VERTICAL FLOW PONDS- DESIGN, PROBLEMS, EXAMPLES

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VERTICAL FLOW PONDS (SAPS)

- Most common passive method for net acidic acid mine drainage.
- Extensive use in past 10 years –

  $50 million by public agencies.
- Some have “failed”
- Why?
- How to design and build them better?
- What are their limits?

APPROACH

- Evaluate performance of 39 systems examined in 1999 and 2003 – case studies.
- Autopsies – excavation and tests on “failed” systems.
- What is the definition of failure vs. success?

TYPICAL GEOMETRY AND PROCESSES

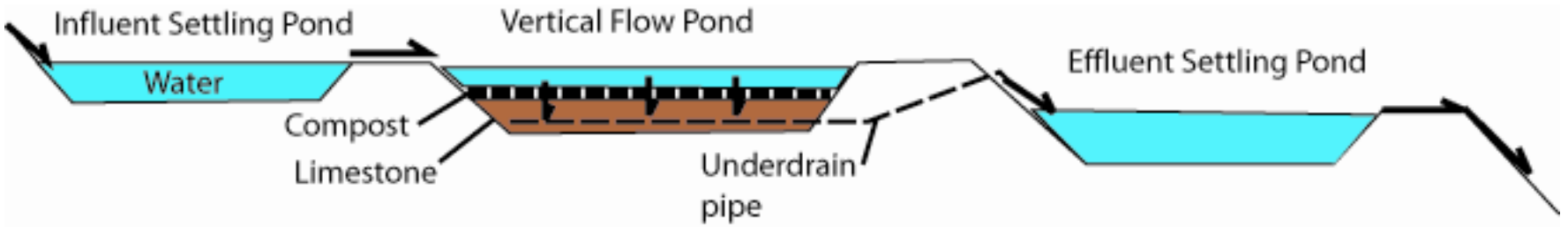
VFP Water layer
Oxidize Fe
Precipitate Fe hydroxide

VFP Compost Layer
Consume diss. Oxygen
Reduce Fe(III) to Fe(II)
Precipitate FeS
Add alkalinity

Influent Settling Pond
Settle out silt and clay
Oxidize Fe
Precipitate Fe hydroxide

VFP Limestone layer
Neutralize acidity
Add Alkalinity, CO_2
Precipitate Al hydroxide
Precipitate gypsum ($CaSO_4$)

Effluent Settling Pond
Oxidize Fe
Precipitate Fe hydroxide
Settle Fe and Al hydrox.

