USE OF INGROUND NITROGEN - REDUCING BIOFILTERS TO REDUCE NITROGEN LOADS FROM SEPTIC SYSTEMS

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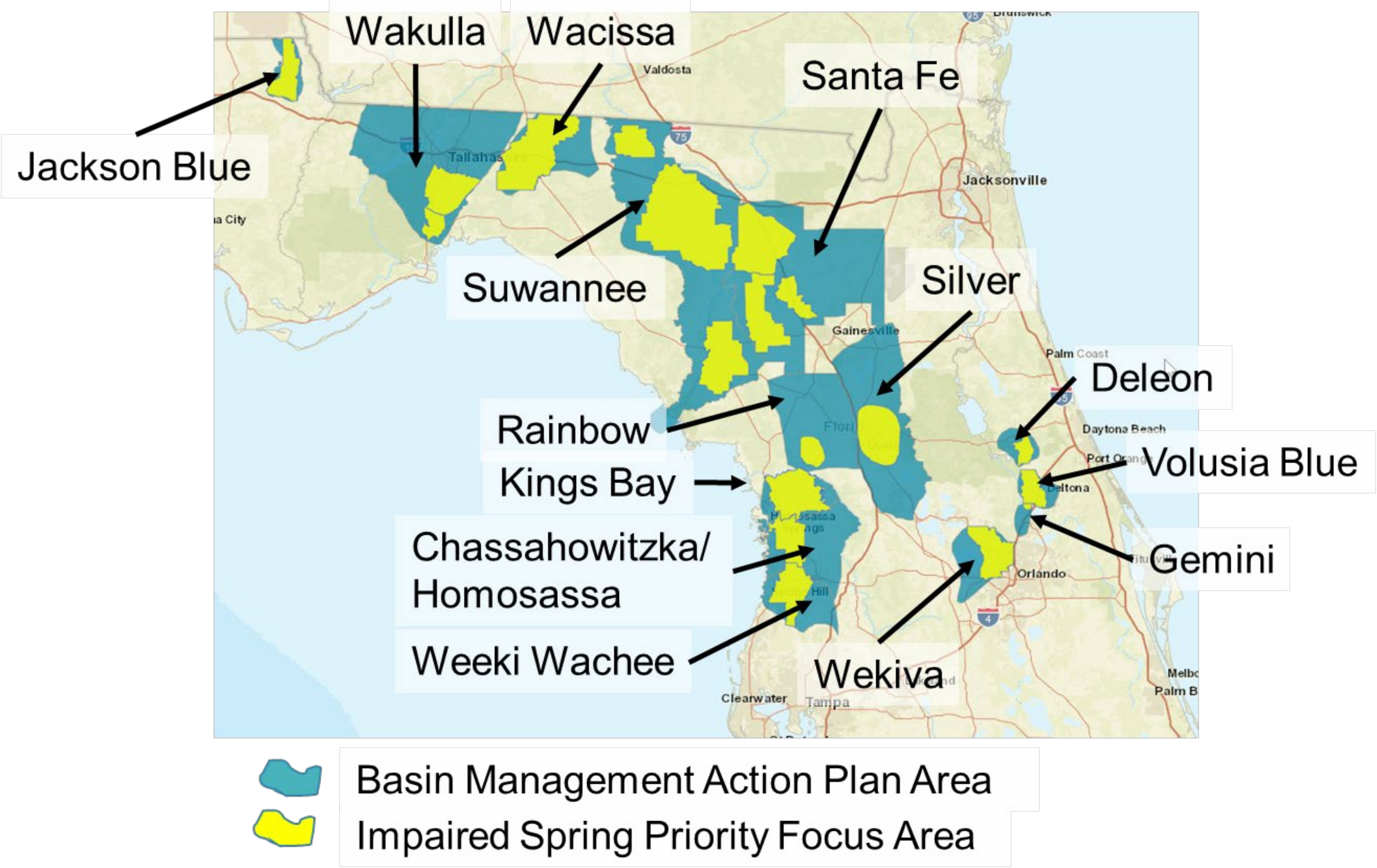
FLORIDA SPRINGS NITROGEN IMPAIRMENT



STATUTE REQUIREMENTS

SECTION 373.811, F.S.

“The following activities are prohibited within a priority focus area in effect for an Outstanding Florida Spring:

…(2) New onsite sewage treatment and disposal systems on lots of less than 1 acre, if the addition of the specific systems conflicts with an onsite treatment and disposal system remediation plan incorporated into a basin management action plan in accordance with s. 373.807(3).”

BASIN MANAGEMENT ACTION PLAN (BMAP)

Upon Basin Management Action Plan (BMPA) adoption, the onsite sewage treatment and disposal system (OSTDS) remediation plan prohibits new systems on lots of less than one acre within a Priority Focus Area (PFA) of an impaired Outstanding Florida Spring (OFS) **unless one of the two scenarios is applicable.**

- The system includes enhanced treatment of nitrogen (a nitrogen-reducing OSTDS).
- OSTDS permit applicant demonstrates that sewer connection will be available within five years.

NITROGEN-REDUCING OSTDS

- Aerobic treatment units (ATU) certified as meeting the NSF-245 standard.
- Nitrogen-reducing performance-based treatment systems (PBTS).
- Inground nitrogen-reducing biofilter (INRB).

REMOVING NITROGEN FROM DOMESTIC WASTEWATER

Nitrogen exists in various forms and must be dealt with progressively in each form to ensure removal.

CONCEPTUALLY

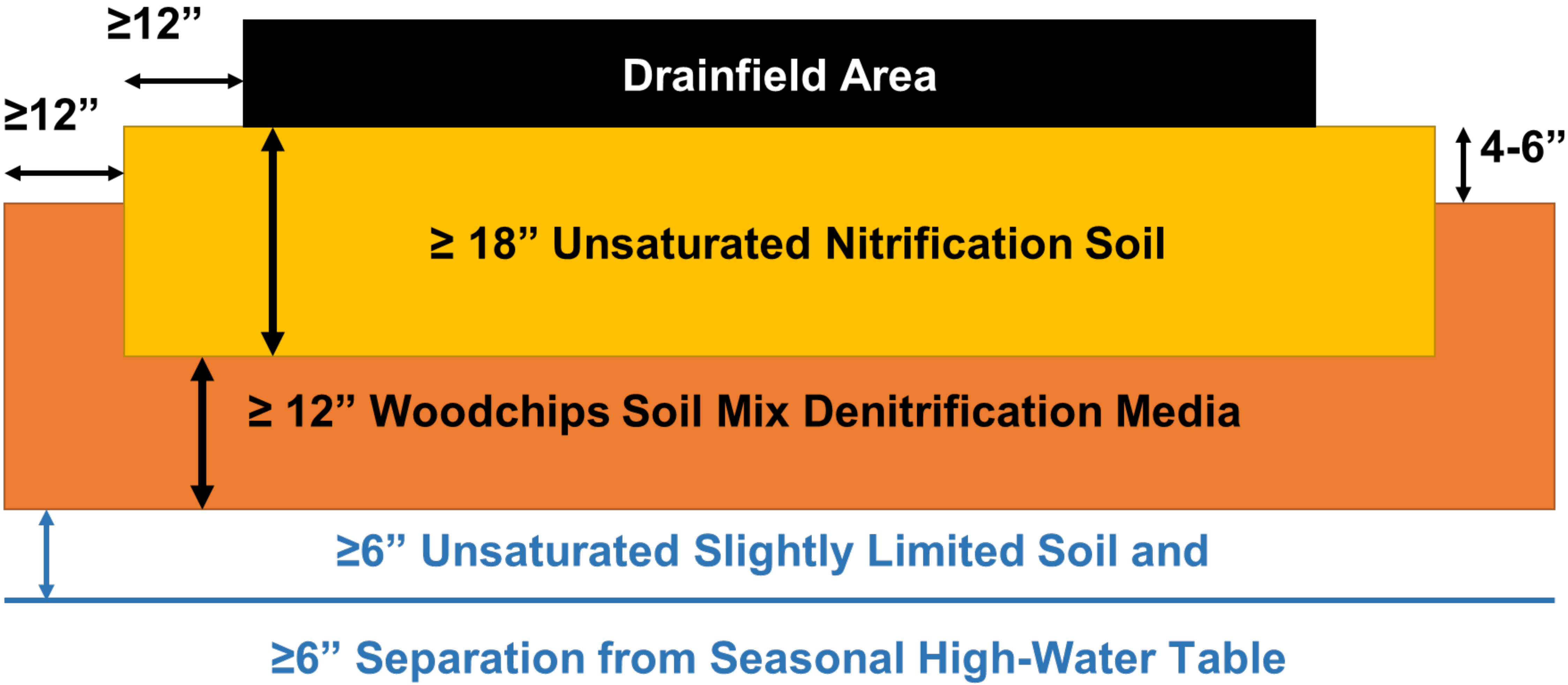
Organic → **Nitrogen ammonia** → **Nitrate** → **Nitrogen gas**

Ammonification
septic/anaerobic

Nitrification
aerobic

Denitrification
anoxic (need food)

INGROUND NITROGEN – REDUCING BIOFILTER



LEON COUNTY PROJECT
UPGRADE EXISTING SEPTIC SYSTEMS

- DEP funded Leon County $1.5 million to upgrade existing septic systems in Wakulla PFA to passive nitrogen-reducing systems (2016).
- Leon County selected two subdivisions as the pilot project area.
- The project recruited volunteer system owners to participate in the upgrade.
- Leon County and DEP cooperate in monitoring and sampling several upgraded systems.

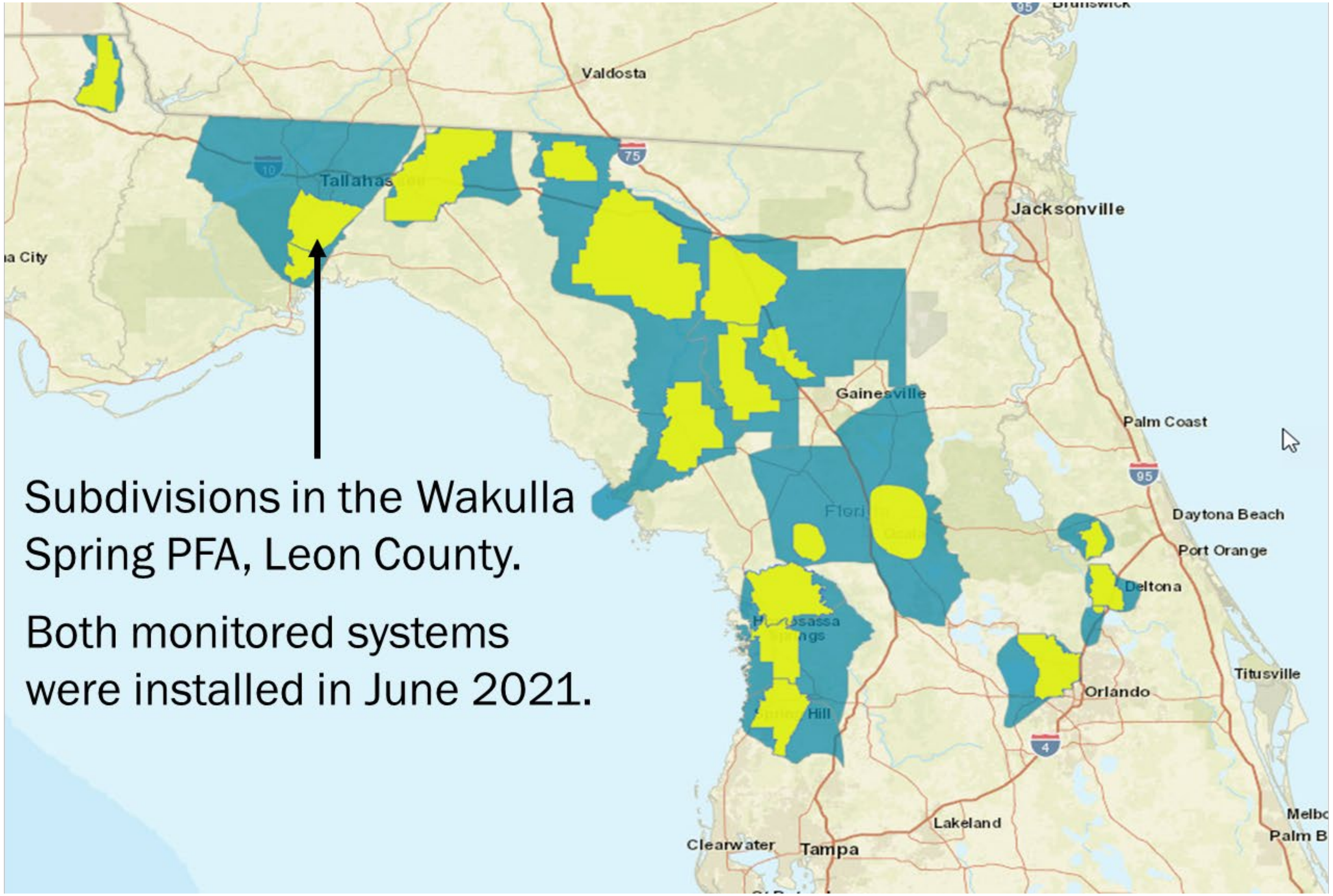
INRB MONITORING PROJECT

- Experimental INRB systems installed previously showed about 65% of nitrogen-removal.
- More systems are needed to provide more robust evaluation of the performance of the technology in Florida.
- DEP's Onsite Sewage Program is monitoring two INRB systems and is looking for more volunteer INRB owners to participate in the monitoring.
- This monitoring project is funded by the U.S. Environmental Protection Agency.

GOALS OF THE MONITORING PROJECT

- Determine the nitrogen-reducing efficiency of INRB systems.
- Evaluate the capability of INRBs of removing total phosphorus, fecal coliform and organic carbon.
- Evaluate media decay through monitoring the change of elevations of the media layers.
- Compare monitoring results from different monitoring equipment (i.e., pan lysimeter and suction lysimeter).

PROJECT LOCATION



Subdivisions in the Wakulla Spring PFA, Leon County.

Both monitored systems were installed in June 2021.

BMAP Area

PFA

INRB SYSTEM MONITORING

- Inspect the systems to ensure proper function.
- Conduct elevation survey to evaluate change of depth of media layers.
- Collect samples.
  - Total Kjeldahl nitrogen (TKN).
  - Ammonium nitrogen (NH4-N).
  - Nitrate/nitrite nitrogen (NOx-N).
  - Total phosphorus (TP).
  - Total organic carbon (TOC).
  - Fecal coliform.
  - Alkalinity.
  - Chloride.

INRB SYSTEM MONITORING (2)

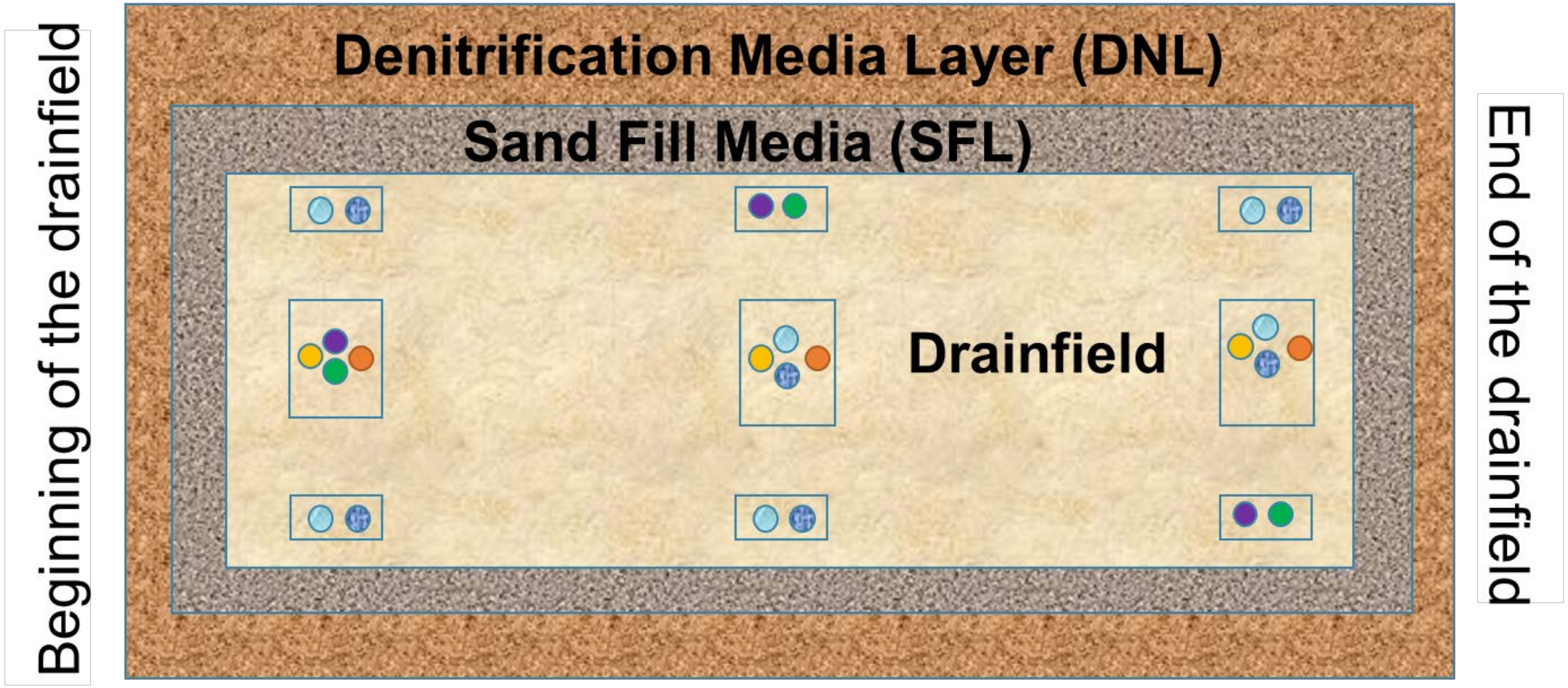
- Collect field measurements.
  - Water temperature.
  - Dissolved oxygen.
  - Specific conductivity.
  - pH.
  - Oxidation reduction potential.
  - Flowmeter reading.

