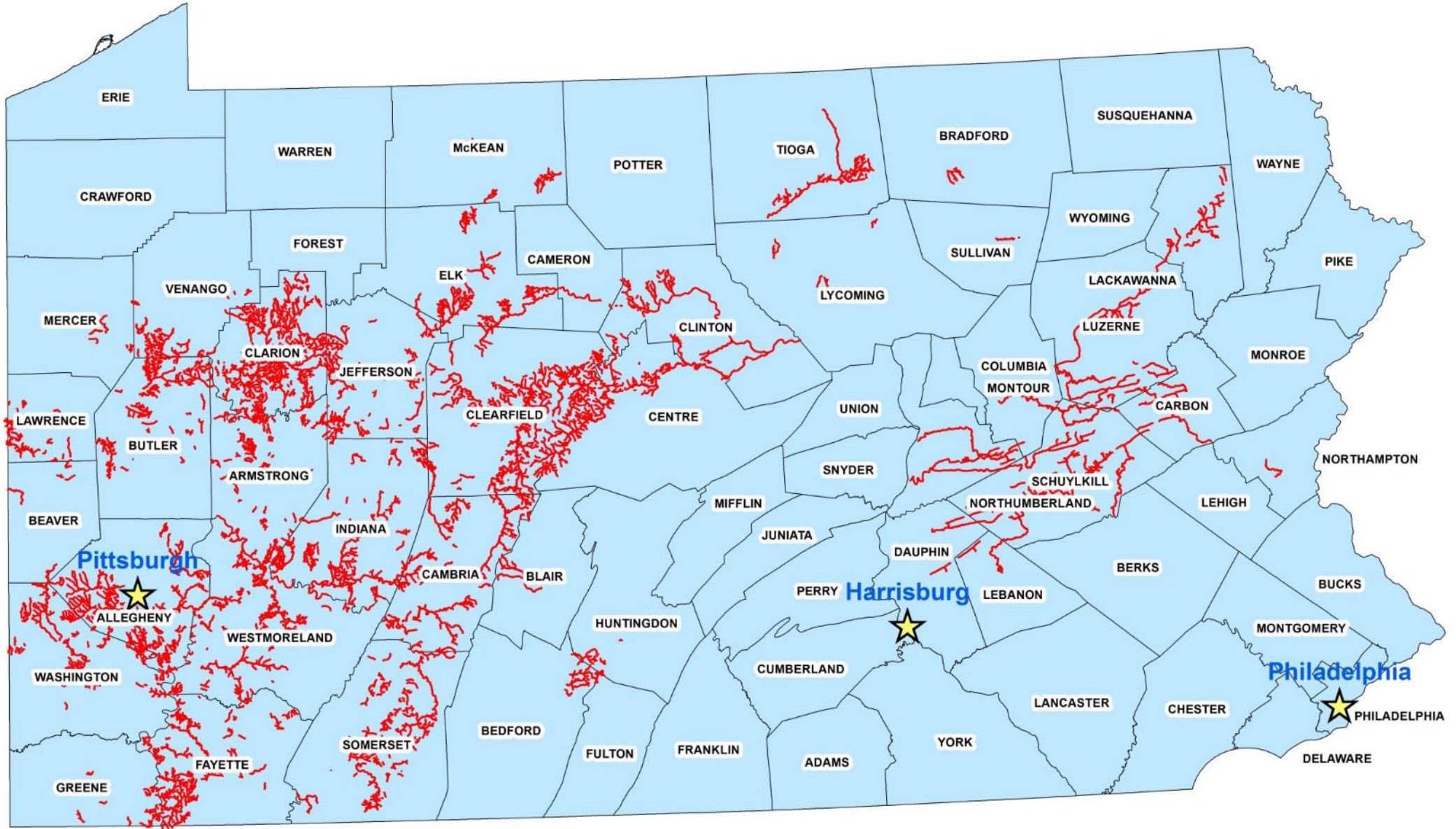


Operation and Maintenance of Passive Treatment Systems

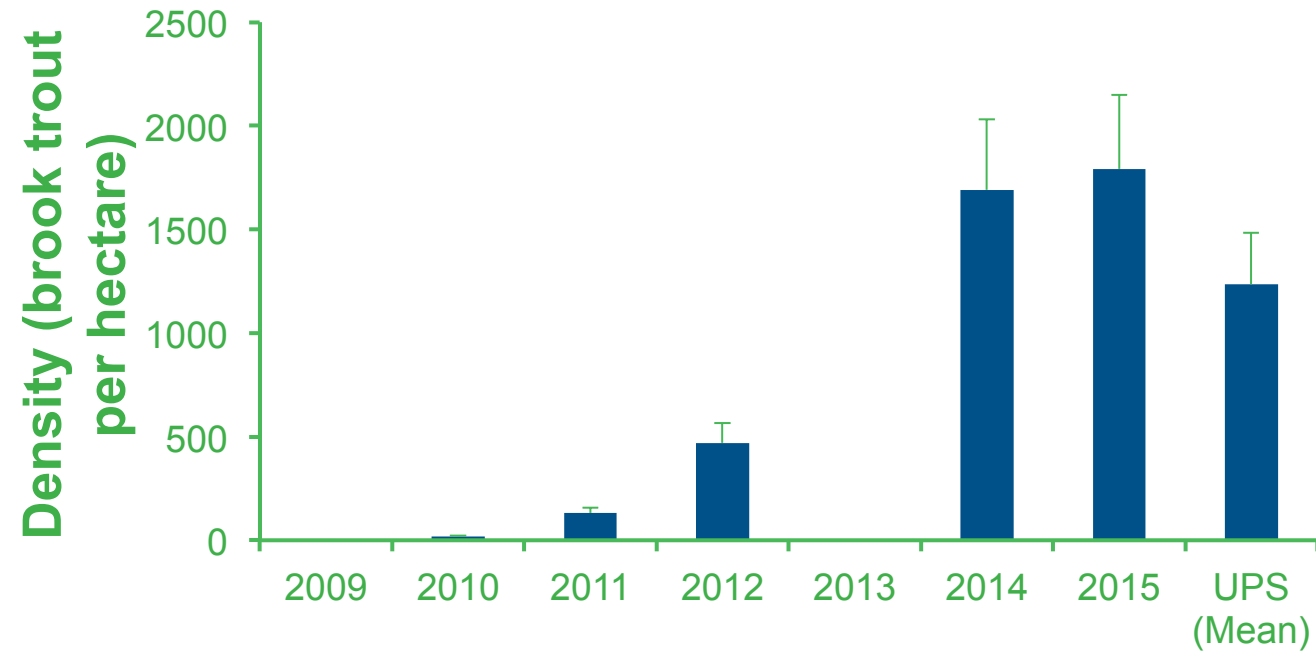
Robert Hedin

Hedin Environmental

Pittsburgh, Pennsylvania



Passive treatment systems have led to biological recovery



- Nearly 7 miles of native brook trout habitat have been reconnected
- Brook trout are now thriving and reproducing in previously dead stream sections

- Convened by Amy Wolfe (Director of Trout Unlimited's Eastern Abandoned Mine Lands Program) at request of PA Dept Environmental Protection
- Inventoried passive treatment systems installed by non-profit and government organizations in Pennsylvania
 - 273 systems with installed cost of \$93,794,000