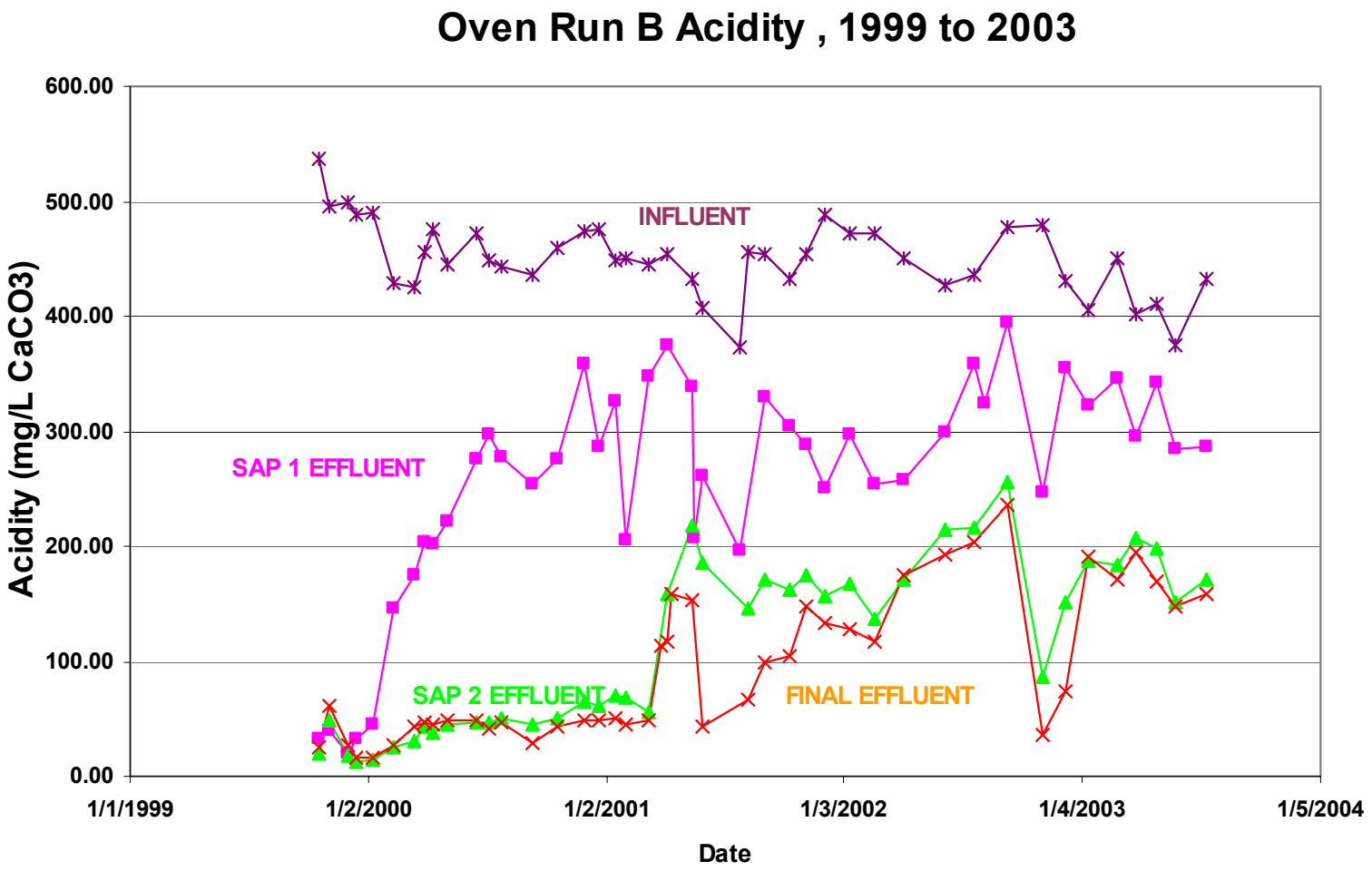


SCHEMATIC DIAGRAM OF VERTICAL FLOW SYSTEM

Evaluation of “Success”

- Meet discharge standards (Mn?)
- Net alkaline (by how much?)
- Cost of acid removal ($/ton of acid)
- Lifetime (25 years?)
- Initial satisfactory performance, then decline
- Significant acid removal, stream improvement