MONITORING EQUIPMENT

Pan Lysimeter (PL)

Suction Lysimeter (SL)

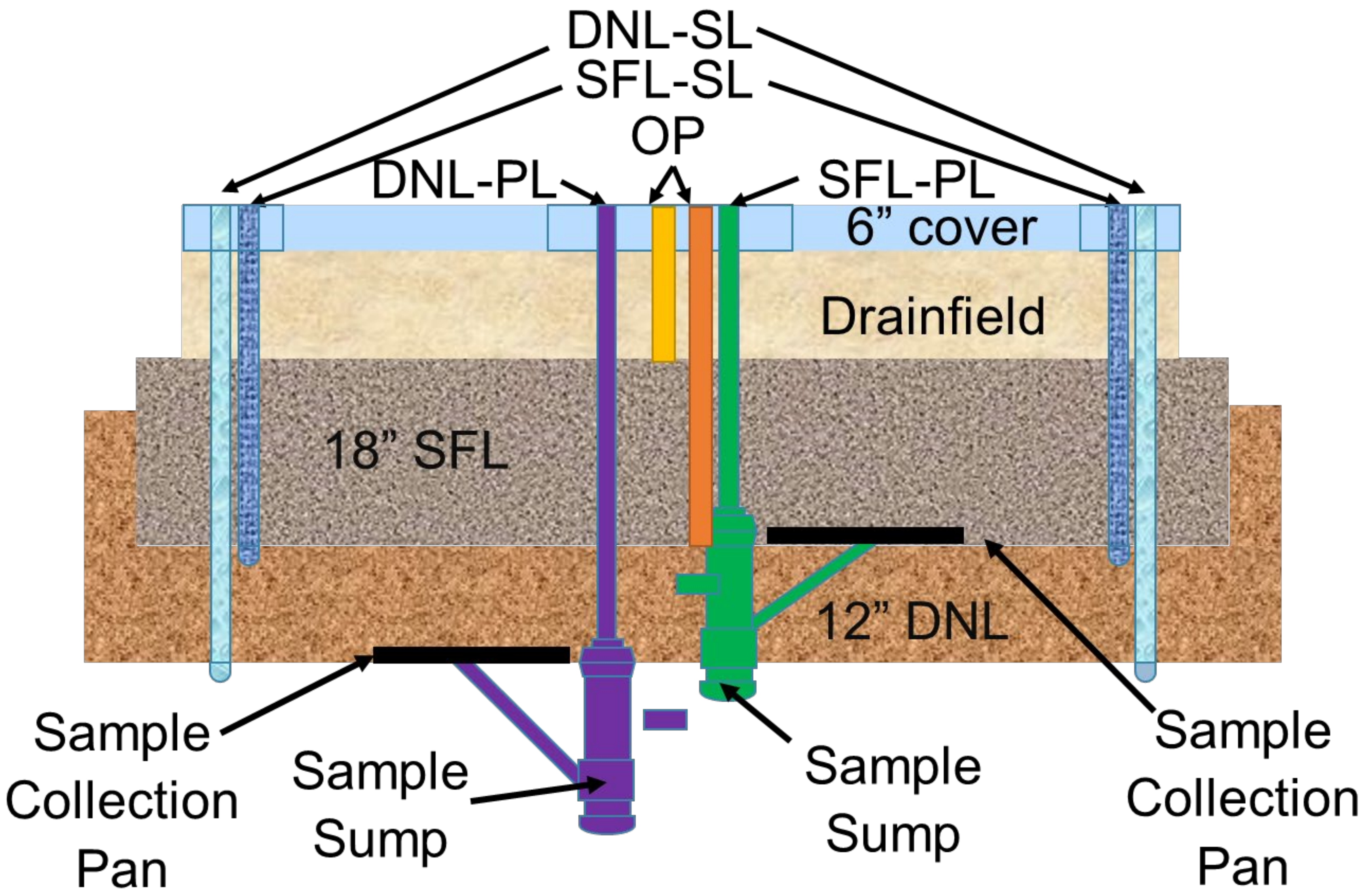
MONITORING EQUIPMENT ARRANGEMENT



DNL-SL SFL-SL DNL-PL SFL-PL SFL-OP DNL-OP

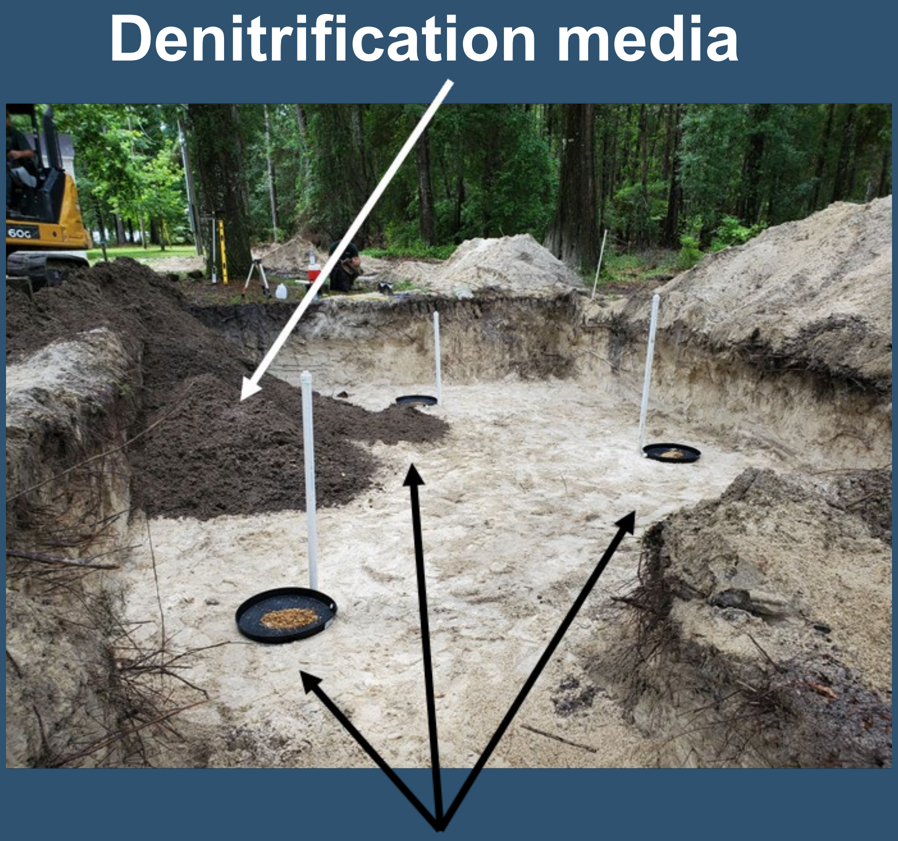
SL: Suction Lysimeter. **PL**: Pan Lysimeter. **OP**: Observation Port.

MONITORING EQUIPMENT ARRANGEMENT (2)

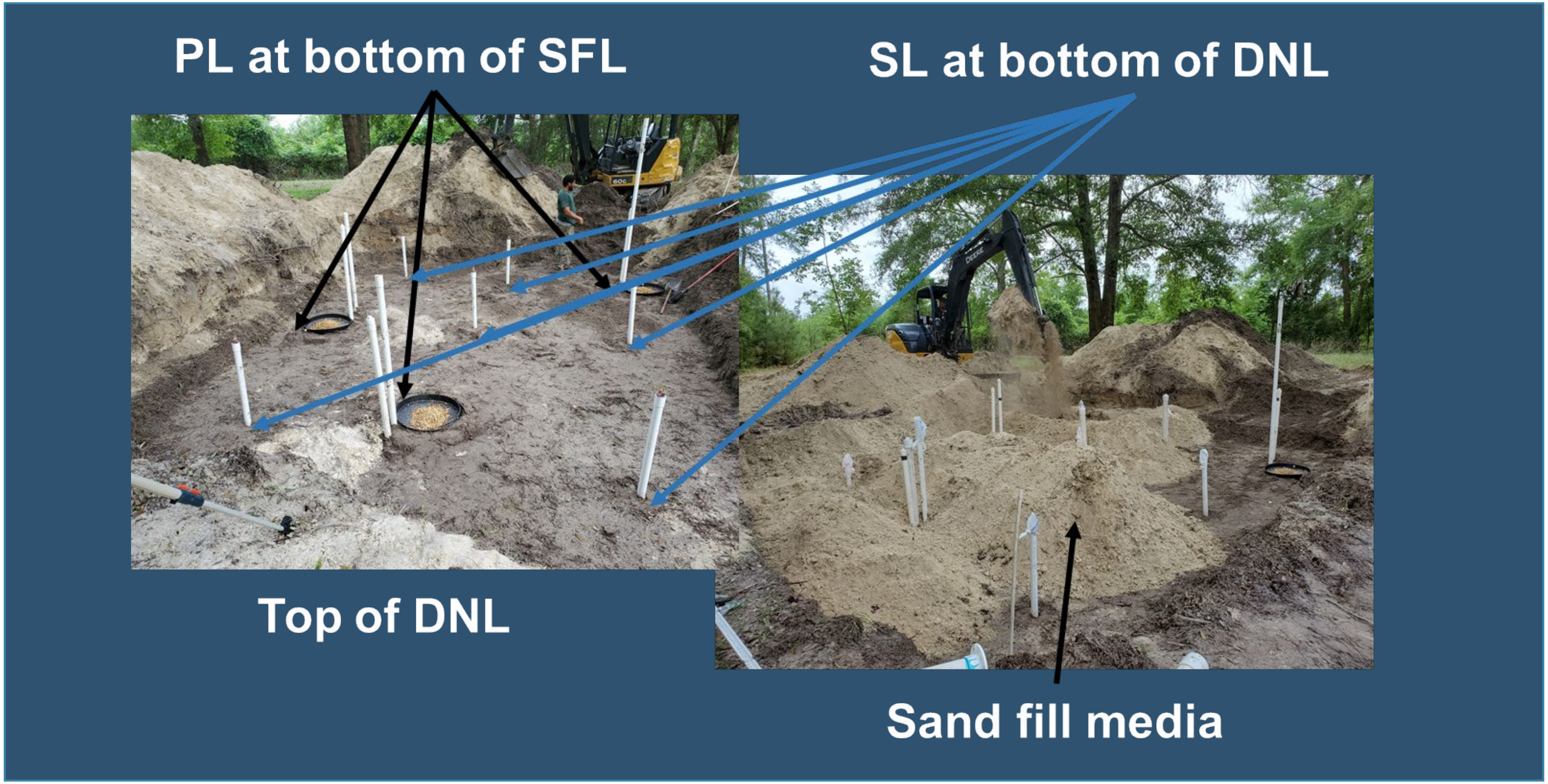


MONITORING EQUIPMENT INSTALLATION

Bottom of INRB



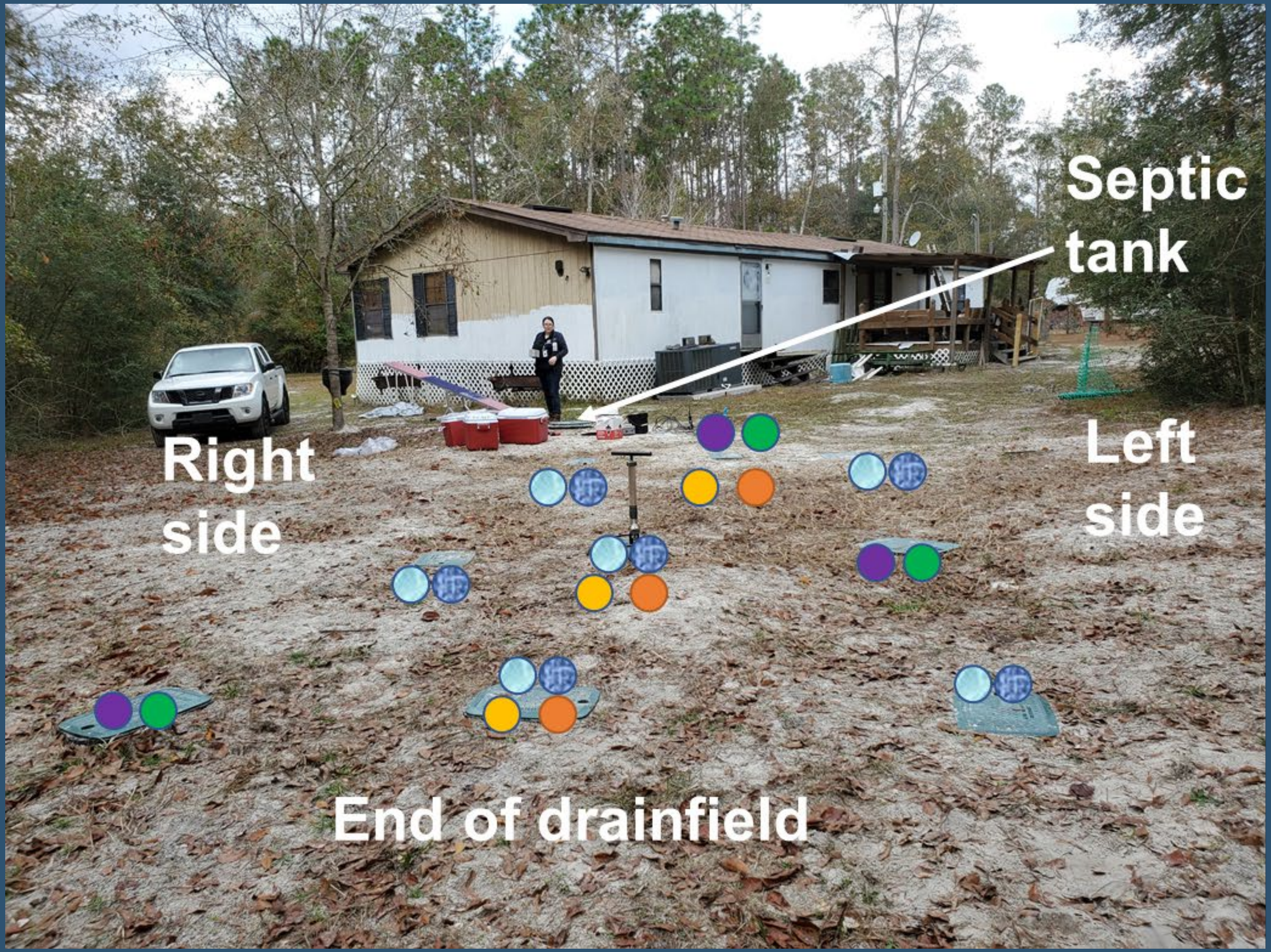
MONITORING EQUIPMENT INSTALLATION (2)



MONITORING EQUIPMENT INSTALLATION (3)

Top of sand fill media layer

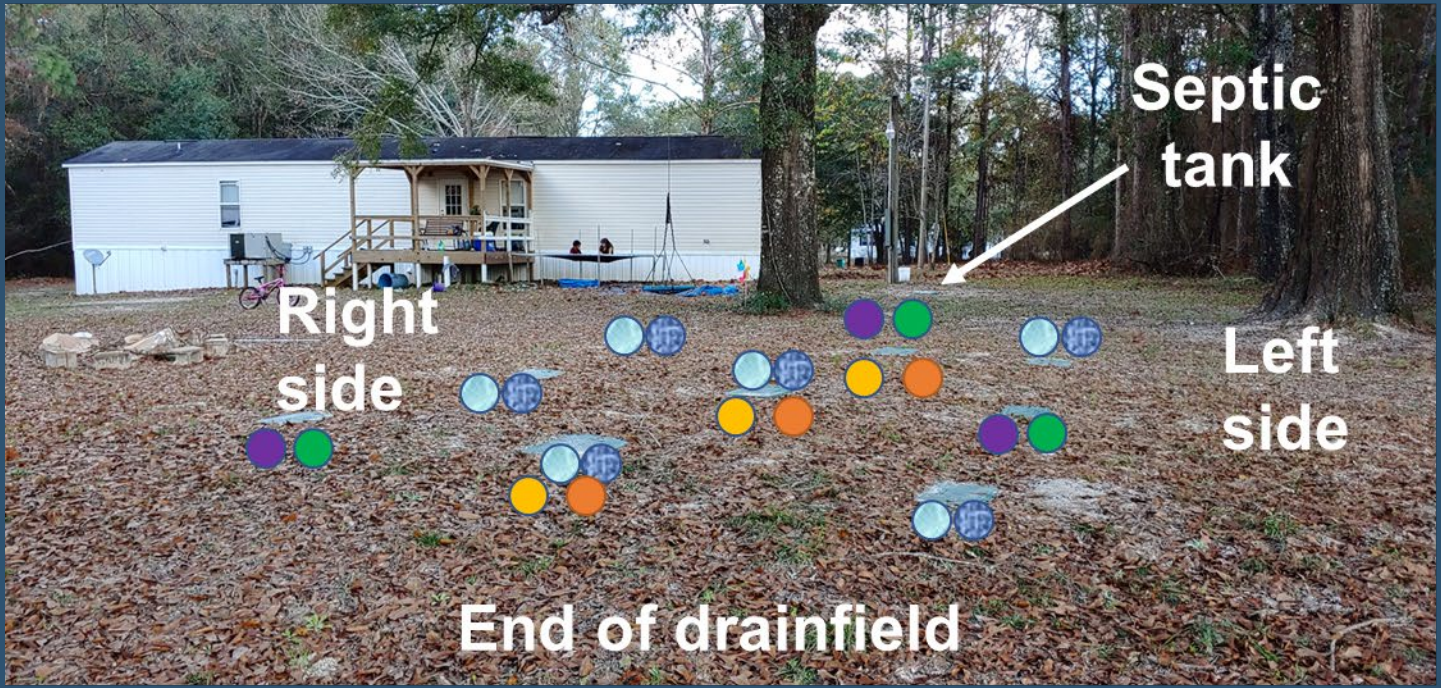
SYSTEM 3 (S3)
INSTALLED IN JUNE 2021



DNL	SFL
SL	SL
PL	PL
OP	OP

No irrigation.

