United States Environmental Protection Agency

Long-term monitoring of macronutrients in infiltrate from three types of permeable pavement

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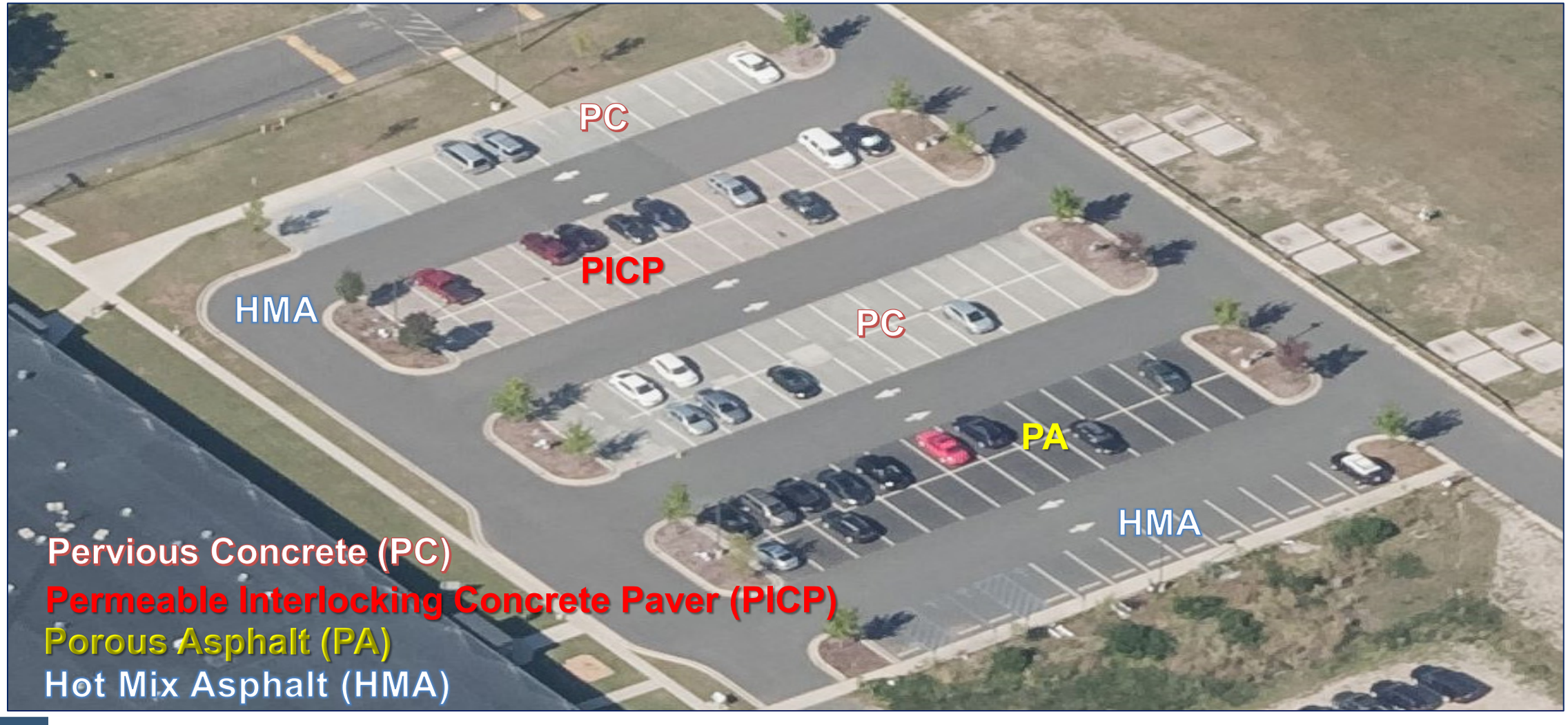
Research goals

1. What is the long term effect of three types of side by side permeable pavements on nutrient infiltrate concentrations?



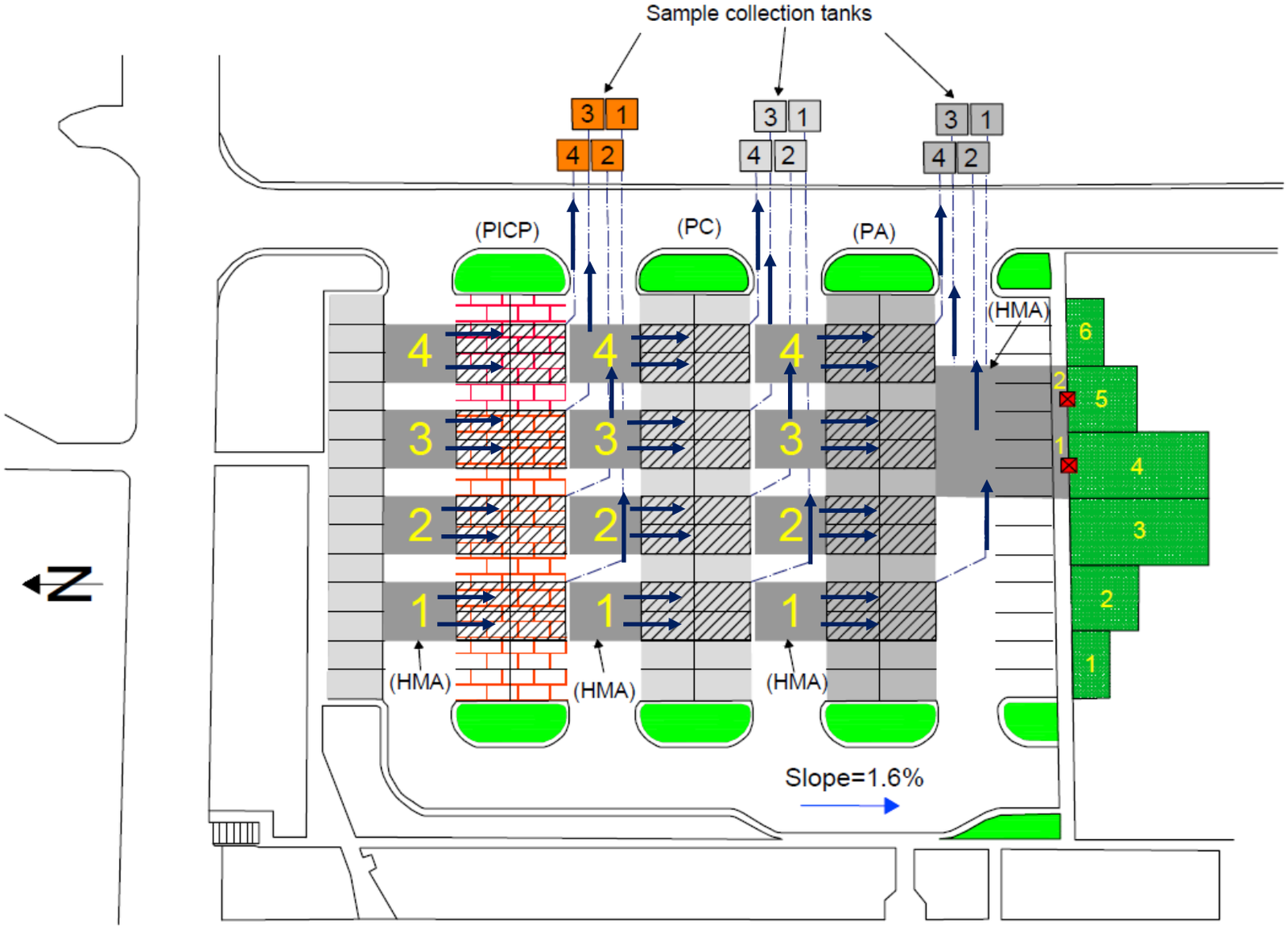
2. What are the macronutrient concentration trends with time?
3. What are the effects of the air temperature on infiltrate concentrations?