MISLEADING INITIAL ACIDITY

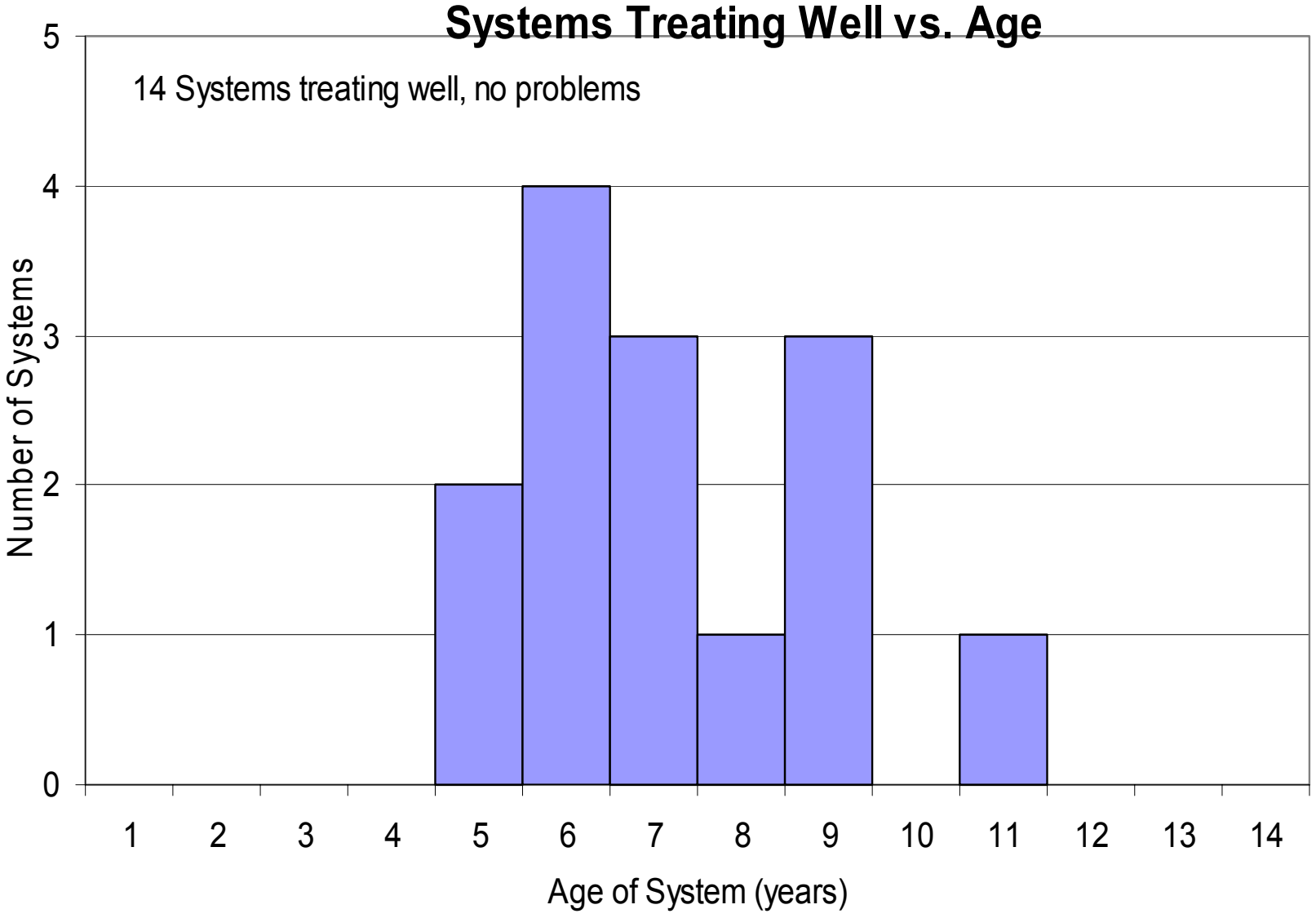


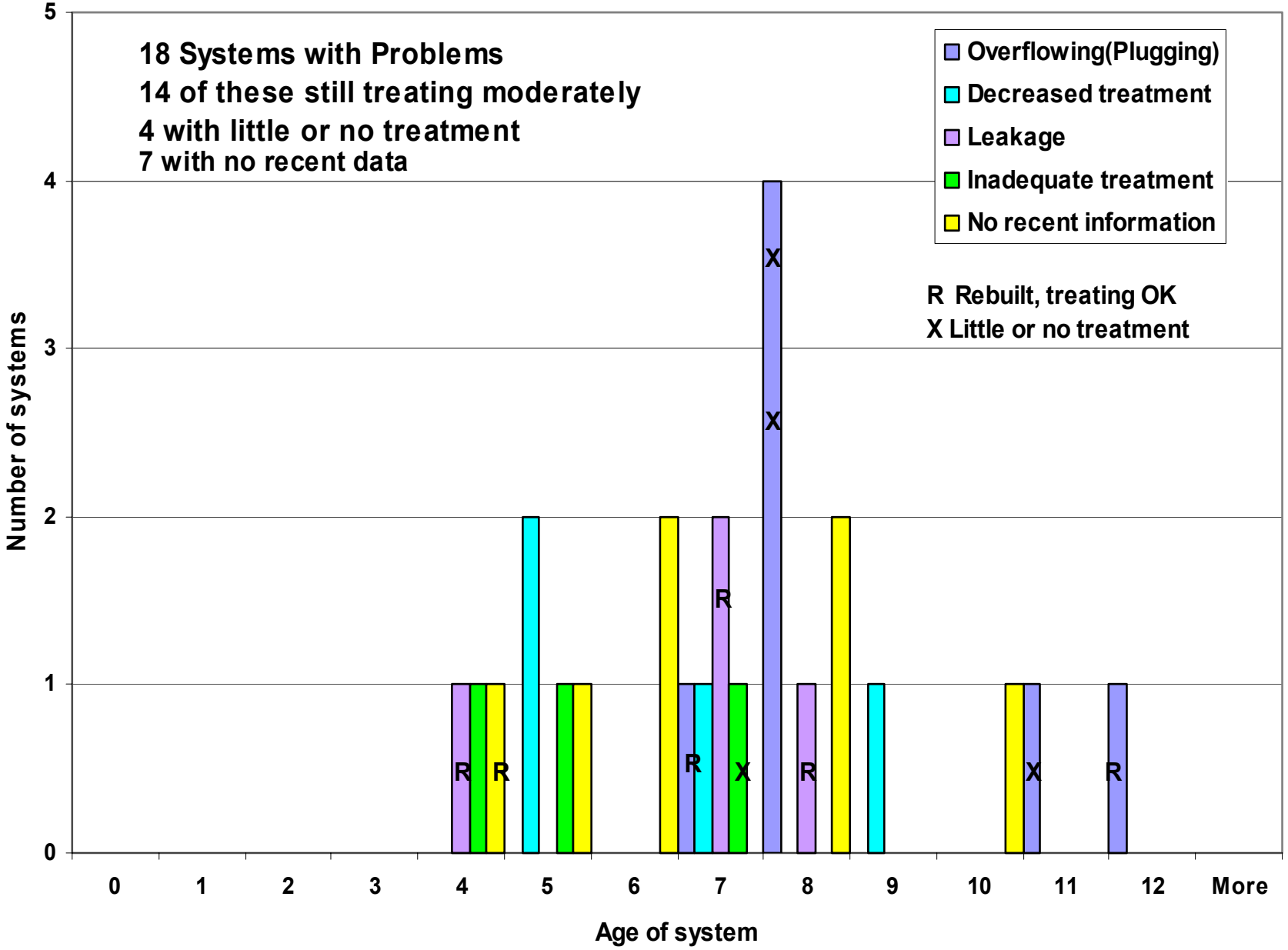
Classification of Problems

- Overflow (probable plugging with Fe or Al)
- Decreased treatment (coating or plugging)
- Inadequate treatment (too small)
- Leakage
- Design/Construction problems (inadequate relief, built-in short circuits)

Frequency of Problems

How common are problems?
How long have systems lasted?
How difficult is it to fix problems?


Systems Treating Well vs. Age
14 Systems treating well, no problems
Number of Systems
0
1
2
3
4
5
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Age of System (years)


18 Systems with Problems
14 of these still treating moderately
4 with little or no treatment
7 with no recent data
Overflowing(Plugging)
Decreased treatment
Leakage
Inadequate treatment
No recent information
R Rebuilt, treating OK
X Little or no treatment
Number of systems
Age of system
0
1
2
3
4
5
6
7
8
9
10
11
12
More