SYSTEM 4 (S4)
INSTALLED IN JUNE 2021



DNL	SFL
SL	SL
PL	PL
OP	OP

No irrigation.

PROPERTY CHARACTERISTICS

System	# of Bedrooms	Drainfield Size (SQFT)	Soil Type	# of Occupants
S3	3	360	Fine Sand	1
S4	3	375	Fine Sand	5

WATER USE

SYSTEM 3

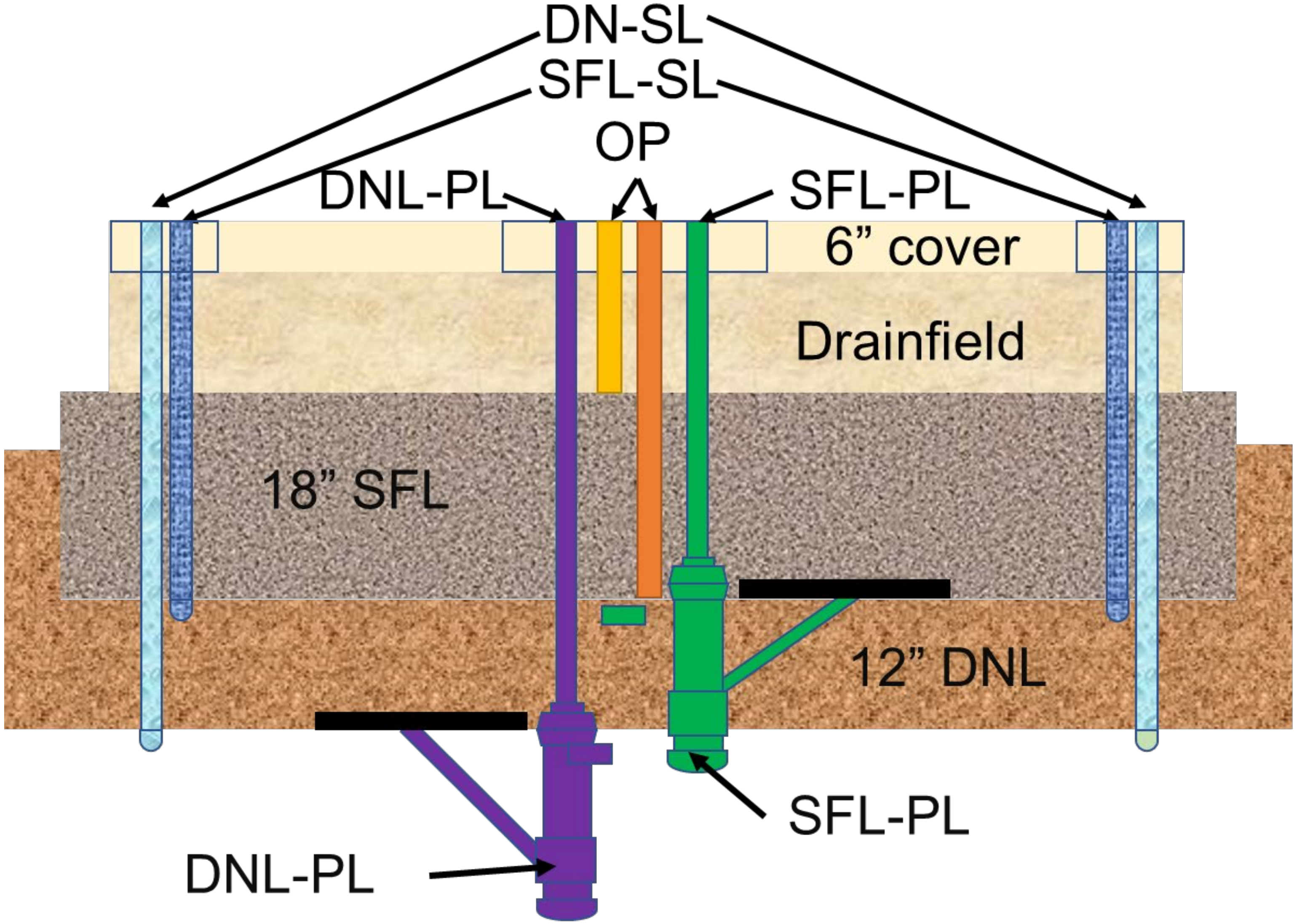
Date & Time - Water Meter Reading	Cumulative Flow Meter Reading (gallons)	Time Lapse (days)	Daily Water Use (gallons/day)
12/6/2021 13:57	1462	-	-
12/8/2021 11:32	1495	1.90	17.4
12/9/2021 12:02	1507	1.02	11.8
2/28/2022 11:46	3158.6	80.99	20.4
3/2/2022 8:42	3210.4	1.87	27.7
3/3/2022 12:57	3234.5	1.18	20.5
5/23/2022 9:09	4760.2	80.84	18.9
5/25/2022 8:44	4780.9	1.98	10.4
5/26/2022 10:58	4800.9	1.09	18.3
Long-term average daily water use	-	-	**20.0**

WATER USE

SYSTEM 4

Date & Time - Water Meter Reading	Cumulative Flow Meter Reading (gallons)	Time Lapse (days)	Daily Water Use (gallons/day)
12/13/2021 15:10	24350.6	-	-
12/15/2021 8:16	25980.3	1.71	951.6
12/15/2021 15:13	26059.7	0.29	274.2
3/21/2022 11:35	63455.5	95.85	390.2
3/23/2022 8:18	63656	1.86	107.6
3/23/2022 13:33	63880.4	0.22	1025.8
5/31/2022 10:19	107110.1	68.87	627.7
5/31/2022 13:24	107530.3	0.13	3270.7
6/2/2022 14:20	111490.5	2.04	1942.3
Long-term average daily water use	-	-	**570.0**

ARRANGEMENT OF MONITORING EQUIPMENT



WATER DEPTHS IN OP (INCHES)

SYSTEM 3

Sampling Event	Location in Drainfield	Bottom of Drainfield	Bottom of Sand Fill Layer
1st sampling event (12/2021)	Beginning	0.00	0.00
1st sampling event (12/2021)	Middle	0.00	0.00
1st sampling event (12/2021)	End	0.00	0.00
2nd sampling event (3/2022)	Beginning	0.00	0.00
2nd sampling event (3/2022)	Middle	0.00	0.00
2nd sampling event (3/2022)	End	0.00	0.00
3rd sampling event (5/2022)	Beginning	0.00	0.00
3rd sampling event (5/2022)	Middle	0.00	0.00
3rd sampling event (5/2022)	End	0.00	0.00

WATER DEPTHS IN OP (INCHES)

SYSTEM 4

Sampling Event	Location in Drainfield	Bottom of Drainfield	Bottom of Sand Fill Layer
1st sampling event (12/2021)	Beginning	0.00	3.50
1st sampling event (12/2021)	Middle	0.00	4.50
1st sampling event (12/2021)	End	0.00	10.25
2nd sampling event (3/2022)	Beginning	0.00	0.00
2nd sampling event (3/2022)	Middle	0.00	5.75
2nd sampling event (3/2022)	End	0.00	4.50
3rd sampling event (5/2022)	Beginning	0.00	3.50
3rd sampling event (5/2022)	Middle	0.00	13.0
3rd sampling event (5/2022)	End	0.00	11.0

VOLUME OF SAMPLES GENERATED (ML)

SYSTEM 3

Sampling Event	Location in Drainfield	Left SFL	Left DNL	Center SFL	Center DNL	Right SFL	Right DNL
1st sampling	Beginning	600	200/80	0	0	800	1050
1st sampling	Middle	0	0	850	150/50	800	160/100
1st sampling	End	800	130/70	800	220/100	0	0
2nd sampling	Beginning	800	150/160	0	0	822	1200
2nd sampling	Middle	0	0	900	100/0	800	200/100
2nd sampling	End	900	200/75	800	600	0	0
3rd sampling	Beginning	850	0/40	0	0	950	1250
3rd sampling	Middle	0	0	850	100/50	950	180/80
3rd sampling	End	1000	180/80	675	220/100	0	0

Brown font: Pan lysimeter sample volume. **Blue** and **black** fonts: Suction lysimeter volume.

VOLUME OF SAMPLES GENERATED (ML)

SYSTEM 4

Sampling Event	Location in Drainfield	Left SFL	Left DNL	Center SFL	Center DNL	Right SFL	Right DNL
1st sampling	Beginning	400	1000	**1050**	**1250**	825	850
1st sampling	Middle	**2800**	**2000**	900	1200	900	1100
1st sampling	End	1200	0	750	750	**1900**	**2300**
2nd sampling	**Beginning**	900	600	**1400**	**900**	900	N/A
2nd sampling	**Middle**	**0**	**800**	900	900	900	N/A
2nd sampling	**End**	900	0	950	800	**0**	**0**
3rd sampling	Beginning	850	1200	**1000**	**1000**	1200	**1000**
3rd sampling	Middle	**1000**	**2000**	950	1000	950	180/80
3rd sampling	End	950	0	950	1100	**1000**	**2000**

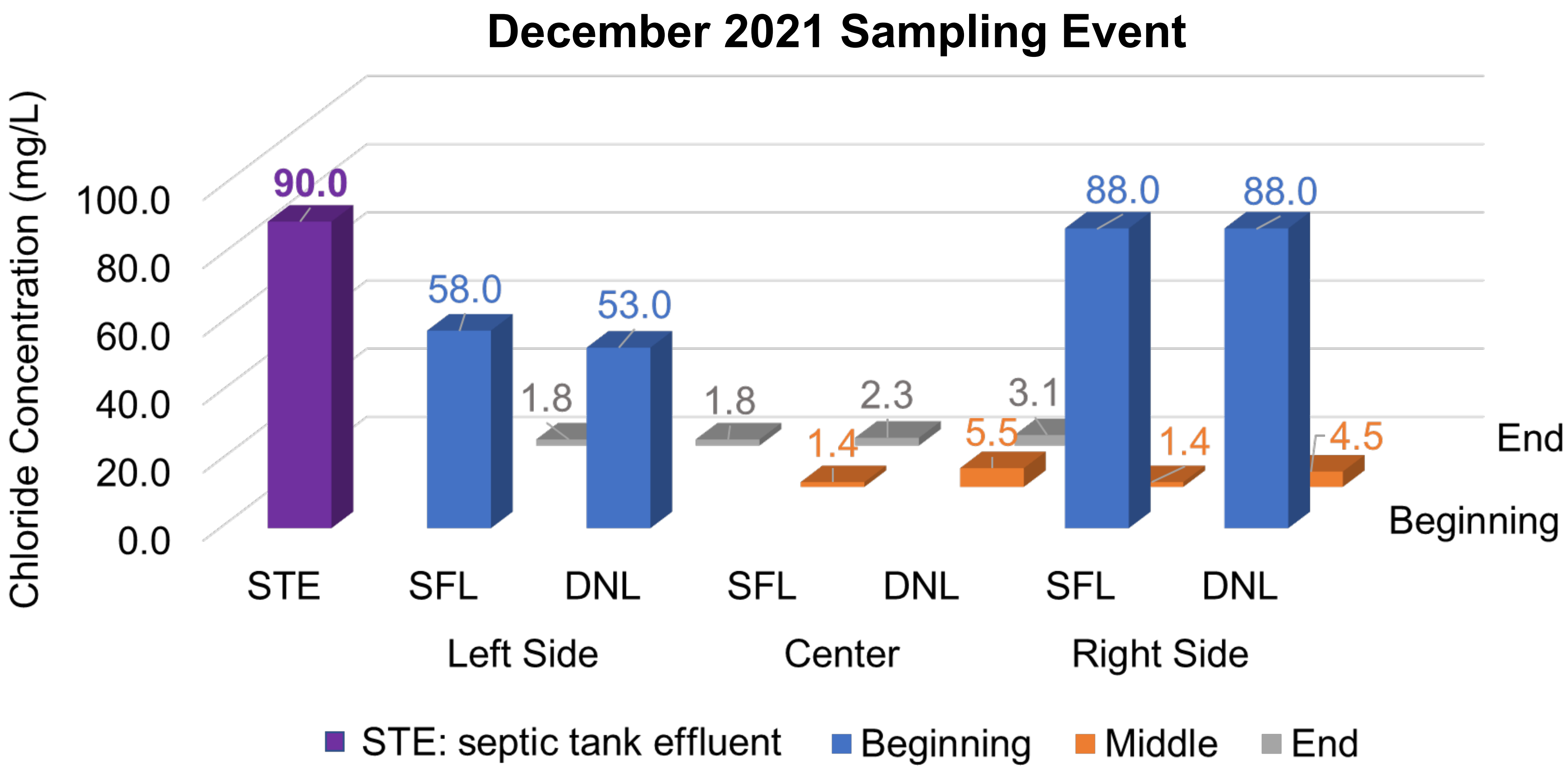
Brown font: Pan lysimeter sample volume. **Blue** and **black** fonts: Suction lysimeter volume.

NITROGEN REDUCTION IN SYSTEM 3

Lysimeter Results

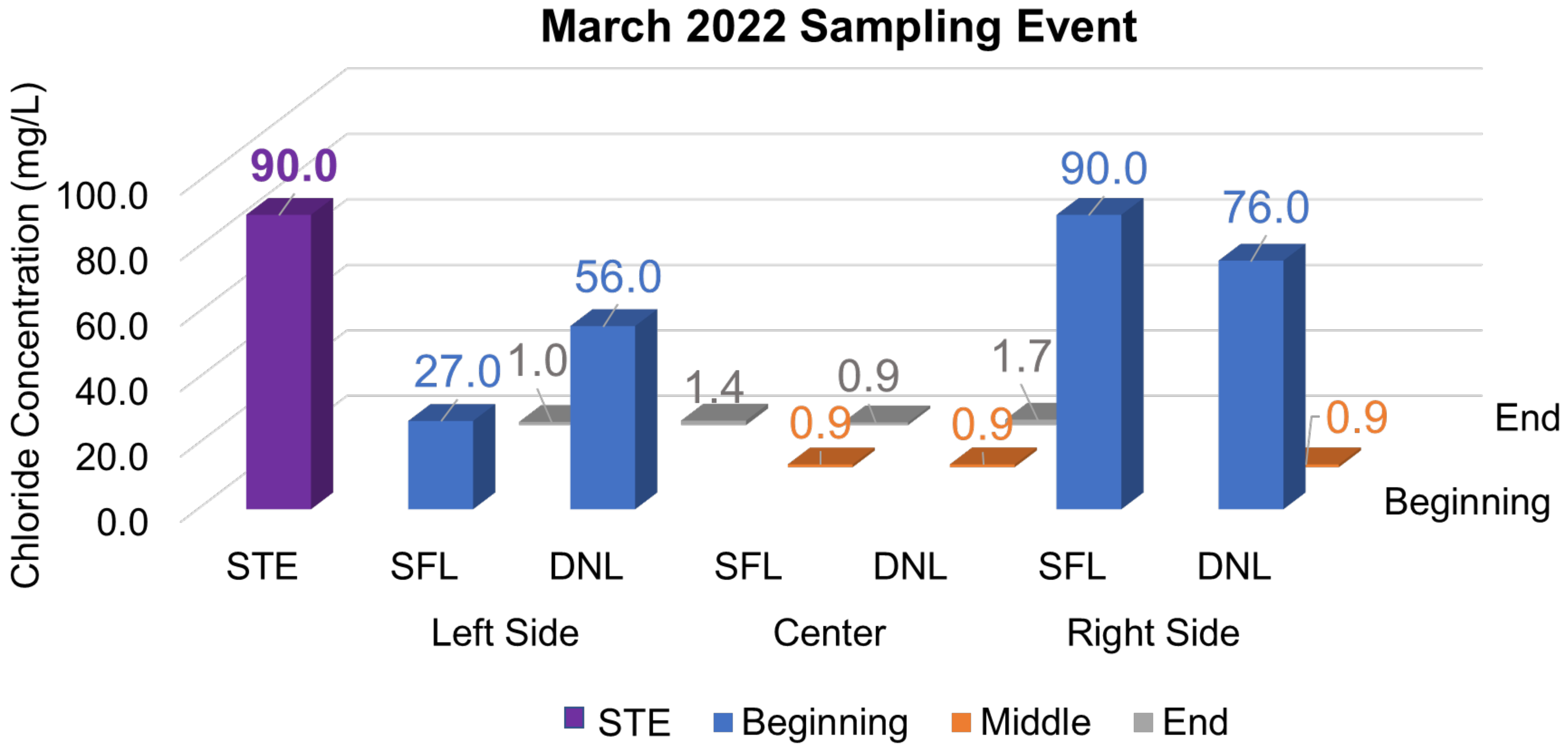
CHLORIDE CONCENTRATION (MG/L)

