Using AMD Solids for Managing Phosphate in Manure

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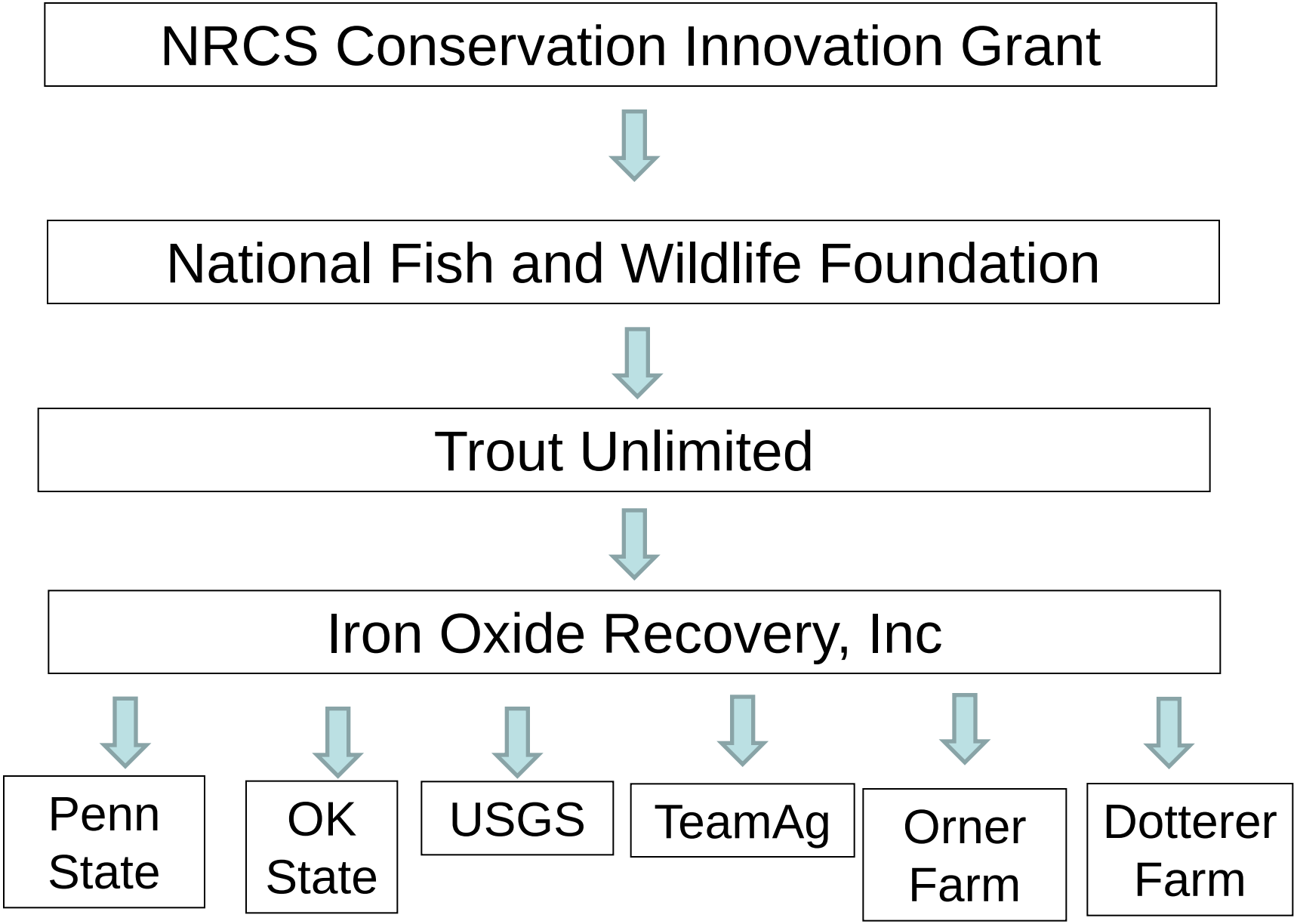
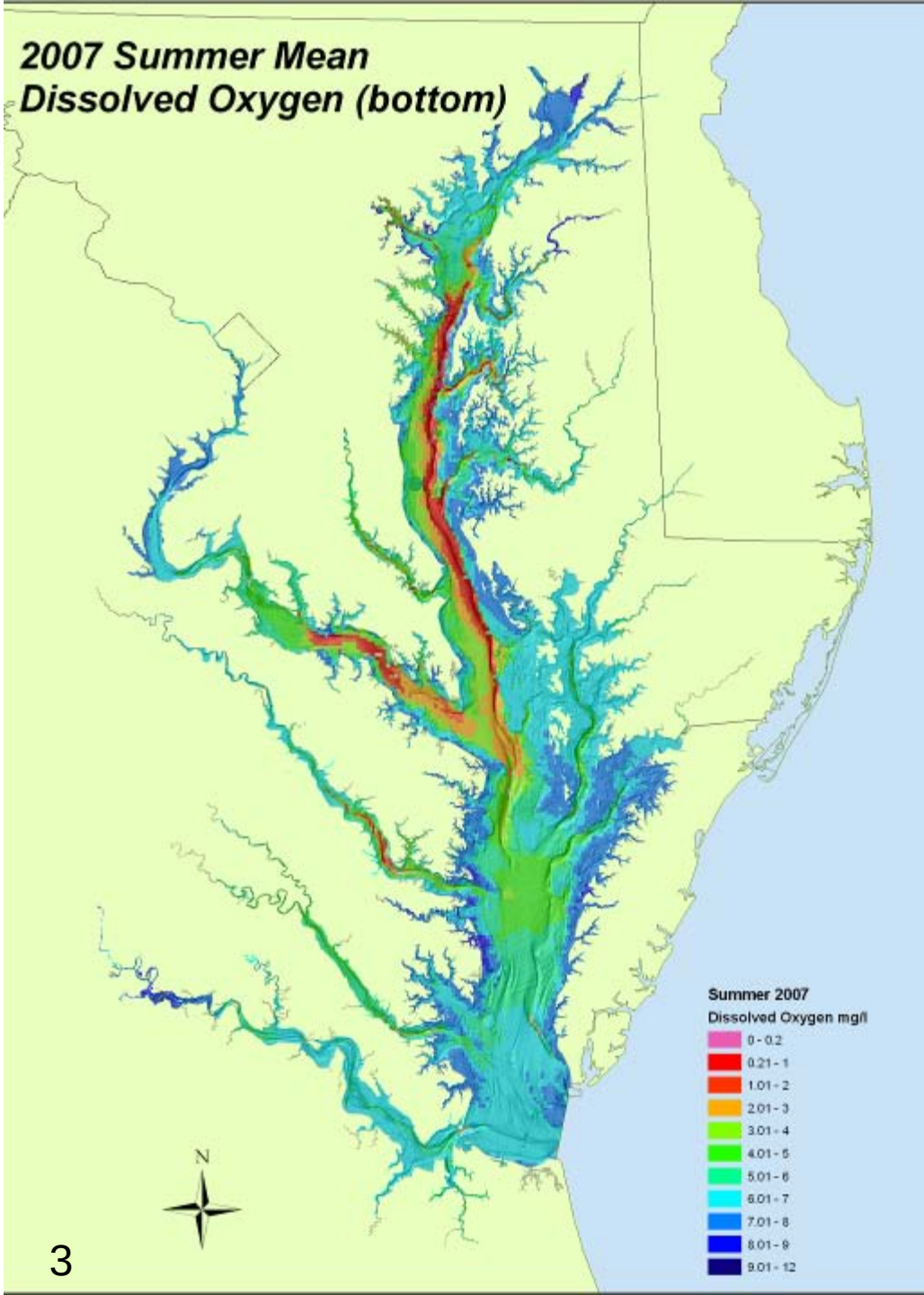
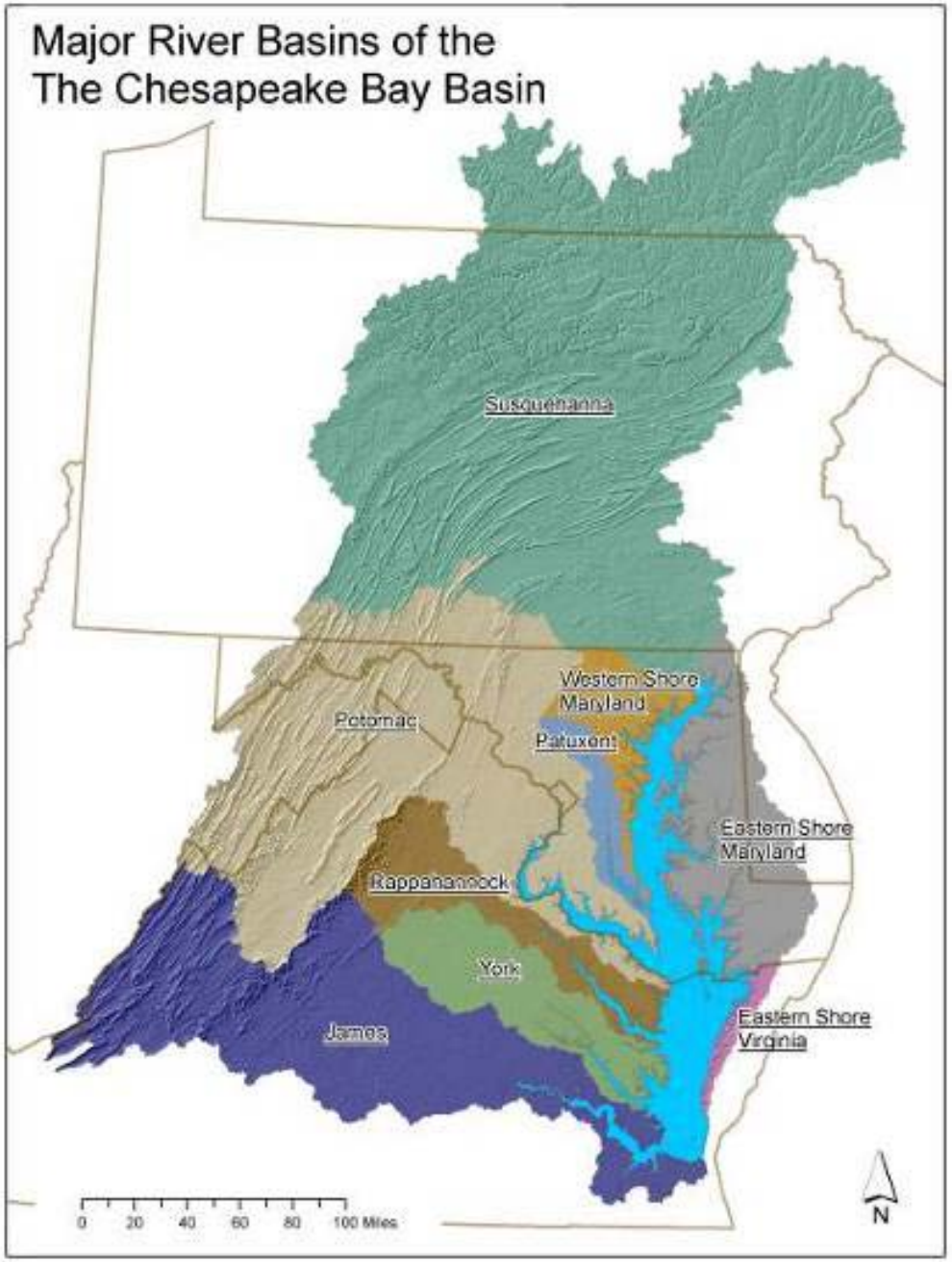