Fe hydroxide precipitation at Howe Bridge

Plugging by Settled Fe hydroxide

Howe Bridge prior to rebuilding

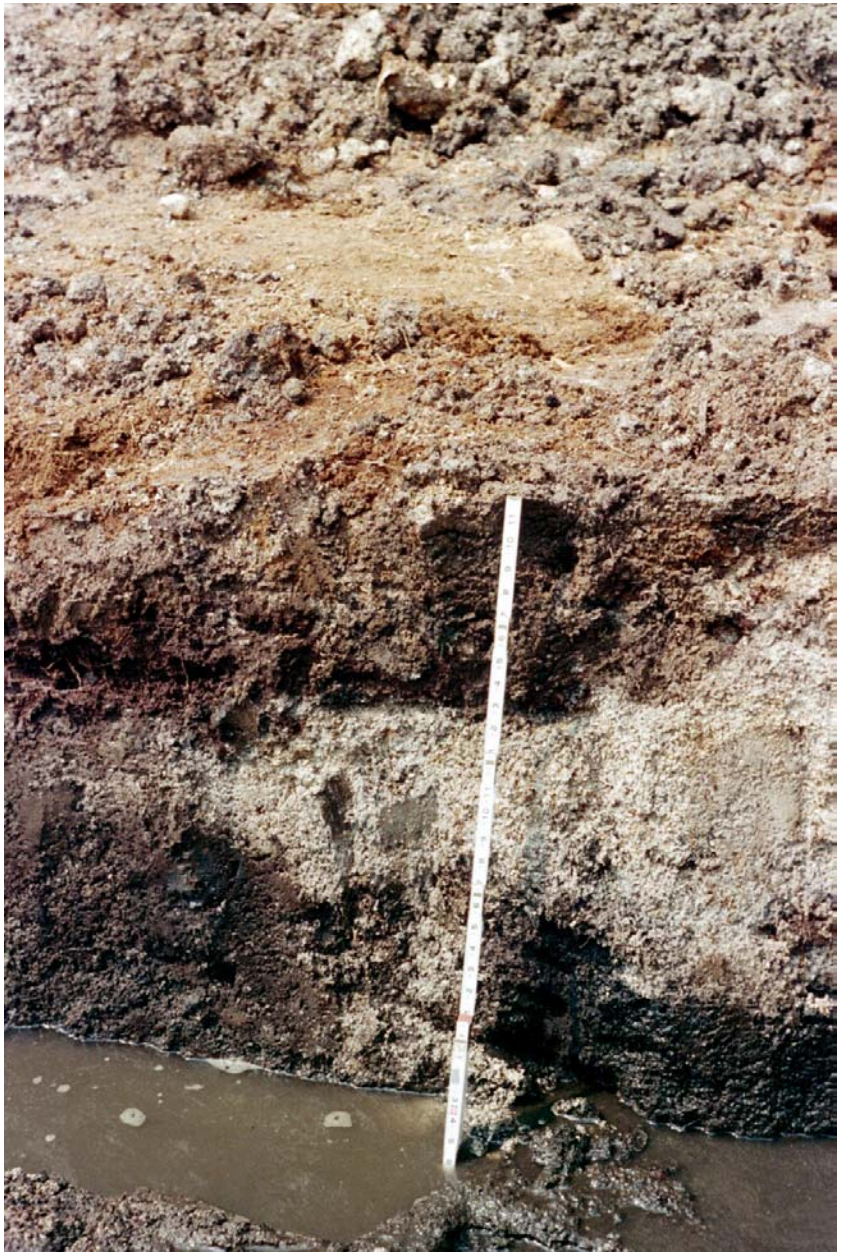
Outflow of ALD overwhelmed the intervening wetland
The VFP overflowed owing to Fe hydroxide settled on top of the compost (9 inches thick)

The Fe was removed for pigment and the system was rebuilt.
Now functioning well.

Possible Solutions to Plugging by Settled Fe Hydroxide

- Add oxidation-settling ponds preceding VFP
- Scrape off Fe hydroxide (Howe Bridge)
- Slurry up Fe hydroxide with fire hose and pump out slurry

Partial Plugging of Compost and Limestone by Al Hydroxide (Tangascootack)



JENNINGS
PARTIAL PLUGGING BY AL AND FE HYDROXIDES, AND COMPOST COMPACTION

System used a mix of fine limestone and compost.

Top (red) zone: Fe hydroxide, settled and in compost-ls.

White Zone: Limestone-rich with a mixture of Al hydroxide and gypsum in pore space.