EPA completed construction of the 110 space (0.4 ha) parking lot in 2010. The surface incorporates three permeable pavements.



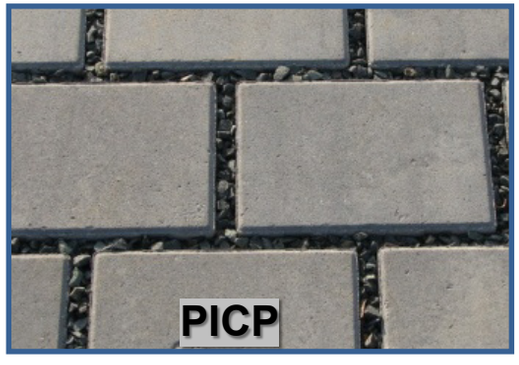
Source: www.bing.com

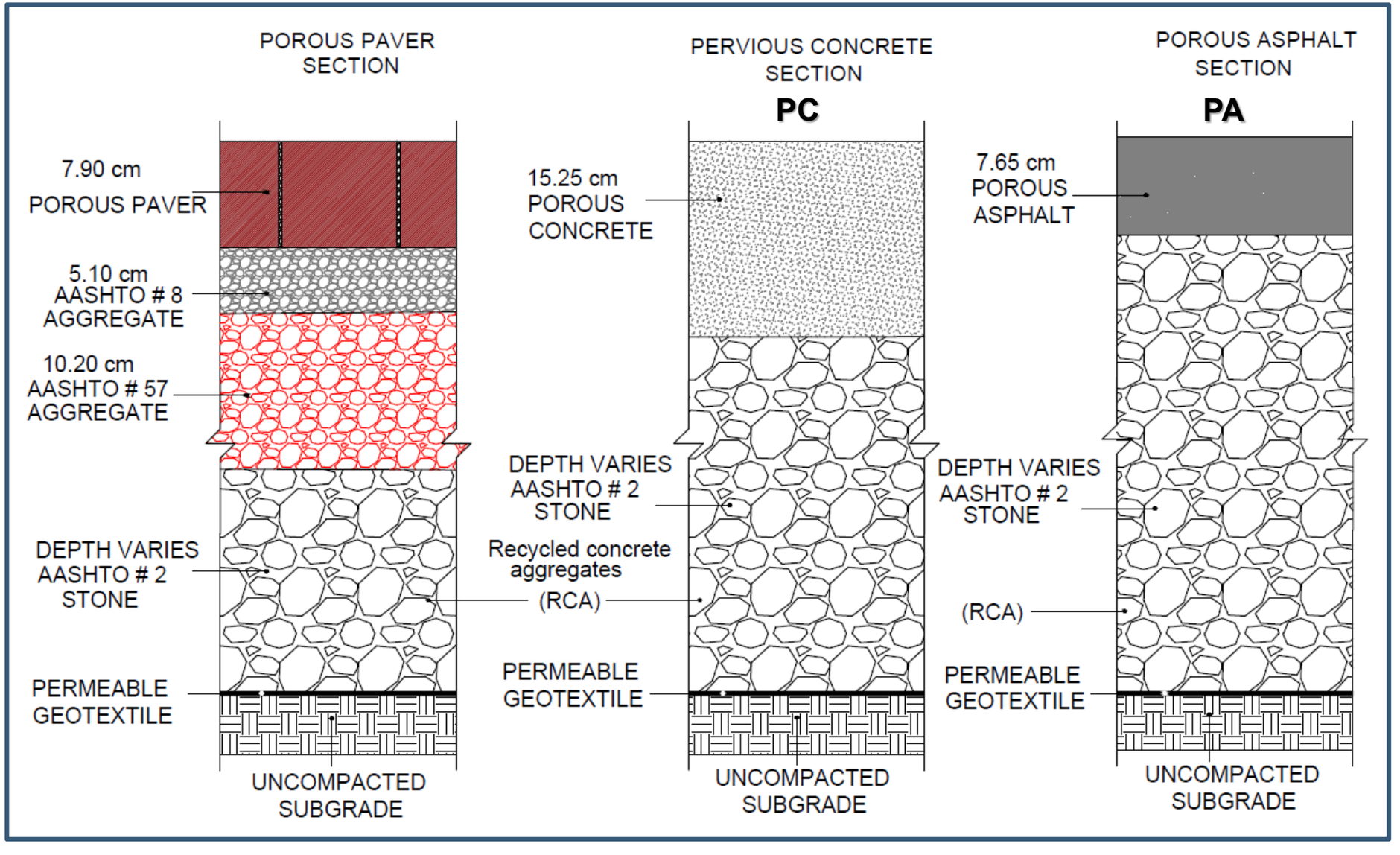
Where samples have been collected since parking lot opening.



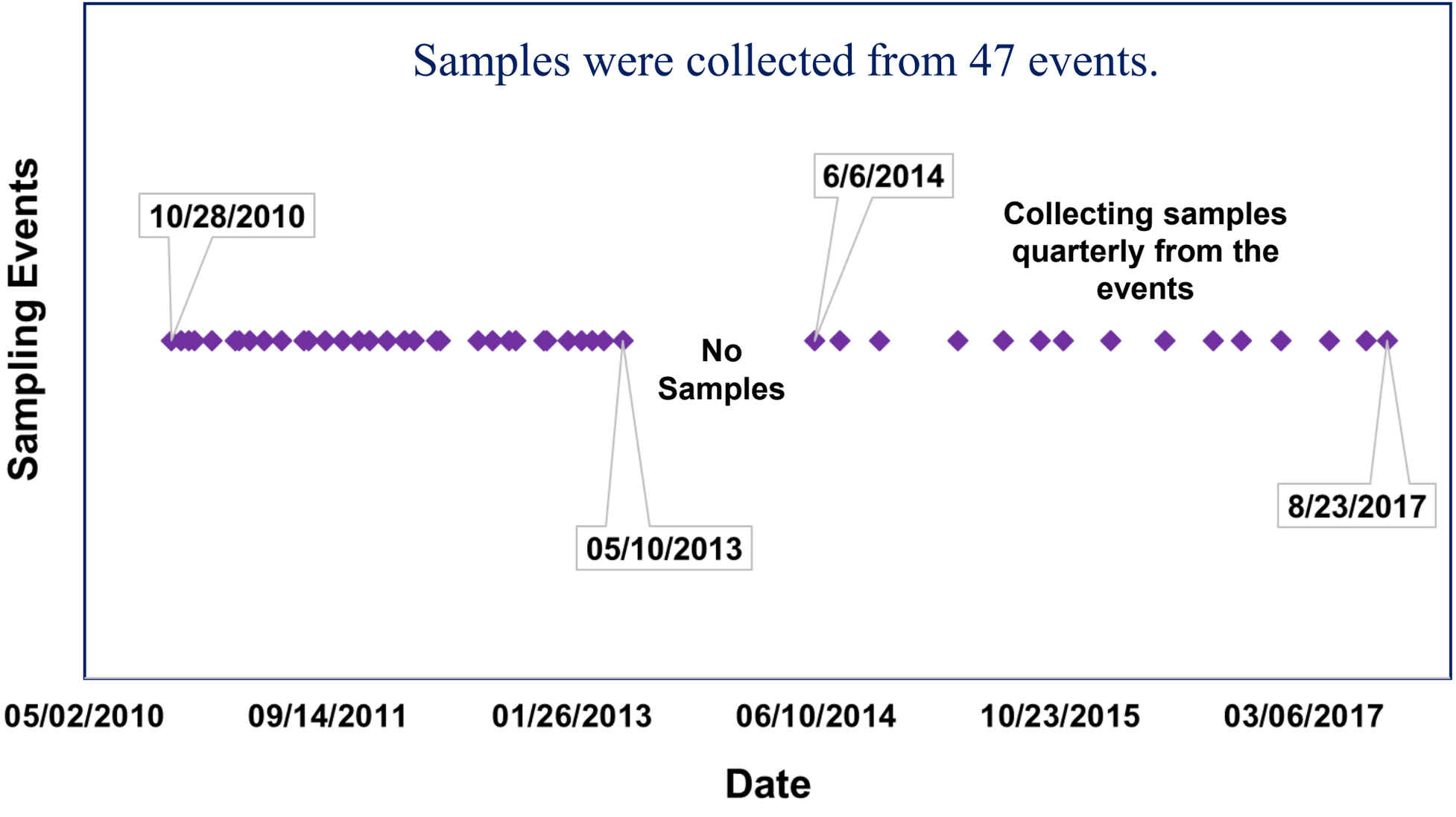
Infiltrate is routed to 5,700-L collection tanks that can fully capture events up to 38 mm.