SYSTEM 3



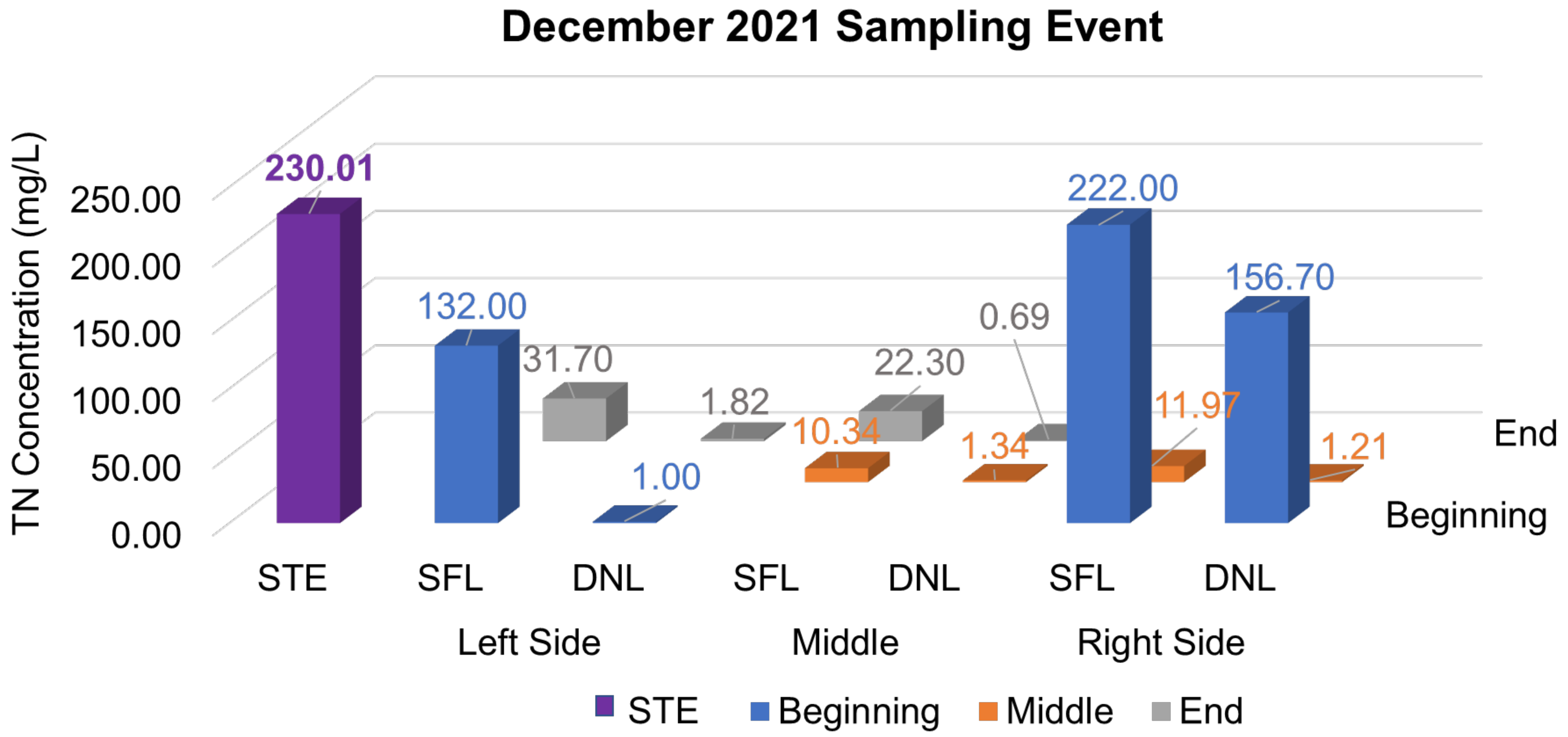
CHLORIDE CONCENTRATION (MG/L)

SYSTEM 3 (2)



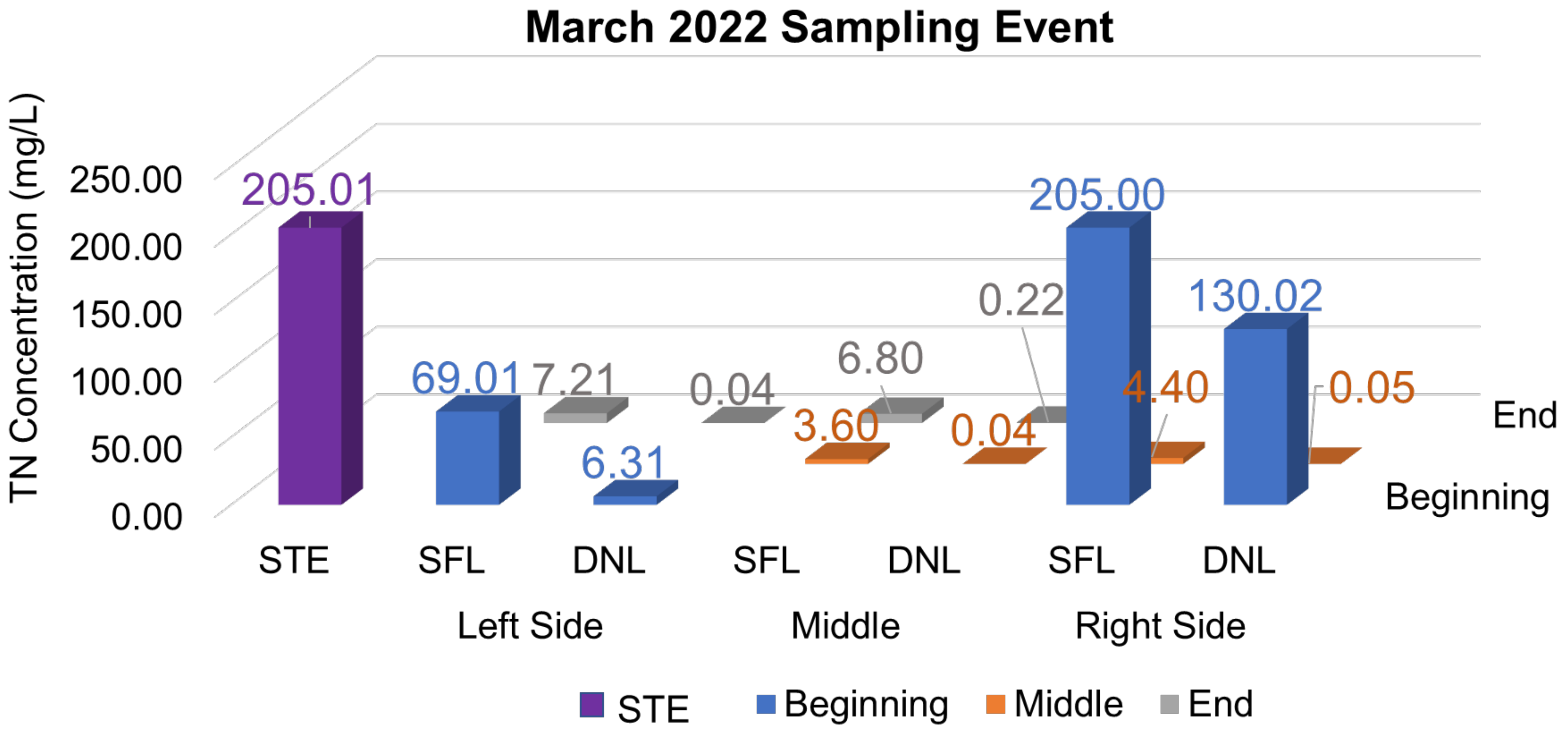
TN CONCENTRATION (MG/L)

SYSTEM 3

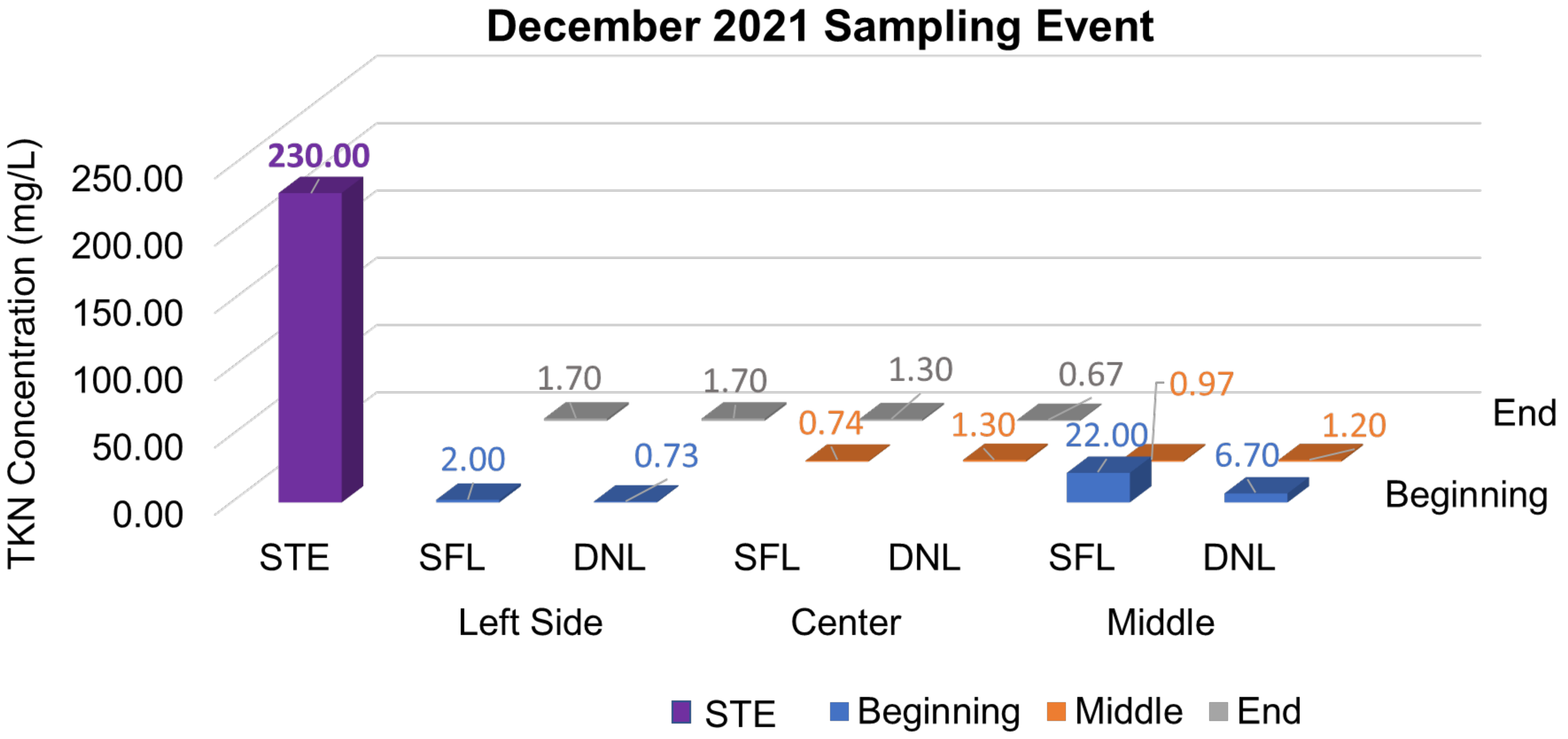


TN CONCENTRATION (MG/L)

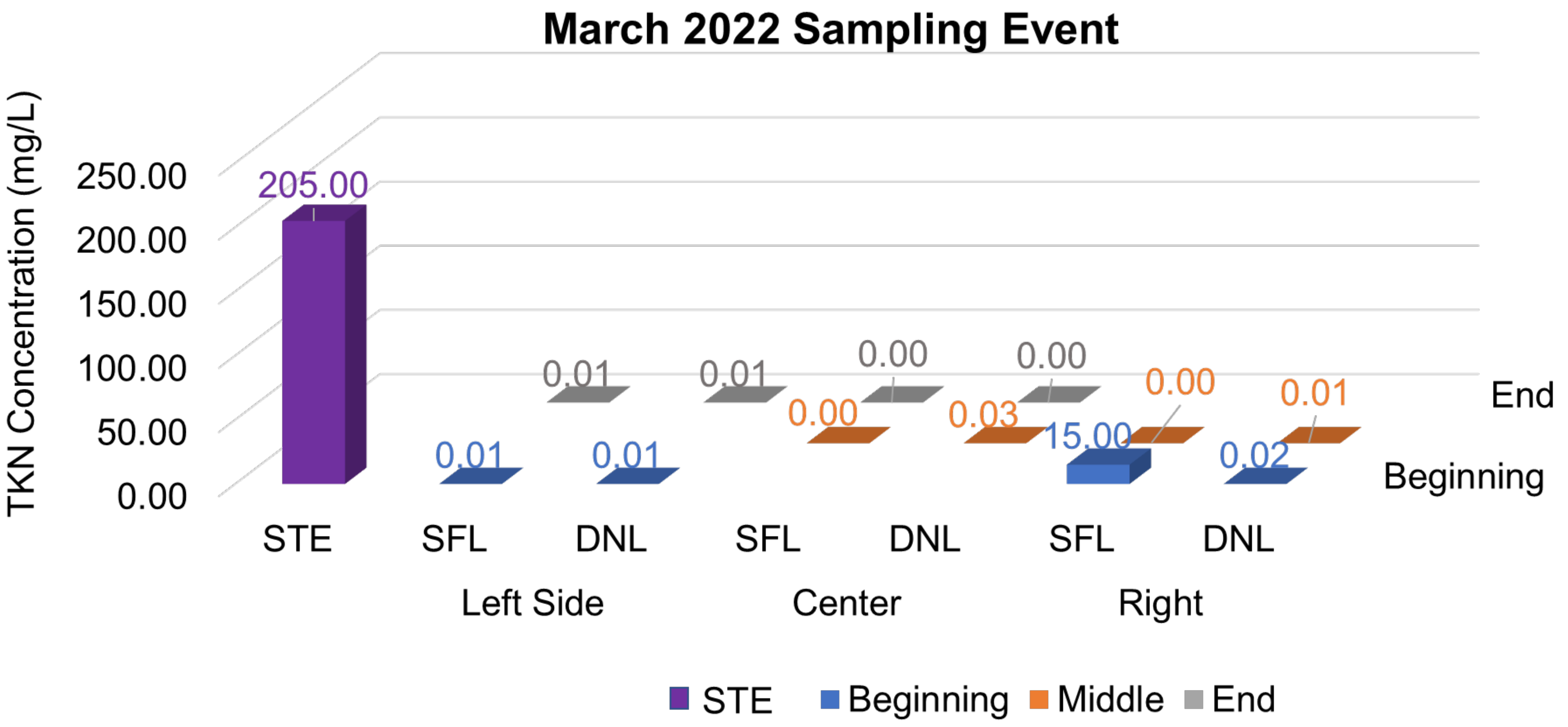
SYSTEM 3 (2)