 - 225 managed by non-profits with installed cost of \$67,494,000
- Non-profit systems: operation and maintenance (O&M)
 - 20 year estimate of O&M costs: \$54,447,000
 - Trust Fund (5% net discount): \$35,112,000
 - Total 20 year cost of passive systems: ~1.5 X Capital Costs

What O&M Activities were Considered?



- Routine inspections, sampling, minor maintenance done quarterly (20%)
- Professional evaluations every 5 years (4%)
- Major maintenance of systems every 10 years (68%)
- Program Administration (8%)

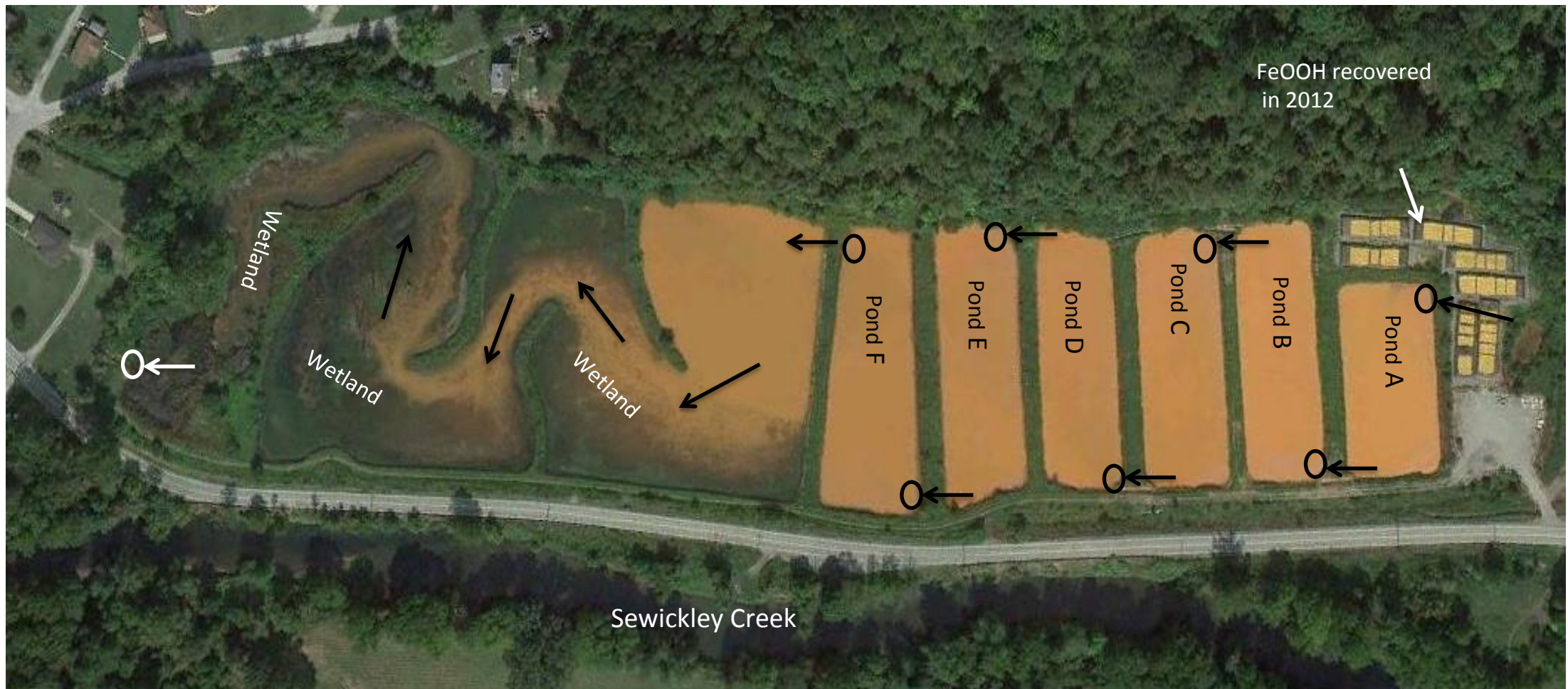
Major Maintenance

Long-term effectiveness of mine water treatment systems depends on management of solids produced and reactive materials consumed.