Profiles of underground layers of three types of permeable pavements.





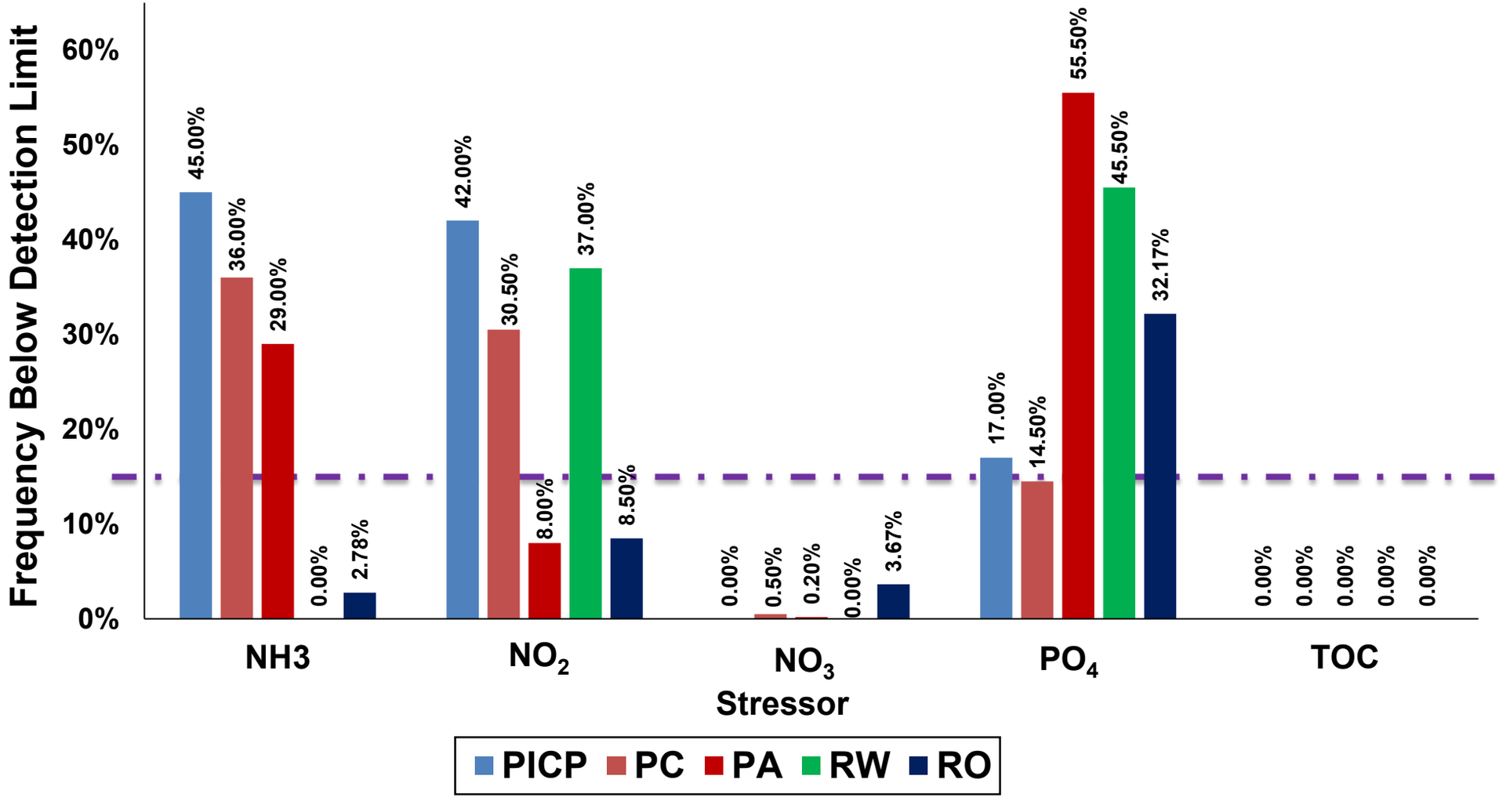
Sample collection timeline



Analytical methods

Stressor	Preservation	Analytical Method	Detection Limit (mg/L)
NH_3-N	–20 °C	EPA 350.1	0.03
NO_2-N	–20 °C	EPA 353.2	0.01
NO_3-N	–20 °C	EPA 353.2	0.02
TN	H_3PO_4; 4 °C	EPA 415.3	0.01
TOC	H_3PO_4; 4 °C	EPA 415.3	0.10
PO_4-PO_4	–20 °C	EPA 365.1	0.025

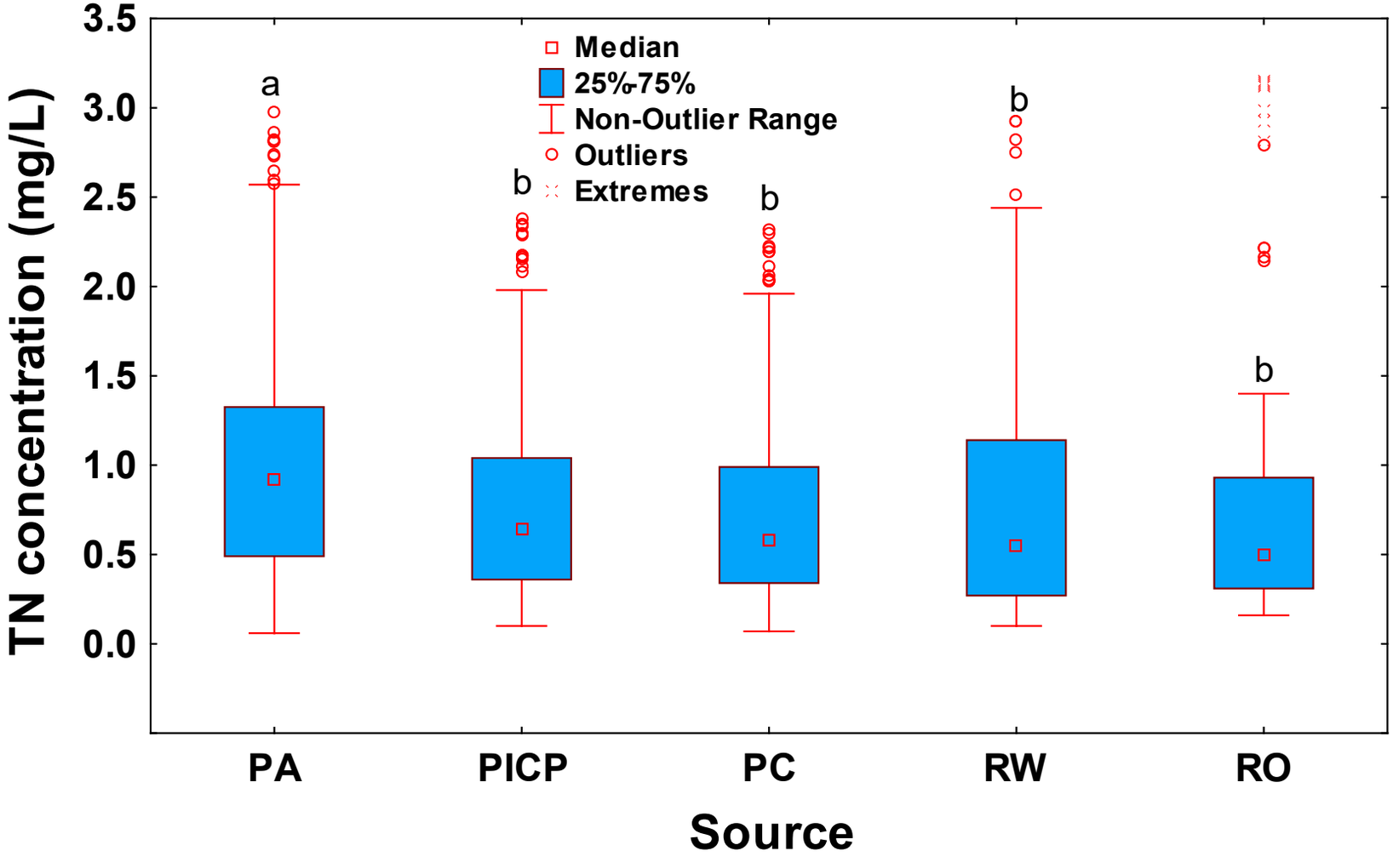
The data are left-censored with up to 55% of samples having concentrations below the laboratory detection limit.