TKN CONCENTRATION (MG/L)
SYSTEM 3

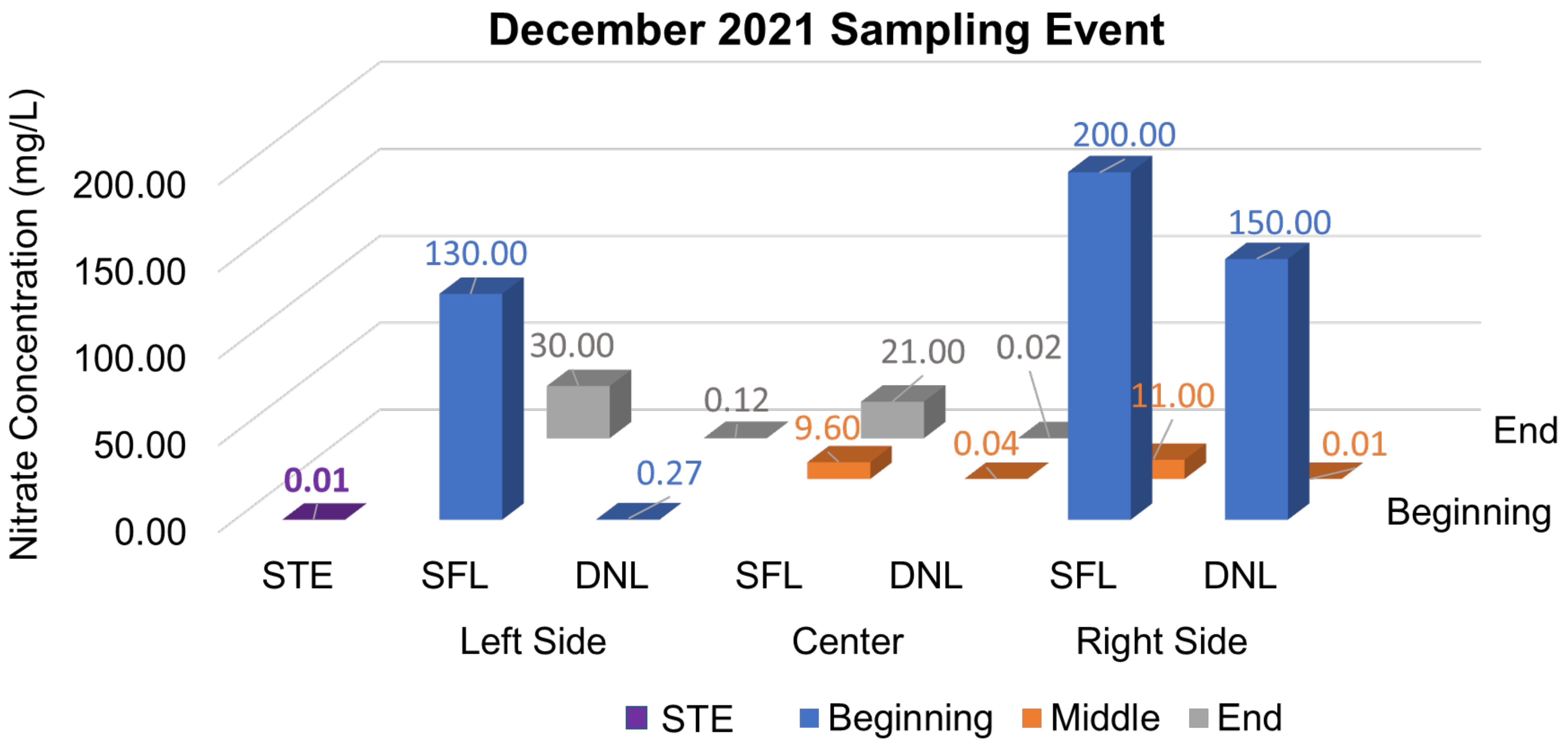


TKN CONCENTRATION (MG/L)
SYSTEM 3 (2)



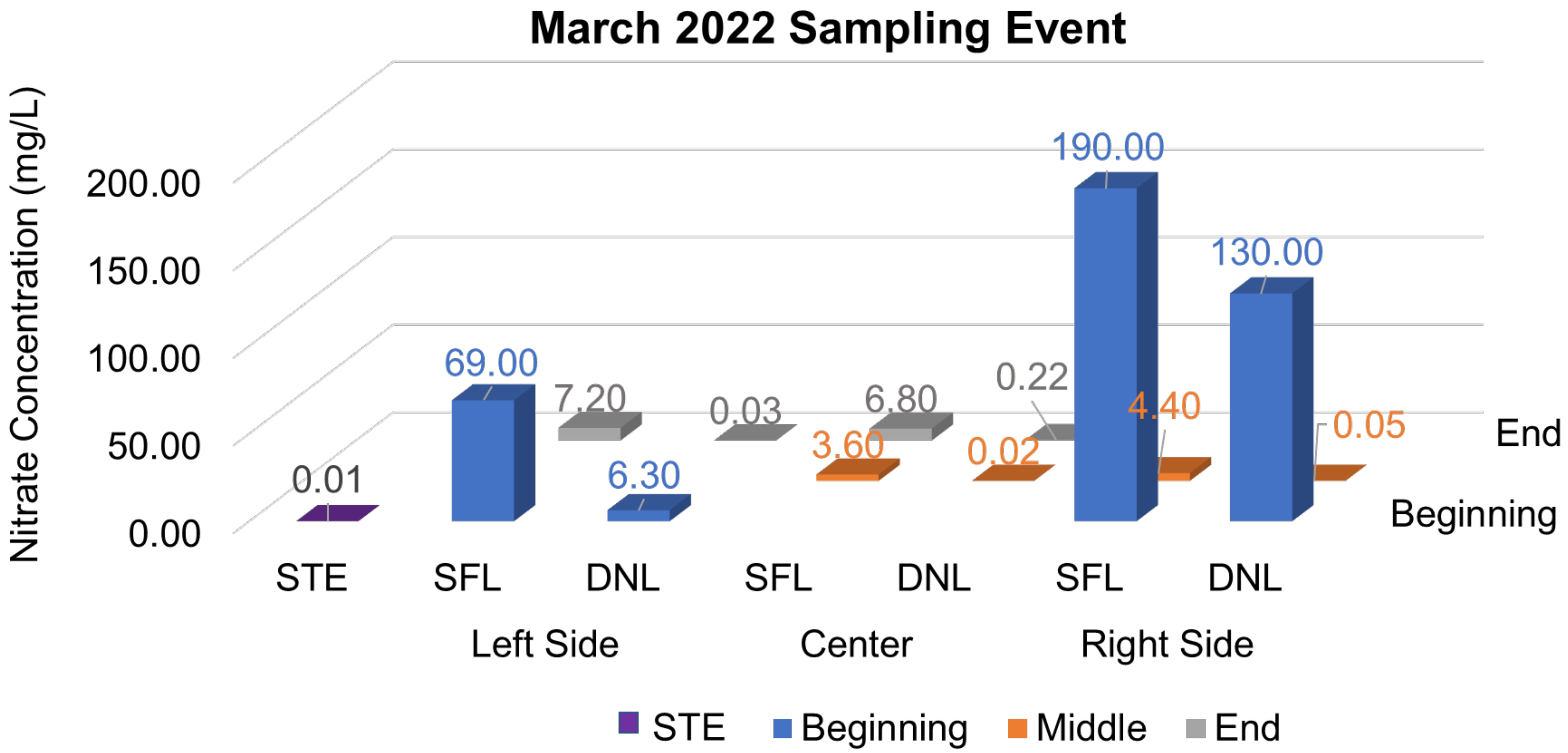
NO_X CONCENTRATION (MG/L)

SYSTEM 3



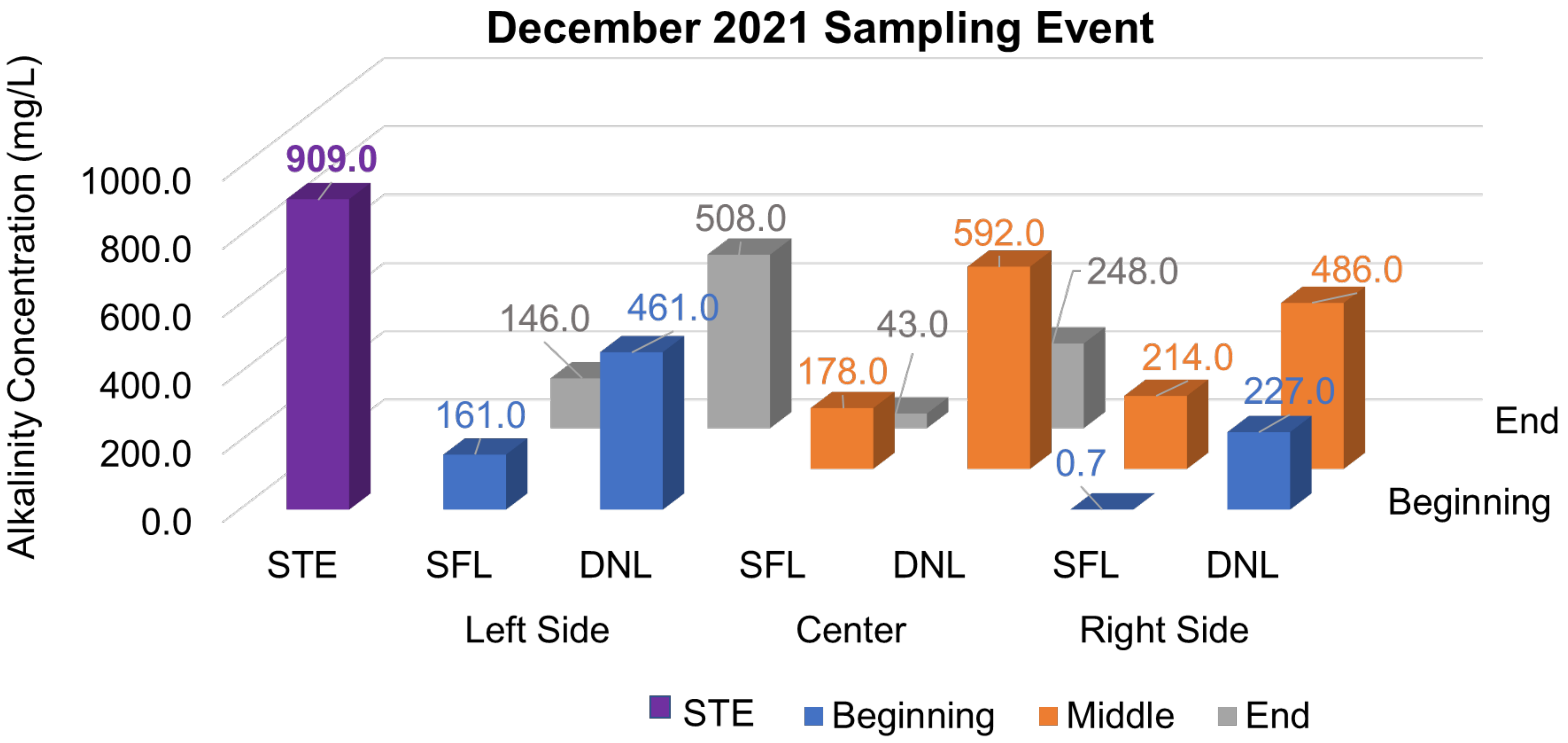
NO_X CONCENTRATION (MG/L)

SYSTEM 3 (2)



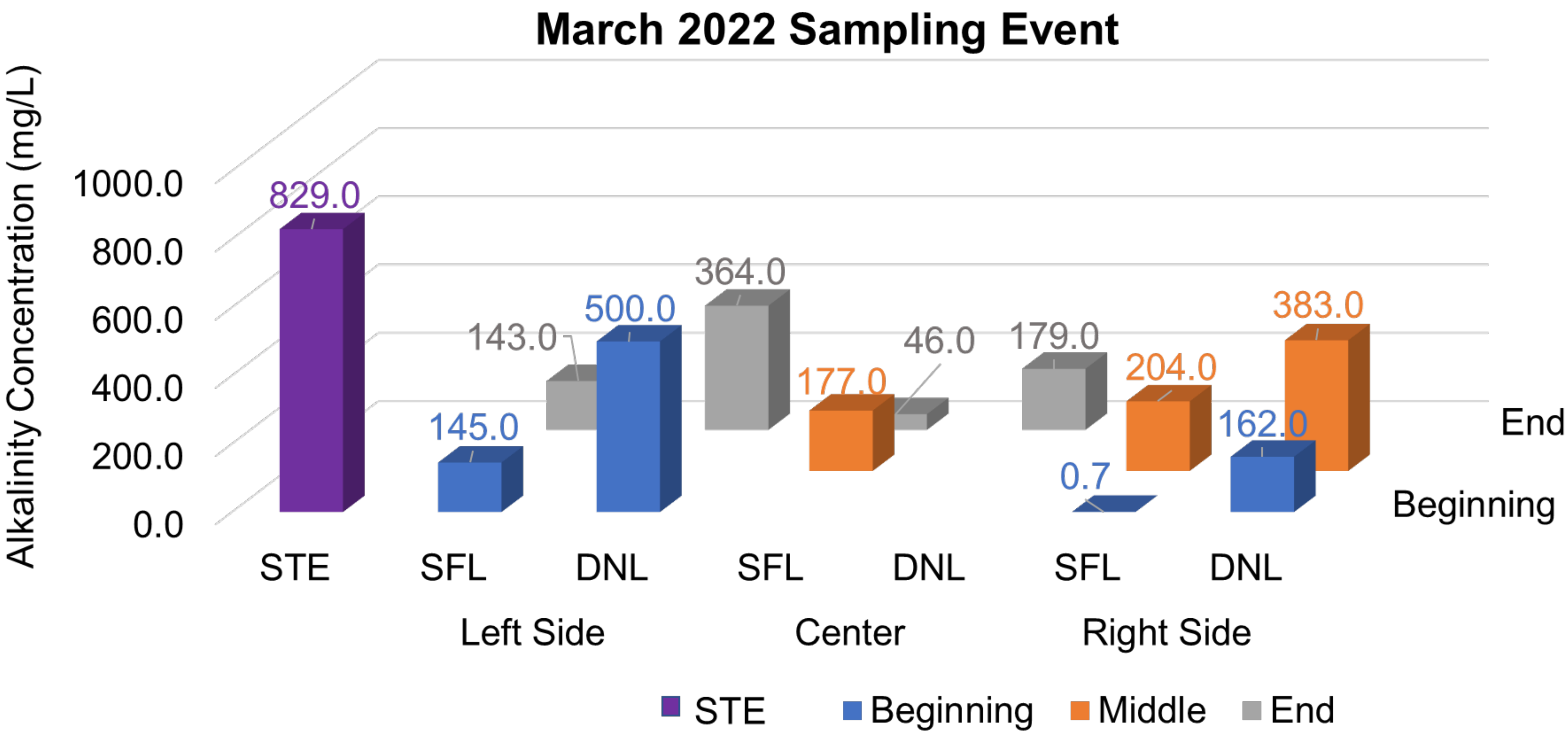
ALKALINITY CONCENTRATION (MG/L)

SYSTEM 3

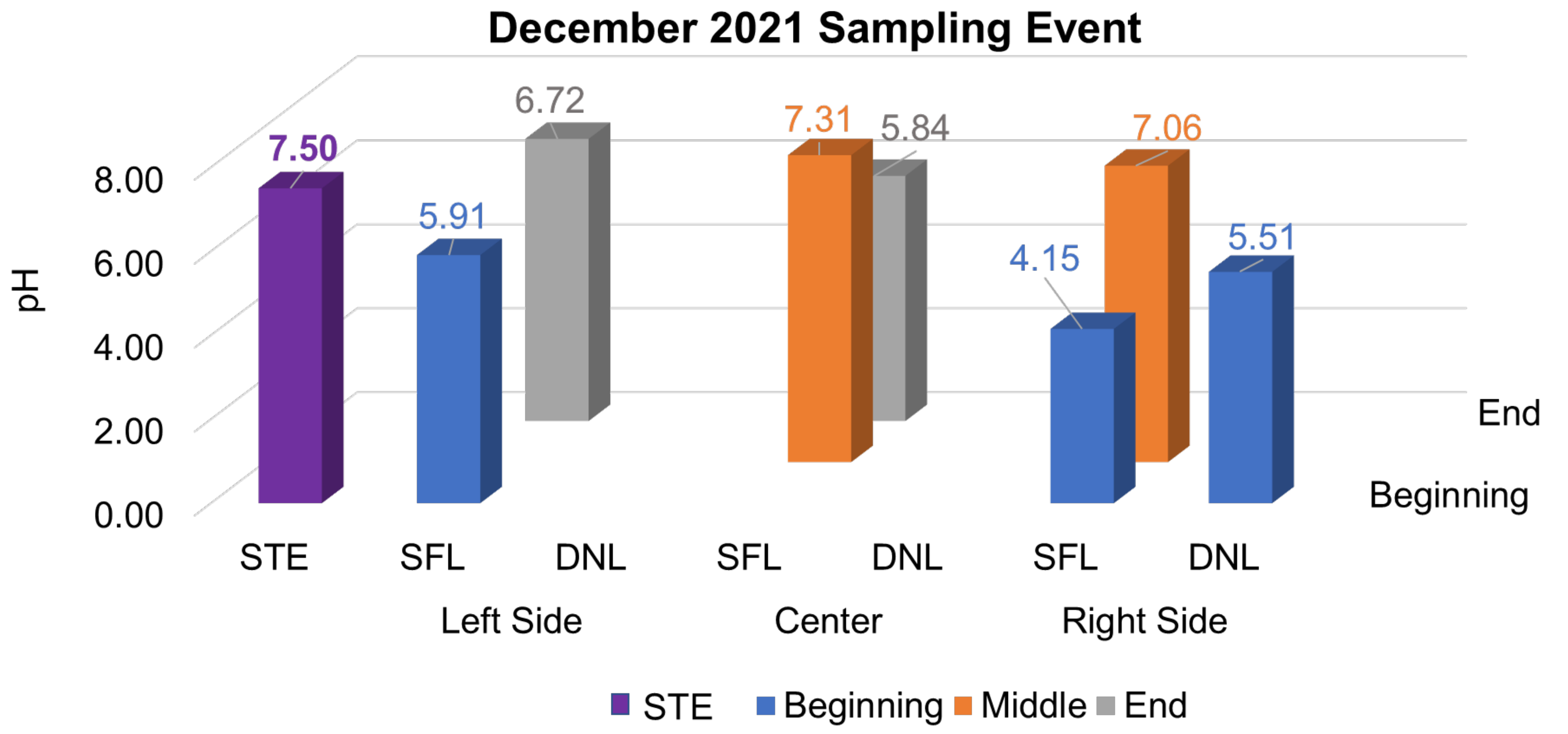


ALKALINITY CONCENTRATION (MG/L)