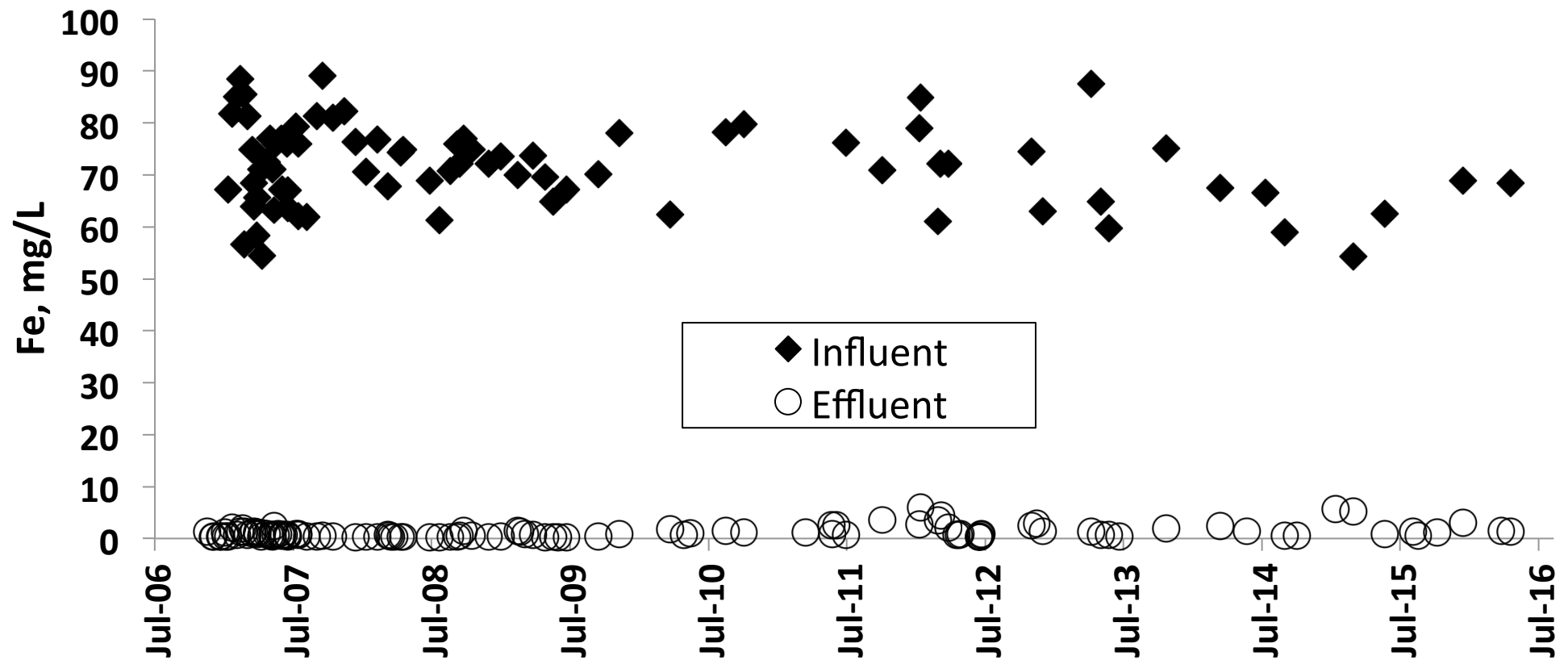
A treatment system where solids are managed and reactive materials replaced will provide reliable long-term treatment

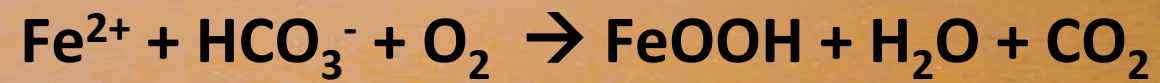
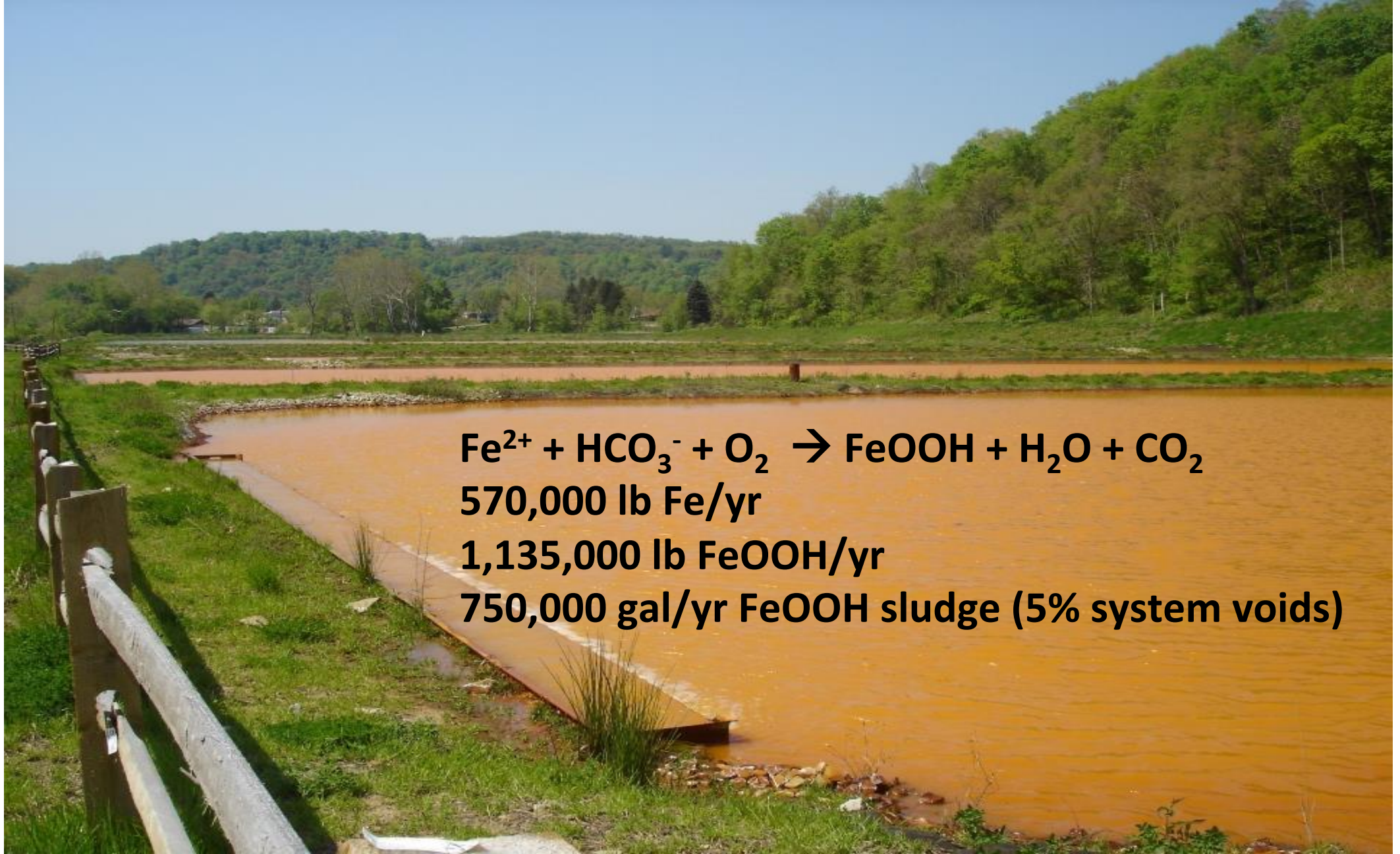
Sludge Management

