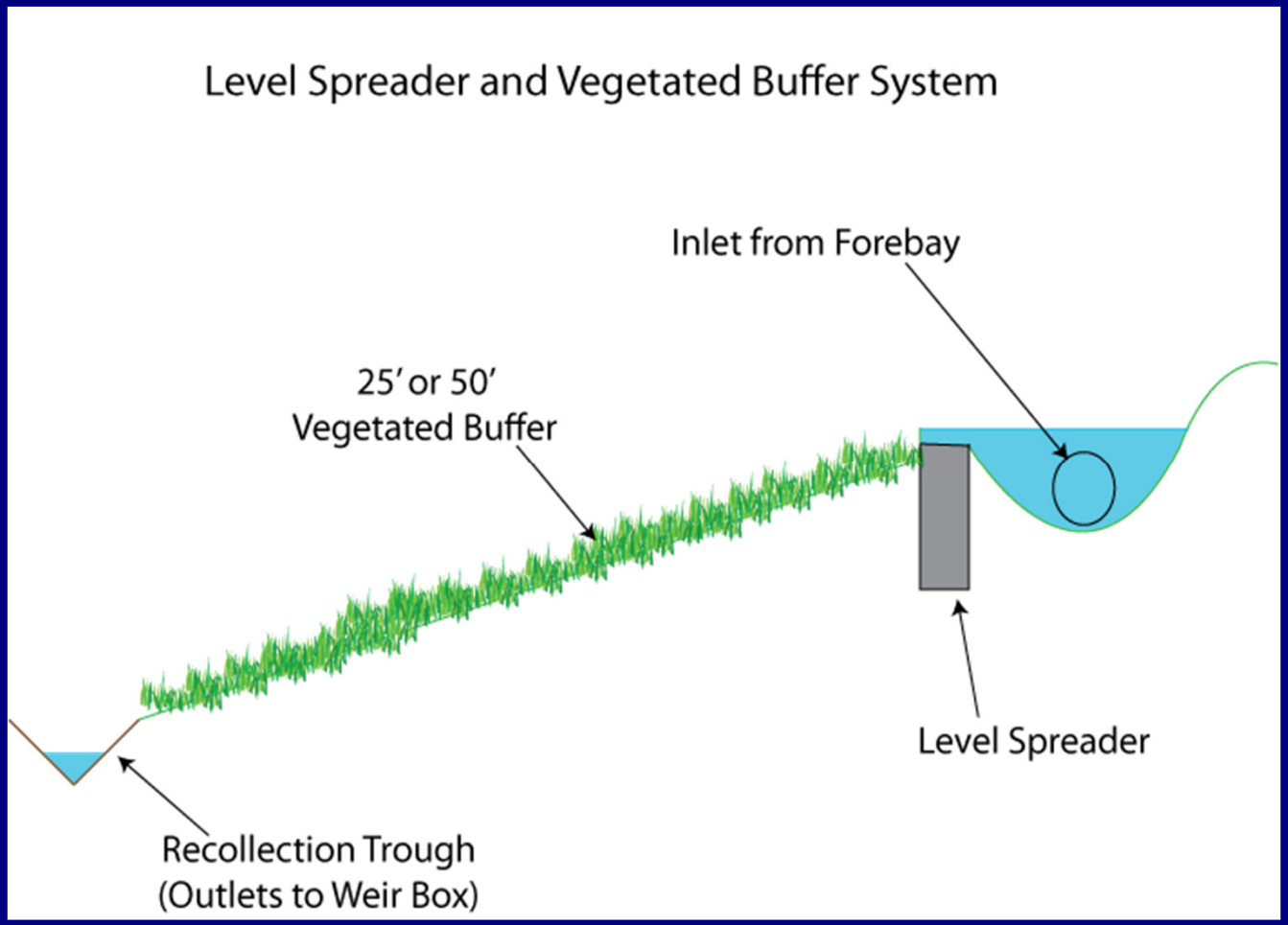
Site Cross-Sectional View



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Monitoring Equipment

Manual and Automatic Rain Gages

3 ISCO model 6712 WQ samplers with bubbler inserts

1 ISCO model 4230 bubbler stage recorder