NRCS Conservation Innovation Grant
National Fish and Wildlife Foundation
Trout Unlimited
Iron Oxide Recovery, Inc
Penn State
OK State
USGS
TeamAg
Orner Farm
Dotterer Farm

Chesapeake Bay Dead Zone

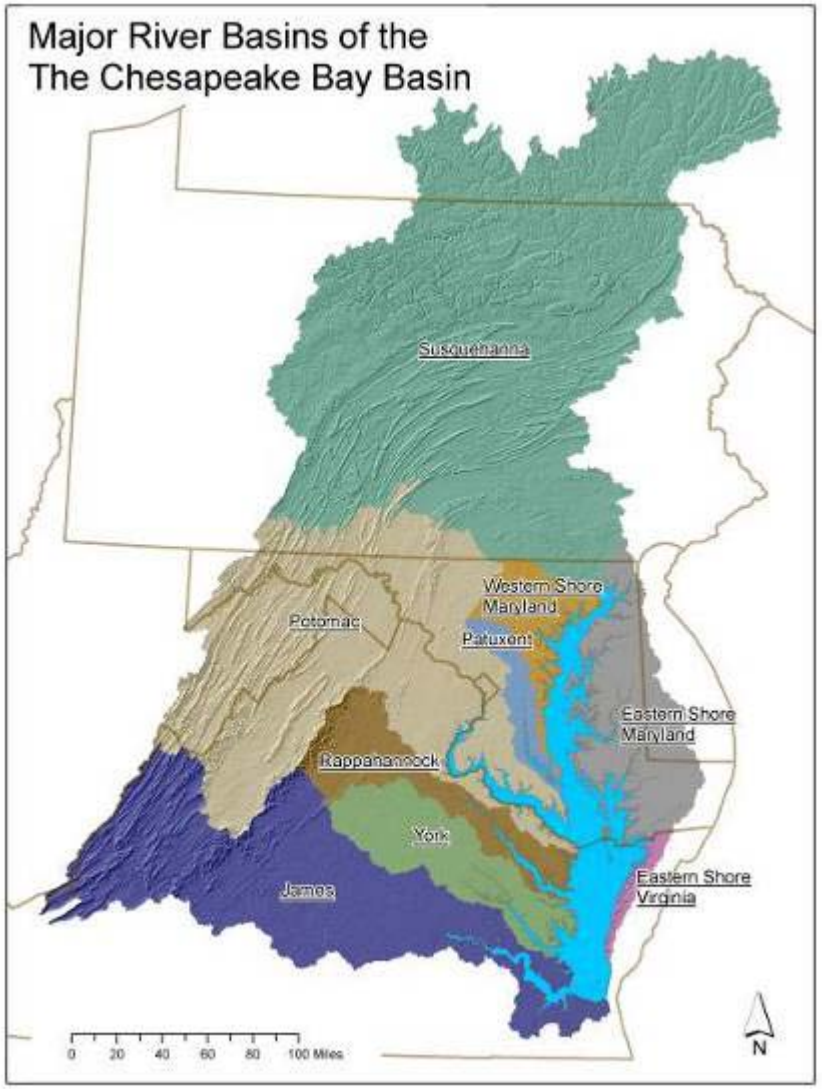
Low to no dissolved oxygen in the Bay and tidal rivers <u>every</u> summer