Marchand Passive System (Westmoreland County, PA)



<i>Marchand passive treatment system effectiveness, Oct 2006 – May 2016</i>								
	Flow	pH	Alk	Fe	Al	Mn	SO ₄	TSS
	gpm	s.u.	----- mg/L -----					
Inflow	1,870	6.3	334	71.6	<0.1	1.2	1,141	26
Effluent	na	7.7	218	1.1	<0.1	0.5	1,163	<6





570,000 lb Fe/yr

1,135,000 lb FeOOH/yr

750,000 gal/yr FeOOH sludge (5% system voids)

Operation and Maintenance

- Routine inspections and sampling
 - Quarterly, ½ day
- System improvements
 - Berm reinforcement; trough installations
- Sludge management
 - Every 7-10 years

Sludge Management: 2012

- Cleaned first three ponds
- Installed bypass system to enable pond dewatering and continuous treatment
- Replaced three problem pipes with open troughs



Disposal of solids

- Landfill: \$50/ton (50% solids)
- Beneficial use (neutral cost?)
- Sell as product (income?)

Elemental composition of solids

Al	C	Ca	Fe	K	Mg	Mn	Na	P	S	Si	LOI
%	%	%	%	%	%	%	%	%	%	%	%
0.2	0.7	0.6	52.6	< 0.1	0.1	< 0.1	0.1	< 0.1	0.2	0.9	17

- Solids are ~50% Fe and are mixture of FeOOH and $\text{Fe}(\text{OH})_3$
- Concentrations of hazardous metals all below limits in EPA Part 503 Biosolids rule
- Solids have value as pigment and for remediation purposes



Marchand costs, 2000 – 2016

(1,850 gpm, 72 mg/L Fe)