SYSTEM 3 (2)



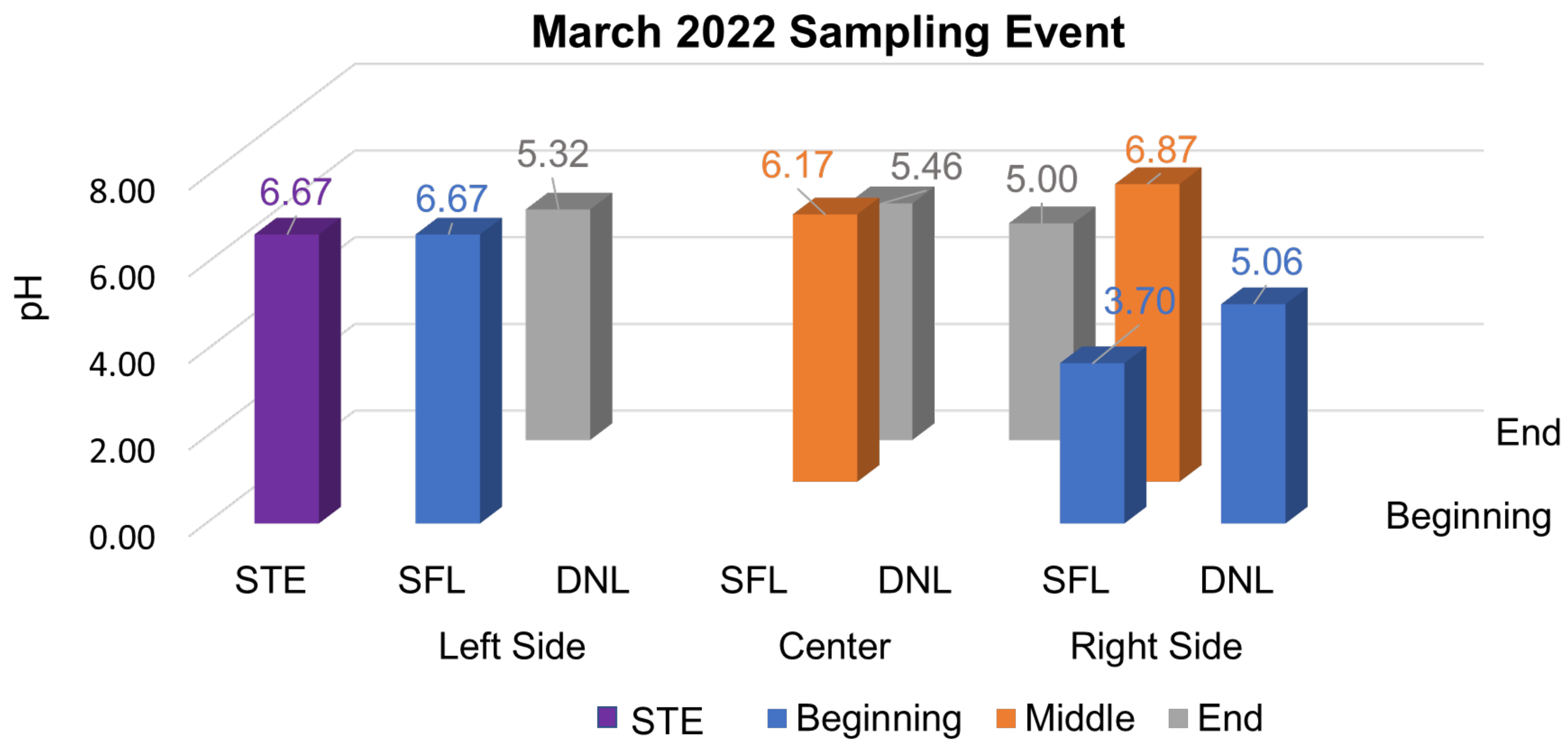
PH
SYSTEM 3



December 2021 Sampling Event
pH
8.00
6.00
4.00
2.00
0.00
7.50
5.91
6.72
7.31
5.84
4.15
7.06
5.51
End
Beginning
STE
SFL
DNL
SFL
DNL
SFL
DNL
Left Side
Center
Right Side
STE
Beginning
Middle
End

PH

SYSTEM 3 (2)



March 2022 Sampling Event
pH
8.00
6.00
4.00
2.00
0.00
6.67
6.67
5.32
6.17
5.46
5.00
6.87
3.70
5.06
End
Beginning
STE
SFL
DNL
SFL
DNL
SFL
DNL
Left Side
Center
Right Side
STE
Beginning
Middle
End

NITROGEN REDUCING EFFICIENCY

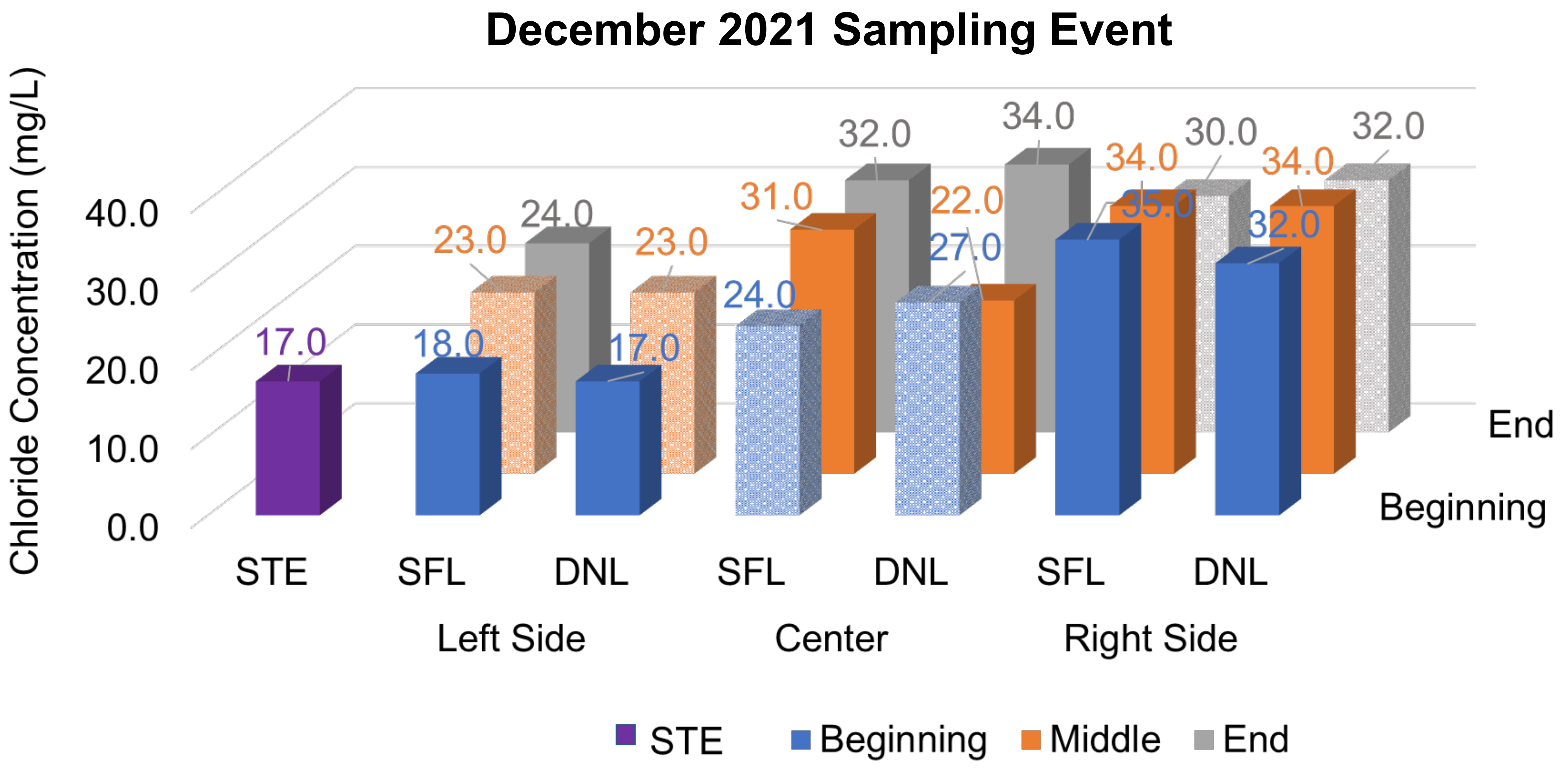
SYSTEM 3

Sampling Event	STE (mg/L)	Left Side (mg/L)	Right Side (mg/L)	Mean Effluent Concentration (mg/L)	Treatment Efficiency
December 2021	**230.00**	1.00	156.70	**78.85**	**65.7%**
March 2022	**205.01**	6.31	130.02	**68.17**	**66.7%**

NITROGEN REDUCTION IN SYSTEM 4

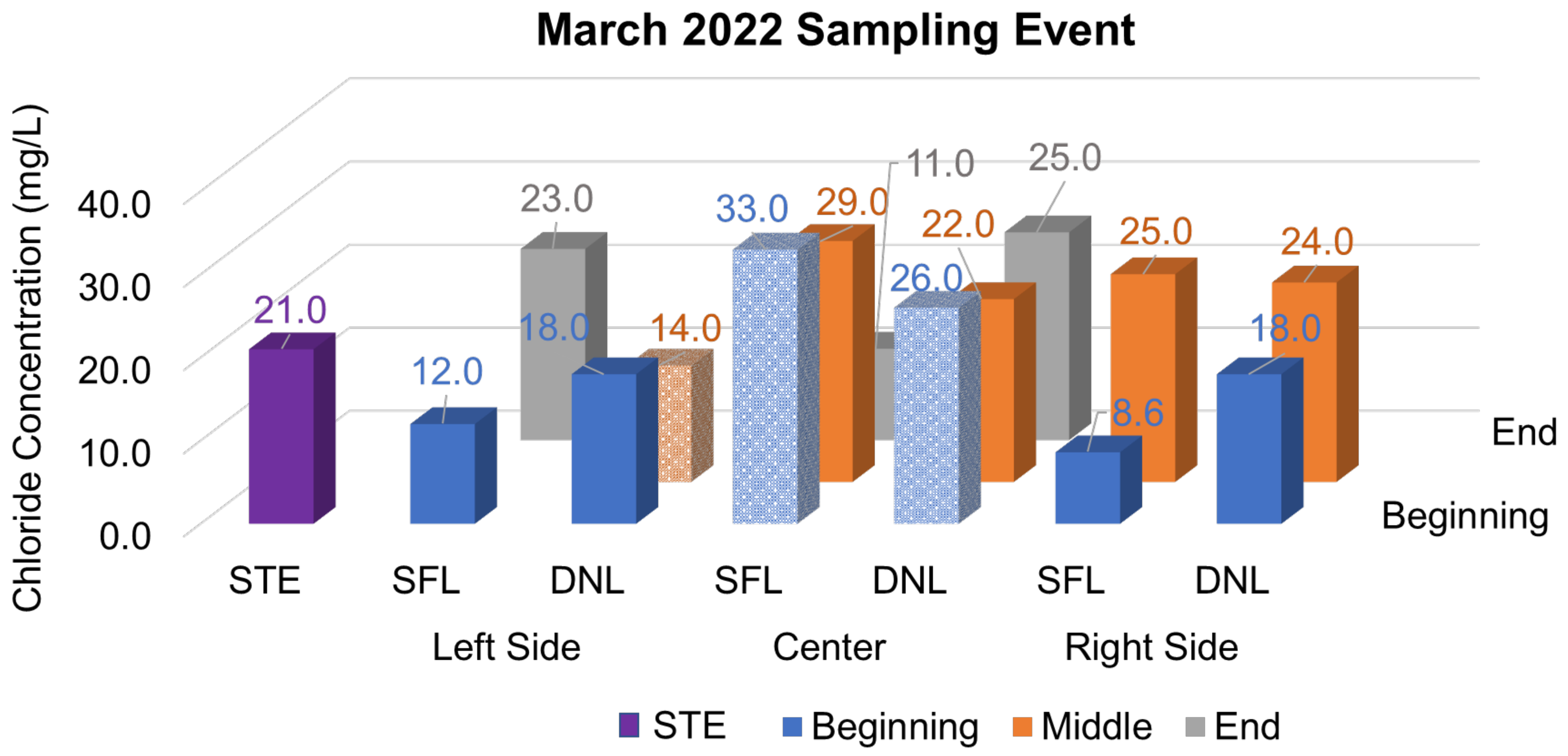
Lysimeter Results

CHLORIDE CONCENTRATION (MG/L)
SYSTEM 4

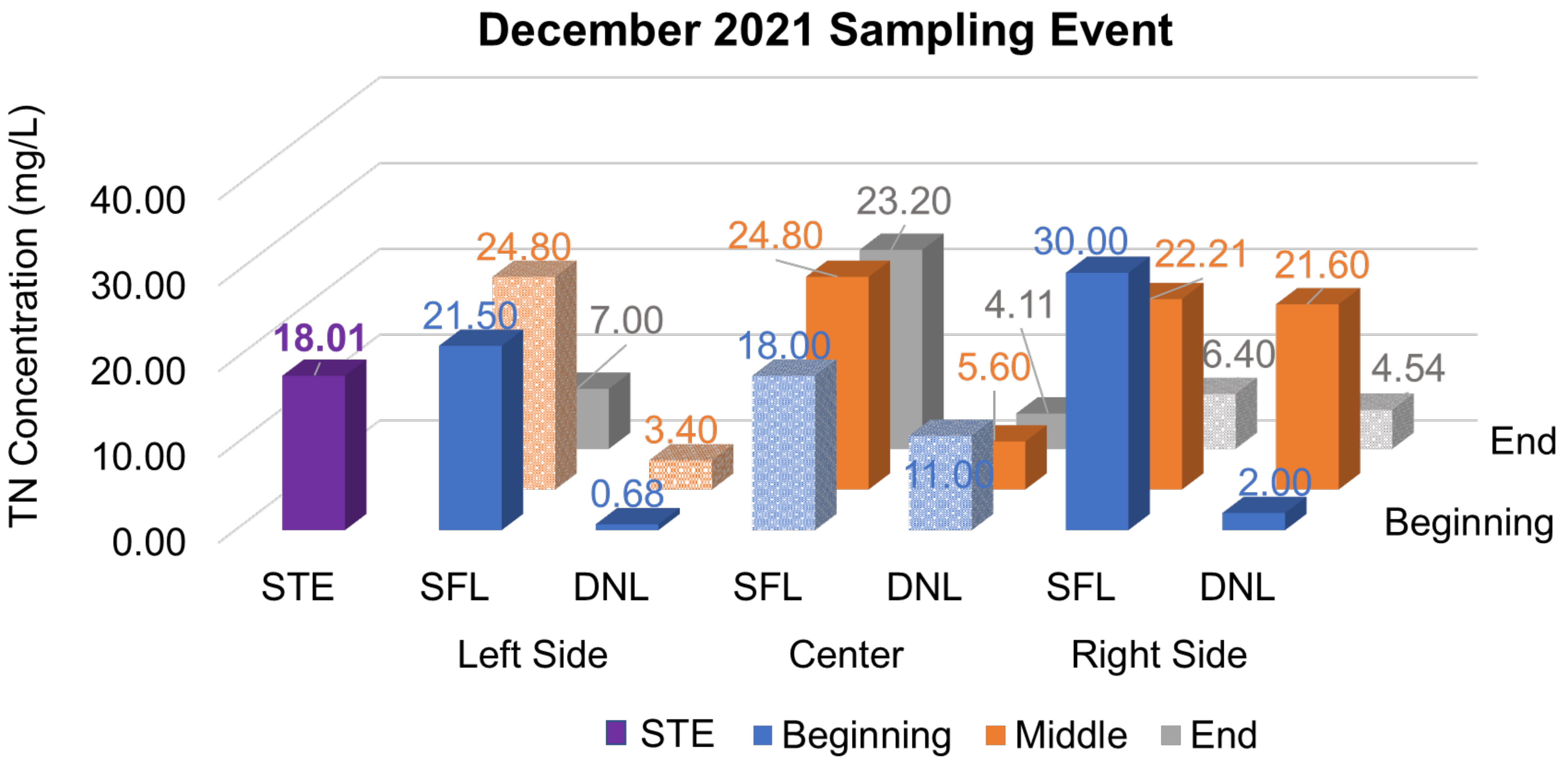


CHLORIDE CONCENTRATION (MG/L)

SYSTEM 4 (2)