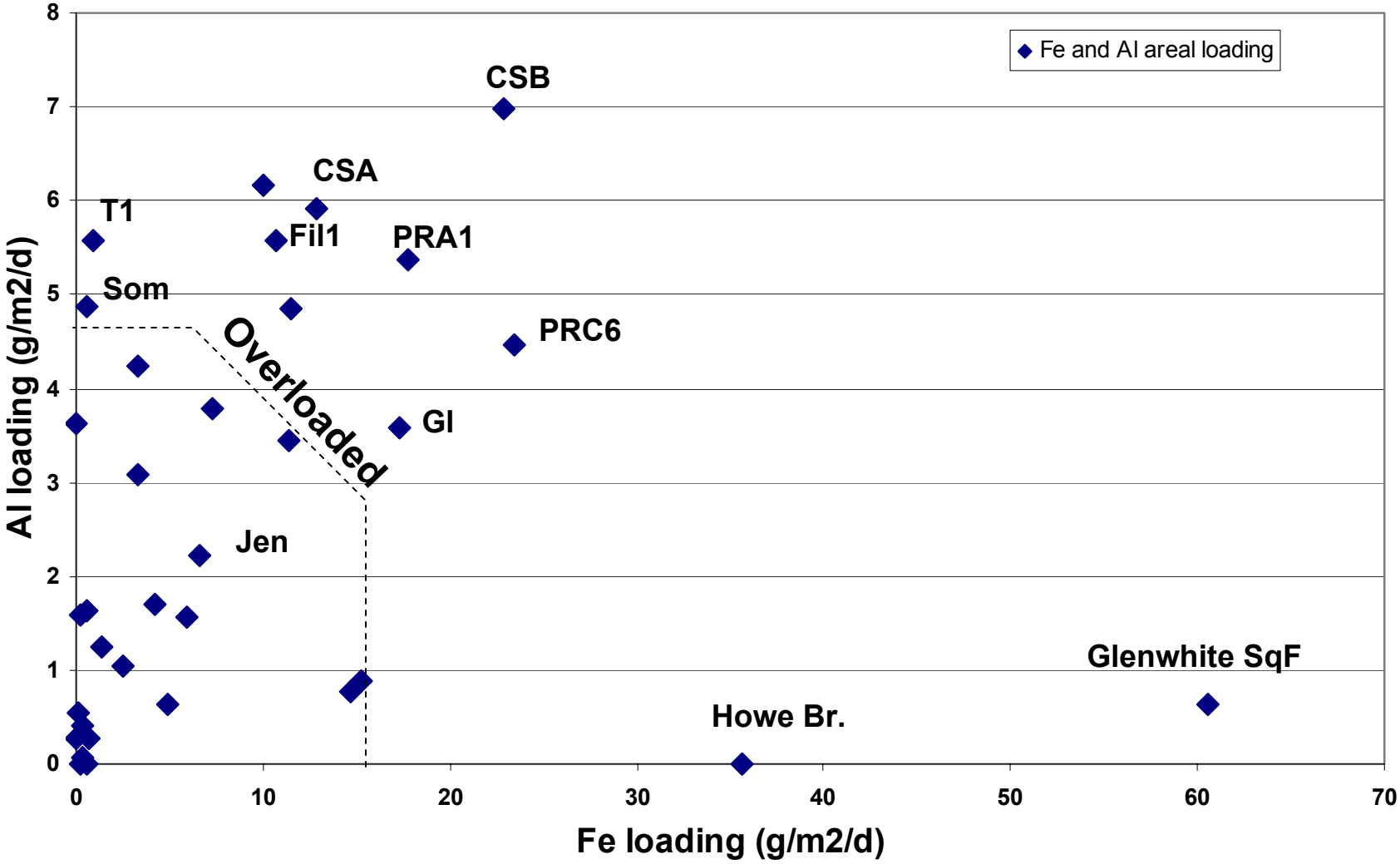
Basal Black zone: Compost with some limestone, and precipitated FeS, compacted and low permeability.

Mixture was stirred up and now treating satisfactorily.