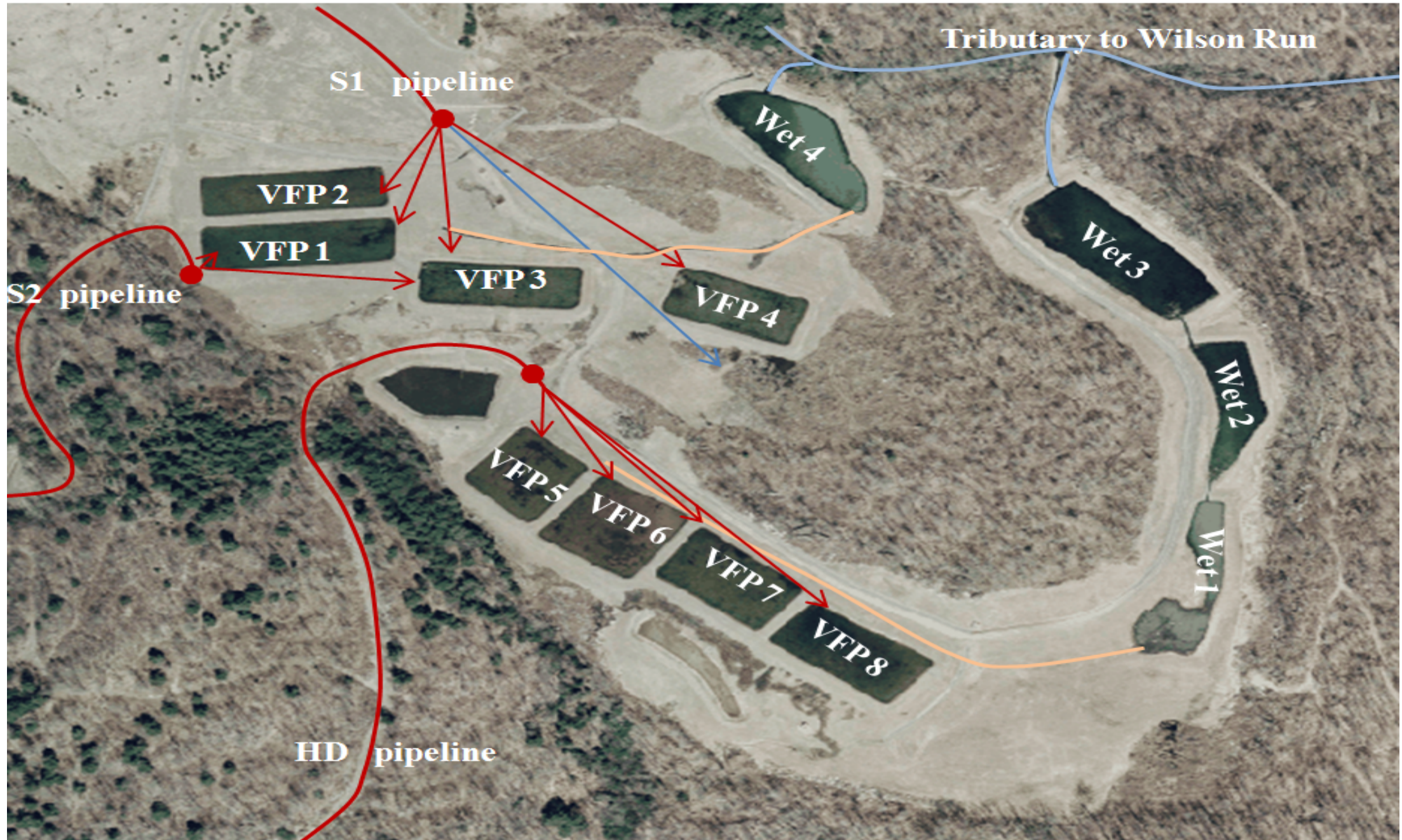
Year	Cost	Activity
2000	\$105,000	Treatment feasibility (PA DEP Grant)
2004	\$1,282,000	System design, permitting, and construction
2010	\$15,000	Berm repairs and pipe cleaning
2012	\$87,935	Sludge removal (3 ponds); trough and bypass installation
2016	\$18,000	Trough installation and repairs
Annual	\$3,000/yr	quarterly inspections and routine maintenance
Periodic	\$140,000/event	Remove iron sludge every 10 years
Periodic	\$490,000/event (49,000)	Landfilling cost every 10 years Sale and royalty on iron sludge every 10 years
	\$1,438,000	Total Capital
	\$242,000 - \$1,320,000	Total 20 year O&M (sale) Total 20 year O&M (landfill)

