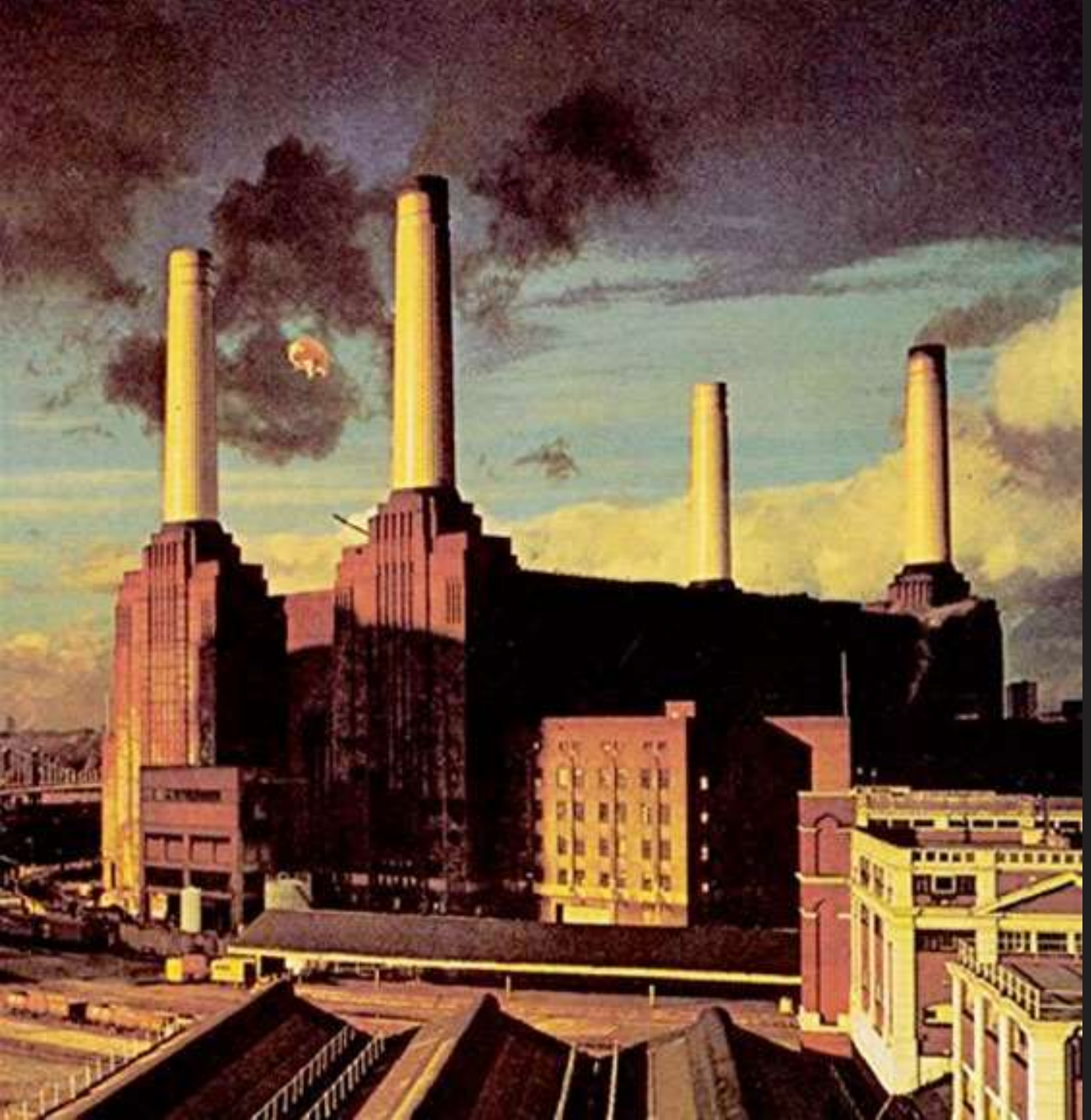

Lessons Learned from the FGD WWTS Pioneers

Compliance Isn't Just Driven by ELGs

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Bill Kennedy, PE
Industrial Water Discipline Leader
Bill.Kennedy@Stantec.com

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Agenda

1. History of FGD WW Regulations
2. NPDES Permits
3. Lessons Learned Along the Trail
4. Questions

History of FGD WW Regulations

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History & Regulatory Overview