EPA ProUCL Version 5.1 regression on order statistics (ROS) method

Half of the detection limit substituted USEPA (2000)

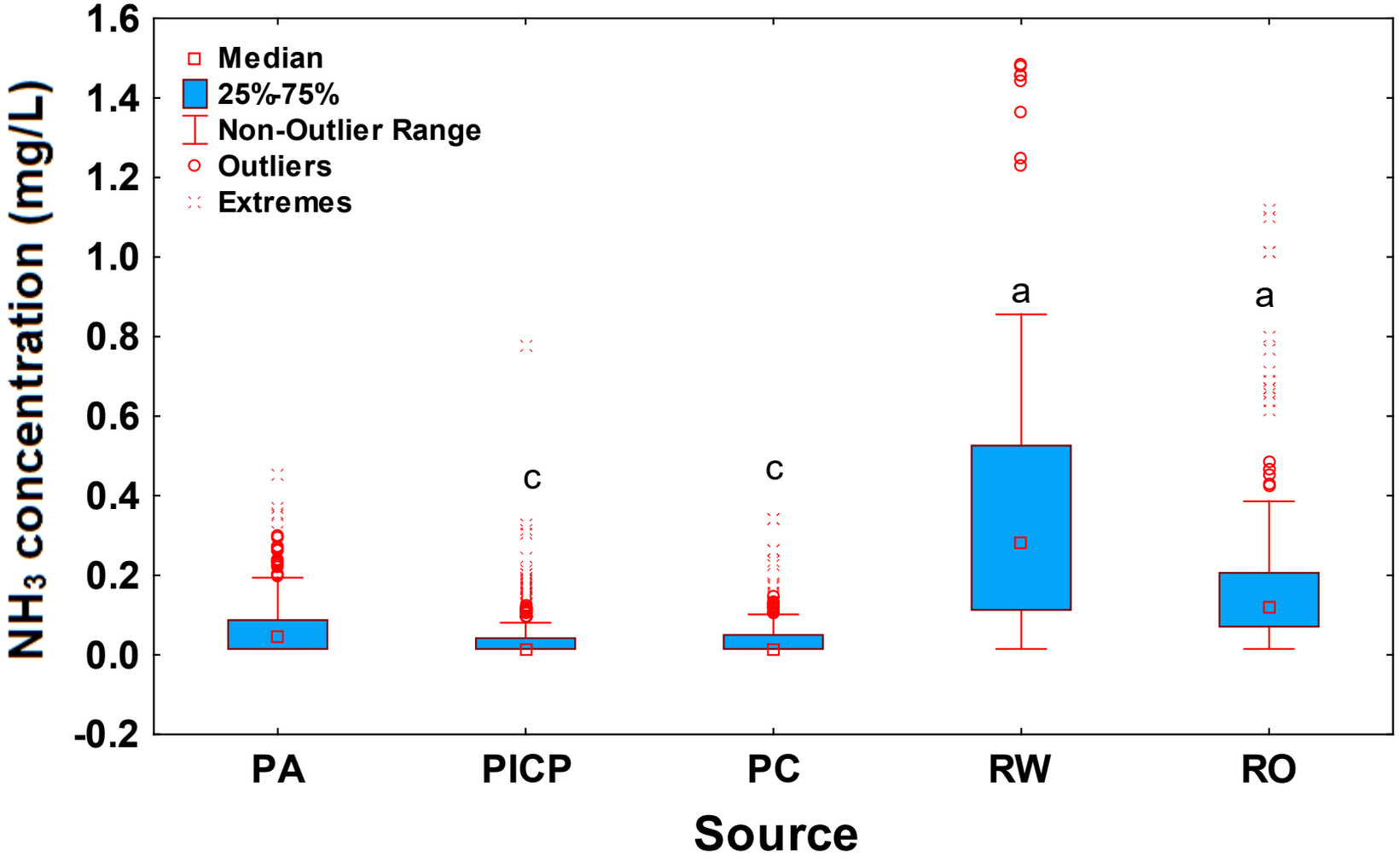
The largest TN median concentration was observed in PA infiltrate.



Kruskal-Wallis ANOVA, (H (4, N= 1463) =62.44 p <0.01)