Anna S Passive System Complex

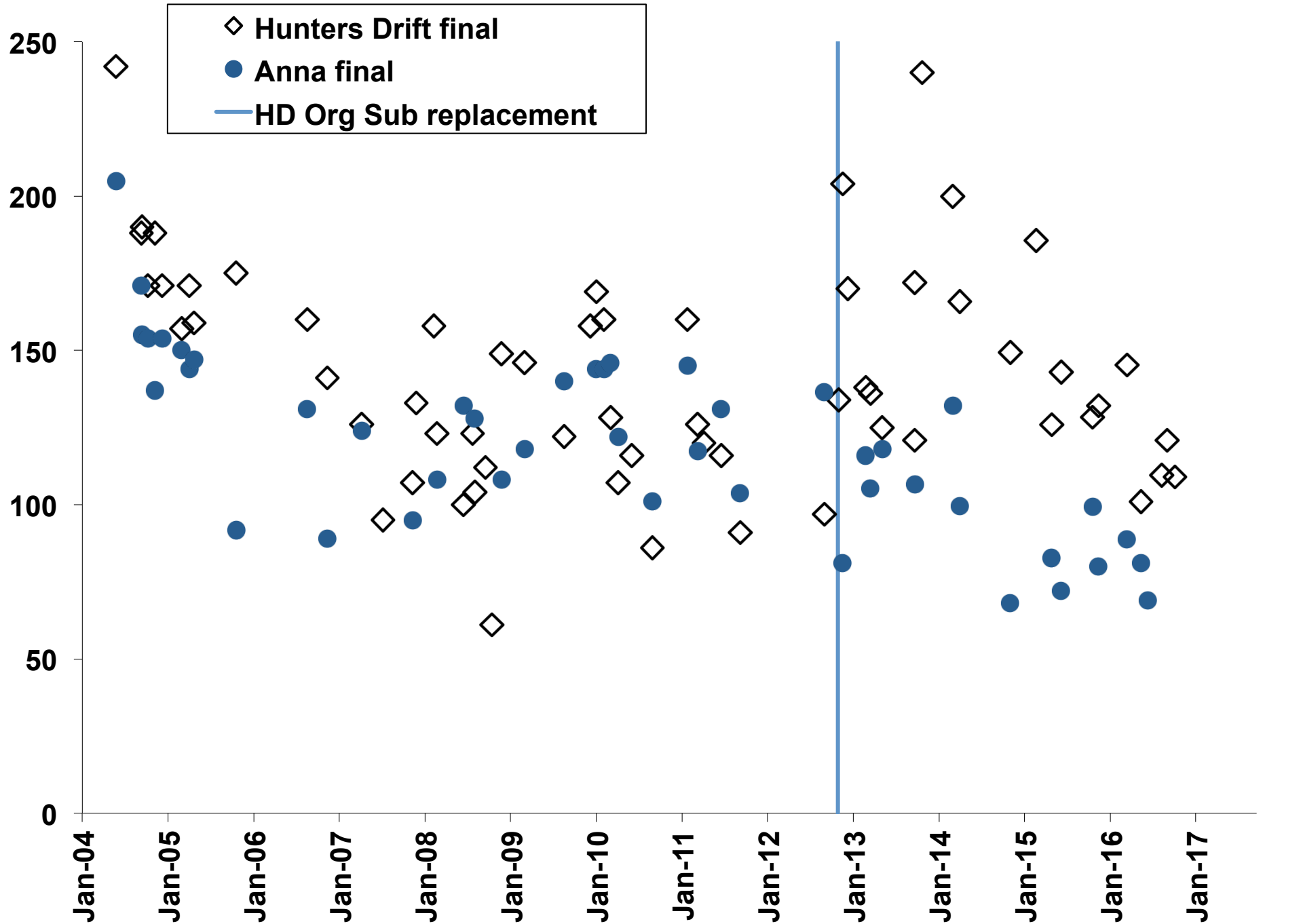
Replace reactive organic substrate

Replace reactive organic substrate

Anna S Mine Passive Treatment Complex

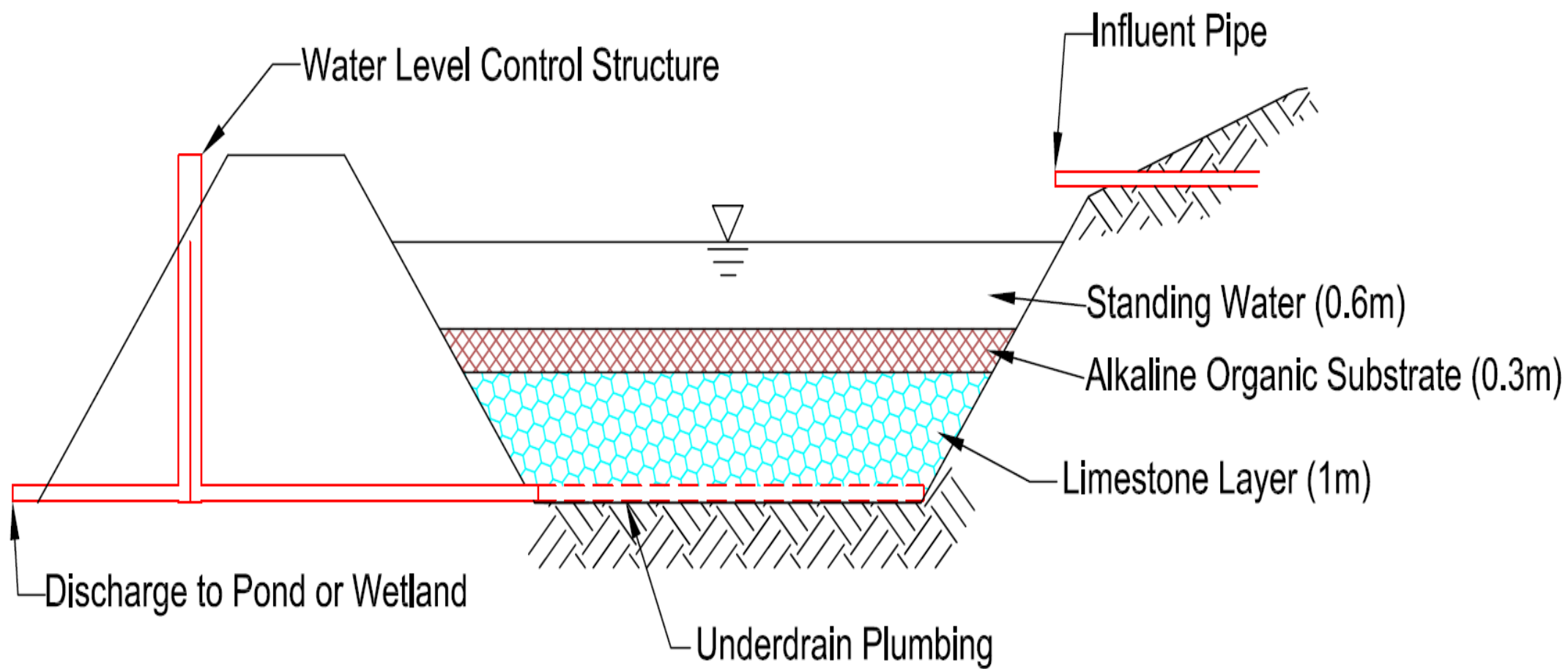


Alkalinity, mg/L CaCO₃



Operation and Maintenance

- Routine inspections and sampling
 - Bi-monthly by Babb Creek Watershed Association
- System improvements and minor maintenance
 - Hunters Drift collection system upgrades; channel cleanouts
- Organic substrate replacement



Organic Substrate Assessment

- Drained individual VFPs and inspected substrate
 - Black substrate (FeS) indicates reducing conditions and viability
 - Brown/grey substrate indicates oxidizing conditions and accumulation of iron and Al hydroxides

