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Storm-event-transport of urban-use pesticides to streams likely impairs invertebrate assemblages

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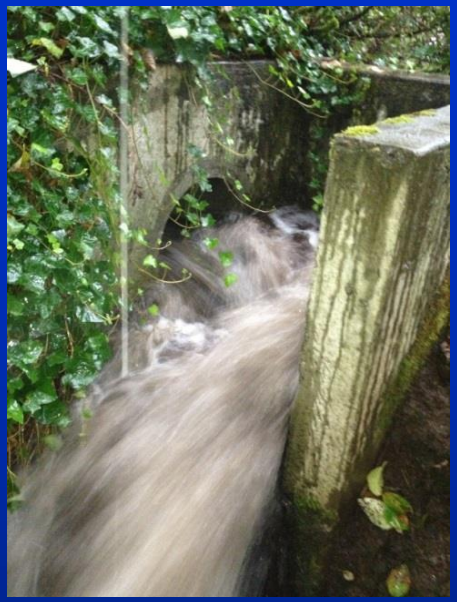
[2] Cole Environmental, Inc.

Willamette River Toxics Reduction Steering Committee
May 8, 2017

U.S. Department of the Interior
U.S. Geological Survey

Clackamas County MS4 Pesticide Study (Municipal Separate Storm Sewer System)



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Project funded by:
Clackamas County MS4 Co-permittees
Clackamas River Water Providers
USGS Cooperative Water Program

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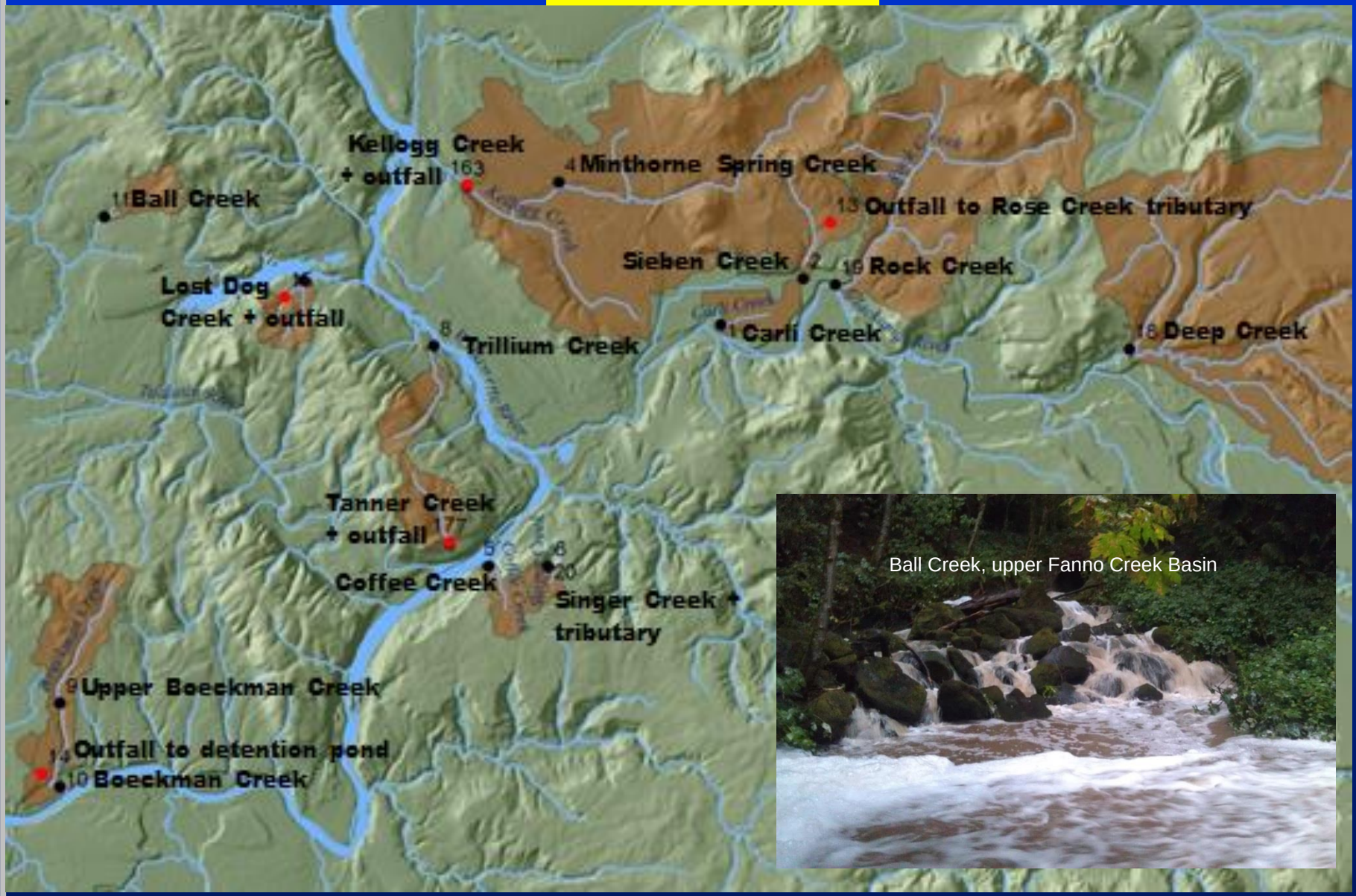
Study Area