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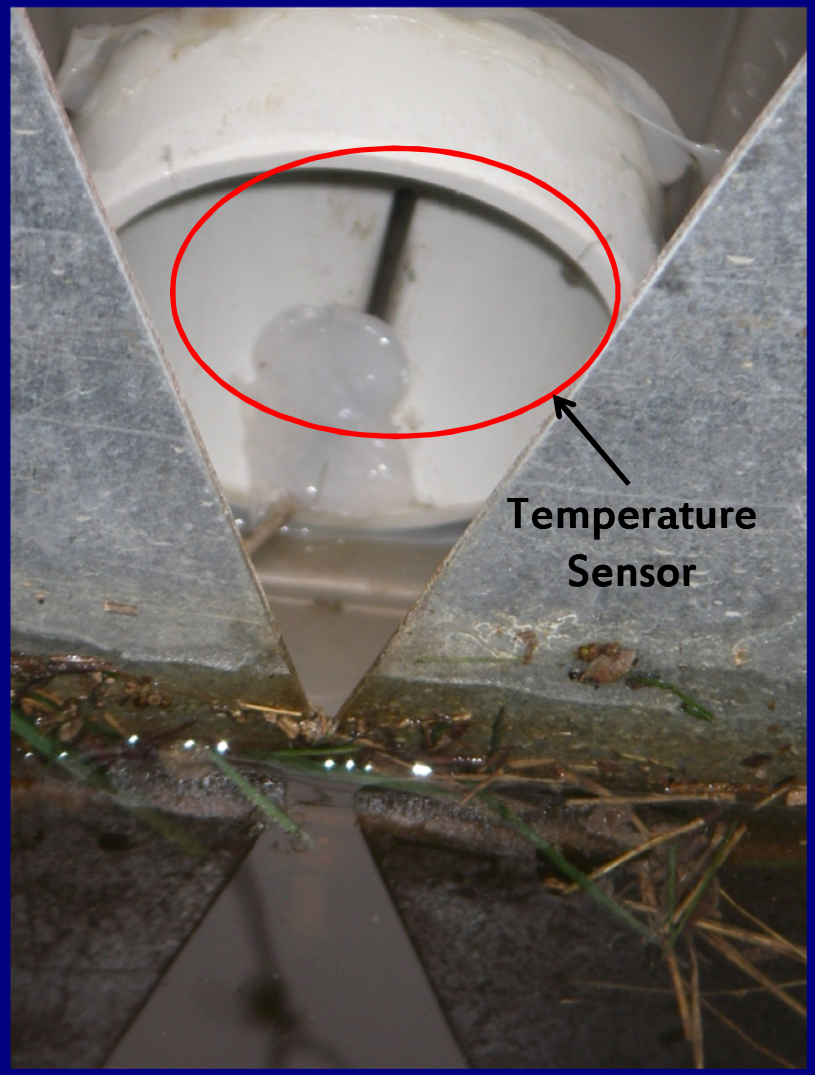
Thermal Impacts of LS-VFS

- Temperature of stormwater measured at inlet and outlet of VFS at Louisburg site
- Combine temperature and flow data to calculate thermal load