Photos of substrate





Anna S Passive Complex Costs, 1999 – 2016

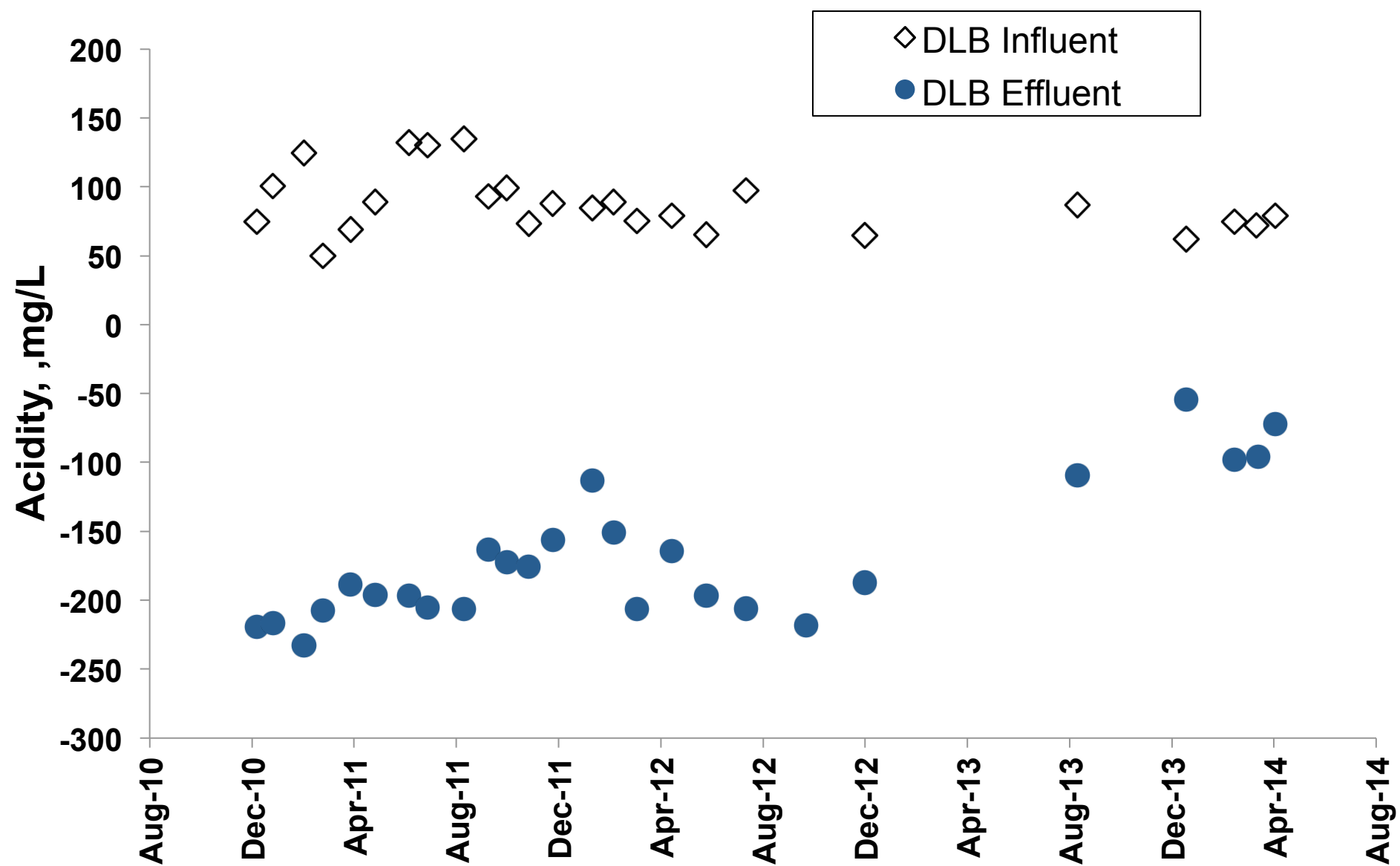
(456 gpm, 235 mg/L acidity, 22 mg/L Al, 20 mg/L Fe)

Year	Cost	Activity
1999	25,000	Feasibility and conceptual design
2002	\$2,512,000	System design, permitting and construction
2012	\$210,008	New organic substrate in 4 VFPs
2015	\$201,706	New organic substrate in 4 VFPs
Annual	\$7,670/yr	Babb Creek Watershed Association, bi-monthly inspections and routine maintenance
Periodic	\$400,000/event	New organic substrate in 8 VFPs every ten years
	\$2,537,000	Total Capital
	\$953,000	Total 20 year O&M

Limestone Rehabilitation and Replacement

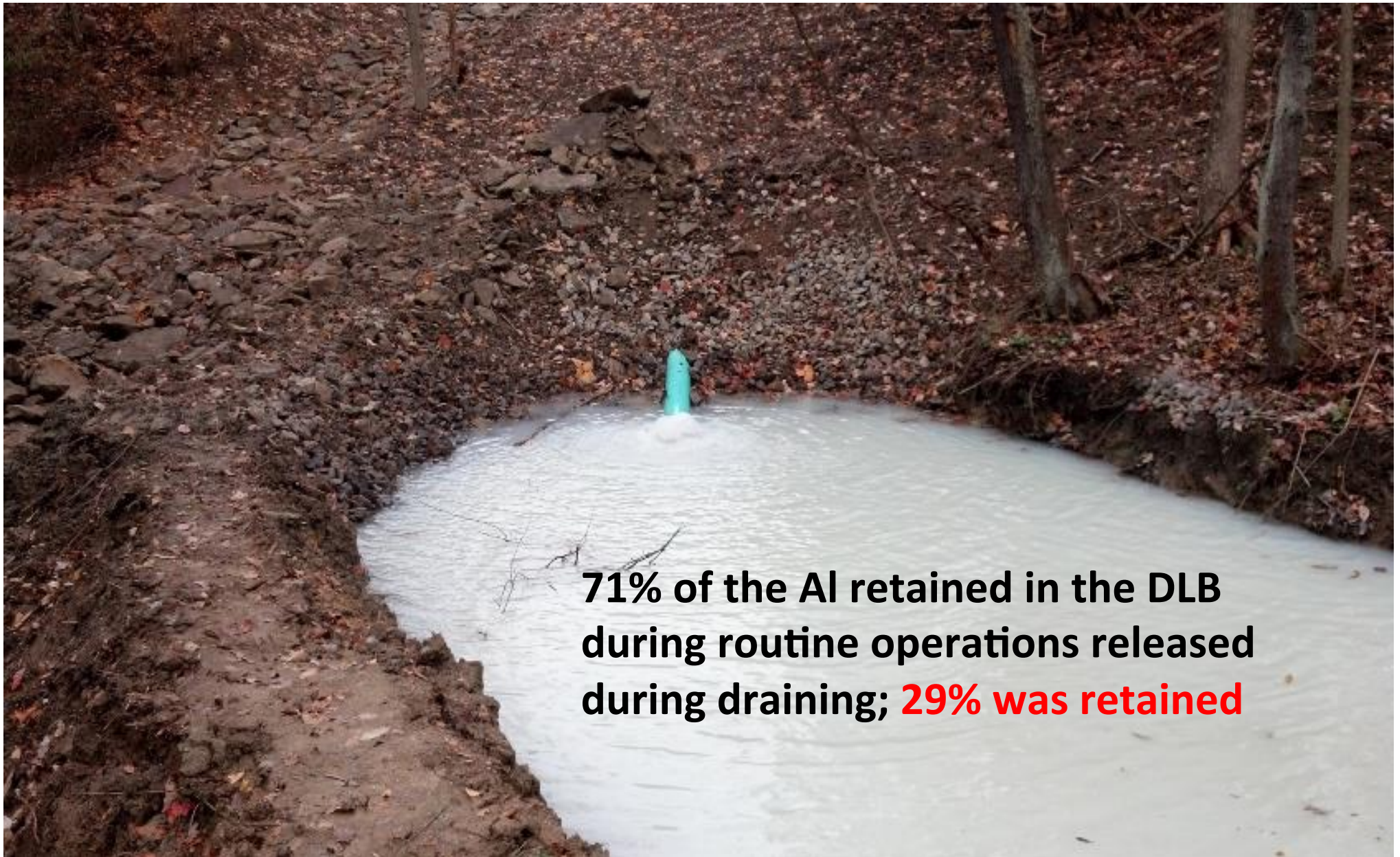
Tangascootac #1 Drainable Limestone Bed System