- **Early work ~1850's in Great Britain**
  - London Fog: "Pea Soup Fog"
  - First significant case 1929 for damages caused by SO_2
    - Landowner vs. Barton Electricity Works
- **First full scale FGD in 1931 London: Battersea Station**
  - Operations suspended during WWII due to highly visible plume
  - Continuous washing with water and alkaline sprays
- **Renewed public interest with the January 1977 release of Pink Floyd's *Animals* album**
- **Clean Air Act passed in 1970 but no EPA regulations until 1977**

History & Regulatory Overview

- **1972 – Clean Water Act (CWA)** passed
- **1973** – 6 FGD units in US and 36 in Japan
- **1982** – **USEPA Steam Electric Generating Effluent Limitation Guidelines (ELG)** identified FGD WW as a low volume waste meriting future consideration
- **2000** – 678 FGD units worldwide
- **2009** - Steam Electric Power Generating Point Source Category: Final Detailed Study Report
- **2015** – ELGs revised to include technology-based limits for As, Hg, Se and nitrites/nitrates for FGD WW
- **2017** – ELG amendment postponed
- **2019** – proposed update to 2015 amendment
- **2020** - ???

1982 ELG Limits

FGD WWT categorized as a **Low Volume Waste Stream**, reserved for future rule making

Parameter	Daily Max	30-day Average
TSS (ppm)	100.0	30.0
Oil & Grease (ppm)	20.0	15.0

2015 ELG Limits

Based on **chemical precipitation + biological treatment**

Parameter	Daily Max	30-day Average
Arsenic, Total (ppb)	11	8
Mercury, Total (ppt)	788	356
Selenium, Total (ppb)	23	12
Nitrite/nitrate as N (ppm)	17.0	4.4

- **As & Hg limits** based on data from Miami Fort, Hatfield's Ferry and Keystone stations
- **Se & nitrite/nitrate limits** based on data from Belews Creek and Allen stations

2019 Proposed Limits

FGD Wastewater Limits based on Best Available Technology (BAT): applies to all boilers except high flow FGD Systems[1], low utilization boilers[2], retirement and voluntary option

Based on chemical precipitation + low residence time biological treatment + UF

Parameter	Daily Max	30-day Average
Arsenic, Total (ppb)	18	9
Mercury, Total (ppt)	85	31
Selenium, Total (ppb)	76	31
Nitrite/nitrate as N (ppm)	4.6	3.2

Compliance: as soon as Nov. 1, 2020, but no later than Dec. 31st, 2025

1 - max daily volume of FGD wastewater that could be discharged by a facility is above 4MGD
2 - defined as a two-year average annual net generation below 876,000 MWh per year

NPDES Permits

NPDES Permits

- National Pollutant Discharge Elimination System
- Created 1972 by the Clean Water Act
- Helps address water pollution by regulating point sources that discharge to the waters of the US
- An NPDES permit is typically *a license for a facility to discharge* a specified amount of a pollutant into a receiving water under certain conditions.

Pollutants

Supplement Facts

Serving Size: 1 Tablet

Amount Per Serving		% DV
Vitamin A (as Acetate & 29% as Beta Carotene)	3,500 I.U.	70%
Vitamin C (as Ascorbic Acid)	60 mg	100%
Vitamin D (as Cholecalciferol)	400 I.U.	100%
Vitamin E (as dl-alpha Tocopheryl Acetate)	45 I.U.	150%
Vitamin K (as Phytonadione)	10 mcg	12%
Thiamin (Thiamin Mononitrate, B1)	1.5 mg	100%
Riboflavin (Vitamin B2)	1.7 mg	100%
Niacin (as Niacinamide)	20 mg	100%
Vitamin B6 (as Pyridoxine HCl)	3 mg	150%
Folic Acid	400 mcg	100%
Vitamin B12 (as Cyanocobalamin)	25 mcg	417%
Biotin	30 mcg	10%
Pantothenic Acid (as d-Calcium Pantothenate)	10 mg	100%
Calcium (as Calcium Phosphate & Carbonate)	200 mg	20%
Phosphorus (as Calcium Phosphate)	48 mg	5%
Iodine (as Potassium Iodide)	150 mcg	100%
Magnesium (as Magnesium Oxide)	100 mg	25%