Letters indicate the statistical groups

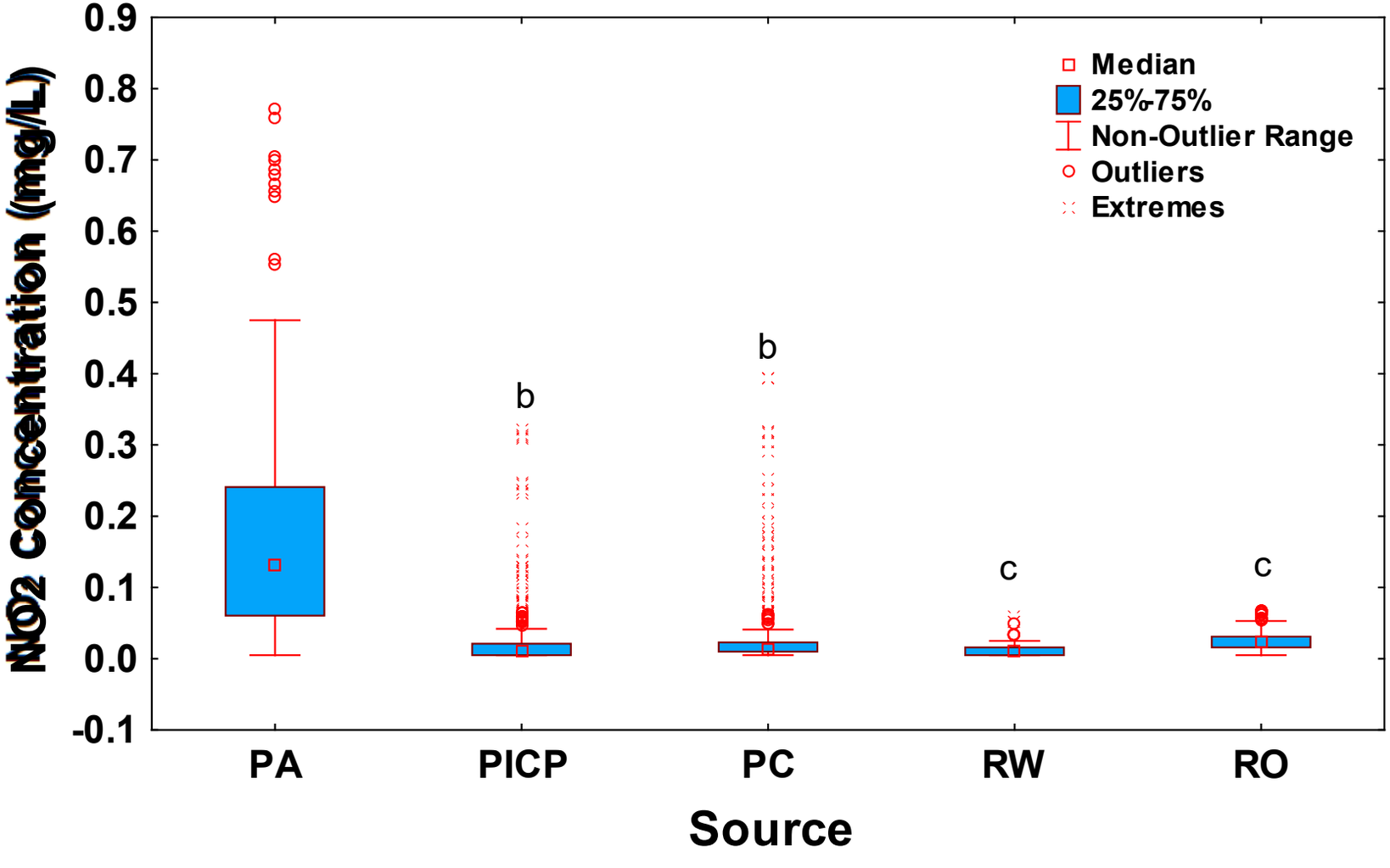
Median concentration of NH_3 was larger in rainwater and runoff than infiltrates.



Kruskal-Wallis ANOVA, (H (4, N= 1506) =442.44 p <0.01)

Letters indicate the statistical groups

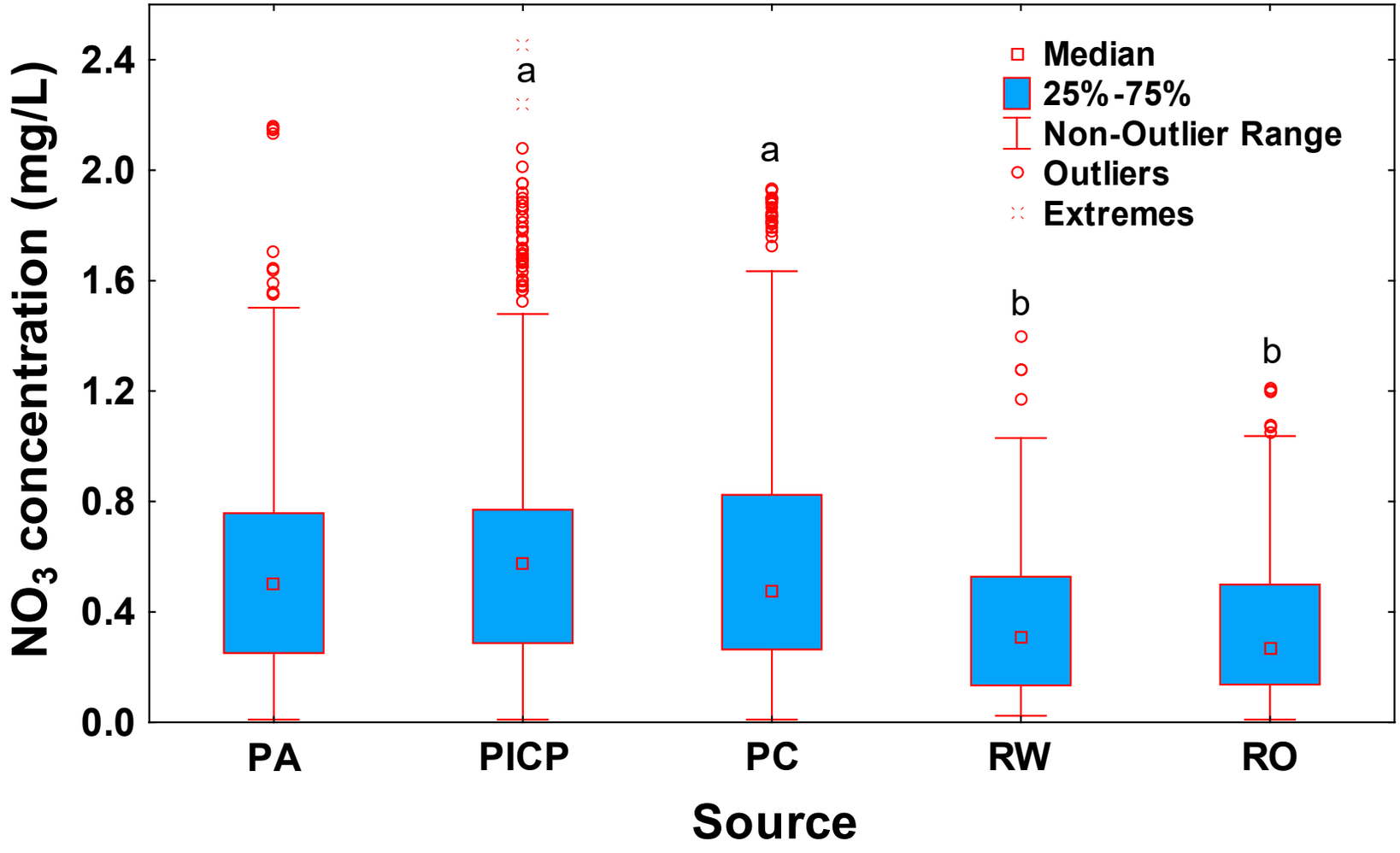
PA infiltrate showed the largest median NO_2 concentration.



Kruskal-Wallis ANOVA, (H (4, N= 1506) =692.16 p <0.01)