Major River Basins of the
The Chesapeake Bay Basin
Susquehanna
Western Shore
Maryland
Potomac
Patuxent
Eastern Shore
Maryland
Rappahannock
York
James
Eastern Shore
Virginia
0 20 40 60 80 100 Miles
N

Chesapeake Bay TMDL

- EPA sets pollution diet to meet states' Bay clean water standards
- Caps on nitrogen, phosphorus and sediment loads for all 6 Bay watershed states and DC
- States set load caps for point and non-point sources
- Final TMDL published by EPA in Dec 2010
- States are required to develop plans to achieve TMDL caps and implement load-reduction actions



TMDL has caps for sediment, nitrogen, and phosphorus

This project deals only with phosphorus (P)

Existing and Proposed P Loadings

State	2008 P load	EPA Target	P removal
	lb/yr P	*lb/yr P*	*lb/yr P*
PA	3,990,000	3,160,000	830,000
DC	140,000	130,000	10,000
DE	340,000	280,000	60,000
MD	3,100,000	3,040,000	60,000
NY	830,000	560,000	270,000
VA	7,180,000	7,050,000	130,000
WV	700,000	620,000	80,000
Total	*16,280,000*	*14,840,000*	*1,440,000*

2006 loads and planned reductions, PA Susquehanna River Basin

	2006 P	Target	Change
	lb/yr P		
Agriculture	1,765,000	1,024,000	741,000
Point Source	737,000	675,000	62,000
Urban	187,000	110,000	78,000
Mixed Open	268,000	313,000	-45,000
Forest	108,000	111,000	-4,000
All Sources	3,106,000	2,282,000	824,000


Keller

P primer

- Primary source of P from agriculture is land applied manure (dairy and swine)
- P is present in many forms in manure, all are measured by Total P analyses
- Not all P is environmentally mobile
  - Water Extractable Phosphorus (WEP) is a measure of soluble P and correlates with environmental mobility

P Control BMPs

- Apply less manure
- Change timing of application
- Change method of application
- Modify connection between field and stream so connectivity is lessened