Ball Creek, upper Fanno Creek Basin

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2013 Data Collection

15 Bed-sediment samples

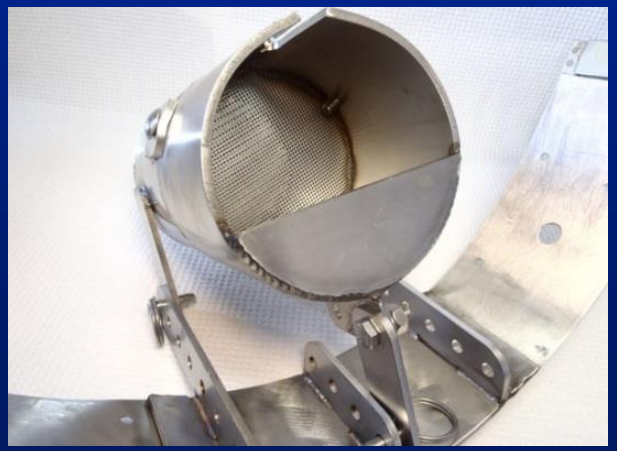
20 Stormwater runoff samples
(15 streams and 5 outfalls)

Analysis of 91-118 pesticides
and degradates

SIFT sediment collection devices
deployed in 3 outfalls

4 Media analyzed:
- Stormwater - Dissolved
- Stormwater - Suspended sediment
- Stormwater - SIFT sediment

plus
Streambed sediments



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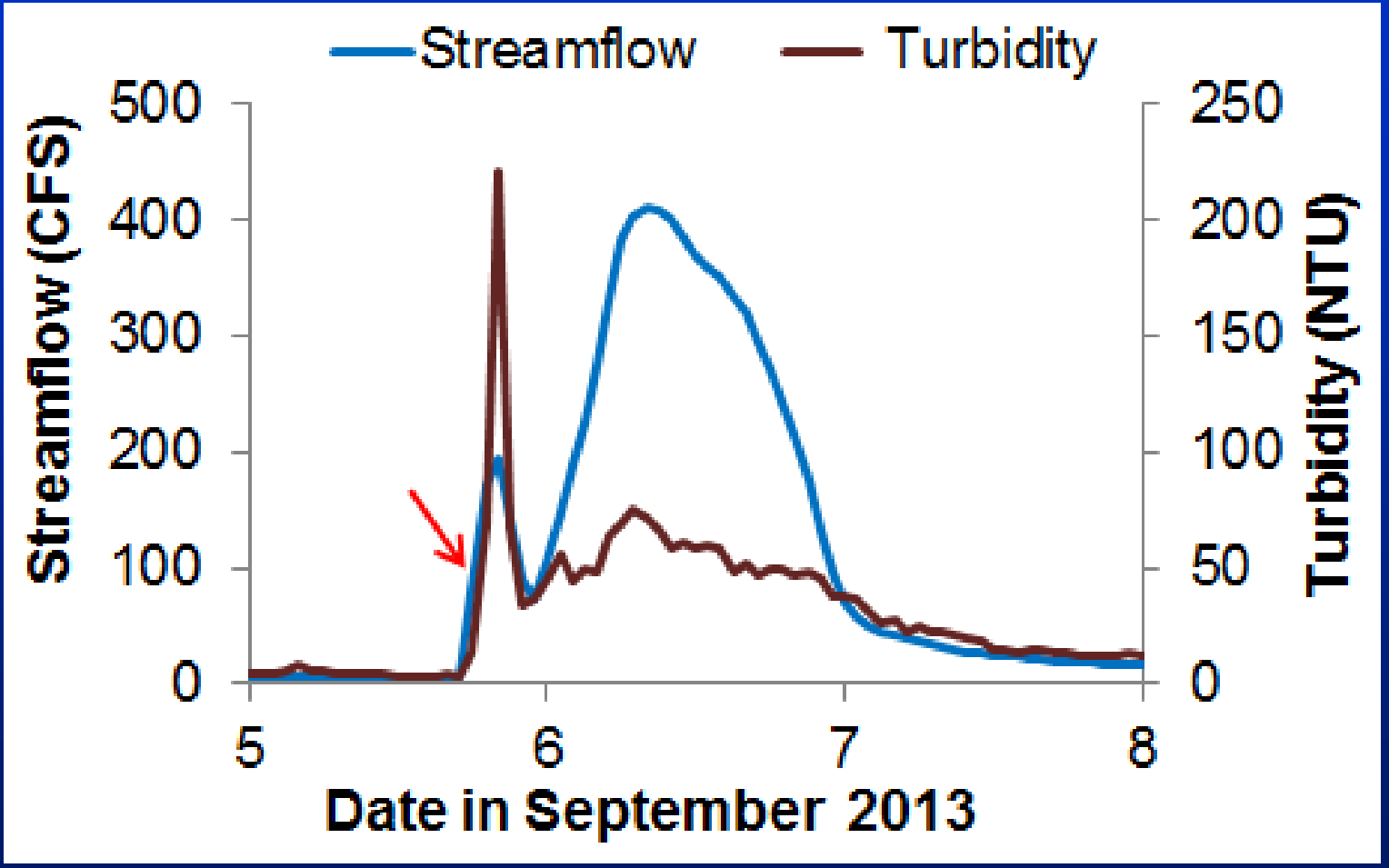
Late Summer Storm