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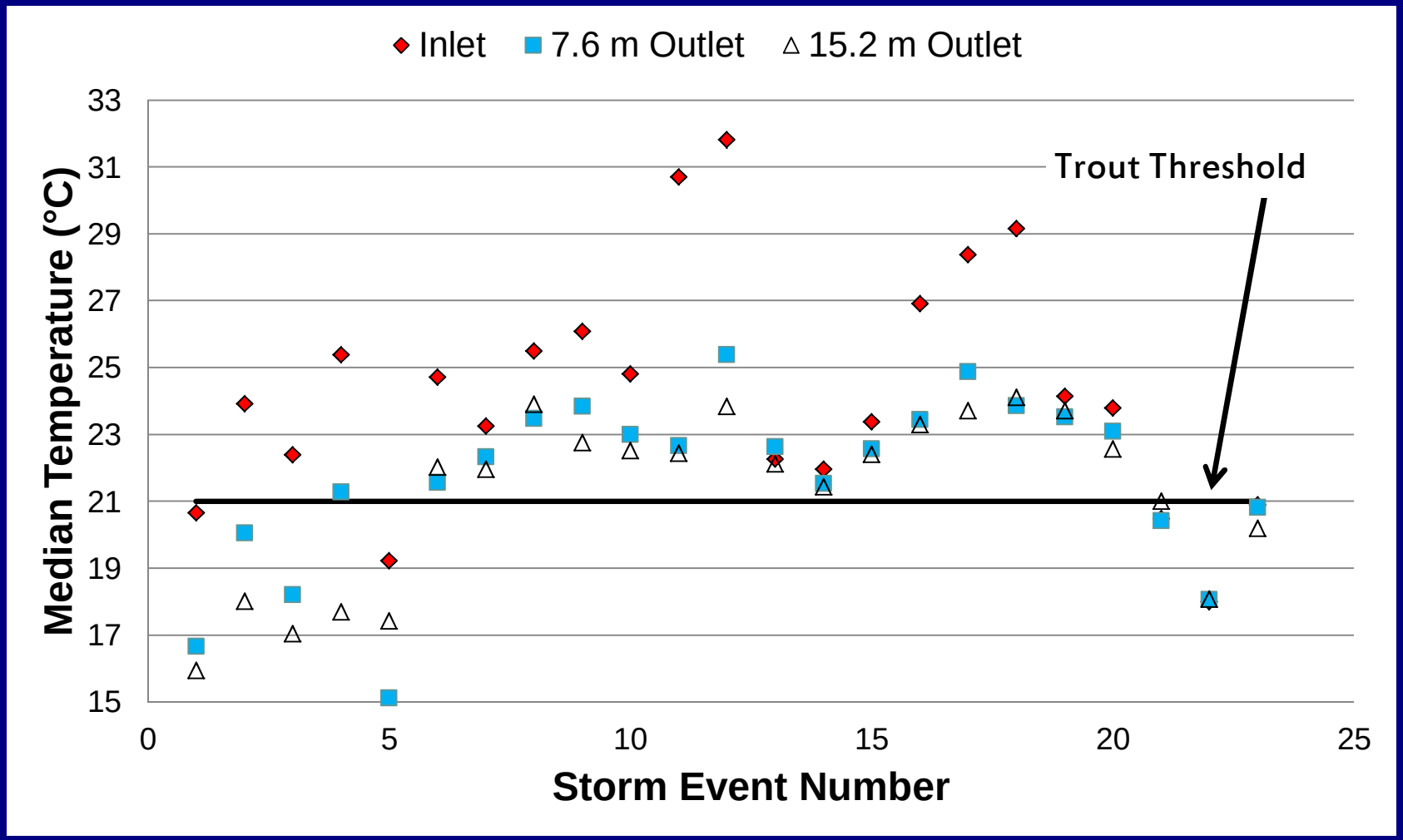
Median Temperature Reduction