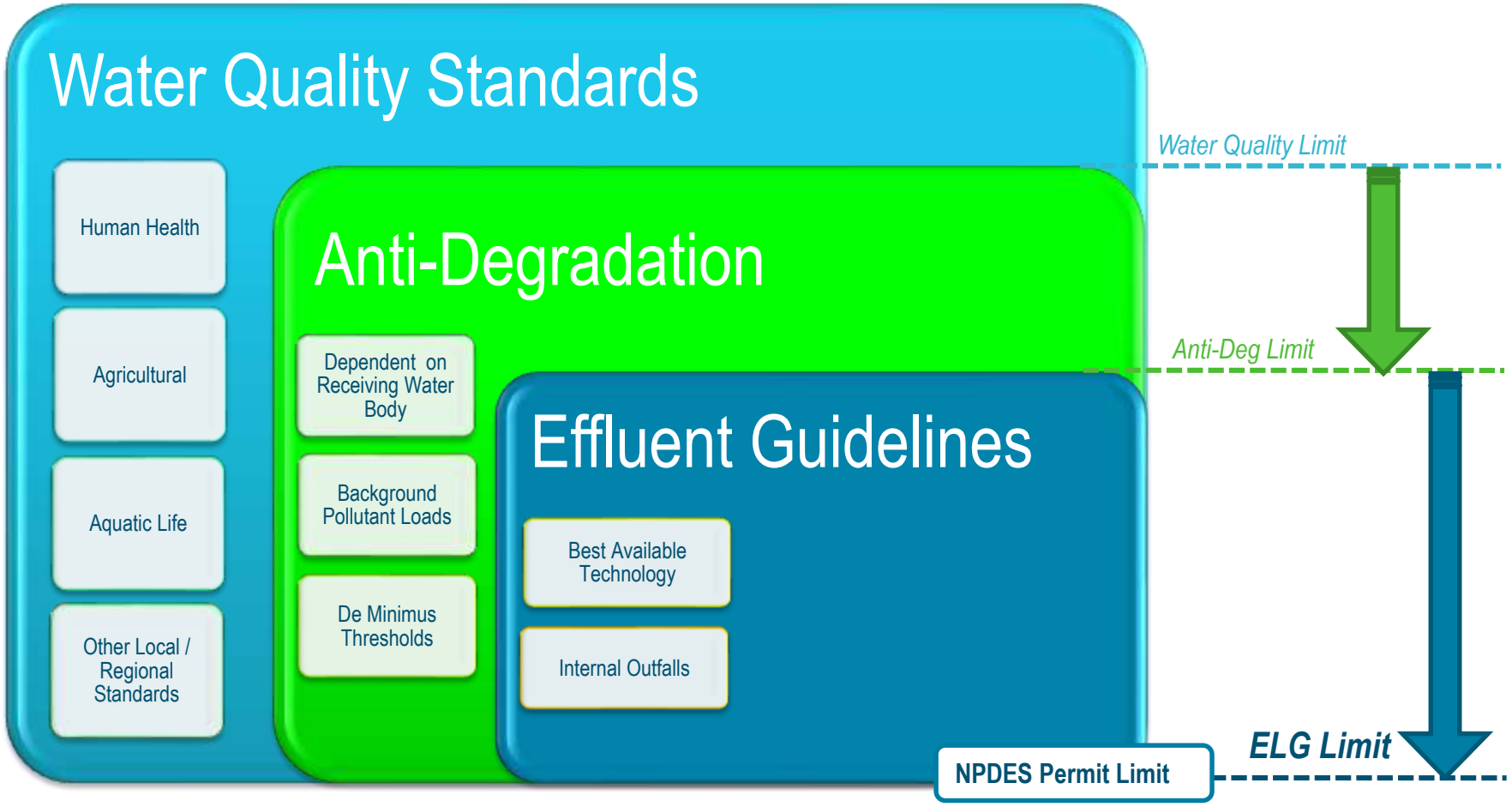
Amount Per Serving		% DV
Zinc (as Zinc Oxide)	15 mg	100%
Selenium (as Sodium Selenate)	20 mcg	29%
Copper (as Cupric Oxide)	2 mg	100%
Manganese (as Manganese Sulfate)	2 mg	100%
Chromium (as Chromium Chloride)	50 mcg	125%
Molybdenum (as Sodium Molybdate)	75 mcg	100%
Chloride (as Potassium Chloride)	72 mg	2%
Potassium (as Potassium Chloride)	80 mg	2%
Boron (as Borates)	150 mcg	**
Nickel (as Nickelous Sulfate)	5 mcg	**
Silicon (as Silicon Dioxide)	2 mg	**
Vanadium (as Sodium Metavanadate)	10 mcg	**
Lycopene	300 mcg	**
Lutein	250 mcg	**

** Daily Value (DV) not established.

Other Ingredients: Cellulose, Starch, Croscarmellose Sodium, Stearic Acid, Silicon Dioxide, Titanium Dioxide, Magnesium Stearate, Artificial Colors (FD &C Blue #2, FD&C Yellow #6, FD&C Red #40).