- "First flush" event produced ~1" rain on Sept 5th
- Fanno Creek responded with initial turbidity pulse



http://or.water.usgs.gov/cgi-bin/grapher/graph_setup.pl?basin_id=tualatin&site_id=14206950

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33 Pesticides Detected

Pesticide (type)	Total Number of Detections	Stormwater runoff			Stream-bed sedi-ment (n=15)
		Storm-water-dissolved (n=20)	Stormwater-suspended sediment (n=20)	SIFT sedi-ment (n=5)	
Bifenthrin (I)	33	15%	75%	100%	71%
Fipronil (I)	13	65%	--	--	--
Fipronil desulfinyl (D)	1	5%	--	--	--
Fipronil sulfide (D)	2	10%	--	--	--
Metolachlor (H)	13	65%	--	--	--
p,p'-DDE (D)	13	--	15%	20%	64%
p,p'-DDD (D)	2	--	5%	--	7%
Pendimethalin (H)	9	--	15%	100%	7%
Trifluralin (H)	8	--	--	80%	29%
Dithiopyr (H)	7	--	--	60%	29%
Carbaryl (I)	6	30%	--	--	--
Iprodione (F)	4	10%	10%	--	--
Zoxamide (F)	4	5%	15%	--	--
Kresoxim-methyl (F)	3	--	15%	--	--
Metalaxyl (F)	3	--	--	--	21%
Pentachloroanisole (D)	3	--	--	20%	14%
Prodiamine (H)	3		--	40%	7%
Propiconazole (F)	3	15%	--	--	--
Cypermethrin (I)	2	--	--	--	14%
Oxyfluorfen (H)	2	--	--	20%	7%