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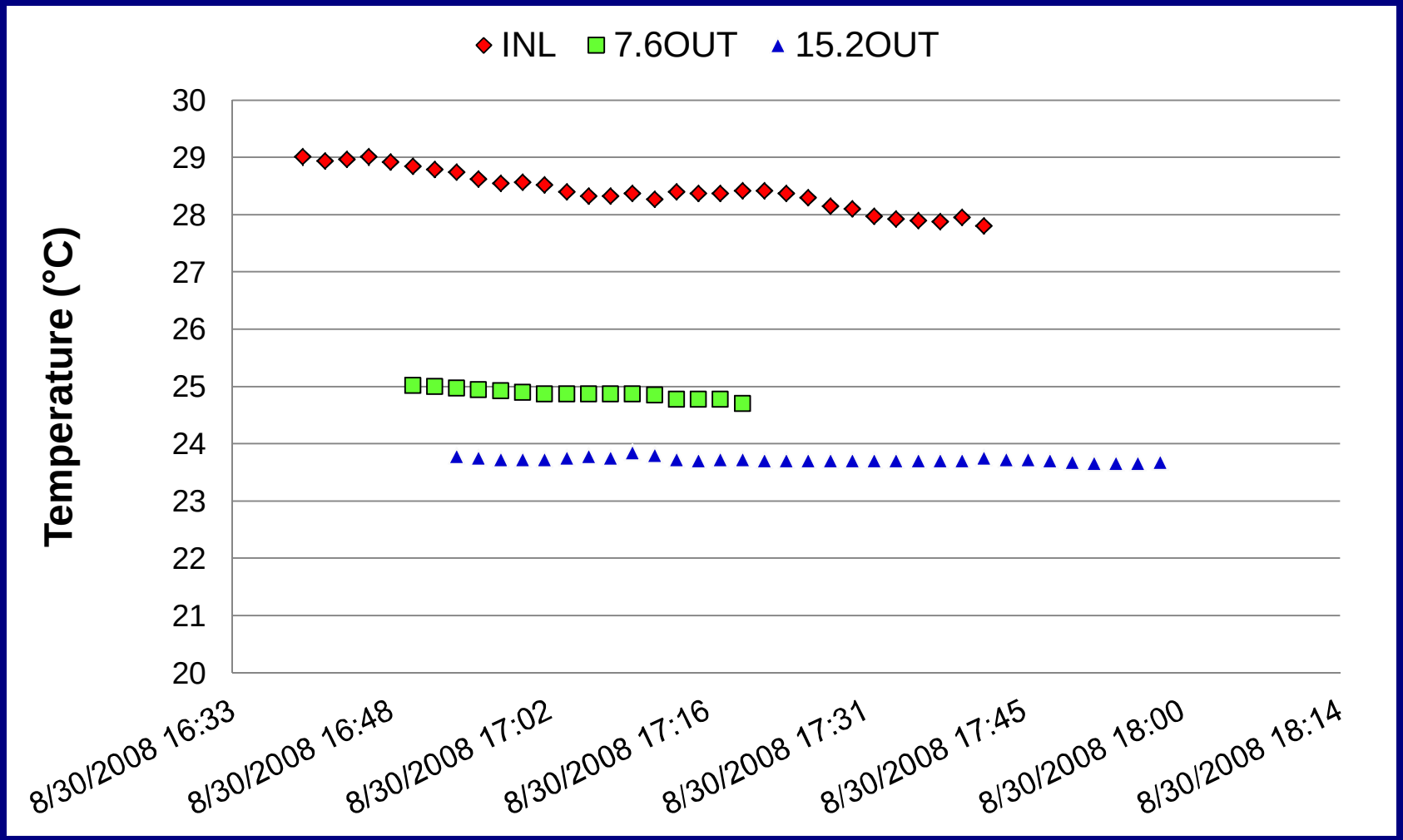
Storm Event Temperature Profile