Letters indicate the statistical groups

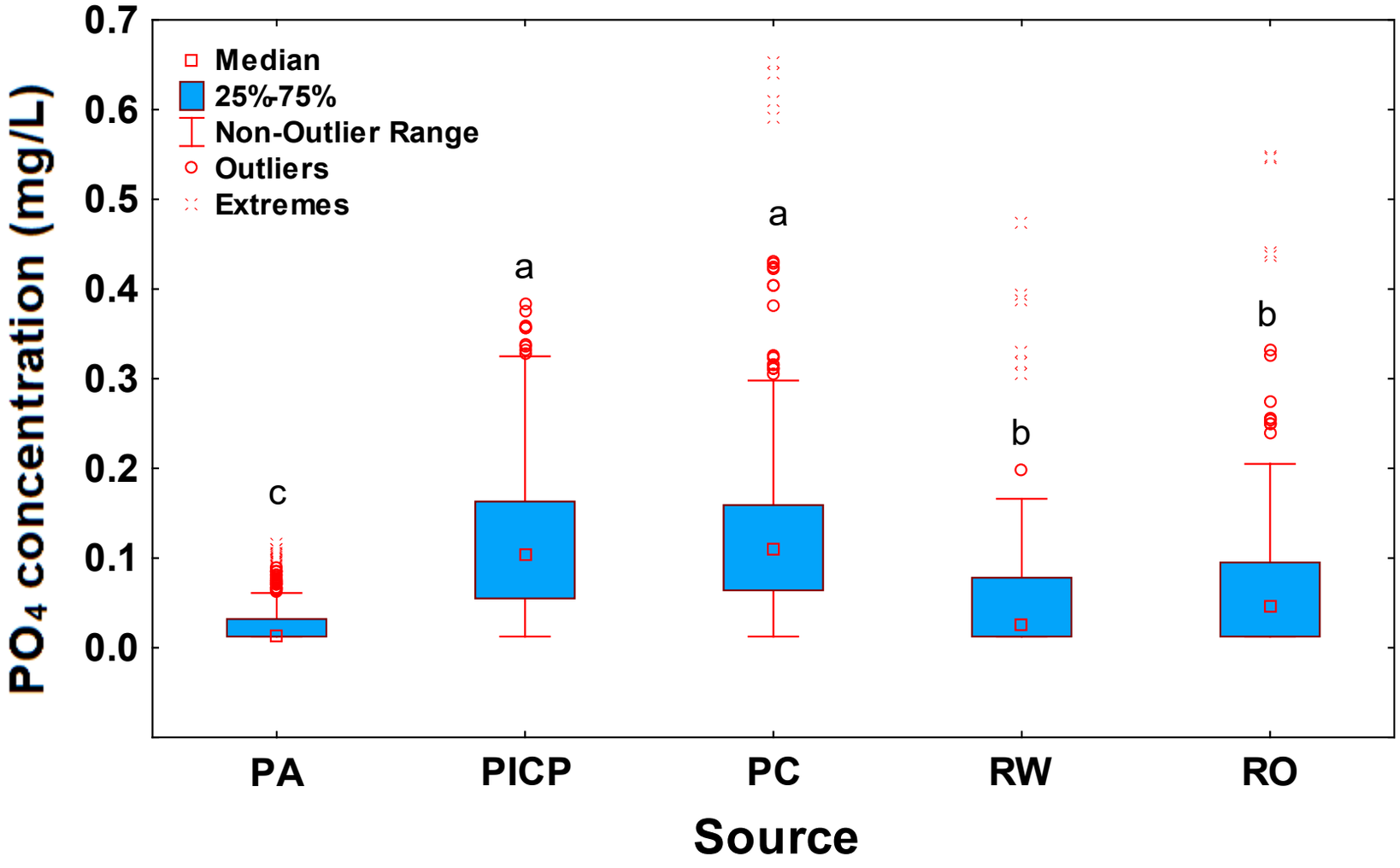
Median NO_3 infiltrate concentration was larger than rainwater and parking lot runoff concentrations.



Kruskal-Wallis ANOVA, (H (4, N= 1506) =99.04 p <0.01)

Letters indicate the statistical groups

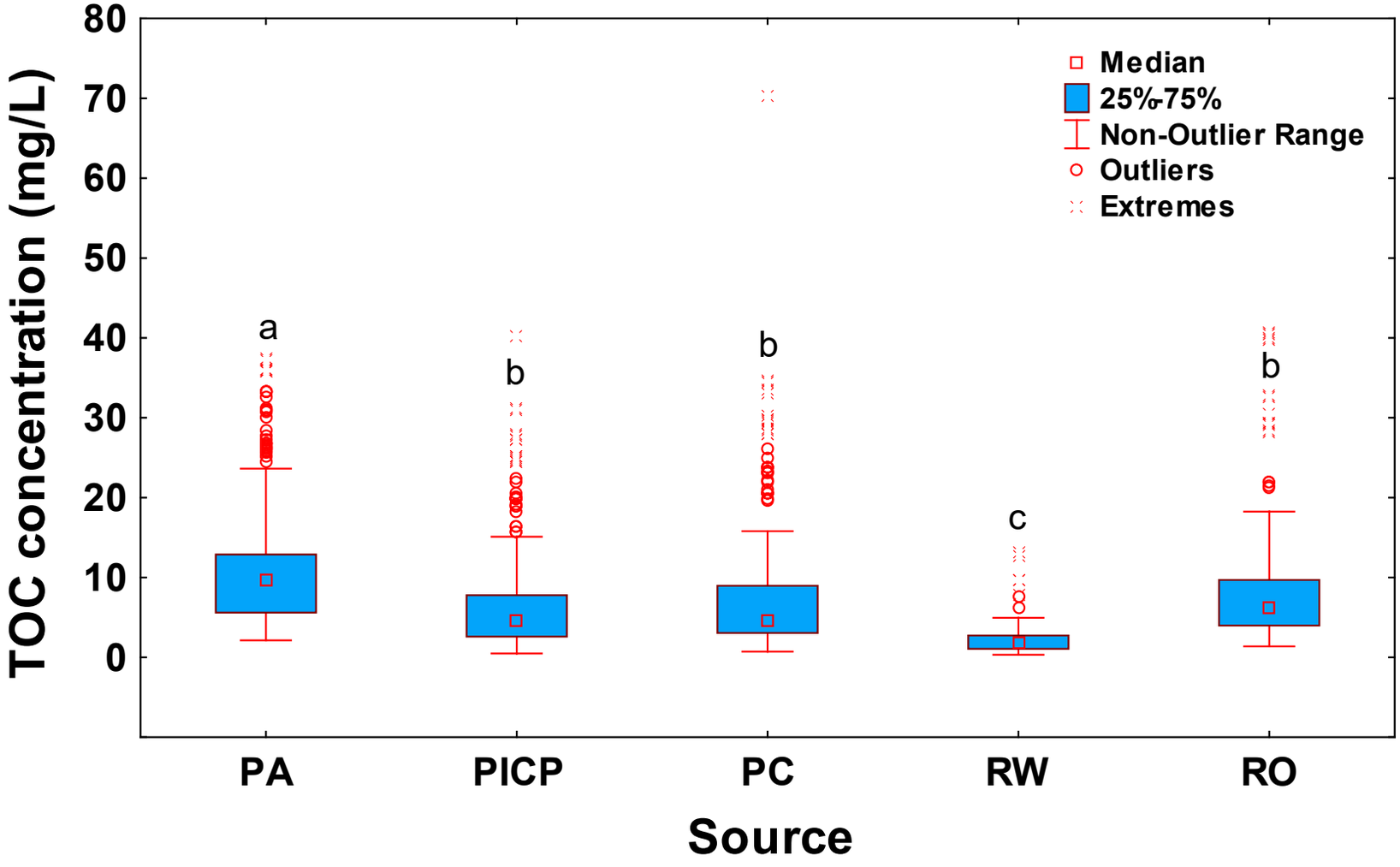
Median PO_4 concentration in PA infiltrate was smaller than PC or PICP.



Kruskal-Wallis ANOVA, (H (4, N= 1506) =546.98 p <0.01)

Letters indicate the statistical groups

The largest TOC median concentration was observed in PA infiltrate.