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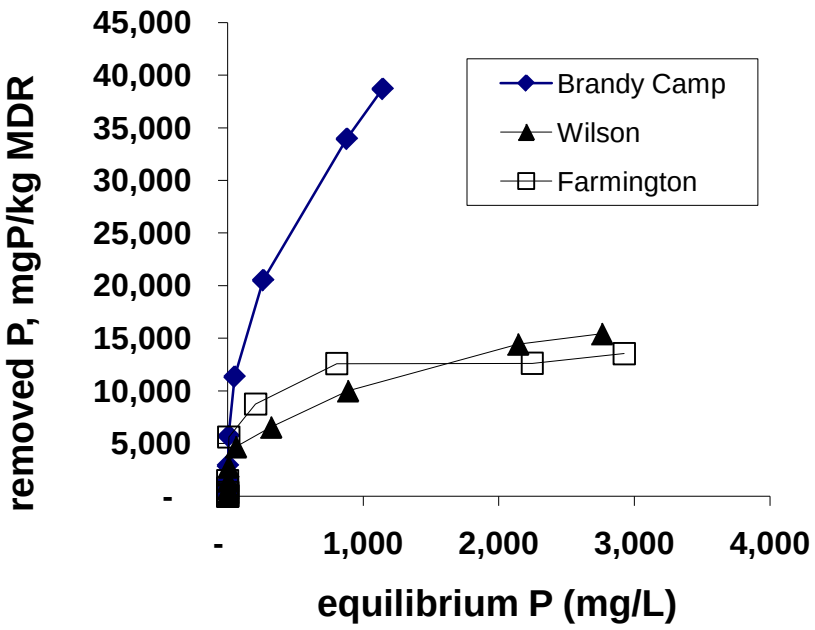
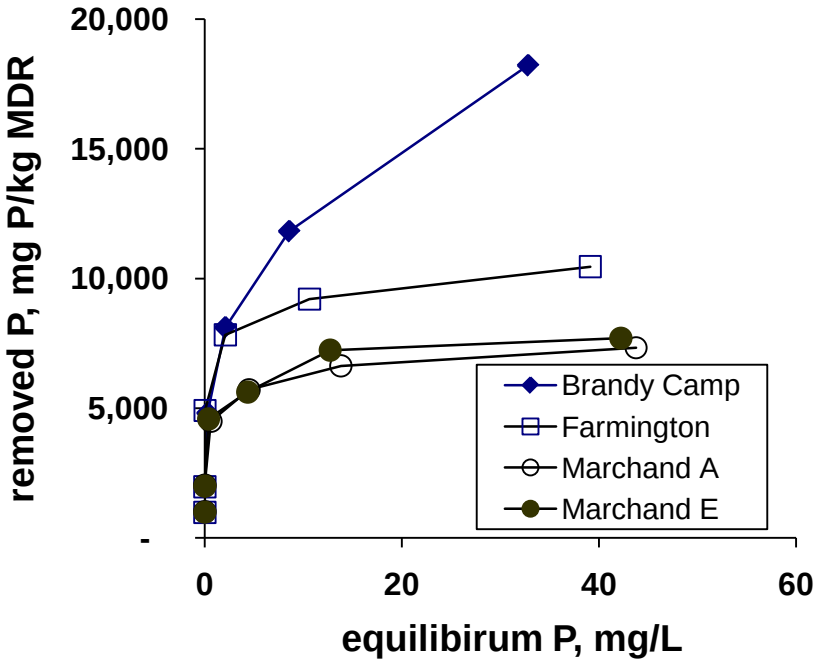
- Change method of application
- Modify connection between field and stream so connectivity is lessened
- P chemistry is assumed fixed: no practices that change P chemistry and lessen environmental mobility

Mine Drainage Solids primer

- Clean passive solids are predominantly Fe and Al oxide minerals with lesser amounts of Si, Ca, and S
  - Phosphate readily sorbs to Fe and Al oxides
- Lime treatment solids are predominantly Ca minerals with lesser amounts of Fe, Al, and Mg
  - Phosphate reacts with Ca to form $CaPO_4$ (apatite)

