Successful Passive Treatment of Coal Mine Drainage, a 2010 Update

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Iron Oxide Recovery

Hedin Environmental

- Construction of 42 passive treatment systems
- Consulting advice on hundreds of AMD discharges
- Clients include
  - Non-profit organizations (watershed associations)
  - Mining companies
  - Bonding companies
  - Large engineering companies
  - State reclamation agencies

Passive Treatment

A treatment philosophy that makes fullest use of gravity, natural materials, and natural biological, geochemical, and physical processes.

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Limestone

Organic substrates

Wetland plants

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Microbial S, Fe, and Mn processes

Carbonate dissolution and equilibria

Neutralization

Solids settling and filtration

Many passive technologies that affect AMD chemistry

Compost wetland	Anaerobic wetland
Aerobic wetland	SAPS
RAPS	Vertical flow pond
Anoxic limestone drain	AROAD
Oxic limestone bed	Oxidation pond
Settling pond	Bioreactor
Sulfate reduction system	Slag bed
Infiltration trench	Aluminator
Open limestone channel	Pyrolusite™
IMPS™, Biocarbs™	low pH iron oxidation

Five Technologies that produce permit-compliant effluents (per HE)

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IMPS™, Biocarbs™	low pH iron oxidation

Technology is based on chemistry, size is based on loading

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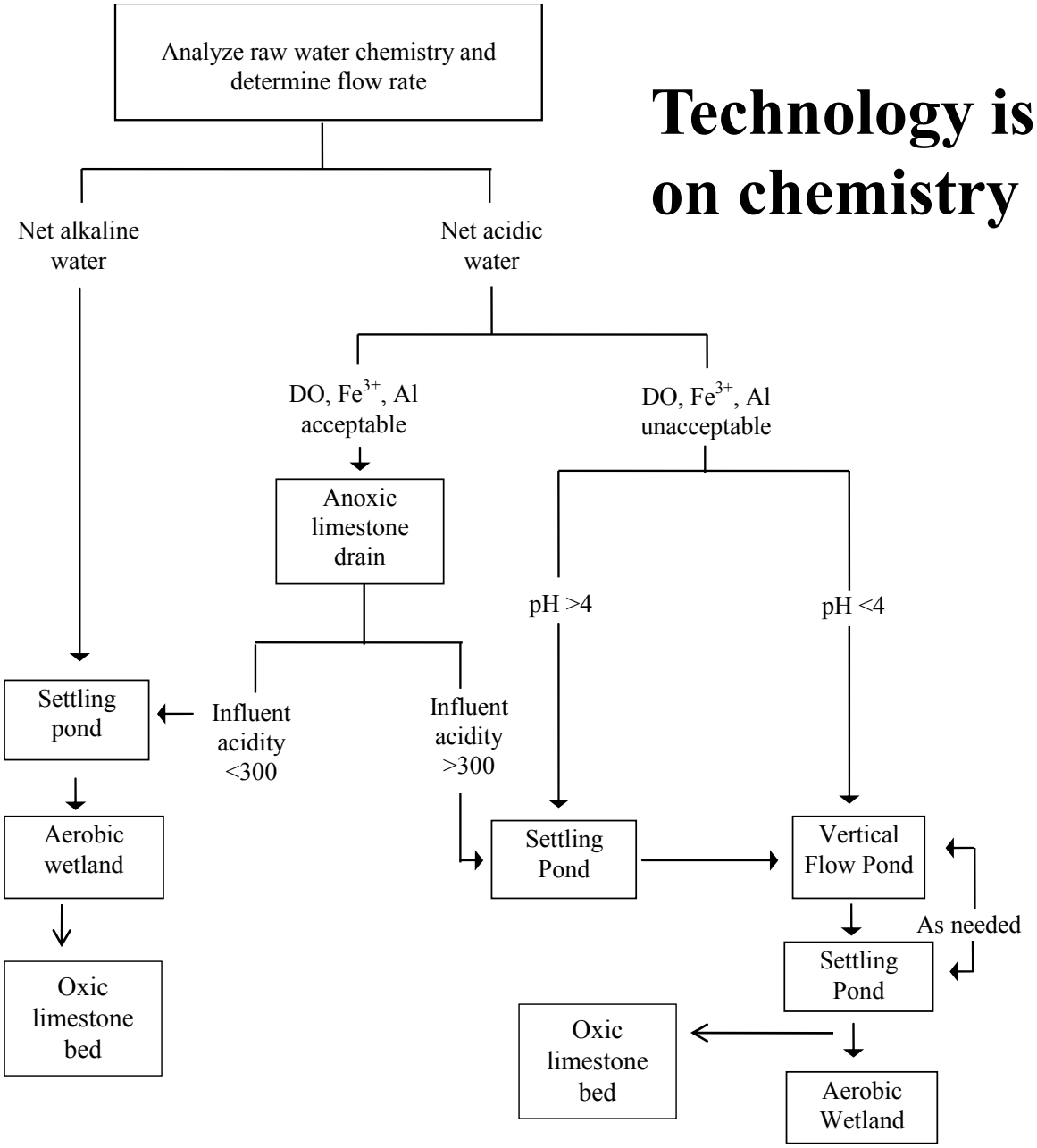
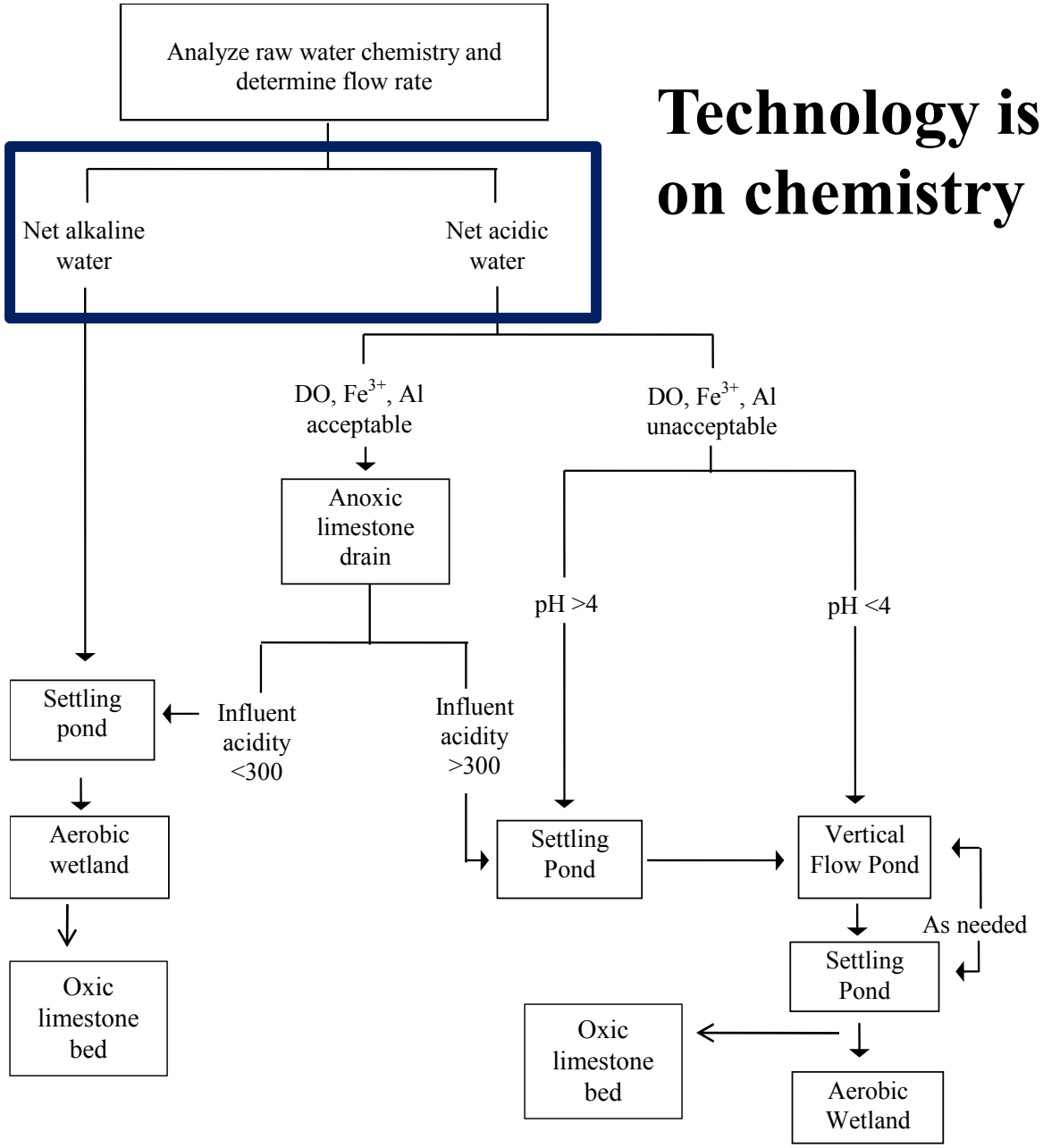