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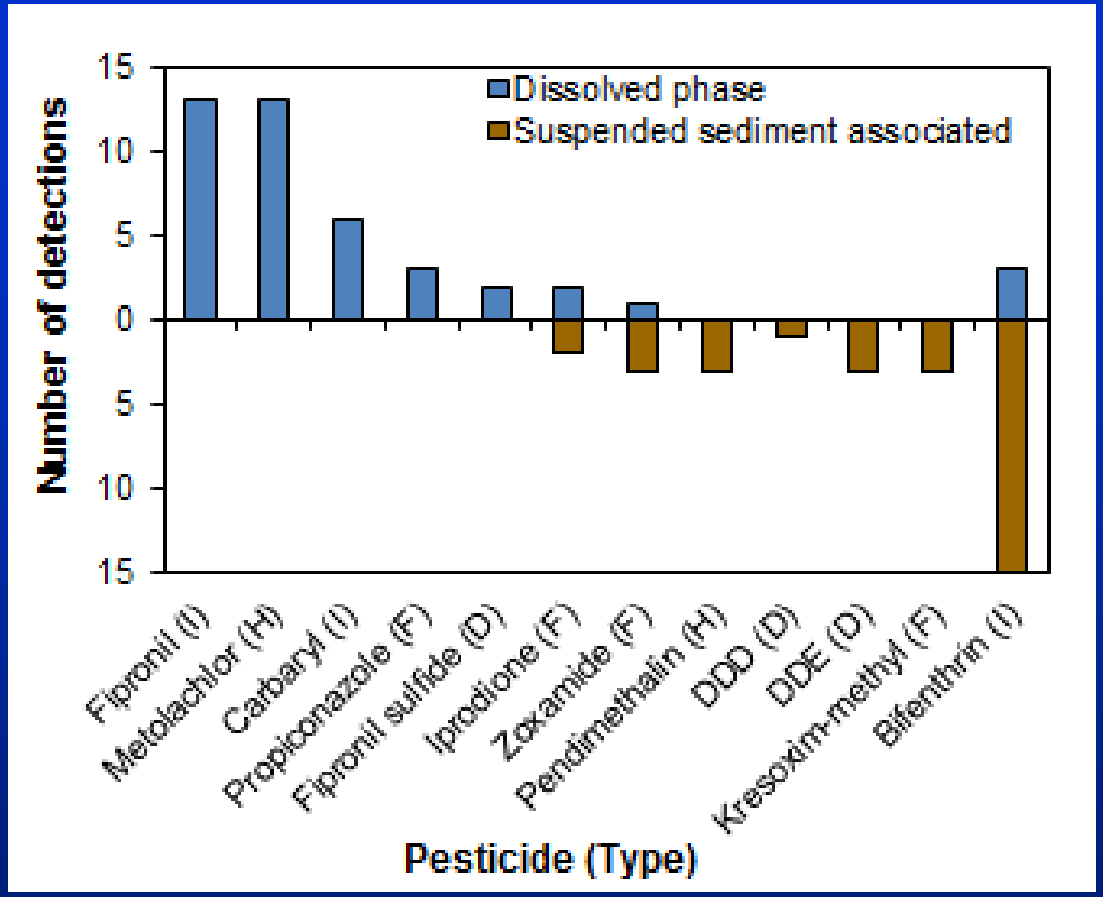
Pesticide Partitioning

- 70% of detections in stormwater were dissolved vs 30% on suspended sediment
- Water solubility and K_{oc} (organic carbon partitioning coefficient) were good predictors of the dominant phase pesticides were found



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Aquatic-Life Benchmarks

Stream	Stormwater Runoff Concentrations in ng/L				Invertebrate Assemblage Disturbance Class
	Bifenthrin	Fipronil	Malathion	DDE+DDD	
Lost Dog Creek	24*	16*	<	1.1***	Severe
Tanner Creek	97*	127**	<	<	Severe
Sieben Creek	39*	10	<	9.2***	Moderate
Ball Creek	21*	19*	<	<	Severe
Deep Creek	22*	<	<	2.7***	--
Trilium Creek	24*	12*	<	<	Moderate-severe
Kellogg Creek	21*	10.5	<	<	Moderate
Boeckman Creek (upper)	31*	<	<	<	--
Carli Creek	23*	<	<	<	Severe
Coffee Creek	23*	6.7	<	<	Slight
Minthorn Spring Creek	24*	6.4	<	<	Severe
Rock Creek	<	12*	<	<	Moderate-severe
Singer Creek	<	<	457**	<	slight-moderate
Singer Creek tributary	<	20*	<	<	--
Boeckman Creek (lower)	<	<	<	<	Severe

Exceeds: *Chronic invertebrate benchmark, **Acute invertebrate benchmark, ***WQ criterion (CWA)