Kruskal-Wallis ANOVA, (H (4, N= 1476) =346.66 p <0.01)

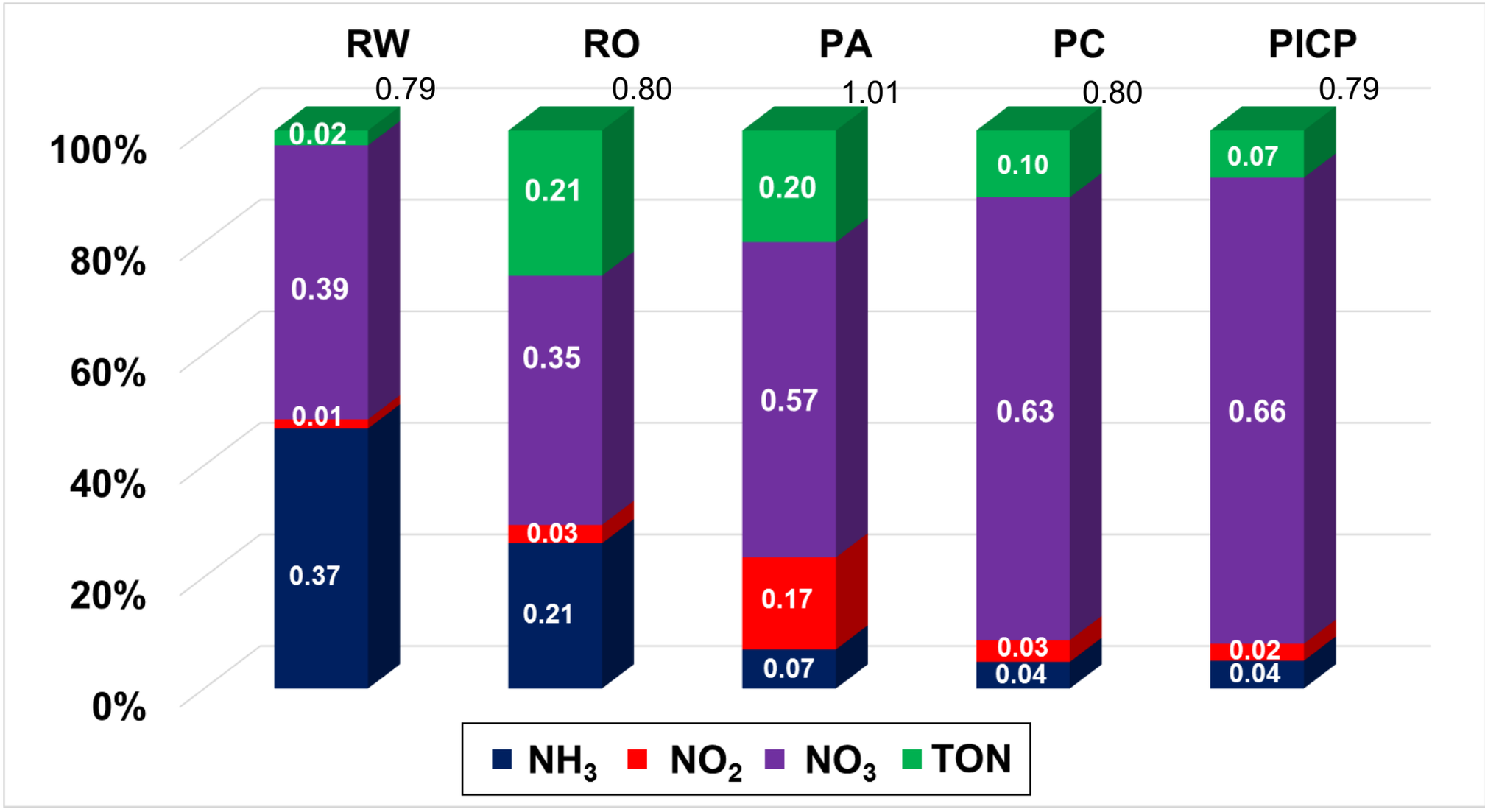
Letters indicate the statistical groups

Median concentrations meet the local criteria for discharge to surface and groundwater.

Stressor	Median (mg/L)					Groundwater effluent limitations for discharges to Class GA waters in New York state (mg/L)	Discharge into the surface waters in New Jersey (mg/L)
	PA	PICP	PC	RW	RO		
NH_3-N	0.045	0.015	0.015	0.280	0.121	2	-------
NO_2-N	0.130	0.012	0.014	0.011	0.023	1	-------
NO_3-N	0.502	0.574	0.478	0.310	0.269	10	2
TN	0.900	0.640	0.580	0.560	0.500	10*	-------
TOC	9.790	2.600	4.650	1.780	6.140	-------	-------
PO_4-PO_4	0.013	***0.104***	***0.109***	0.026	0.047	-------	0.10

*Recommended for Long Island area

Distribution of species is changing and nitrification process was observed from the data.



TON was calculated

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The PA infiltrate showed a trend for NH_3, NO_2 and PO_4 Concentrations.

Stressor	Mann Kendall trend test			Trend
	M-K test value (S)	p-value	OLS regression slope (µg/L/Month)	
NH_3	12920	**0.0001**	0.09	+
NO_2	-10811	**0.0019**	-0.10	-
NO_3	4227	0.1288	0.08	NT
PO_4	72079	**<0.0001**	0.10	+
TN	2003	0.1053	-0.10	NT
TOC	1191	0.3125	0.50	NT

+: Trend Increasing
-: Trend Decreasing
NT: No trend

M-K (S): equals the sum of scores assigned to all pairs
OLS: Ordinary least square
Confidence interval 95%

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All of the nitrogen forms in PC infiltrate increased while PO_4 and TOC decreased.

Stressor	Mann Kendall trend test			
	M-K test value (S)	p-value	OLS regression slope (µg/L/Month)	Trend
NH_3	43165	<0.0001	0.10	+
NO_2	7035	0.0094	0.09	+
NO_3	11906	0.0000	0.80	+
PO_4	-17246	<0.0001	-0.20	-
TN	11747	<0.0001	0.80	+
TOC	-8002	0.0022	10.70	-

+: Trend Increasing
-: Trend Decreasing
NT: No trend

M-K (S): equals the sum of scores assigned to all pairs
OLS: Ordinary least square
Confidence interval 95%

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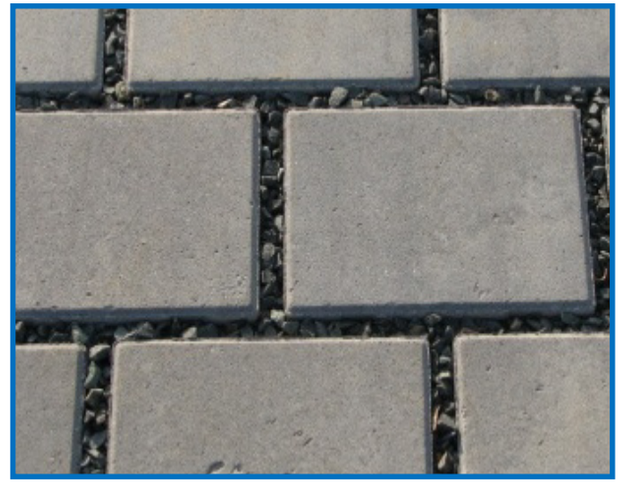
All of the nitrogen forms in PICP infiltrate increased.