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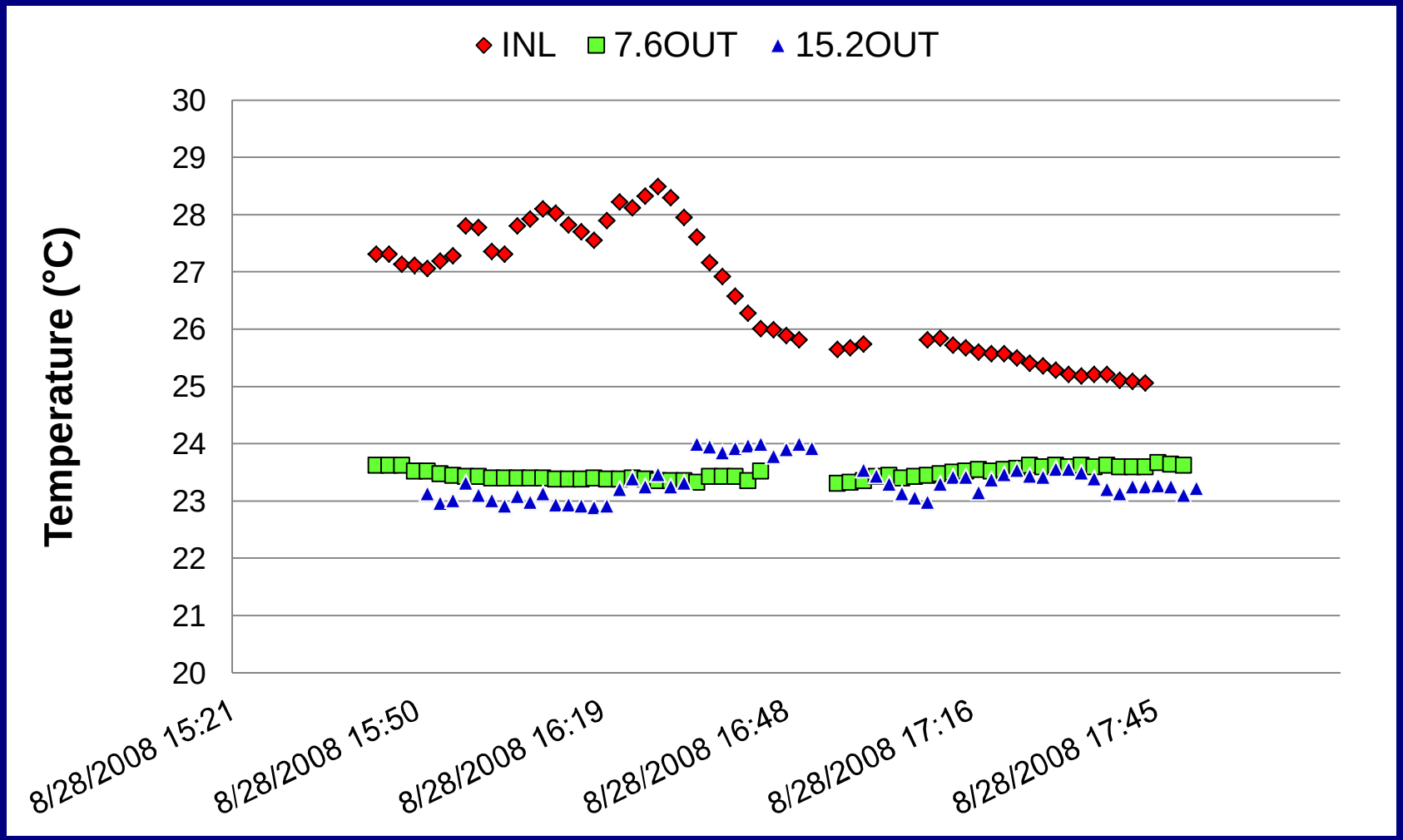
Storm Event Temperature Profile