Technology is based on chemistry



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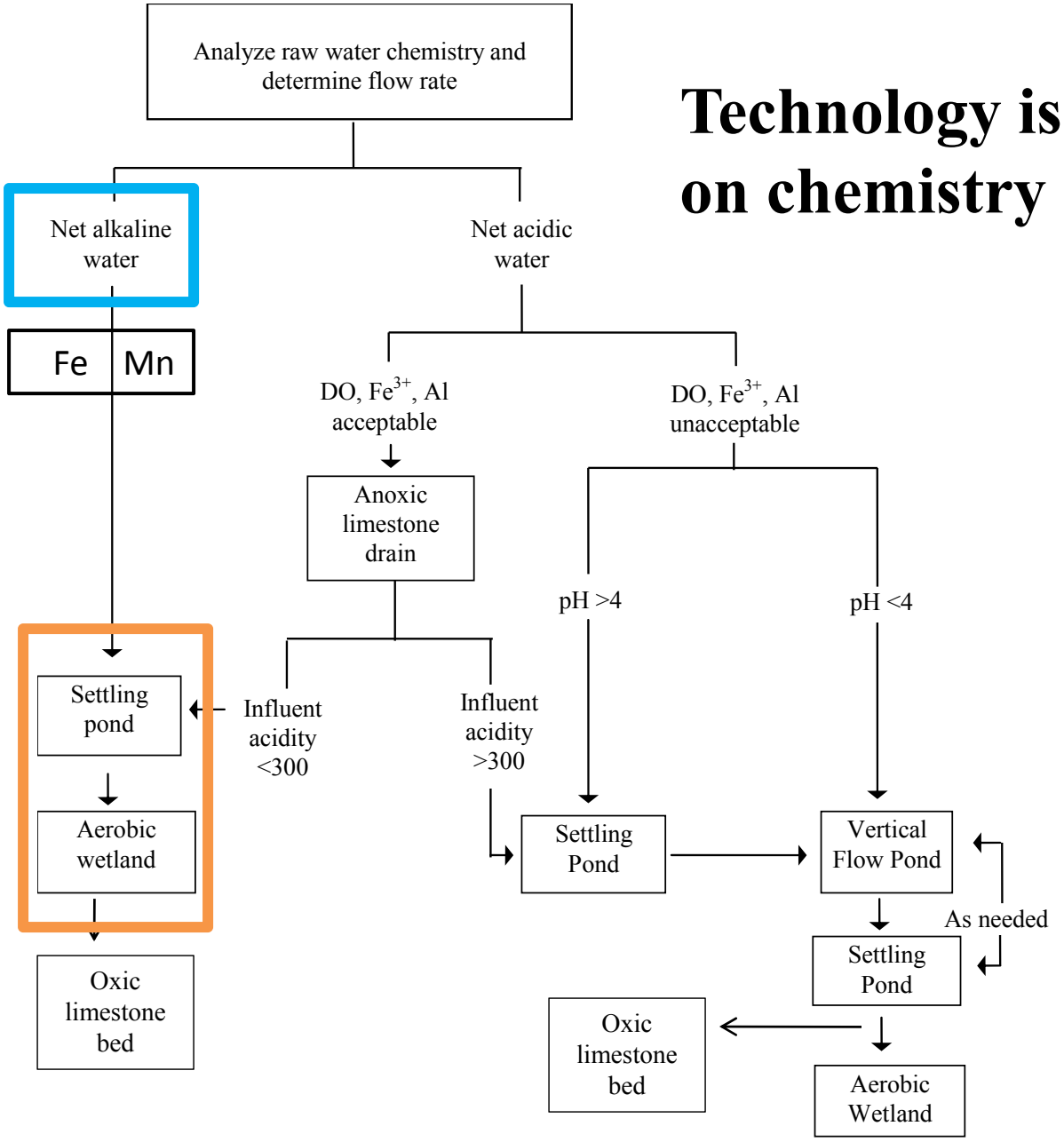


Treatment of *alkaline mine water*: **Fe**

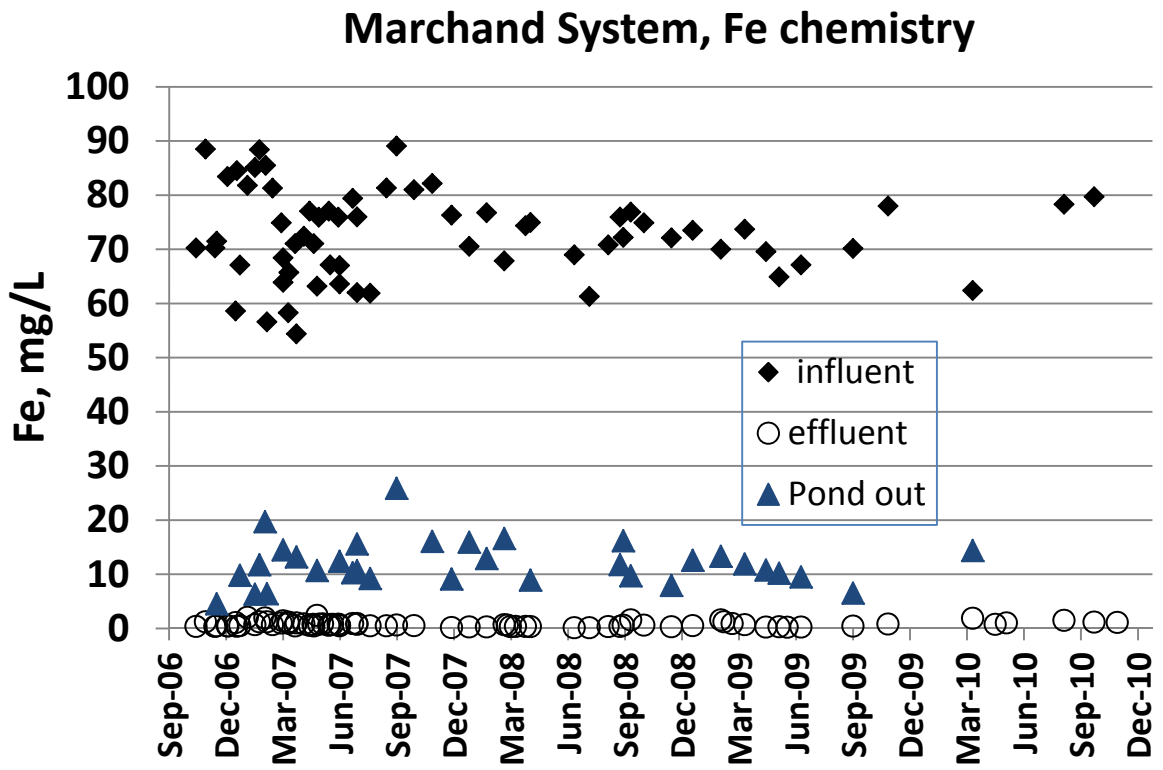
- Ponds that promote Fe oxidation and settling and provide bulk of removal (Fe > 10 mg/L)
- Design goals
  - Aeration
  - Avoid preferential flow
  - Sludge storage
  - ~4 feet deep