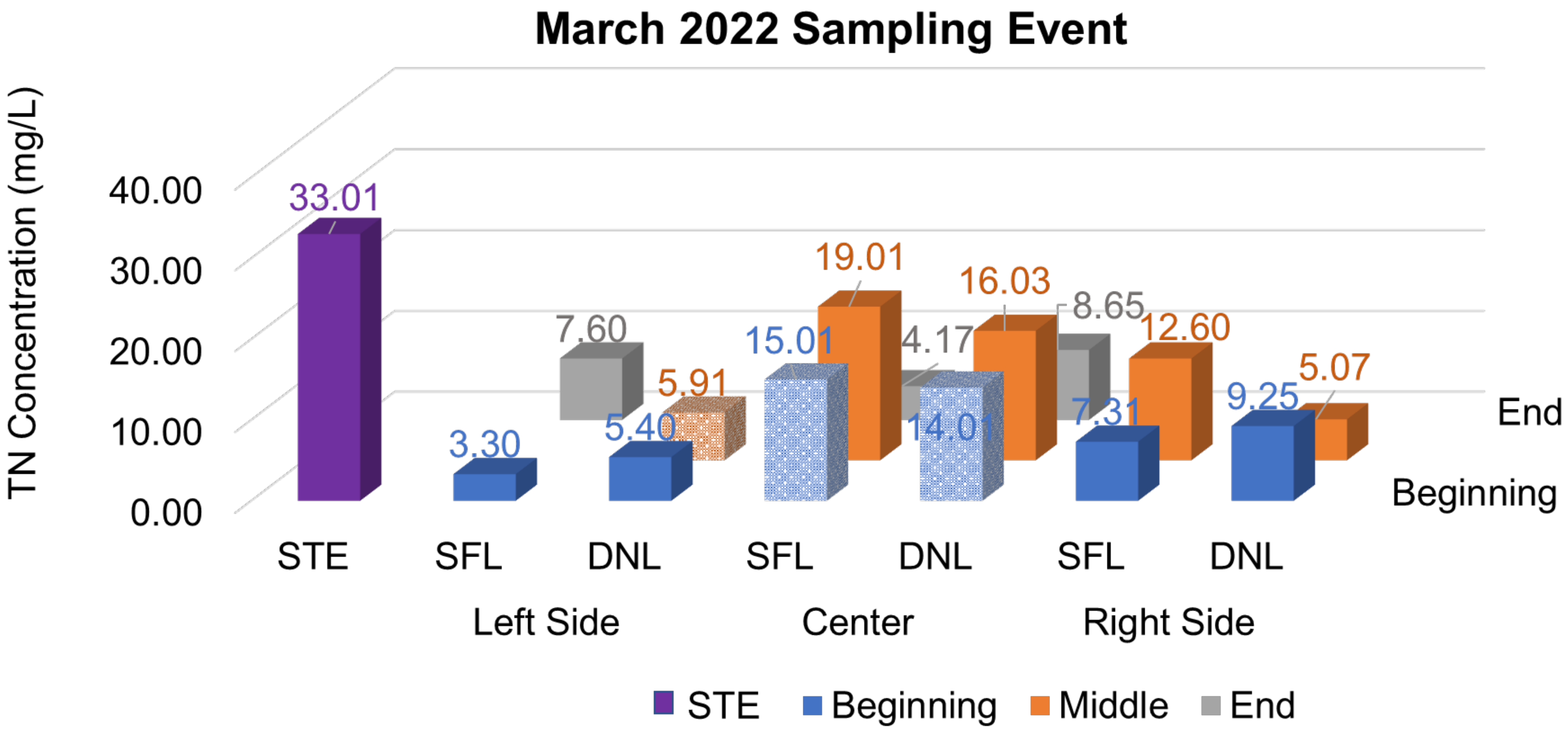


TN CONCENTRATION (MG/L)
SYSTEM 4

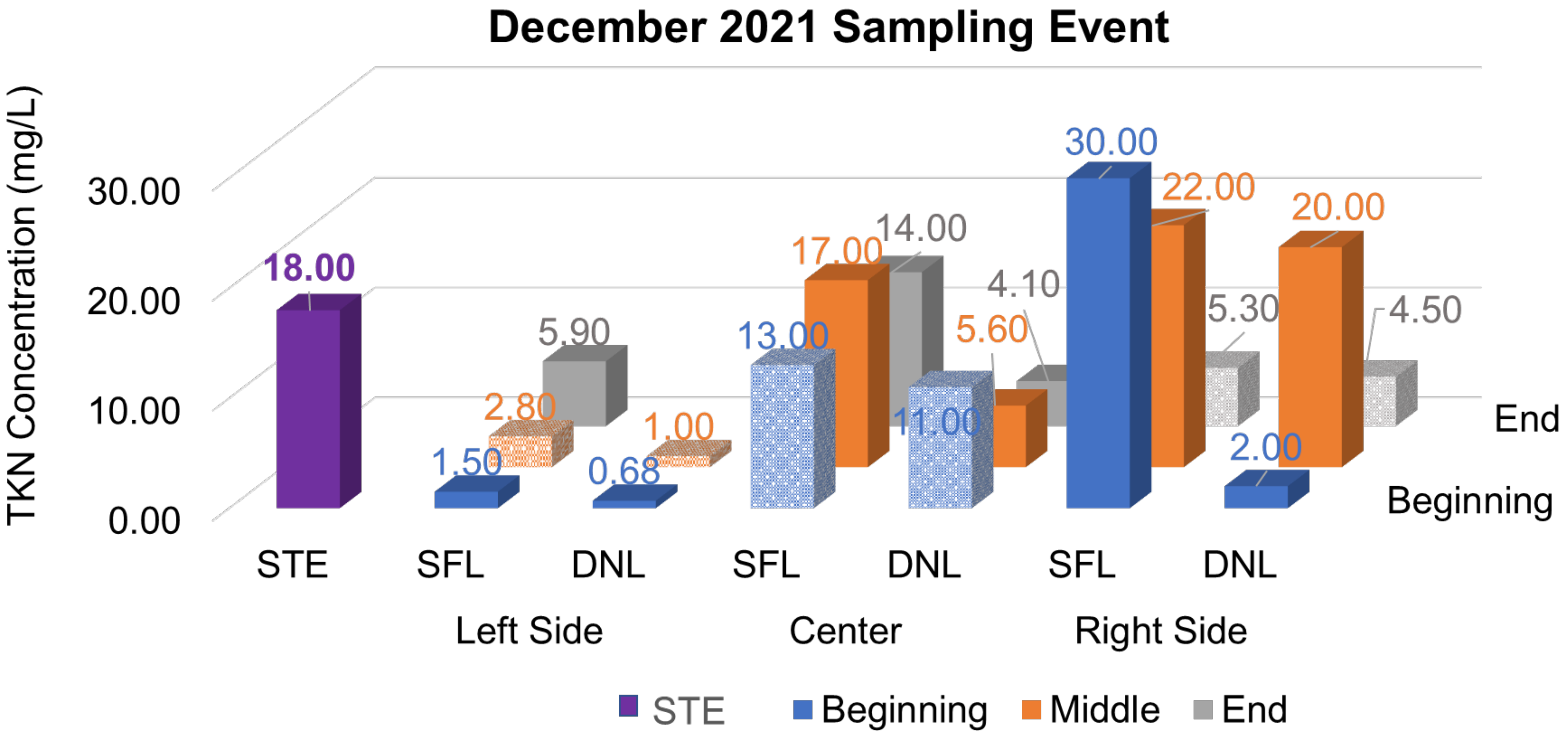


TN CONCENTRATION (MG/L)

SYSTEM 4 (2)

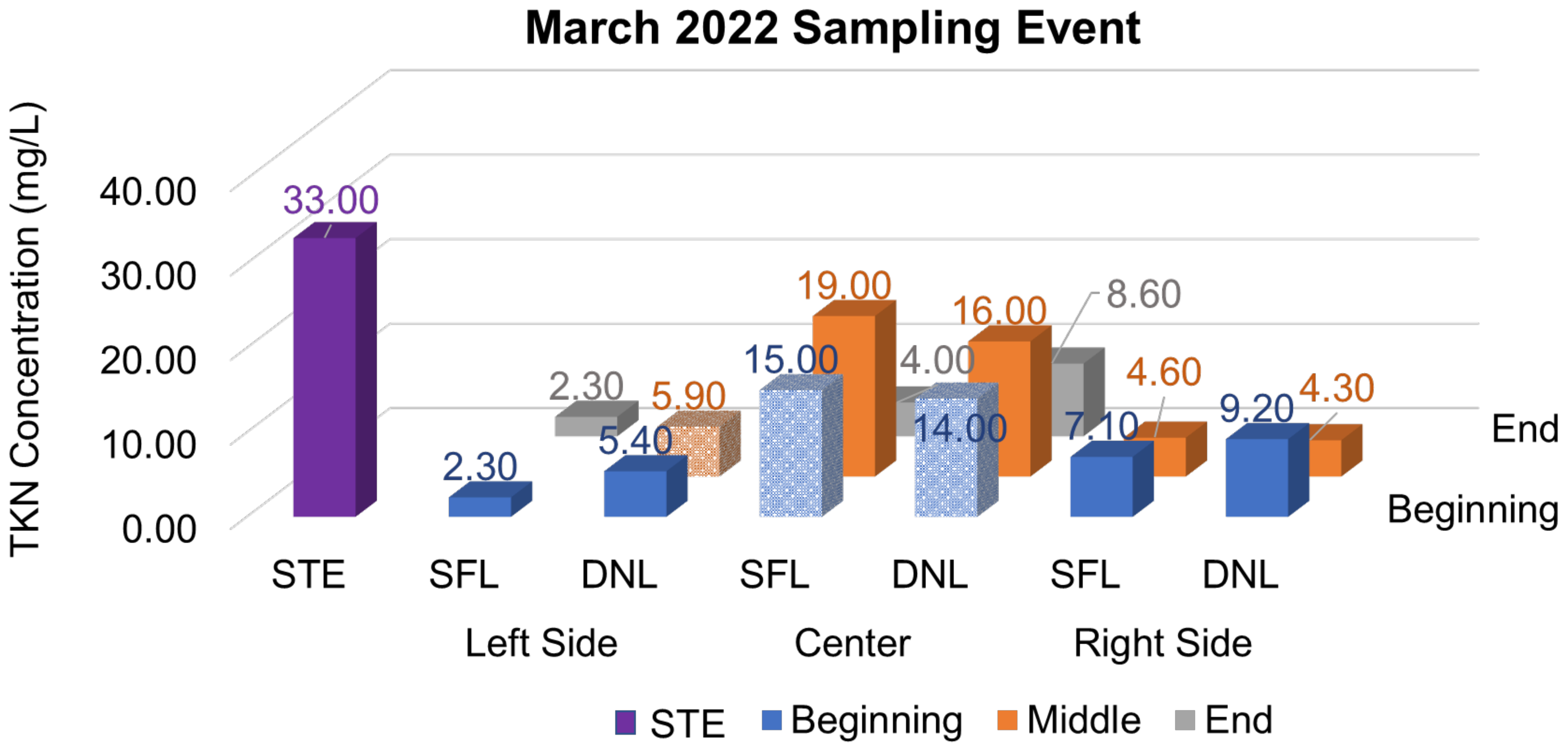


TKN CONCENTRATION (MG/L)
SYSTEM 4



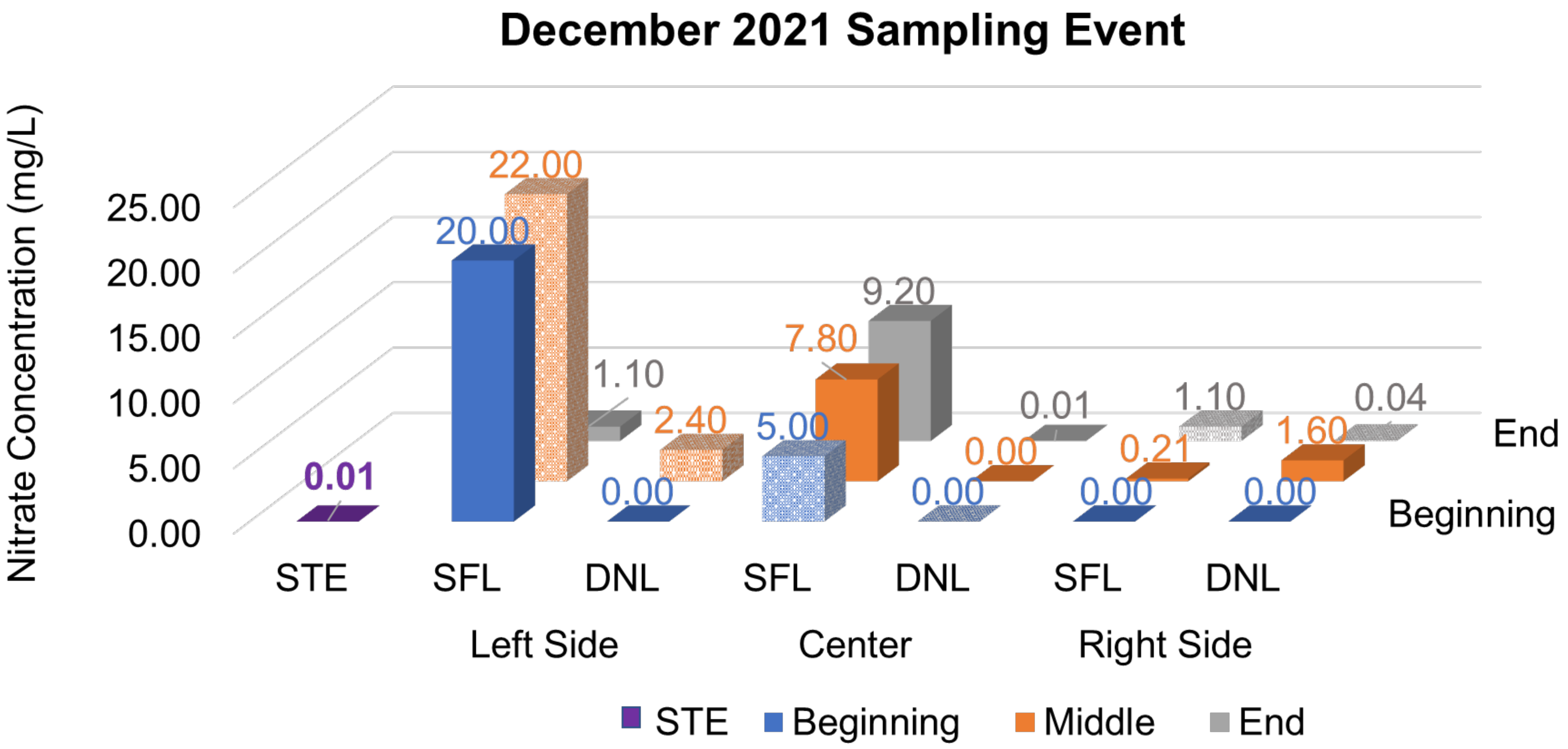
TKN CONCENTRATION (MG/L)

SYSTEM 4 (2)



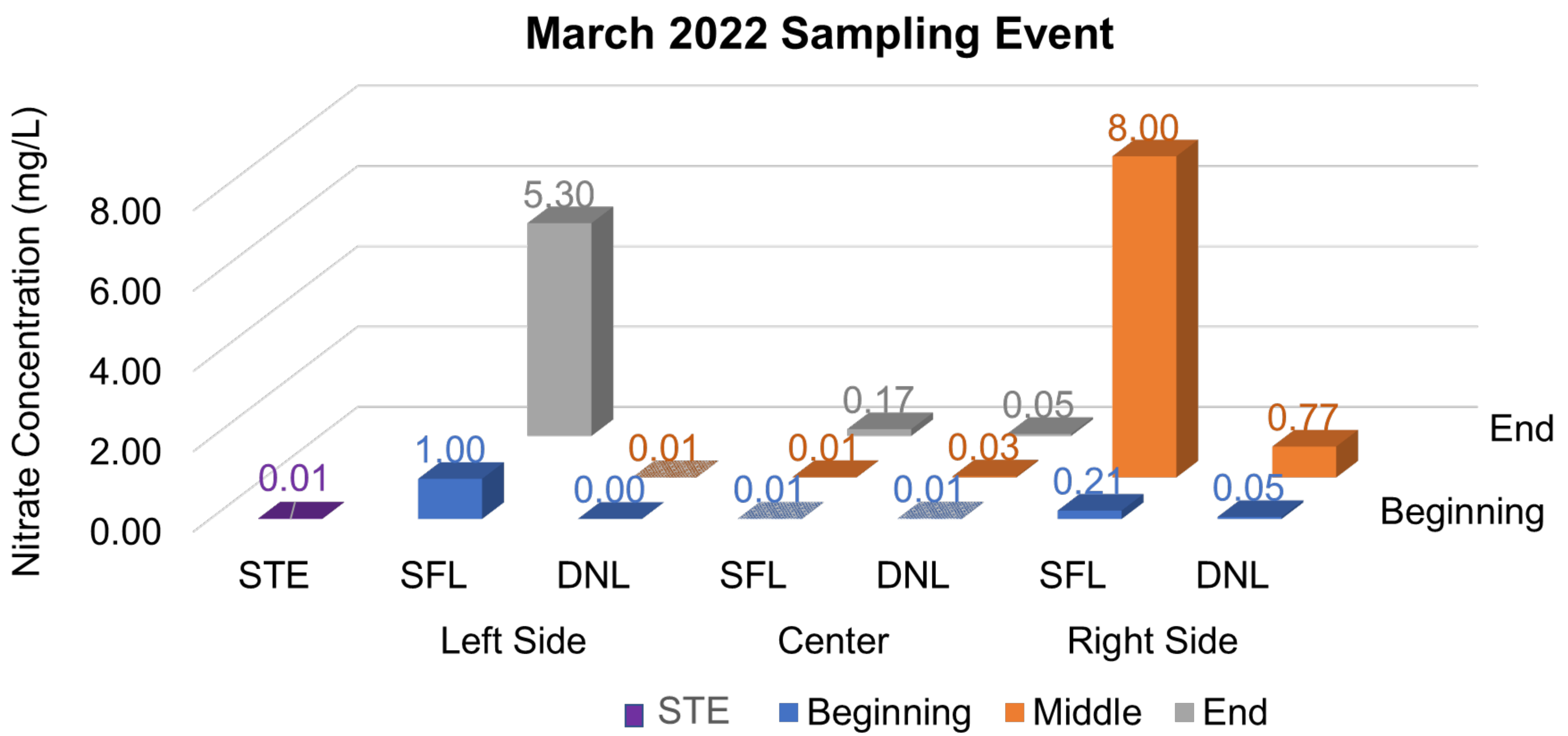
NO_X CONCENTRATION (MG/L)