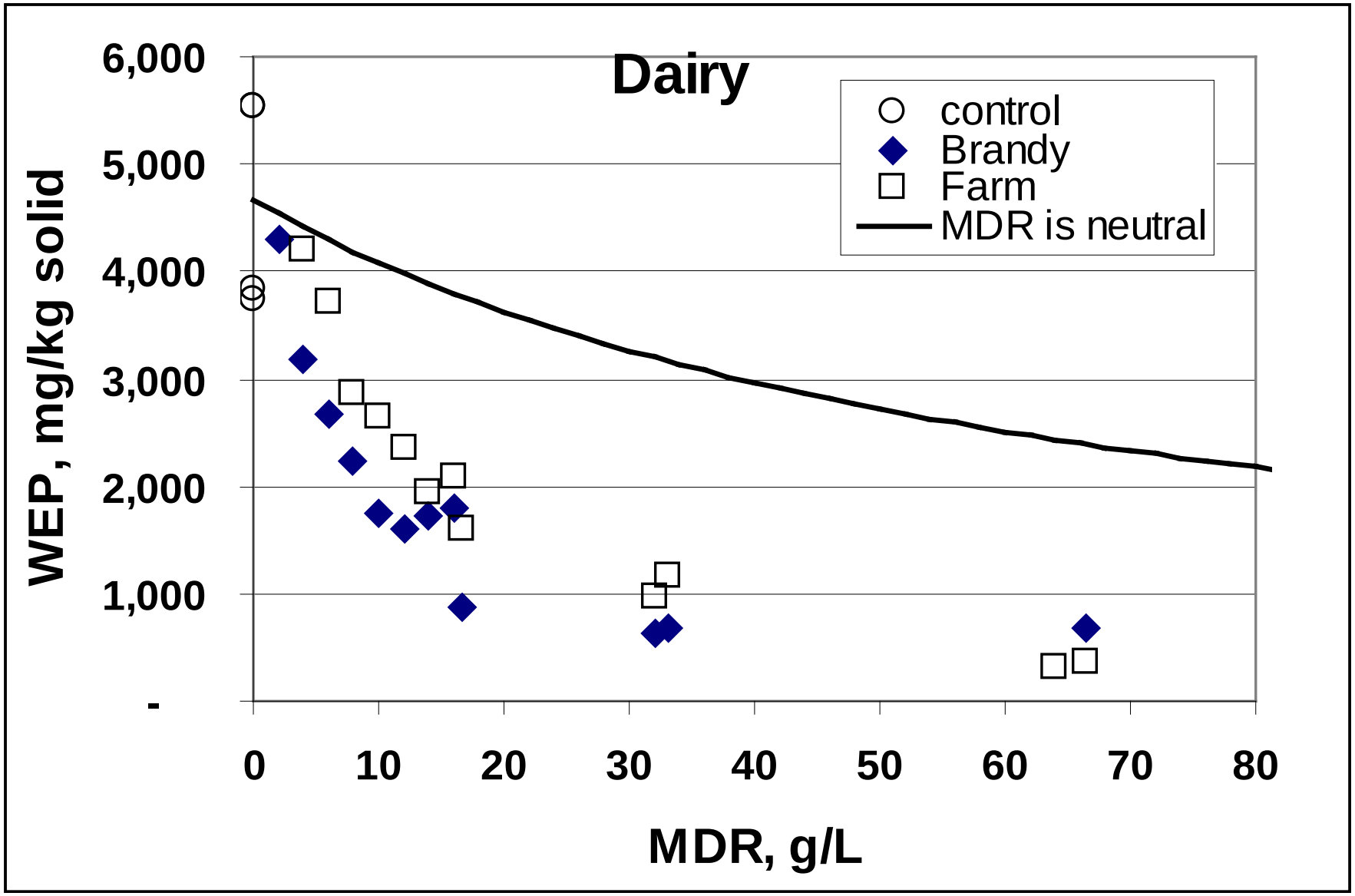
P removal isotherms

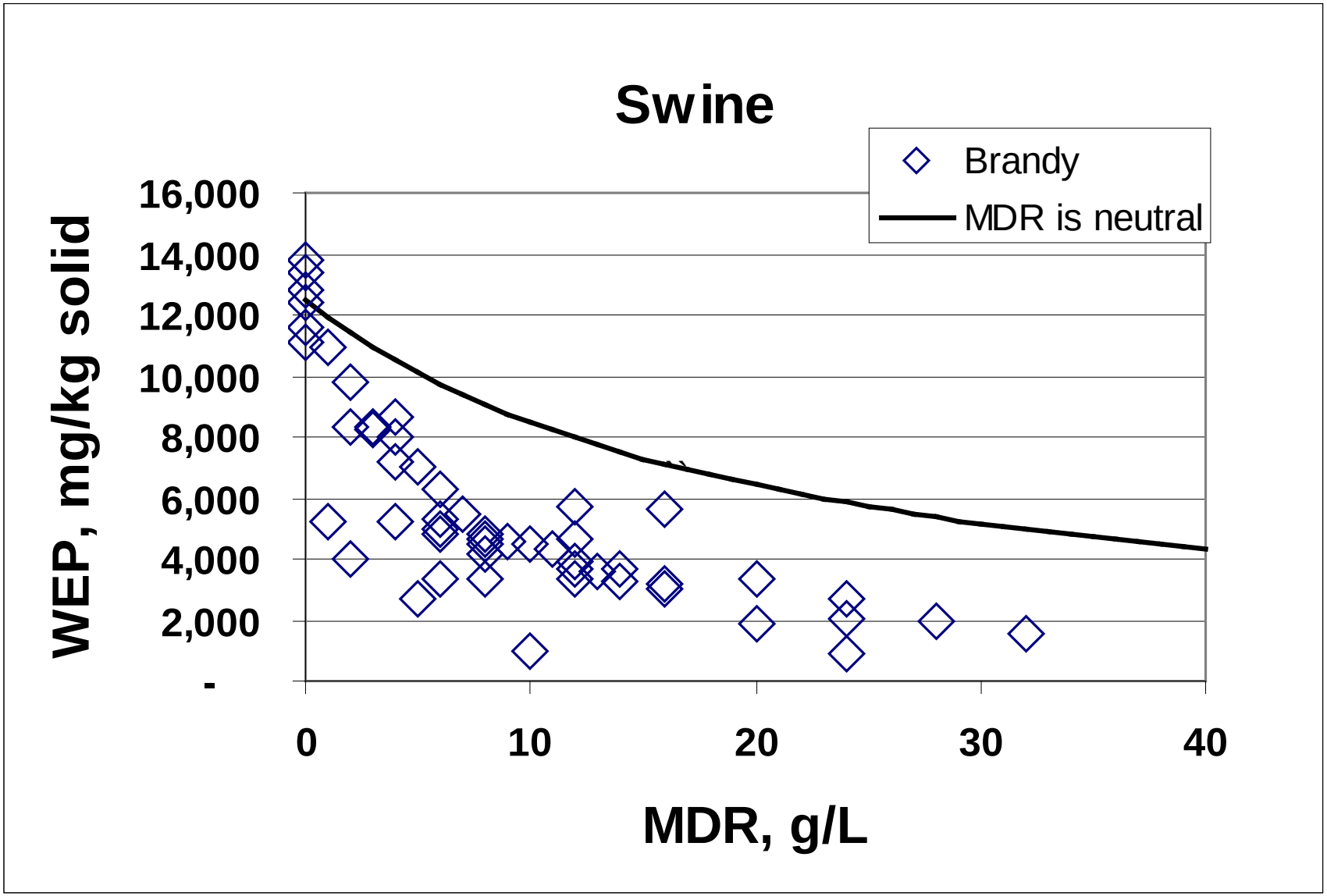




Effect of MDR on WEP in manures

- Two manures: dairy and swine
- Four MDRs
  - Farm: passive acid clean (90% Fe solids)
  - Wilson: passive alkaline muddy (75% Fe solids)
  - Marchand: passive alkaline clean (90% Fe solids)
  - Brandy: lime (30% Fe and Al solids)
- Add variable amounts of MDR to 500 mL of manure; measure WEP
- Assess whether there is a dose-effect relationship


Dairy
control
Brandy
Farm
MDR is neutral
WEP, mg/kg solid
6,000
5,000
4,000
3,000
2,000
1,000
-
0
10
20
30
40
50
60
70
80
MDR, g/L


Swine
Brandy
MDR is neutral
WEP, mg/kg solid
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
-
0
10
20
30
40
MDR, g/L

Cost Evaluation: Dairy

- 8 g/L dose of MDR will decrease WEP and PSC by 50%
- $200/ton (processed) plus $50/ton trucking and application = $250/ton applied
  - $8.33 / 1000 gallons manure
  - At 5,000 gal/acre = $42/acre
  - $25/milking cow per year
  - $0.01-0.02 / gallon milk
- Competitive with alternative BMPs