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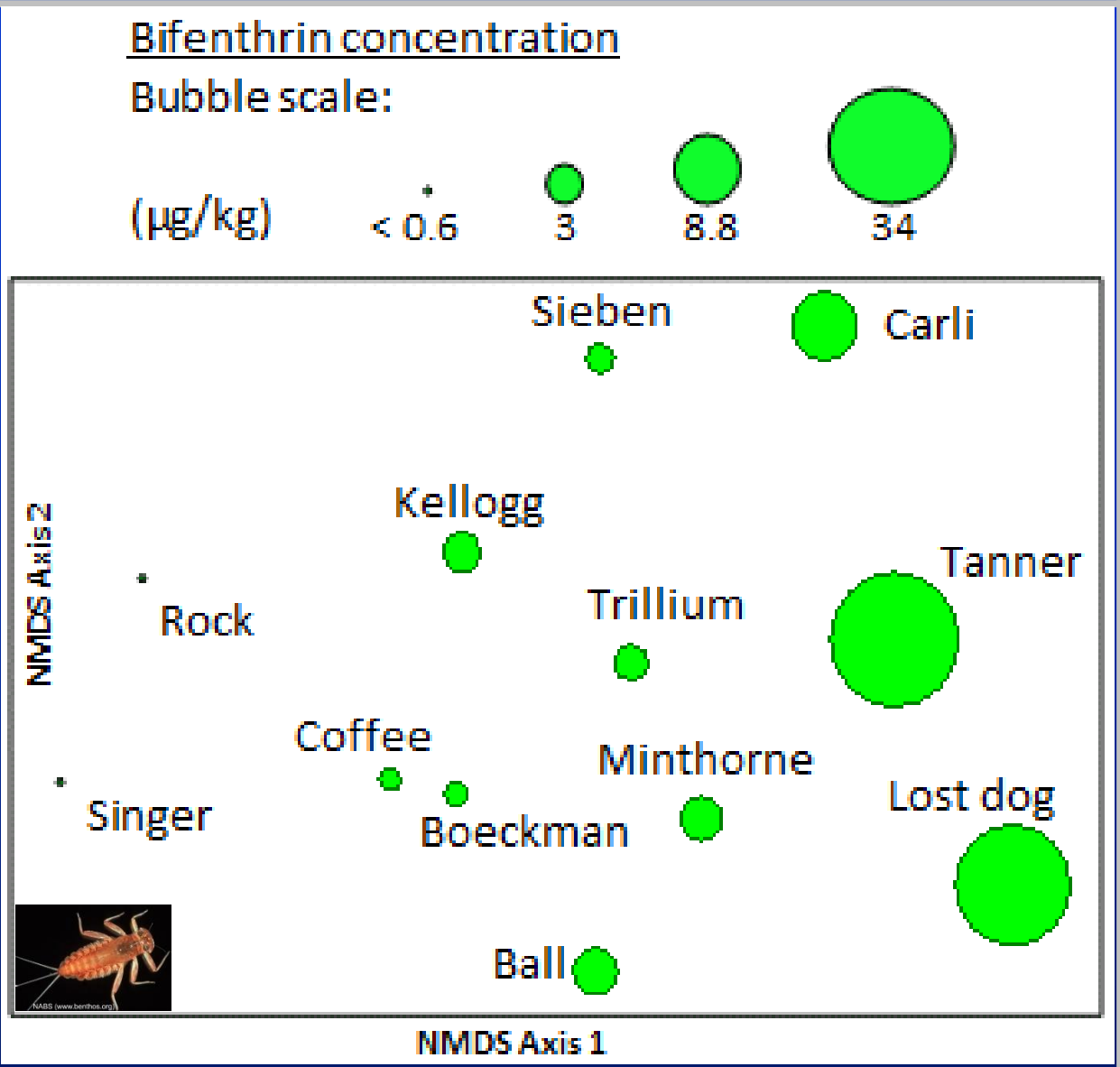
Bifenthrin in Streambed Sediments had the Highest Correlation with Benthic Invertebrate Assemblages

Ordination Shows a Strong Gradient in Bifenthrin along NMDS Axis 1



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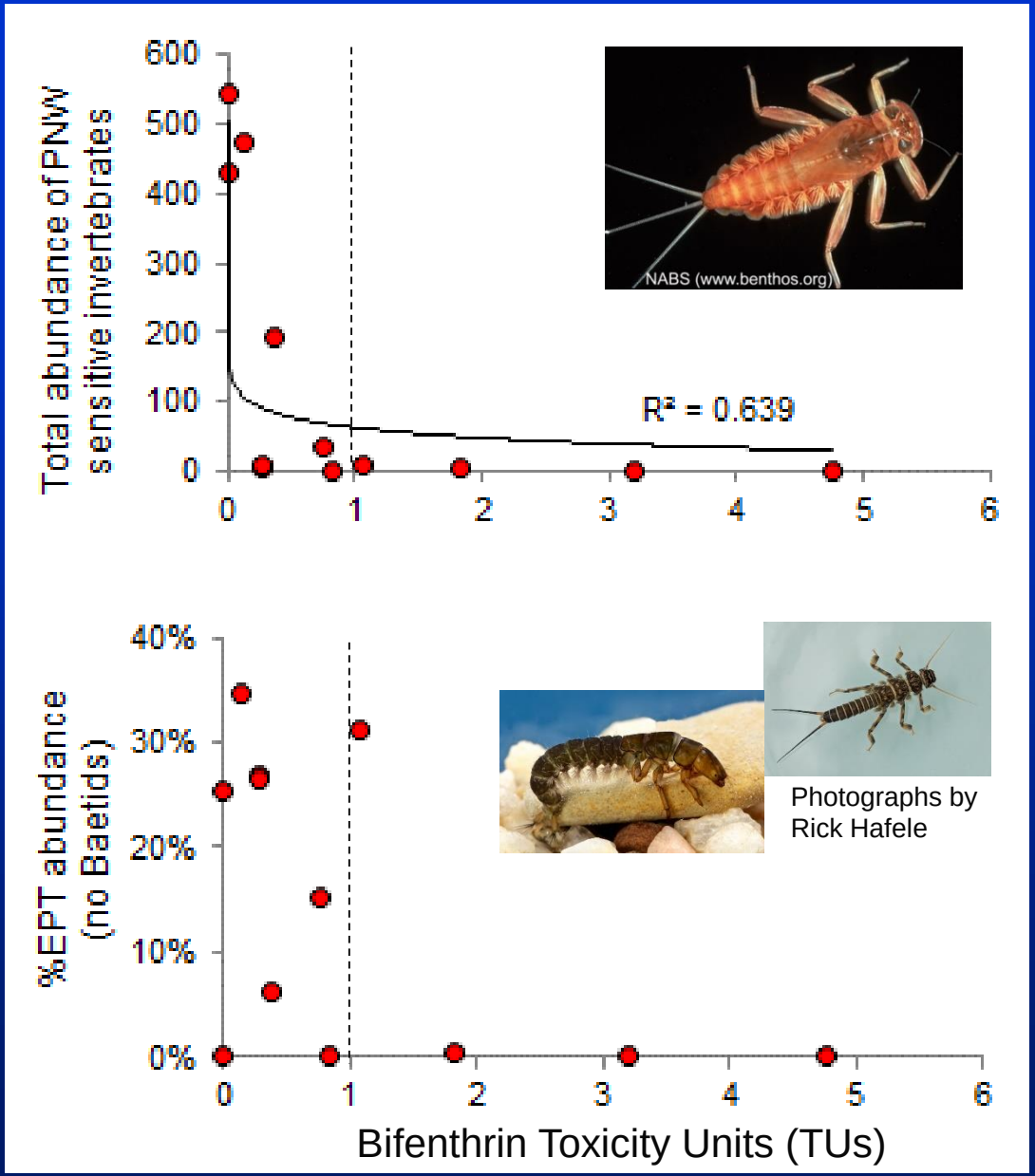
Declines in sensitive insect species