Constituent ≠ Pollutant

How NPDES Permits are Developed



- Both applicability and order will most likely vary site by site

Water Quality Based Standards

Water Quality Based Effluent Limitations (WQBELs)

A numeric criteria that toxicity causes are known for protection against pollutants.

https://www.epa.gov/wqc/national-recommended-water-quality-criteria-aquatic-life-criteria-table

- As – 150 ppb
- Hg – 0.77 ppb
- Nitrite/Nitrate-N – 10 ppm (human health)
- Se – 3.1 ppb
- Whole Effluent Toxicity (WET)

Anti-Degradation Based Standards

Impaired Water Bodies, unable to support beneficial uses:

- Aquatic Life
- Fisheries
- Drinking Water
- Recreation
- Industry
- Agriculture

Are assigned a Total Maximum Daily Load (TMDL)

TMDL

A regulatory term in the U.S. Clean Water Act, describing a plan for restoring impaired waters that identifies the maximum amount of a pollutant that a body of water can receive while still meeting water quality standards.

Don’t make it worse.

Regional TMDLs

	Ohio River	NC	Chesapeake Bay	Great Lakes
As (ppb)	10	N/A	N/A	147.9
Hg (ppt)	12	47	N/A	13
Nitrate/Nitrite (ppm)	10	N/A	Total N*	N/A
Se (ppb)	N/A	N/A	N/A	5

* Subcategorized into 92 sub-watersheds covering 6 States + DC

Technology Based Standards

Technology Based Effluent Limitations (TBELs)

The ELG's!

Only level of permitting evaluation to consider cost of implementation.

Lessons Learned Along the Trail

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Pioneers Led the Way

Before ELGs for FGD WW, treatment was already a requirement.

- Hg on the Great Lakes
- Se in NC and WV
- N in Chesapeake Bay
- WQBELs in PA and NH

Lessons Learned Along the Trail

- Pay attention to high school chemistry
- Arsenic is easy
- There's more to fuels than cost
- ORP is interesting
- Boots are dirty
- Cleanliness is next to compliance
- You get what you pay for
- Beware of clean boots
- Yttrium doesn't matter

More Lessons Learned Along the Trail

- Don’t Debug the System
- Bioreactors really do work
- ZVI is a hot topic
- High TDS water will cause lab managers to curse
- Certified labs are not experienced
- Empirical trumps theory
- Wastewater treatment really is a critical activity
- Beware of Xeroxing Kleenex
- FGD WWTS is not the same as a sewer plant

Even More Lessons Learned Along the Trail

- The Emperor's new wetlands
- Fossil is not the same as Nuclear
- An unanalyzed stream provides no data
- Operators need to use all ~~5~~ 4 senses
- Operators know what is happening
- Engineers know what should be happening
- Sunday is the same as Wednesday at a power plant
- Pay attention to high school chemistry

Redundancy

Webster - Redundant (adj): exceeding what is necessary or normal

- **Define requirement**: N+1...spare parts not available in 24 hrs…repair > than EQ tank capacity…?
  Should be in the form of a mission statement.
- **Confusion by Station Operations…**
  - 100% Everything has pros & cons
  - Duplicate Phys/chem & Biochem systems
- **Confusion by Architecture/Engineering (A/E) Firms…**
  - Redundant HVAC, Desiccant Dryers, Sanitary Lift Pumps, PRVs, etc…
- **Confusion by Vendors…**
  - Ultrafiltration: Maintaining capacity during CIP/backwash is NOT redundancy

Final Rants

This is likely the first of a kind installation for a utility and certainly for the plant. Station input should be ***considered***, but only as one variable in the decision-making equation.

We want orange handrails.

We used to just send it to the basin.

None of our other safety showers use tempered water.

Times, technology and regulations have changed.


Bill’s Truck
300k miles
Bill’s Truck

Great Resources

- *State of Knowledge: Biological Treatment for Wet Flue Gas Desulfurization Wastewater,* EPRI, Palo Alto, CA: 2019. 3002016780
- *Wet Flue Gas Desulfuriation Wastewater Physical/Chemical Treatment Guidelines,* EPRI, Palo Alto, CA: 2016. 3003008515
- Kennedy, W. M., Potts, J., "*Sources of Variability in Flue Gas Desulfurization Waters*", International Water Conference, 2015 (15-41)
- Steam Electric Power Generation Point Source Category: Final Detailed Study Report , USEPA, October 2009, 821-R-09-008
- Brookins, D. G., *Eh-pH Diagrams for Geochemistry*. 1988, Springer-Verlag, ISBN 0-387-18485-6

Questions