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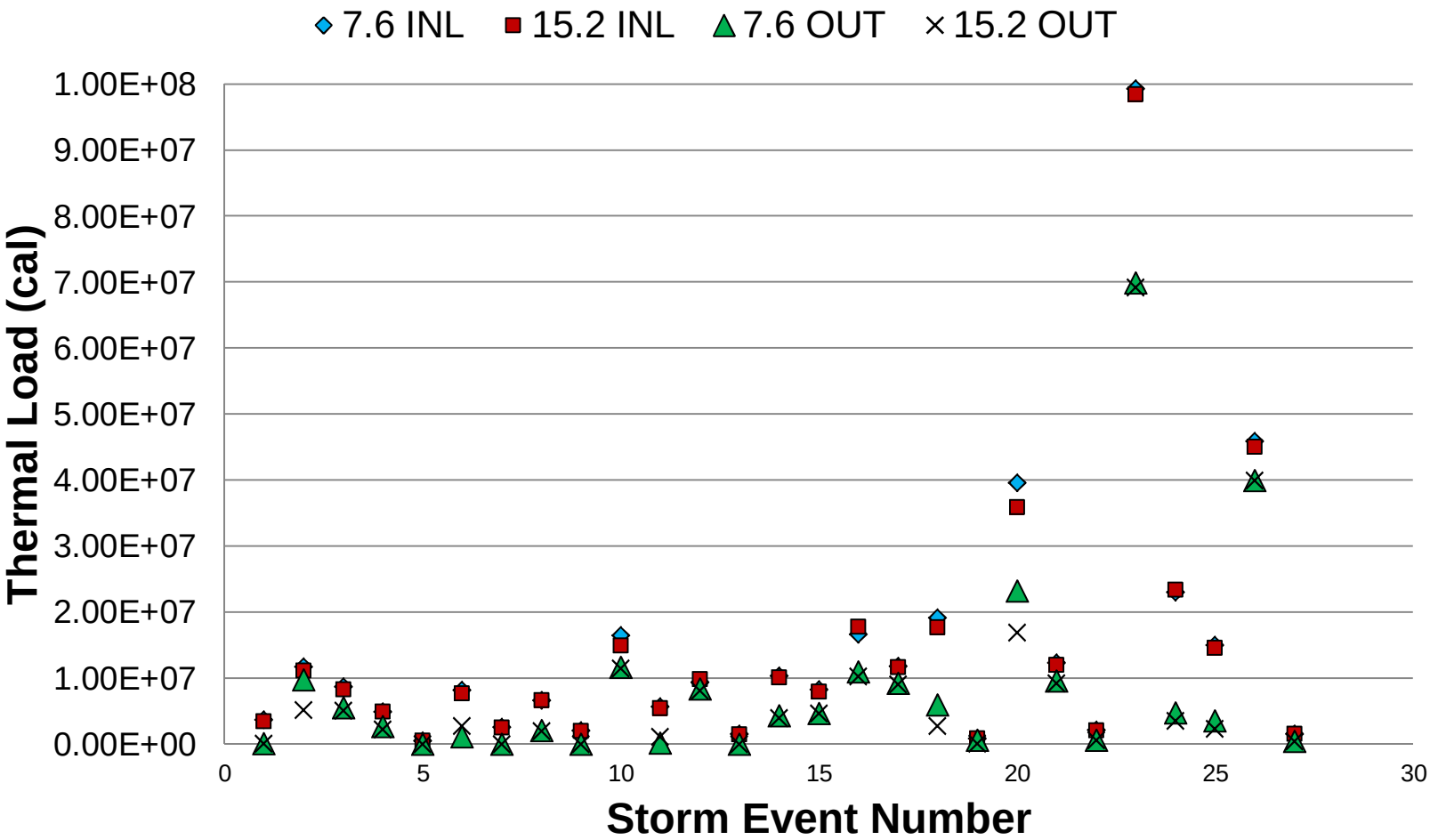
Thermal Load Reductions