Declines in %EPT (mayflies, stoneflies and caddisflies)



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Response in Aquatic Insect Larvae to Bifenthrin

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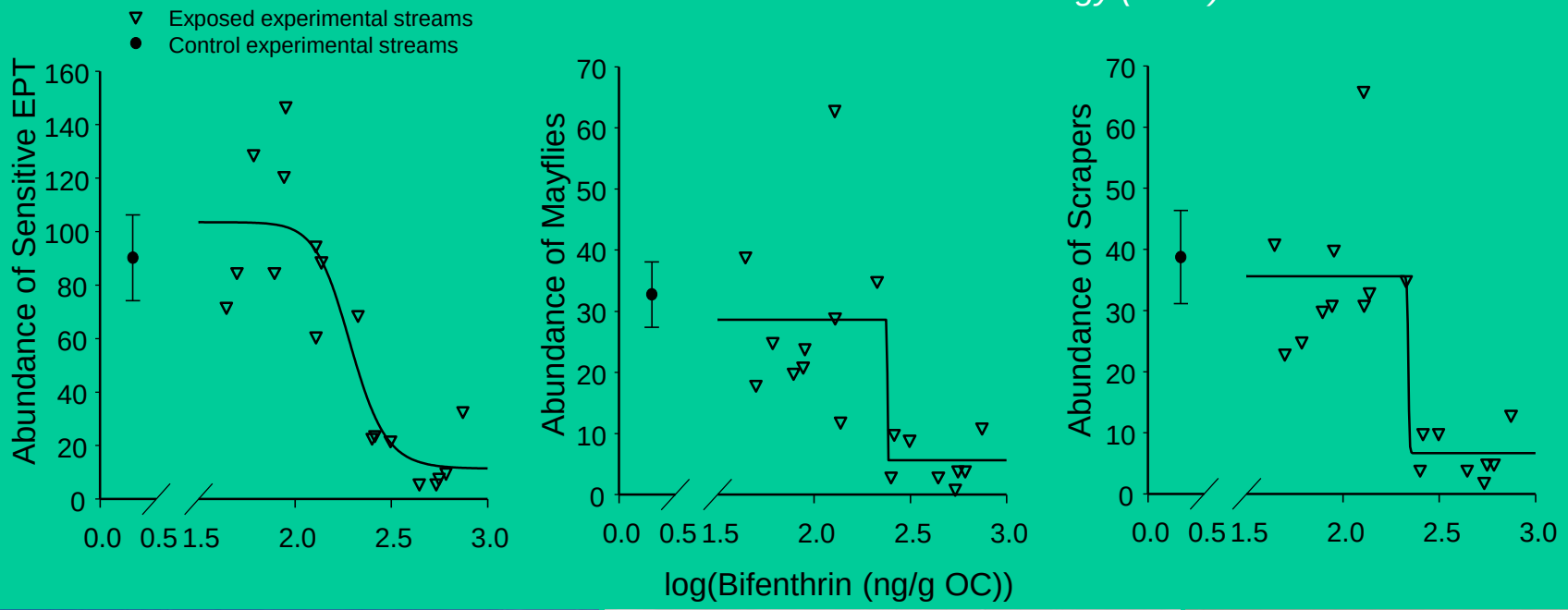