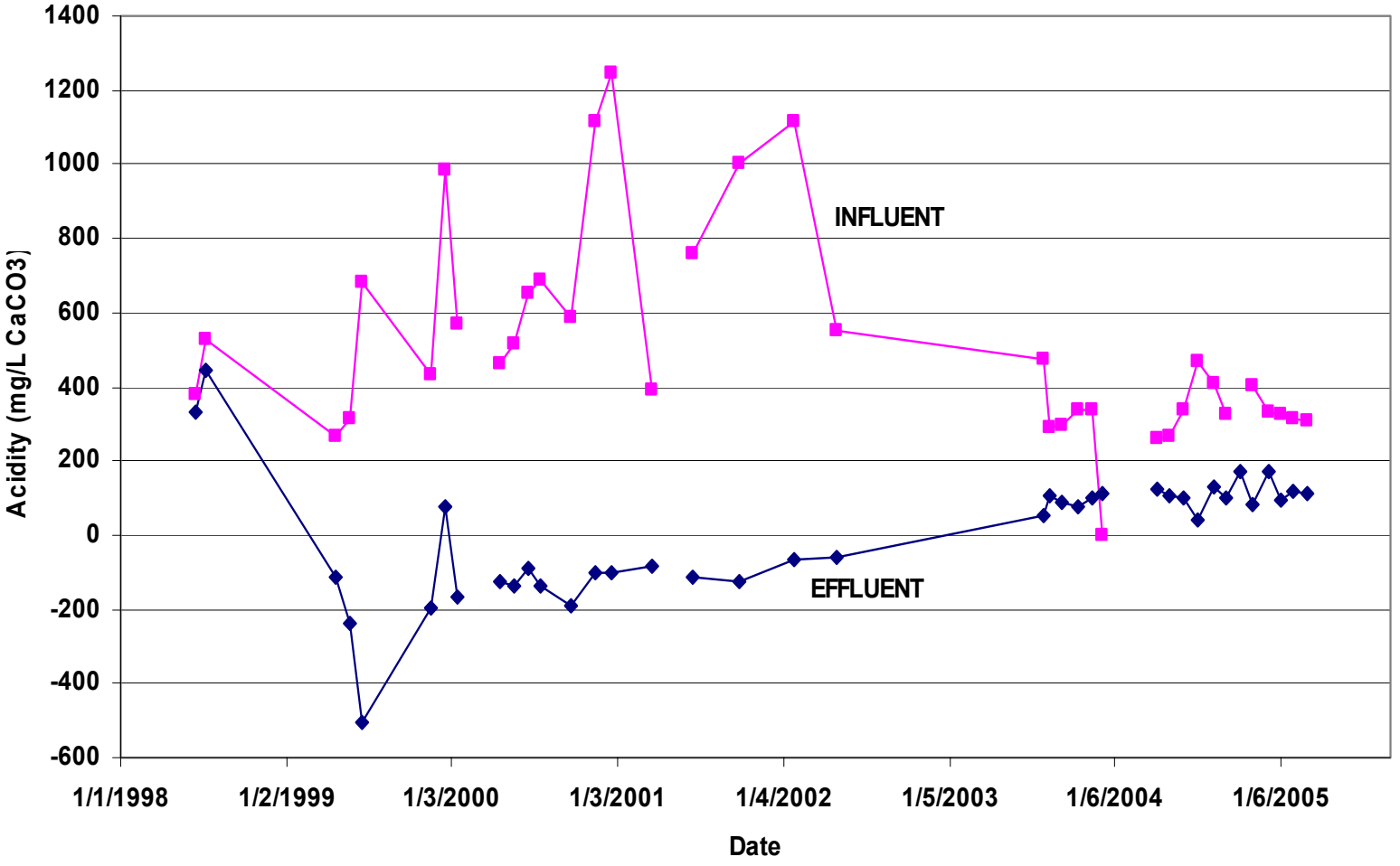
Al Plugging Problems

- Glasgow with 60-150 mg/L Al plugged in 6 months (cf. Hedin), but with only half the flow is now OK at 60 mg/L and no flushing.
- Flushing removes only a few percent of the accumulated Al hydroxide (Watzlaf).
- Systems with 20-25 mg/L Al do not seem to have problems.
- High-Al inflows remain a design problem

LIMITS ON FE AND AL AREAL LOADING
Named sites had plugging or treatment problems



Decreasing Treatment Acidity at Coldstream B Al = 33 mg/L



Leakage Problems

- Some systems leak downward into groundwater (North Point, Joller, Chiller)
- Other systems leak along piping
- Generally need liner (clay or plastic) if system is built in permeable materials, and careful construction.

Inadequate Size

- Some systems designed with 16 hr retention time do not treat adequately.
- Loading must also be considered
- A loading of no more than 35 grams acidity/m^2/day is required (Rose, 2004).
- This is a problem at Tangascootack #1, Middle Branch, Pot Ridge C

CONSTRUCTION AND DESIGN PROBLEMS

- Tangascootack 1 — Too small, inadequate relief, local thin compost
- Middle Branch — Too small, short circuits
- Minersville — Short circuit (cleanout pipes)

MINERSVILLE – TRACER TEST TO UNDERSTAND LACK OF TREATMENT

START OF TRACER TEST

RAPID OUTFLOW OF TRACER

At 22 minutes, tracer was observed at the outflow.

Tracer test by Brent Means, Joe Allison and others.

CAUSE OF SHORT CIRCUITING

Note partly buried cleanout pipes near water level.

Compost shrinks away from cleanouts and allows direct flow to underdrain system.

Observed at Middle Branch as well.

Also, storm flow may have removed compost near the inflow.

Result – Considerable flow runs through with little contact with compost and limestone.

CONCLUSIONS

- Of 32 systems for which data is available, nearly half are treating well, and half are treating moderately. 10% not at all.
- Performance during the initial 6 months is commonly misleading.
- Maintenance and renovation can fix many problems (Fe plugging, short circuits, leakage).

CONCLUSIONS (cont.)

- Some systems designed for 16 hr retention are too small – use 35 g/m^2/d acidity removal rate.
- At high Fe and Al discharges, the Fe and Al loading (g/m^2/d) should be a design parameter.
- Careful monitoring of construction is essential.