50 ft wide fiberglass trough

Treatment of *alkaline mine water*: **Fe**

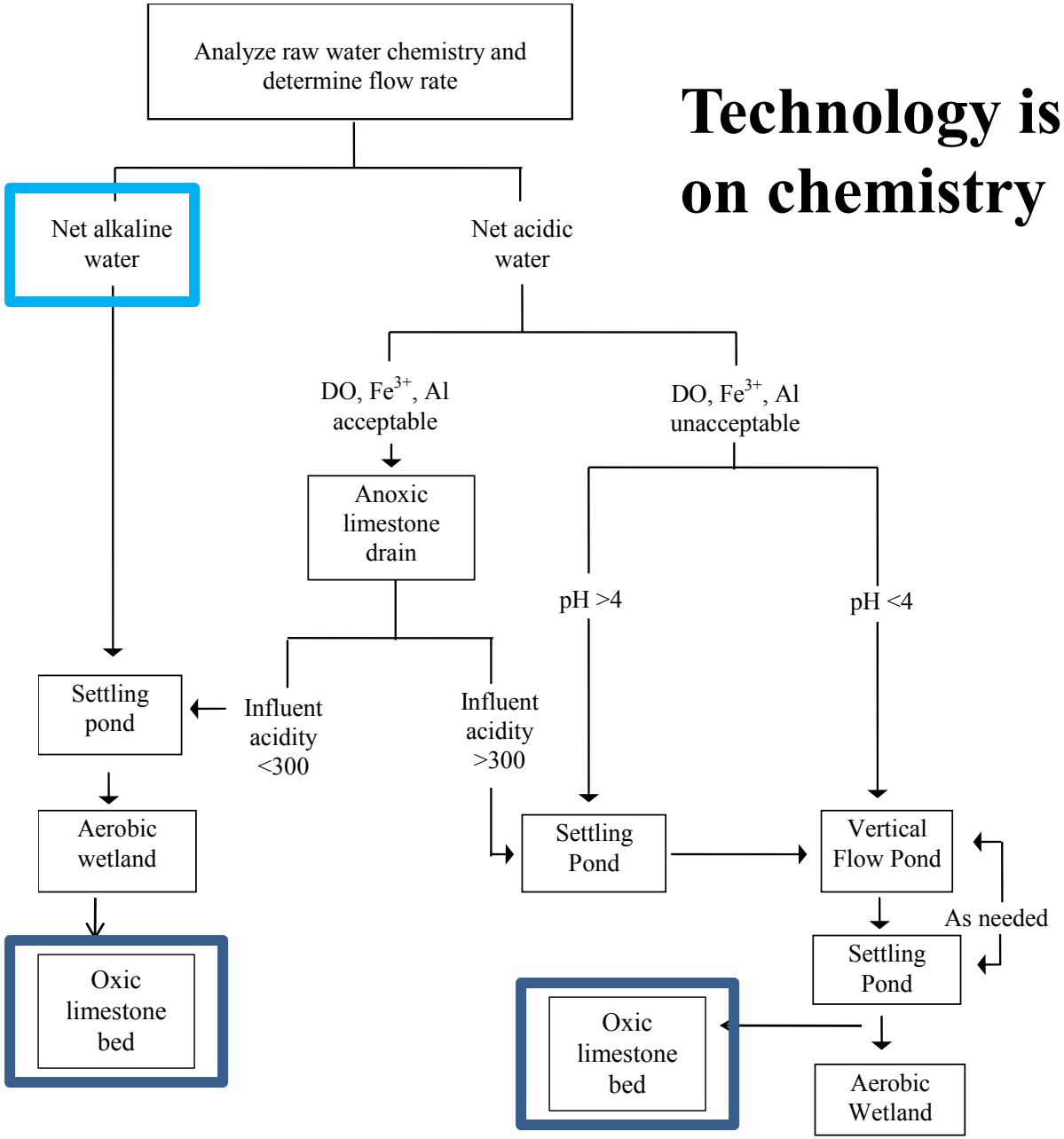
- Wetlands that remove residual Fe (< 10 mg/L)
- Design goals
  - Remove suspended Fe oxide solids
  - Avoid preferential flow
  - 4 – 12 inches deep
  - Diverse plant growth
- Can see minor Mn removal

Marchand Passive System (Westmoreland County, PA, USA)



	Flow	pH	Alk	Fe^T	Mn	Al	SO_4	TSS
	gpm		----------mg/L----------					
Influent	1,842	6.3	334	72.7	1.2	<0.3	1,105	25
Pond out		7.1	228	12.0	1.1	<0.3	1,119	21
Effluent		7.8	213	0.7	0.5	<0.3	1,158	<6