Photographs by Rick Hafele

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Bifenthrin

Mode of action: delays closure of Na^+ ion channels

Low water solubility (0.0001 mg/L)
High log-K_{oc} (5.4)
Long half-life in sediment (8-17 months)

600 Products Contain Bifenthrin

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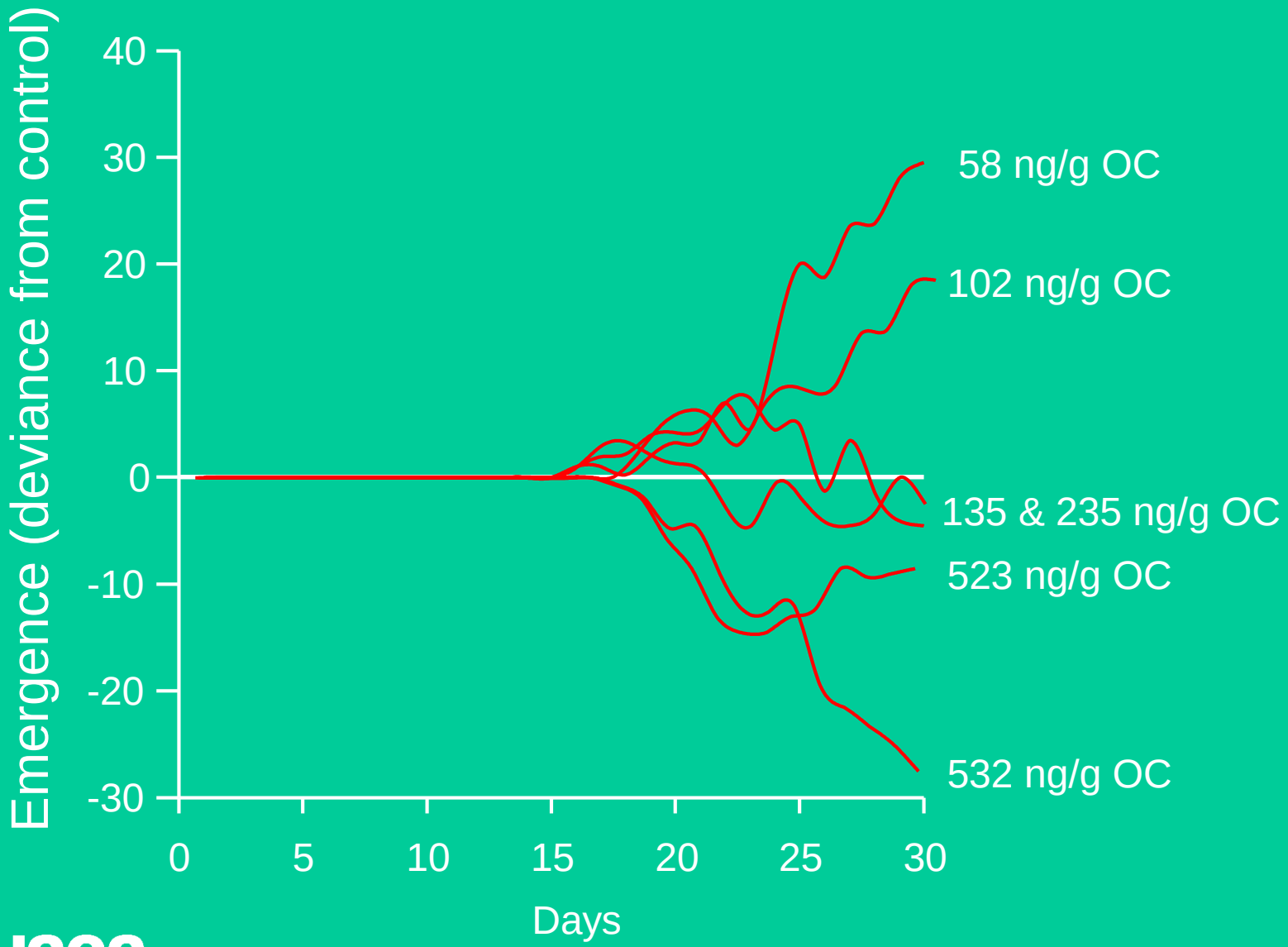
Bifenthrin and Adult Insect Emergence