What’s Wrong with this Idea?

- Is the incorporation of MDR with manure tedious?
- Is MDR hazardous?
- Will MDR decrease plant availability of P and lessen crop yield?


Diller

Table 3. Chemical composition of MDRs and EPA's 503 metal limits for land applied biosolids

Element	units	503 limit	Brandy	Farm
Fe	%	None	13.1	50.0
Ca	%	None	19.6	0.1
Si	%	None	2.3	3.6
Al	%	None	2.0	0.4
S	%	None	1.4	0.8
As	ppm	75	17	12
Cd	ppm	85	0.8	1.8
Cr	ppm	3,000	14	16
Cu	ppm	43,000	22	<1
Mo	ppm	75	<5	<5
Ni	ppm	420	373	50
Pb	ppm	840	<5	14
Se	ppm	100	<3	<3
Zn	ppm	7,500	434	40
Hg	ppm	57	na	na

MDRs and EPA 503 limits

- Tested 13 MDRs
- Two exceeded As limit
- One exceeded Ni limit
- None exceeded Cd, Cr, Cu, Hg, Mo, Pb, Se and Zn

Corn growth: no signs of P deficiency

Control

Control

Farmington MDR

Brandycamp MDR

Greenhouse Test

- Dr. Rick Stehouwer, PSU Soil Scientist
- Grew ryegrass on P-deficient soil with two manure application rates and three MDR treatment rates
  - Manure increased plant growth
  - MDR did not affect plant growth
- Leached pots three times
  - MDR lessened leaching of P