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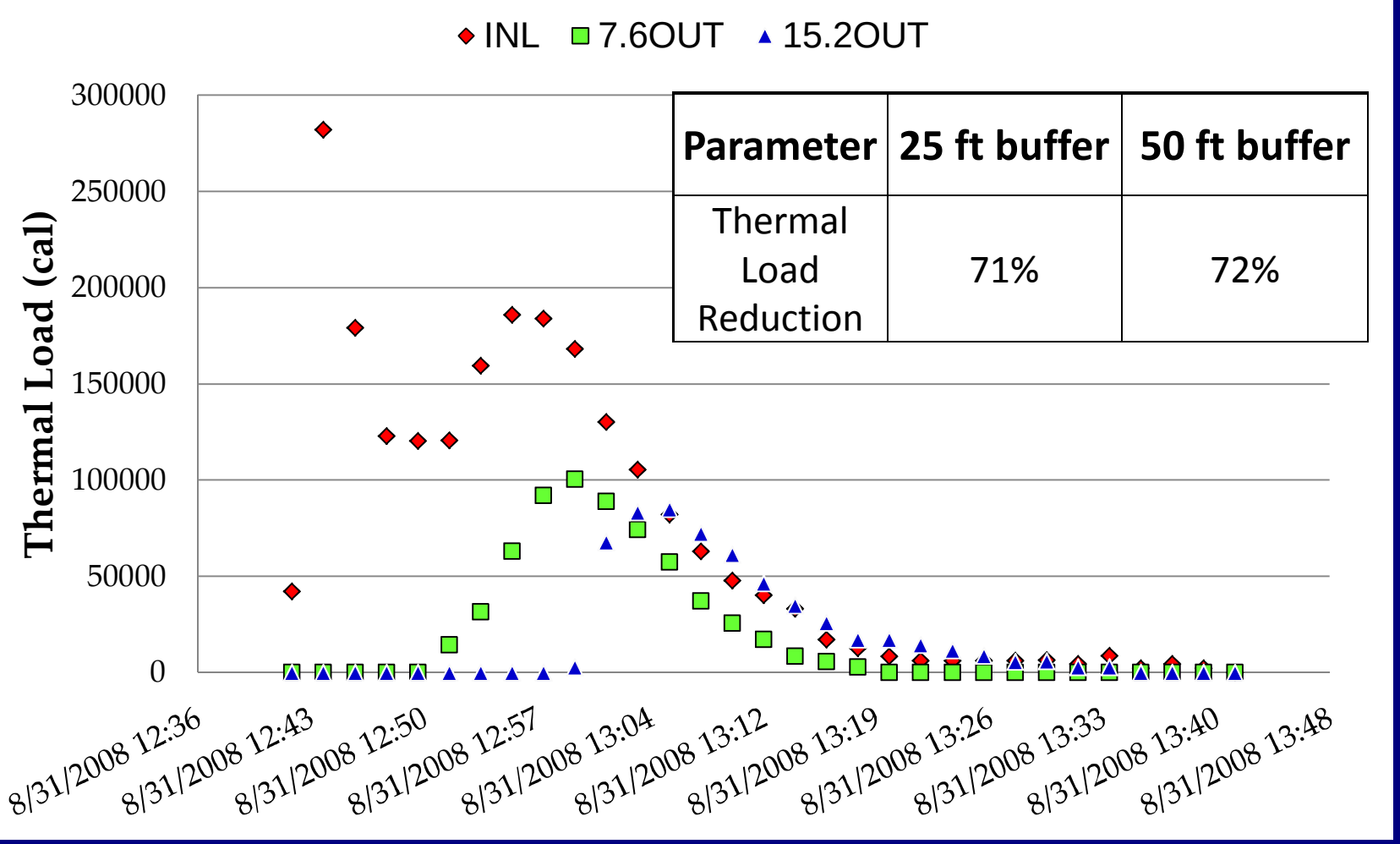
Storm Event Thermal Load Reduction



Parameter	25 ft buffer	50 ft buffer
Thermal Load Reduction	71%	72%

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Conclusions

- Median and maximum stormflow temperatures were significantly reduced across the 7.6 m and 15.2 m LS-VFS systems ($p<0.05$). Thermal load was also significantly reduced for both Louisburg LS-VFSs ($p<0.05$).

- Median and maximum outlet temperatures were significantly greater than 21°C ($p<0.05$)

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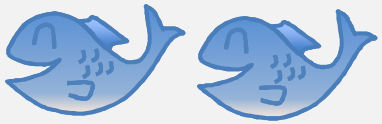
Monitoring Summary

- BMPs can (will) contribute to thermal pollution
- Modifications to wetland and wet pond can reduce thermal impact while maintaining other water quality benefits
- Bioretention, Perm Pave & LS-VFS able to reduce runoff temperature and volume
- Infiltration throughout the watershed may be best management strategy

SCMs for Thermal Mitigation

SCM	Thermal Effects	Source
Bioretention		Jones & Hunt, 2009
Level Spreader-Vegetated Filter Strips		Winston et al., 2011
Stormwater Wetlands		Jones & Hunt, 2010
Underground Conveyance/Detention		Jones & Hunt, 2009; Natarajan & Davis, 2010
Wet Detention Ponds		Jones & Hunt, 2010

Questions
Biological &
Agricultural
Engineering
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