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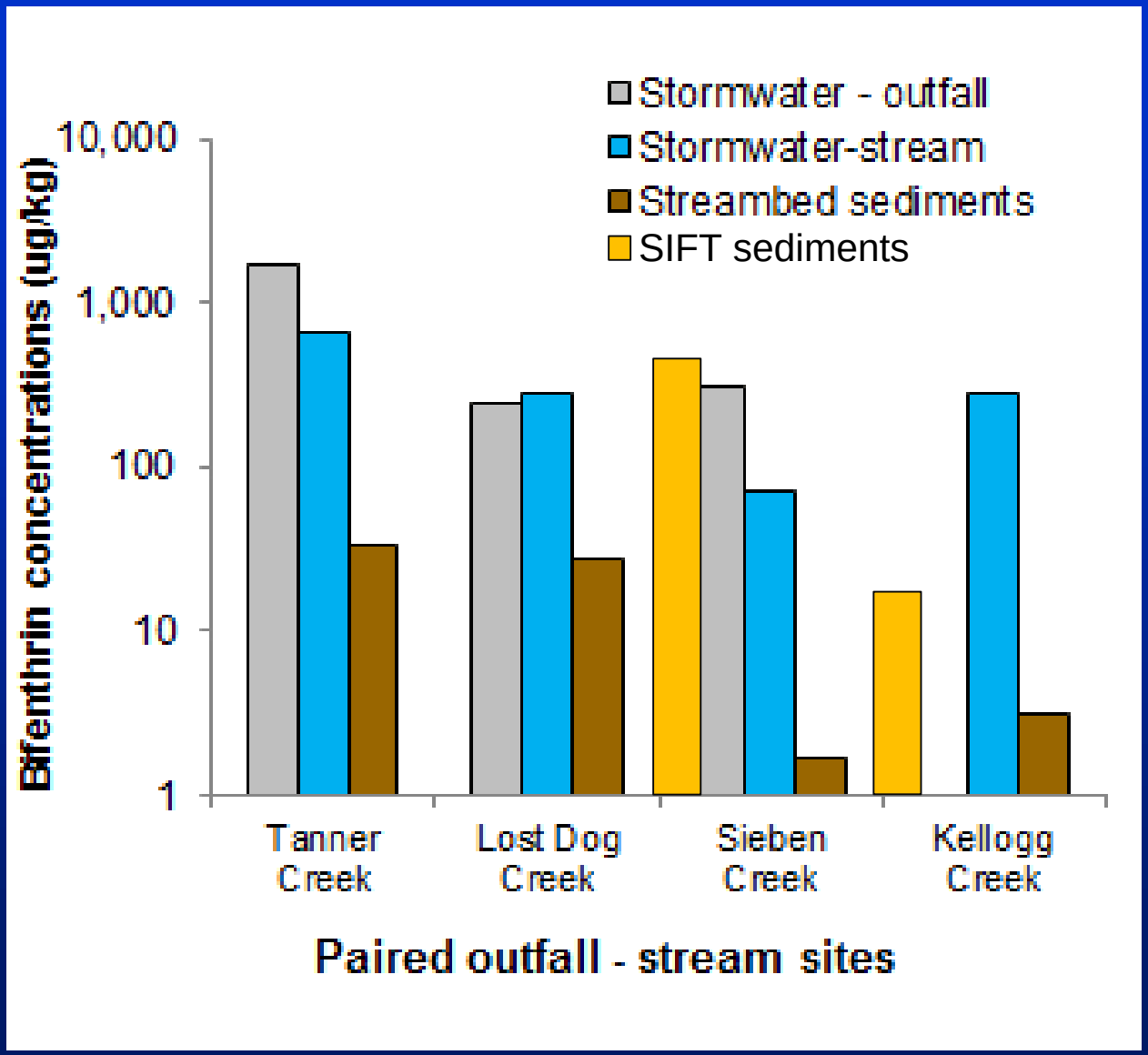
MS4 Outfalls Important Sources of Bifenthrin



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Conclusions

Pesticides in stormwater runoff are likely harming aquatic insect populations in streams with relatively low bifenthrin concentrations

While flashy hydrology and degraded habitat, and other pollutants may also contribute, bifenthrin appears to have a substantial impact

Unclear what mechanism/pathway is most harmful:

- **Short-duration, acute exposures following storms**
- **Long-term exposure to streambed sediments**
- **Dietary, through consumption of algae and fine organic matter**

Bioswales and other sediment retention features could intercept pyrethroids, DDT metabolites, and other hydrophobic contaminants in urban runoff

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Thank you! – Questions?

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