Technology is based on chemistry



Treatment of *alkaline mine water*: **Mn**

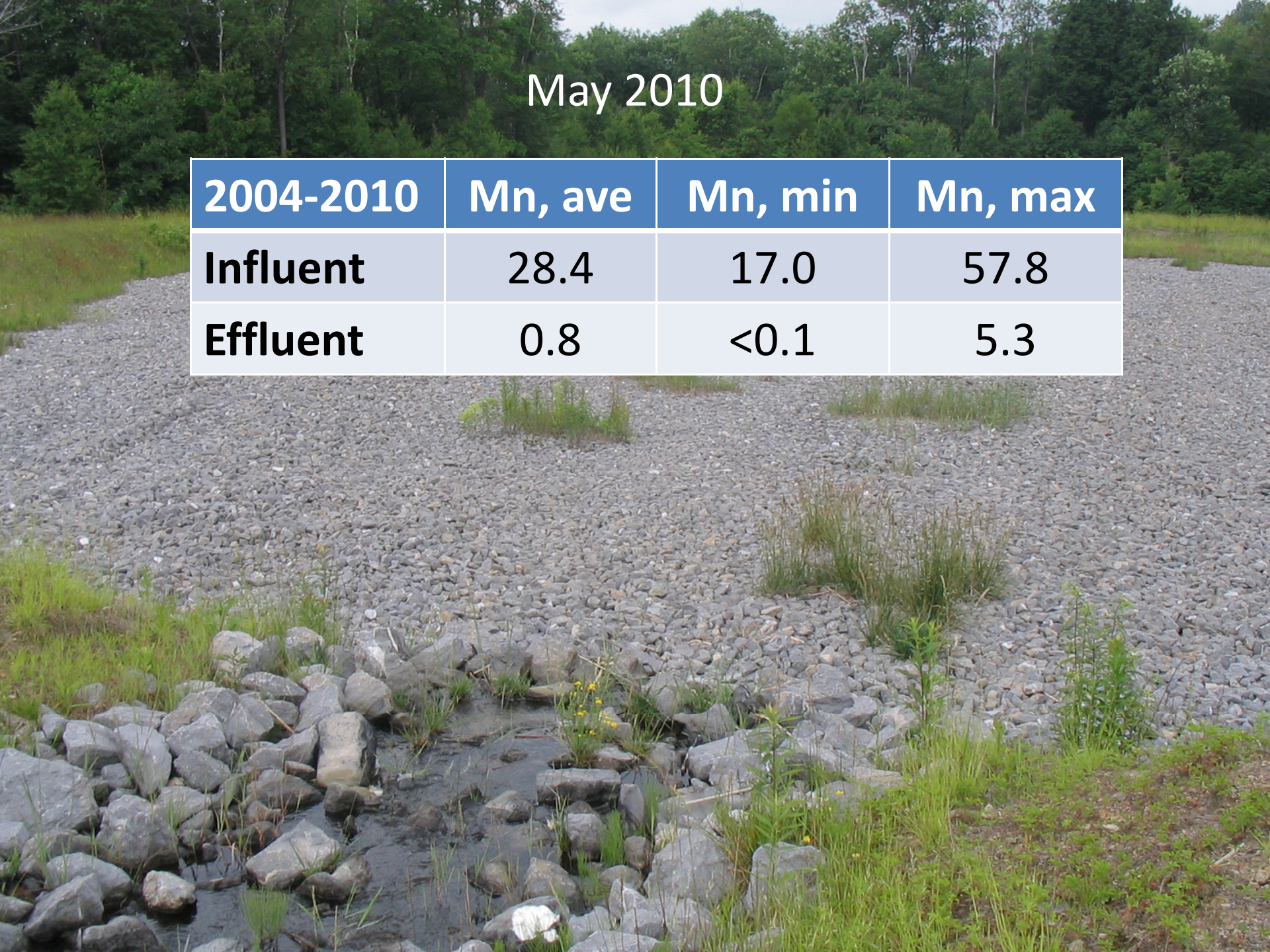
- Wetlands will remove low levels of Mn
- Oxic limestone beds are effective for higher levels of Mn (5-50 mg/L Mn)
  - 3-5 ft deep aggregate, open to atmosphere
  - water level below aggregate surface
  - Fe should be low to avoid Fe solids problems
  - Solids plugging can be lessened by periodic drain-to-empty