SYSTEM 4



NO_X CONCENTRATION (MG/L)

SYSTEM 4 (2)

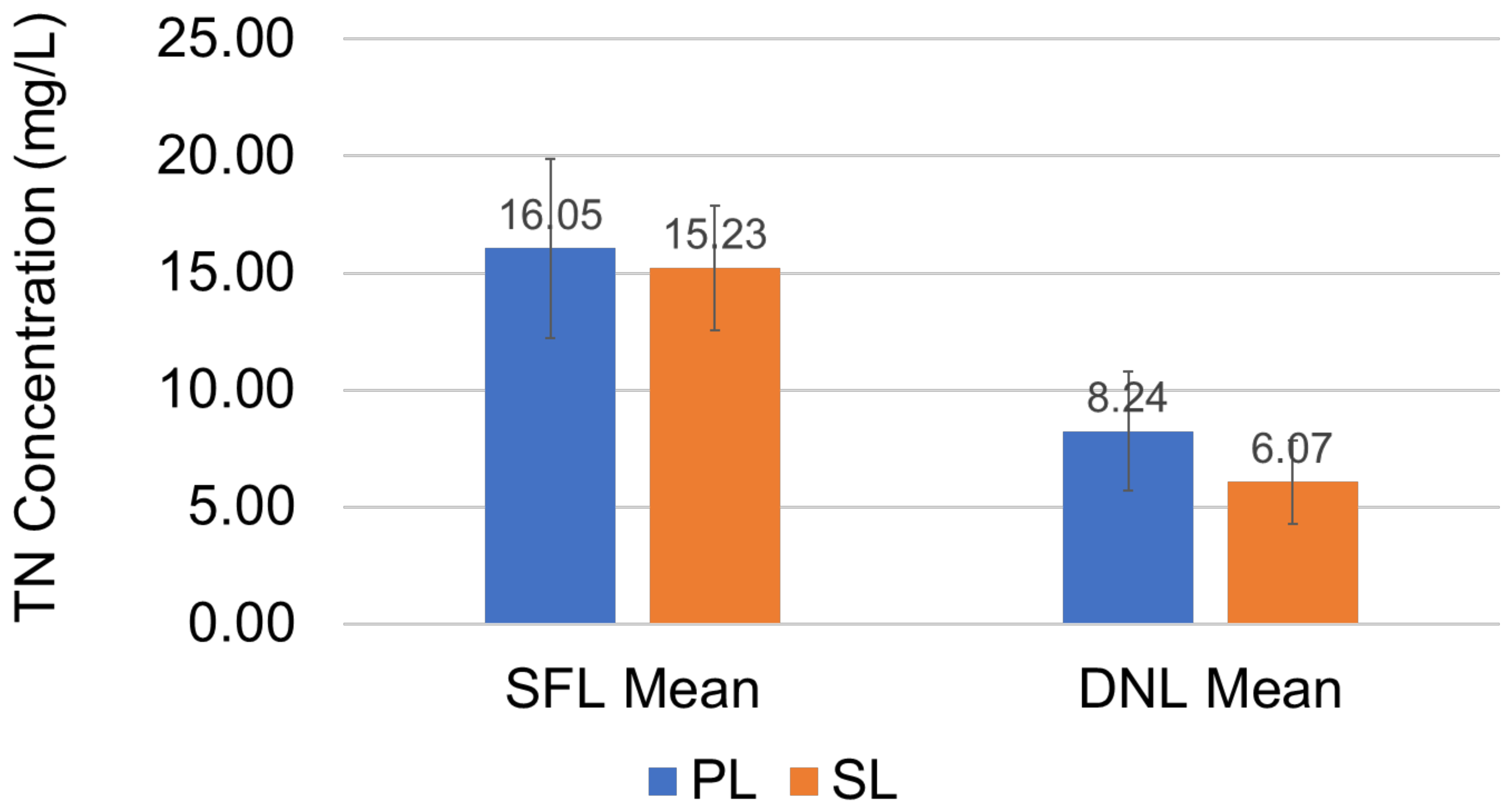


NITROGEN REDUCING EFFICIENCY

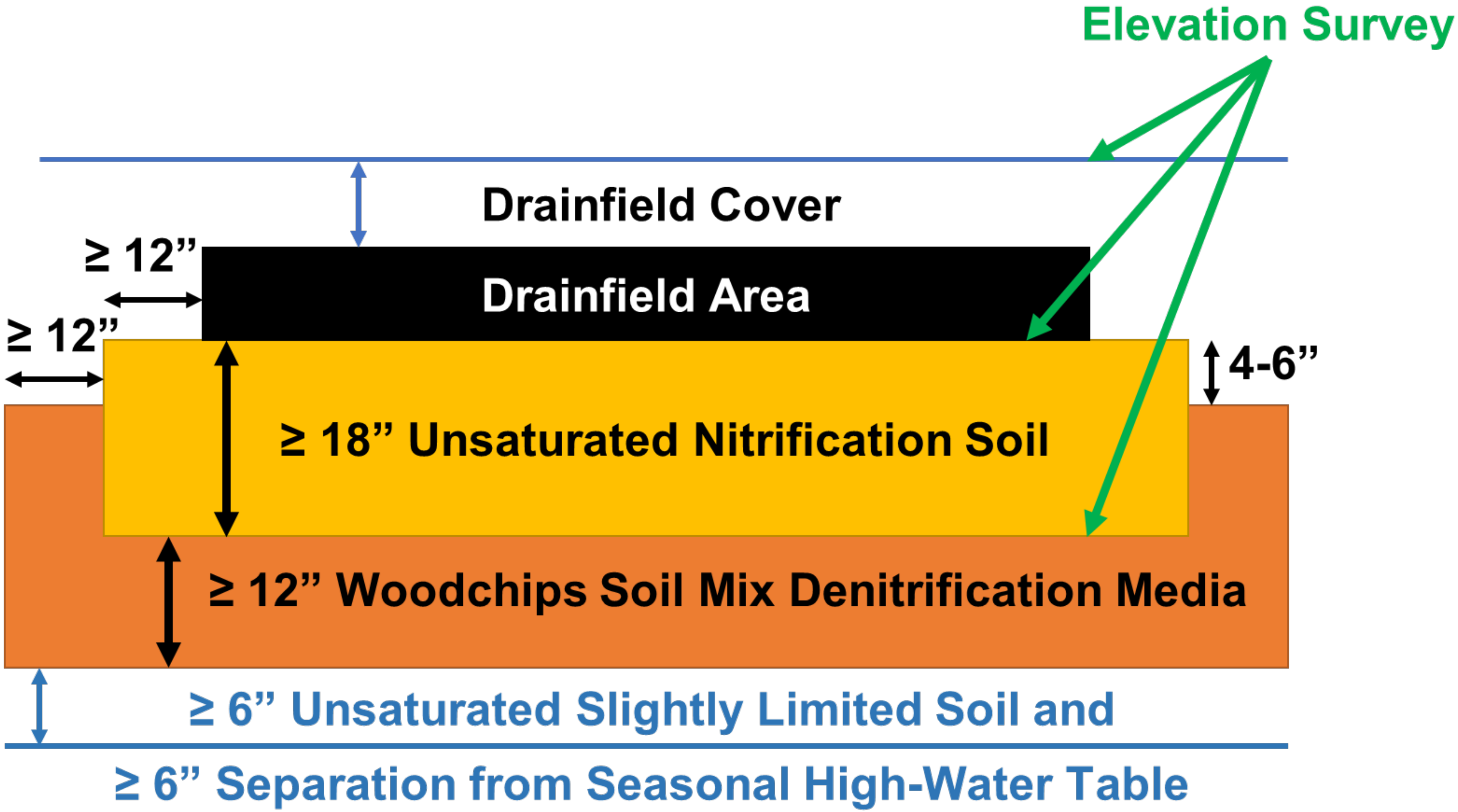
SYSTEM 4

Sampling Event	Location in Drainfield	Left Side (mg/L)	Center (mg/L)	Right Side (mg/L)	Mean Effluent Concentration (mg/L)	Treatment Efficiency
12/2021	Begin	0.68	11.00	2.00		
12/2021	Middle	3.04	5.60	21.60		
12/2021	End		4.11	4.54		
12/2021	Drainfield Mean				**6.57**	
12/2021	STE				**18.01**	**62.7%**
3/2022	Begin	5.4	14.0	9.3		
3/2022	Middle	5.9	16.0	5.1		
3/2022	End		8.7			
3/2022	Drainfield Mean				**9.20**	
3/2022	STE				**33.0**	**72.1%**

COMPARE MEAN TN FROM SL AND PL AT SYSTEM 4

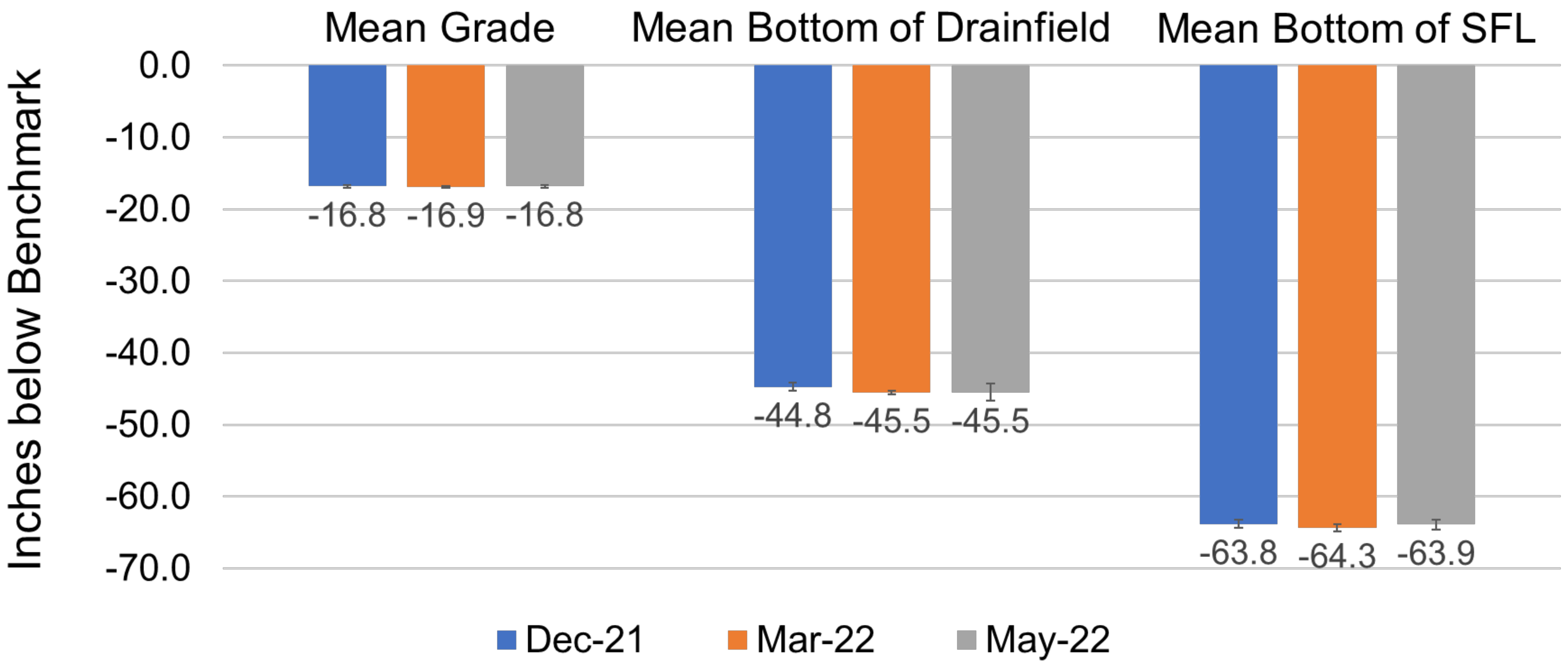


ELEVATION CHANGE OF SYSTEM LAYERS



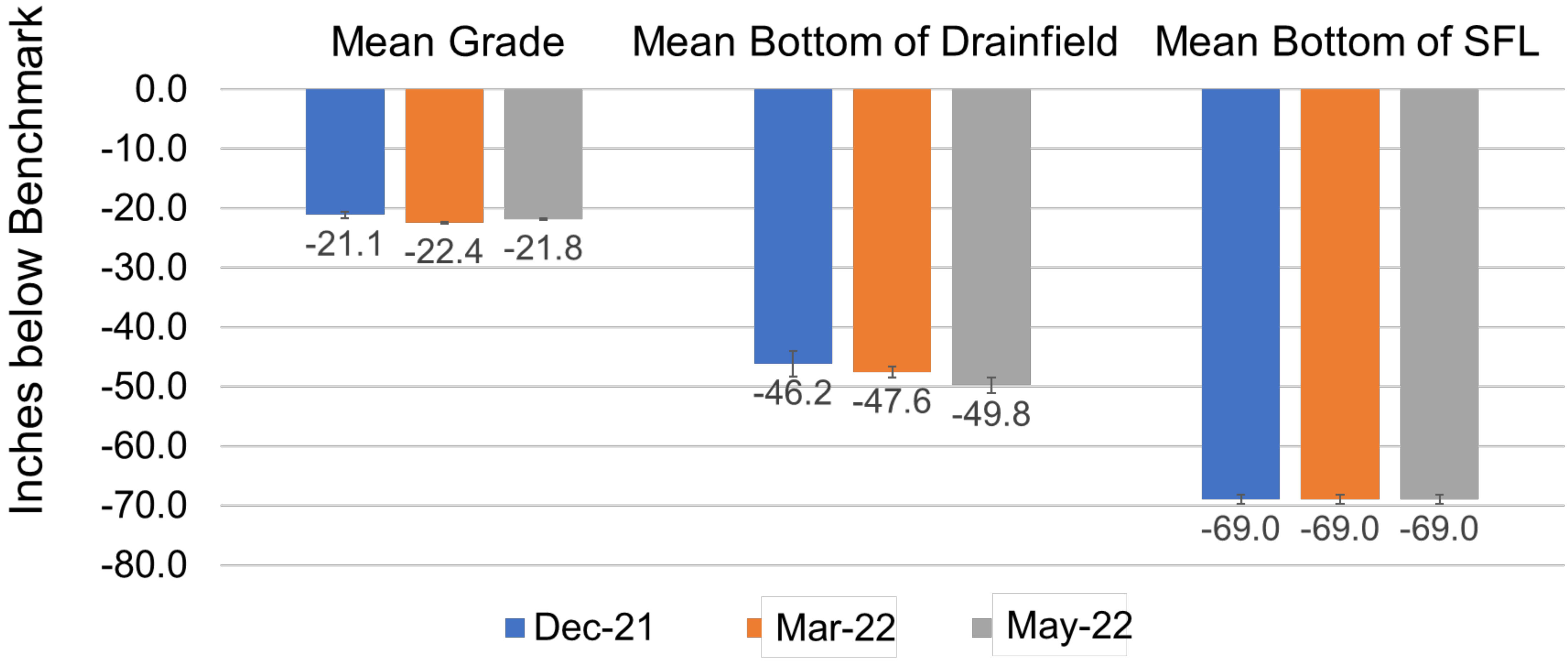
ELEVATION CHANGE OF SYSTEM LAYERS

SYSTEM 3



ELEVATION CHANGE OF SYSTEM LAYERS

SYSTEM 4



SUMMARY

- The sampled INRB systems reduced nitrogen from the septic tank effluent by about 63% to 72%.
- TN concentrations measured from the PL and SL at System 4 did not show a significant difference, suggesting that SL and PL can produce comparable results.
- Results from three monitoring events of elevations at finished grade, bottom of drainfield, and bottom of sand fill layer did show most changes at bottom of drainfield in System 4, and little change elsewhere during the first year of operation.

SUMMARY (2)

- The results from System 3 show uneven distribution of wastewater across the drainfield.
- Uneven distribution of wastewater across the drainfield may negatively impact the nitrogen-reducing efficiency.
- The results from System 4 showed accumulation of water in the sand fill layer and nitrification was incomplete. Still, between 63% and 72% of the nitrogen was removed.
- Longer sampling and sampling of more systems are needed to evaluate more thoroughly the performance of the INRBs.

THANK YOU

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