Feasibility Calculation

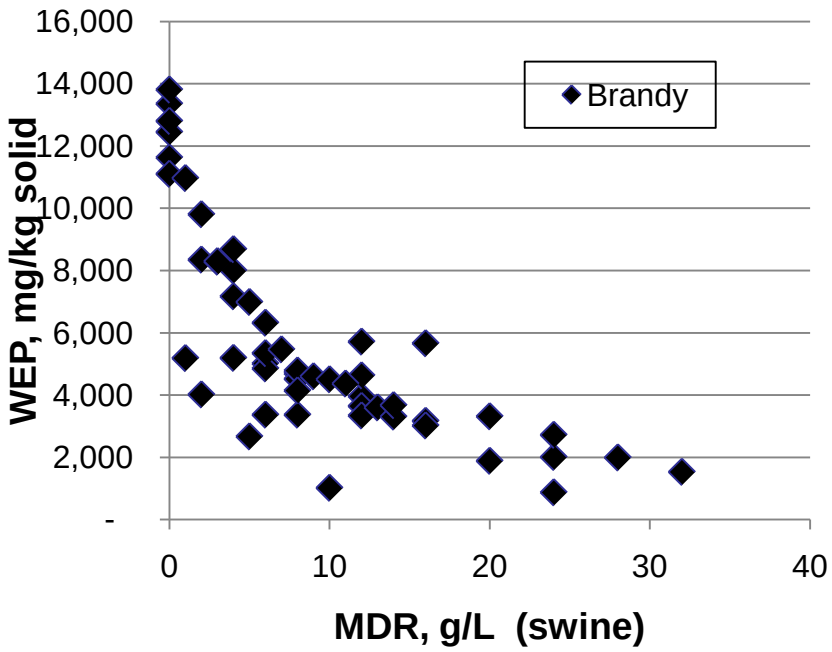
- Large lime plant treating 6000 gpm,60 mg/L Fe makes about 5,000 ton/yr dewatered sludge
  - Could treat 150 million gallons manure
  - About 300 mid-sized dairy farms
  - About 24,000 milking cows
- Amend the Susquehanna River the PA border
  - Estimate 30,000 ton/yr MDR

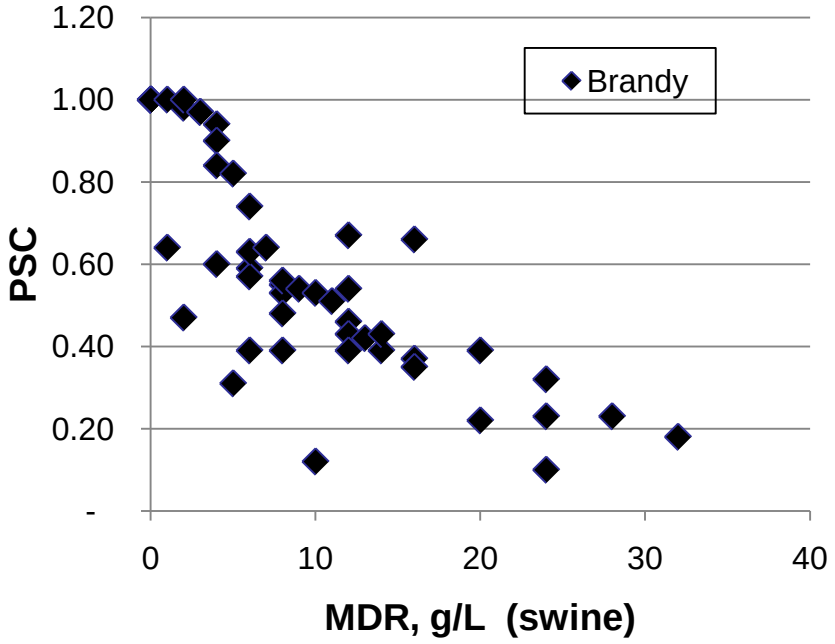
Conclusions

- Mine drainage solids can be used to lessen WEP in dairy and swine manure
  - the most effective solids were from a lime plant
- No evidence that solids inhibit crop growth
- Some MDRs contain high As and Ni – screening is necessity
- Cost is competitive with other BMPs
- If practice was accepted; huge demand for mine drainage solids is possible

removed

Effect of Brandy MDR on Swine P





Animals and P produced in the PA Susquehanna River watershed

	# animals	lb P per year
Beef	541,000	21,634,000
Dairy	413,000	41,784,000
Swine	1,038,000	12,095,000
Layers	23,423,000	10,592,000
Broilers	19,481,000	4,833,000
Turkey	2,300,000	2,344,000