September 2004


May 2010

May 2010

2004-2010	Mn, ave	Mn, min	Mn, max
Influent	28.4	17.0	57.8
Effluent	0.8	<0.1	5.3



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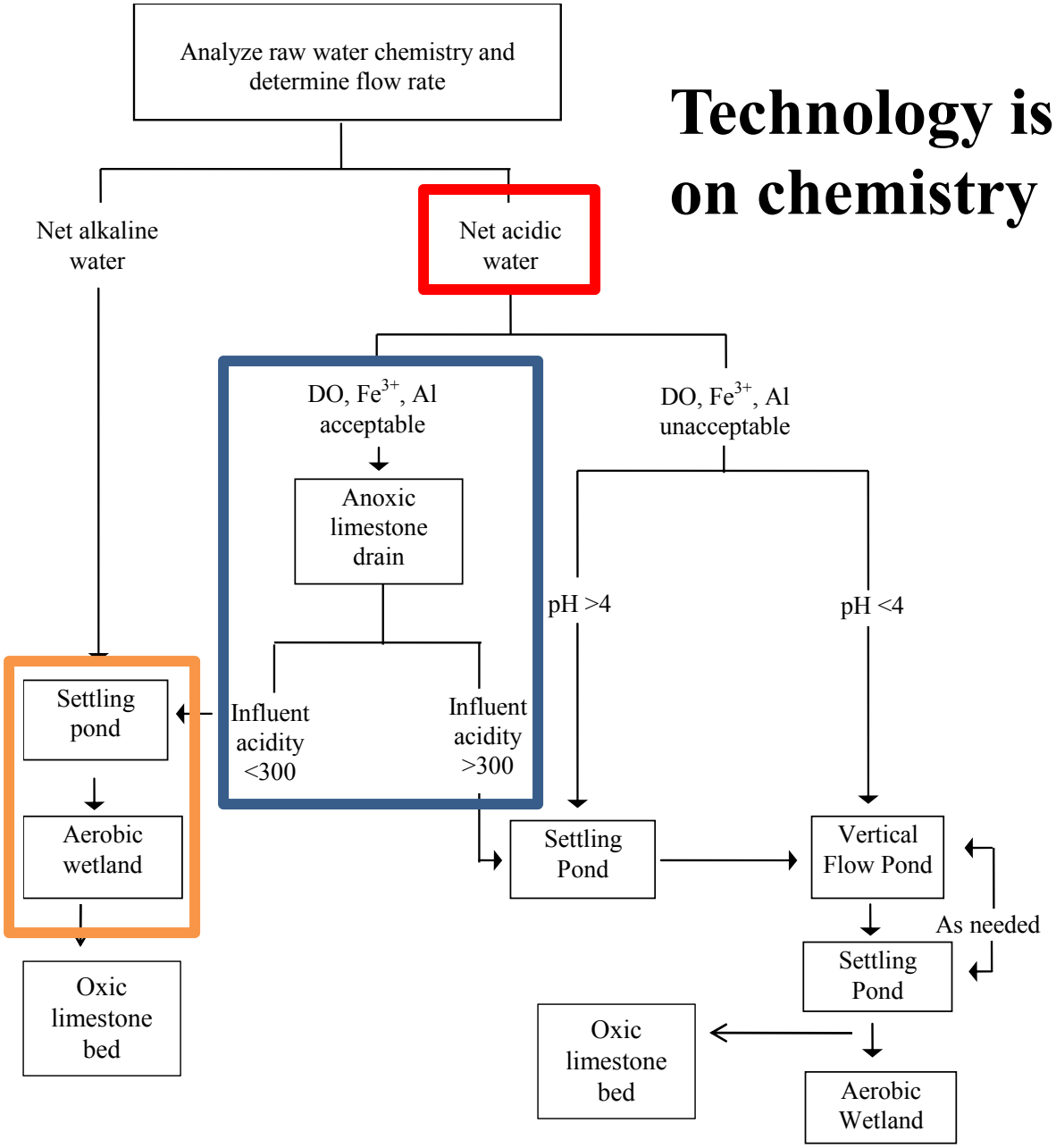