Operation and Maintenance

- Routine inspections and sampling
 - quarterly by Clinton County Conservation District
- Major maintenance
 - Clean limestone aggregate
 - Replace limestone loss to dissolution



**71% of the AI retained in the DLB
during routine operations released
during draining; 29% was retained**



Tangascootac #1 Passive System Costs

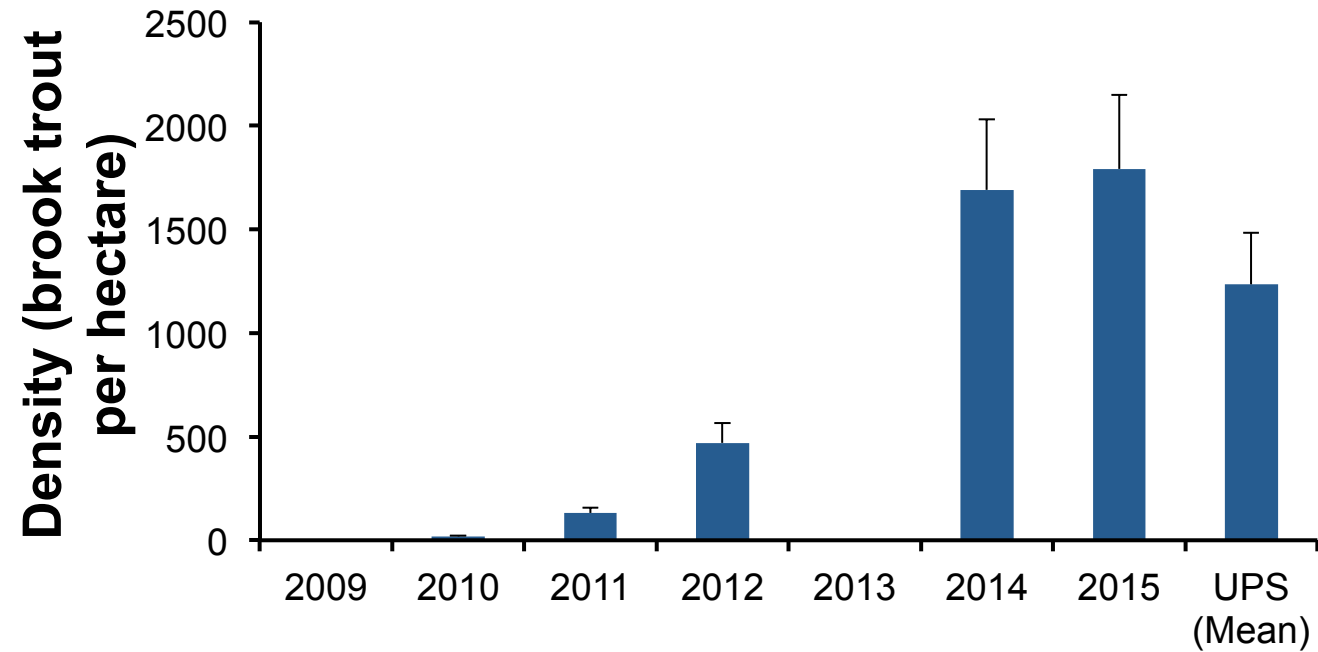
(45 gpm, acidity 89 mg/L, Al 11 mg/L, Mn 26 mg/L)

Year	Cost	Activity
2009	\$65,572	Design, permit and construction (does not include pond)
2012	\$5,000	Clean limestone aggregate
Annual	\$2,000/yr	Clinton County Conservation District, quarterly inspections, sampling, and routine maintenance
Periodic	\$7,500/event	Clean limestone aggregate every four years, \$5,000; replace dissolved limestone, \$2,500
	\$85,000	Total Capital (add in value of existing pond)
	\$77,500	Total 20 year O&M

Projected 20 year treatment costs

			20 year unit costs		
Site	Water chemistry	technology	\$/1000 gal	\$/lb-Fe	\$/ton-CaCO₃
Marchand	Alkaline, Fe	Ponds & wetland	\$0.09	\$0.15	na
Anna	Acid, Fe, Al, Mn	Vertical flow ponds and wetlands	\$0.65	na	\$435
Scootac #1	Acid, Al, Mn	Drainable limestone bed and pond	\$0.35	na	\$332

Maintained passive systems can result in biological recovery



Questions?