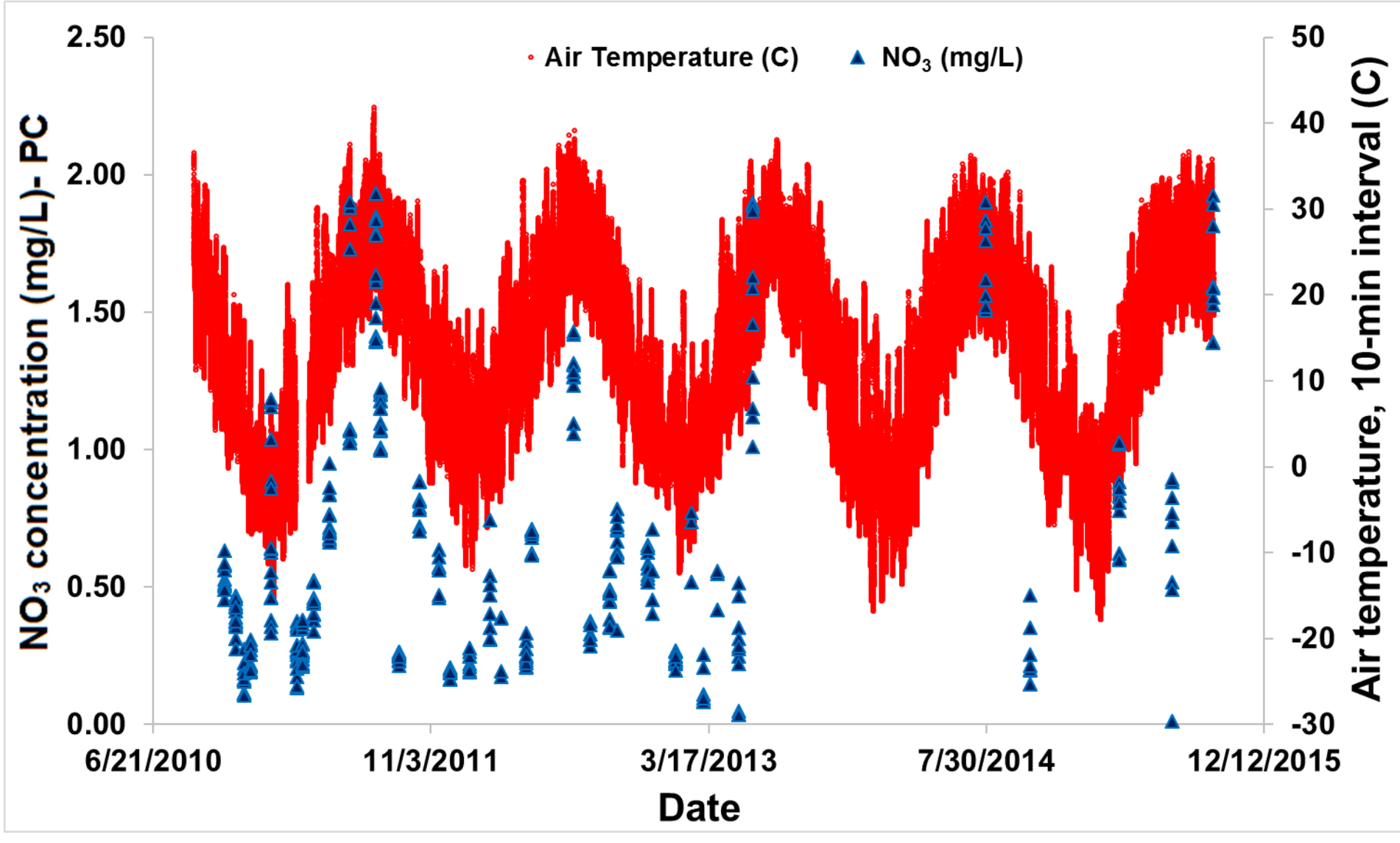


Stressor	Mann Kendall trend test			
	M-K test value (S)	p-value	OLS regression slope (µg/L/Month)	Trend
NH_3	57488	<0.0001	0.09	+
NO_2	23282	<0.0001	0.08	+
NO_3	14422	0.0001	0.80	+
PO_4	-2783	0.2364	0.09	NT
TN	22348	<0.0001	1.11	+
TOC	-8571	0.0103	-4. 90	-

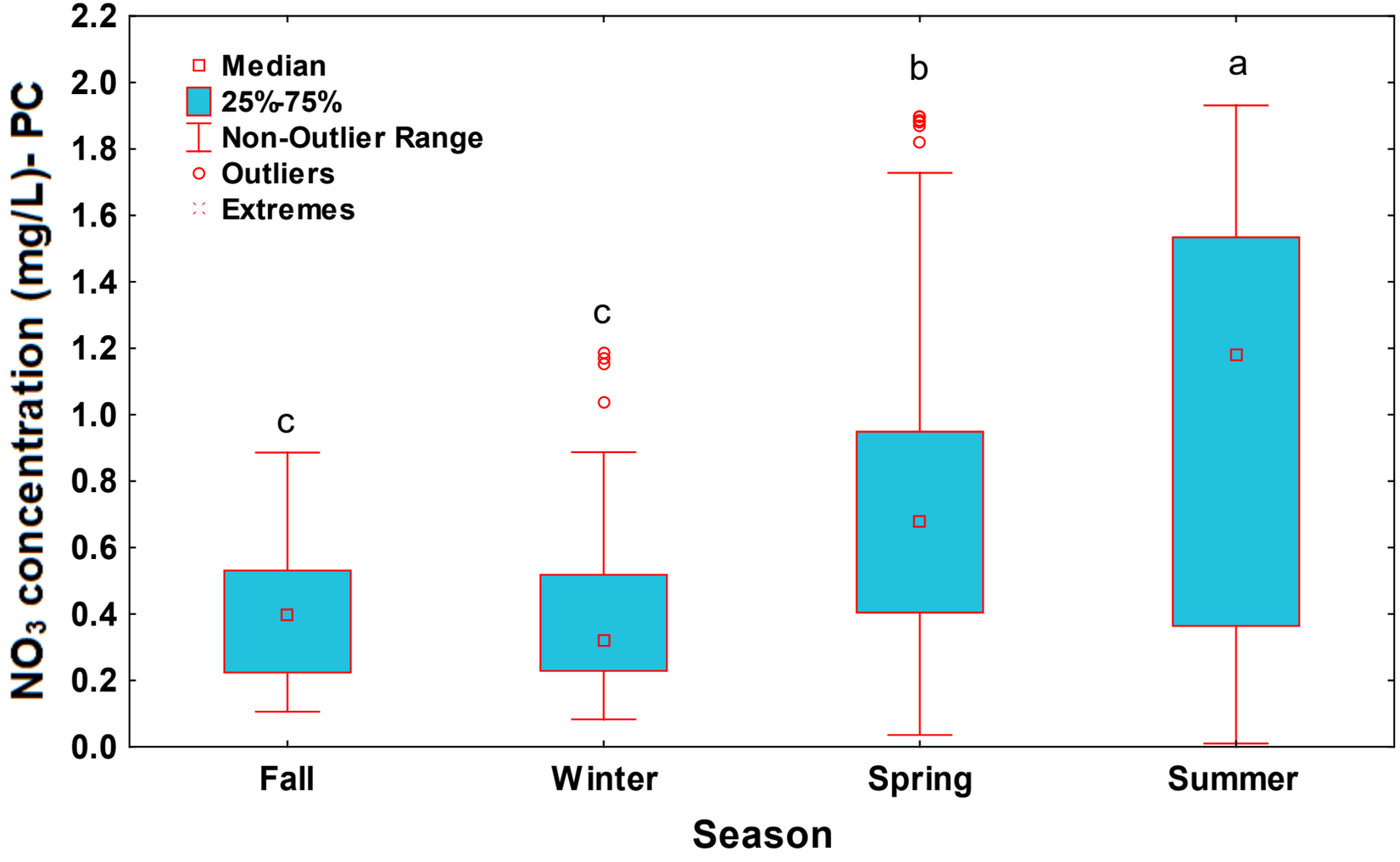
+: Trend Increasing
-: Trend Decreasing
NT: No trend

M-K (S): equals the sum of scores assigned to all pairs
OLS: Ordinary least square
Confidence interval 95%

Air temperature data showed positive correlation with all concentrations (NO_3- example).



There are seasonal differences among median of infiltrate concentrations (NO_3^- example).



Kruskal-Wallis test: H (3, N= 406) =96.91 p <0.001

Letters indicate the statistical groups

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Conclusions

- ✓For all analytes, there were no differences between PICP and PC median concentrations.
- ✓None of the pavements reduced TN concentration.
- ✓The PA infiltrate had the smallest PO_4 concentration.
- ✓Data supported nitrification process and the process was temperature dependent.
- ✓Nitrogen species showed slowly increasing trends in PC and PICP infiltrates.
- ✓Community can select a more suitable permeable surface based on the nutrients and stormwater targets.

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Questions???

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