Anoxic Limestone Drain

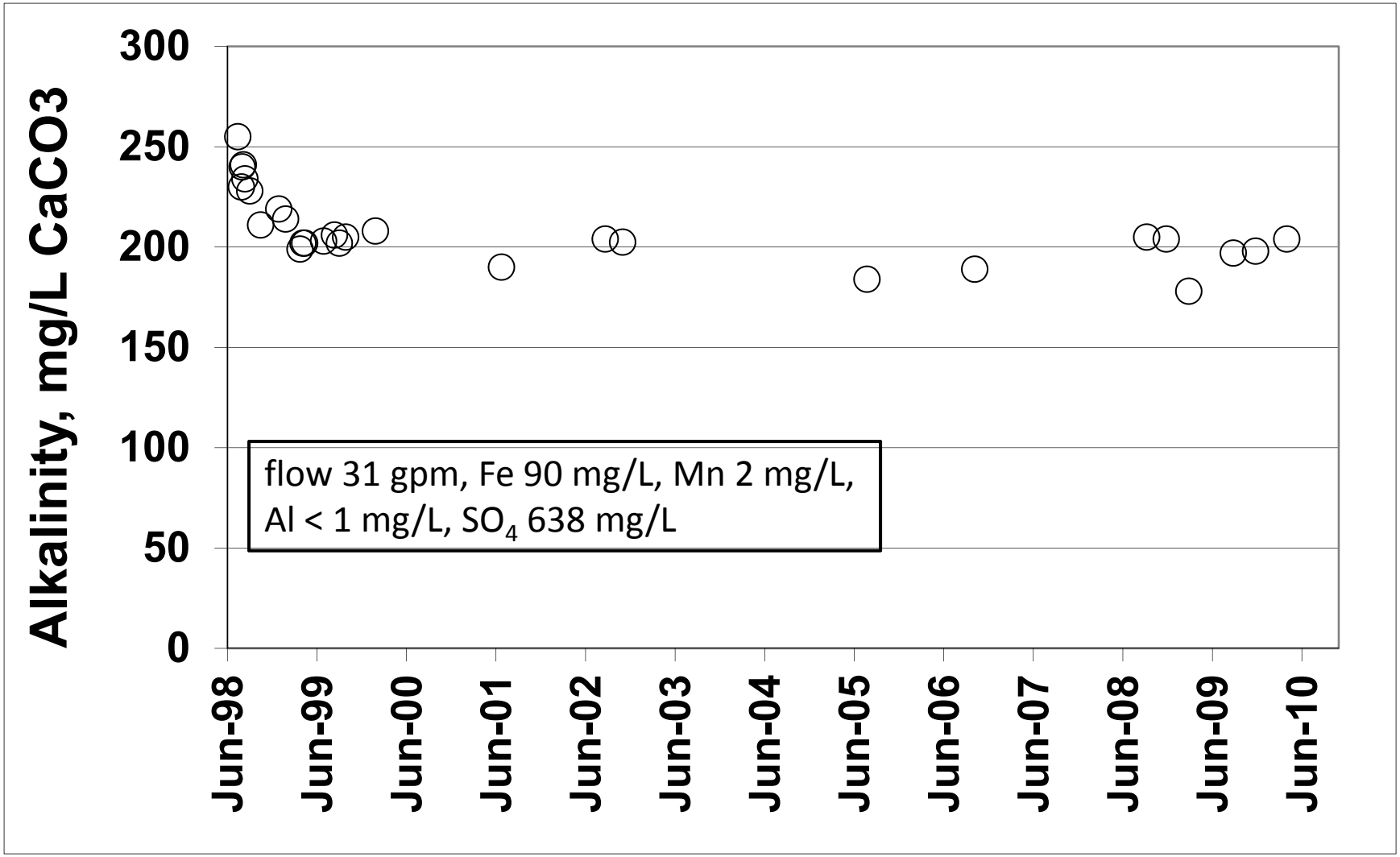
- Anoxic mine water with low Al and Fe^{3+}
- Limestone bed, 3-6 ft thick, that is buried to assure O_2 exclusion and contain CO_2
- Fe^{2+} and Mn flow conservatively through limestone
- $CaCO_3$ dissolves unhindered by solids accumulation
- ALD discharge must be treated for Fe and/or Mn


8'24'99


Anoxic
Limestone
Drain


ALD Effluent
Settling Pond
Influent Aeration and Distribution Trough

SR-101A Anoxic Limestone Drain effluent alkalinity, 1998 – 2010



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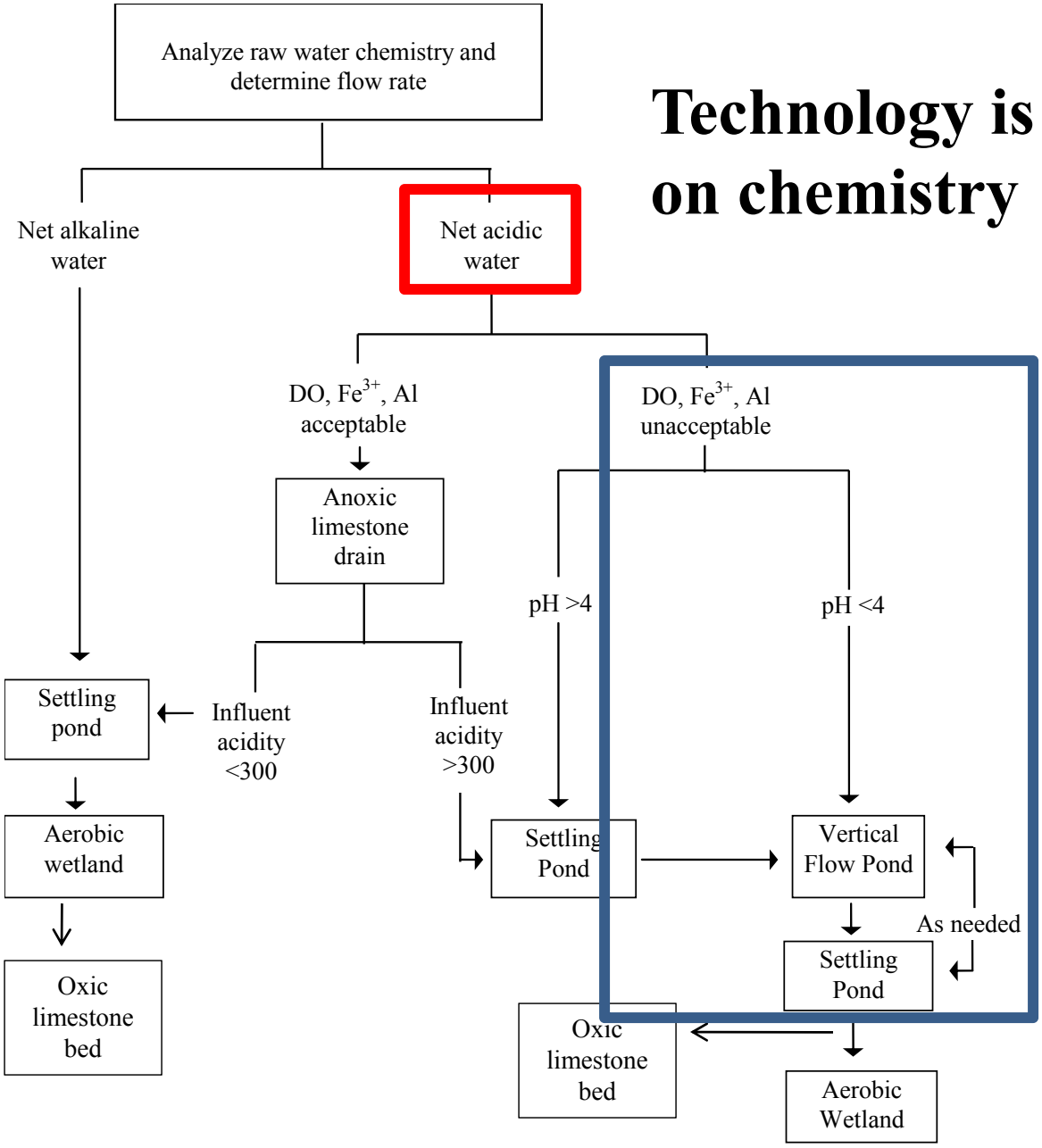
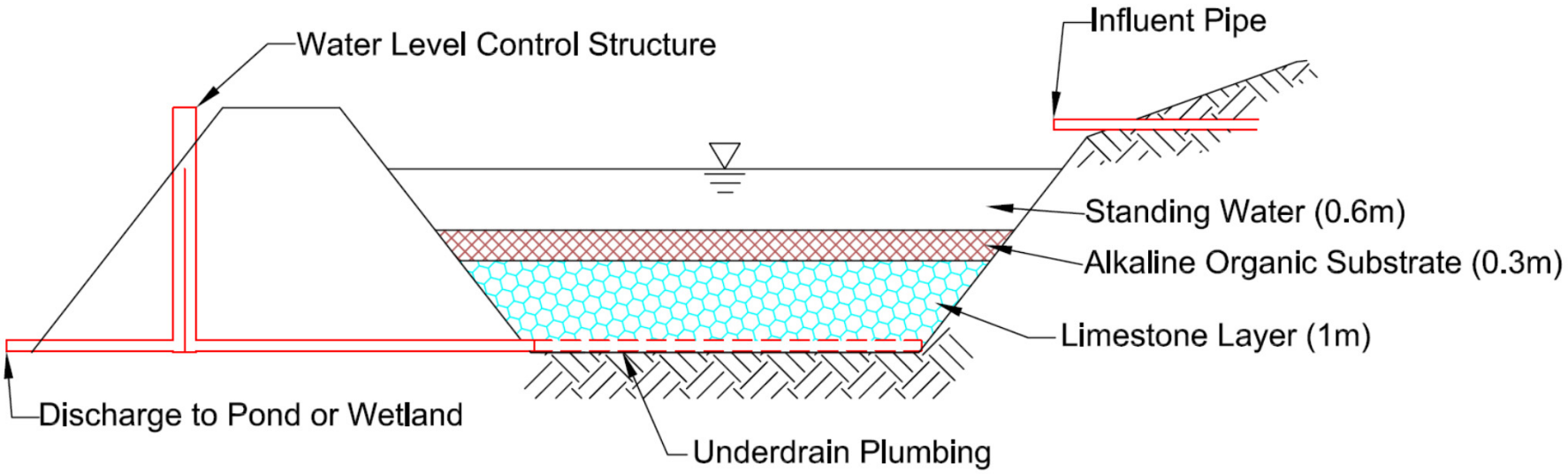


Vertical Flow Pond



Vertical Flow Ponds

- Discharge to pond for Fe, BOD, DOC, H_2S, odor and color removal
- Final polishing (Fe, low Mn) by wetland

Anna S Passive Treatment Complex average chemistry, Jun '04 – Apr '10

	Flow	pH	Alk	Acid	Fe	Al	Mn	SO_4
	gpm		mg/L $CaCO_3$		---------- mg/L ----------			
S in	286	3.1	0	162	6.8	13.2	7.8	333
S VFP out	na	7.0	150	-109	3.1	0.4	7.4	350
S final	na	7.3	134	-96	0.5	0.4	3.5	335
HD in	240	2.8	0	368	37.3	36.0	7.0	552
HD VFP out	na	6.8	180	-117	24.1	0.6	6.6	564
HD-final	na	7.1	145	-112	0.4	0.4	2.2	499

Technology is based on chemistry,

Size is based on loading

Sizing of passive treatment units

- Size = (Design loading) / (removal rate)
- Loading units: g/day of targeted parameter
- Removal rates: $g/m^2/day$ or g/ton/day

HE experience: loading targets are the best predictor of success of system

- Designing for average load is not adequate
- 90th percentile designs have always resulted in attaining treatment goals (NPDES targets)
- 75th percentile designs have provided good results, especially with high flow bypass

Effective Passive Treatment of Coal Mine Drainage (NPDES Compliant Effluents)

1. Pay attention to chemistry
2. Use established treatment techniques
3. Design for 75^{th}-90^{th} percentile loading conditions

Questions?