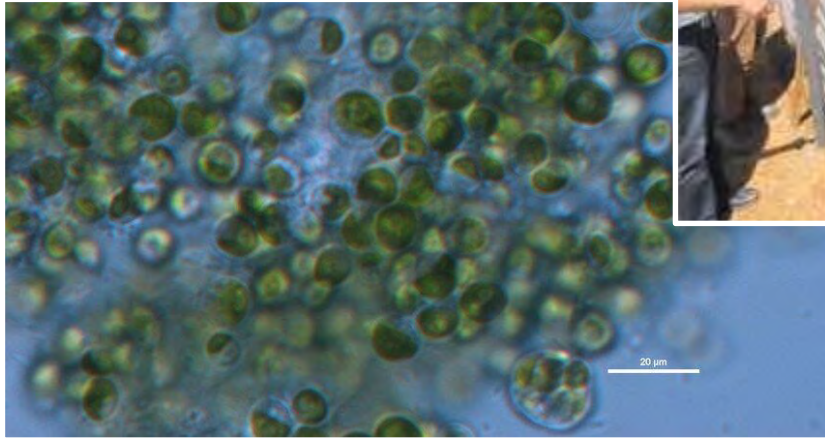
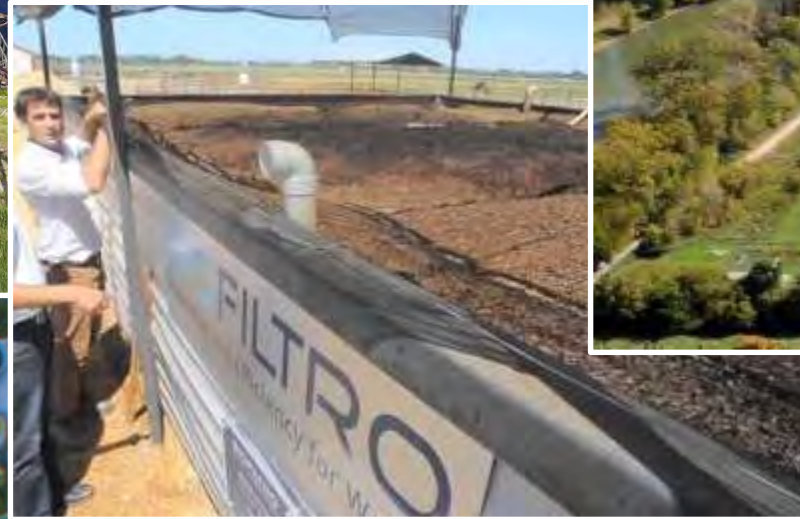


ECOLOGICAL APPROACHES FOR WASTEWATER TREATMENT



Marisa Sowles
msowles@geumconsulting.com



TERMINOLOGY

- **Primary treatment** -- grit removal and sedimentation
- **Secondary treatment** -- biological processes remove organic matter and smaller suspended solids
- **Tertiary treatment** -- polishing

LOOKING TO ADDRESS...

- Total suspended solids (TSS)
- Carbon, or biodegradable organics
- Nutrients--Nitrogen and Phosphorus
- Pathogenic bacteria and other disease-causing organisms
- Synthetics

WHY ECOLOGICAL?

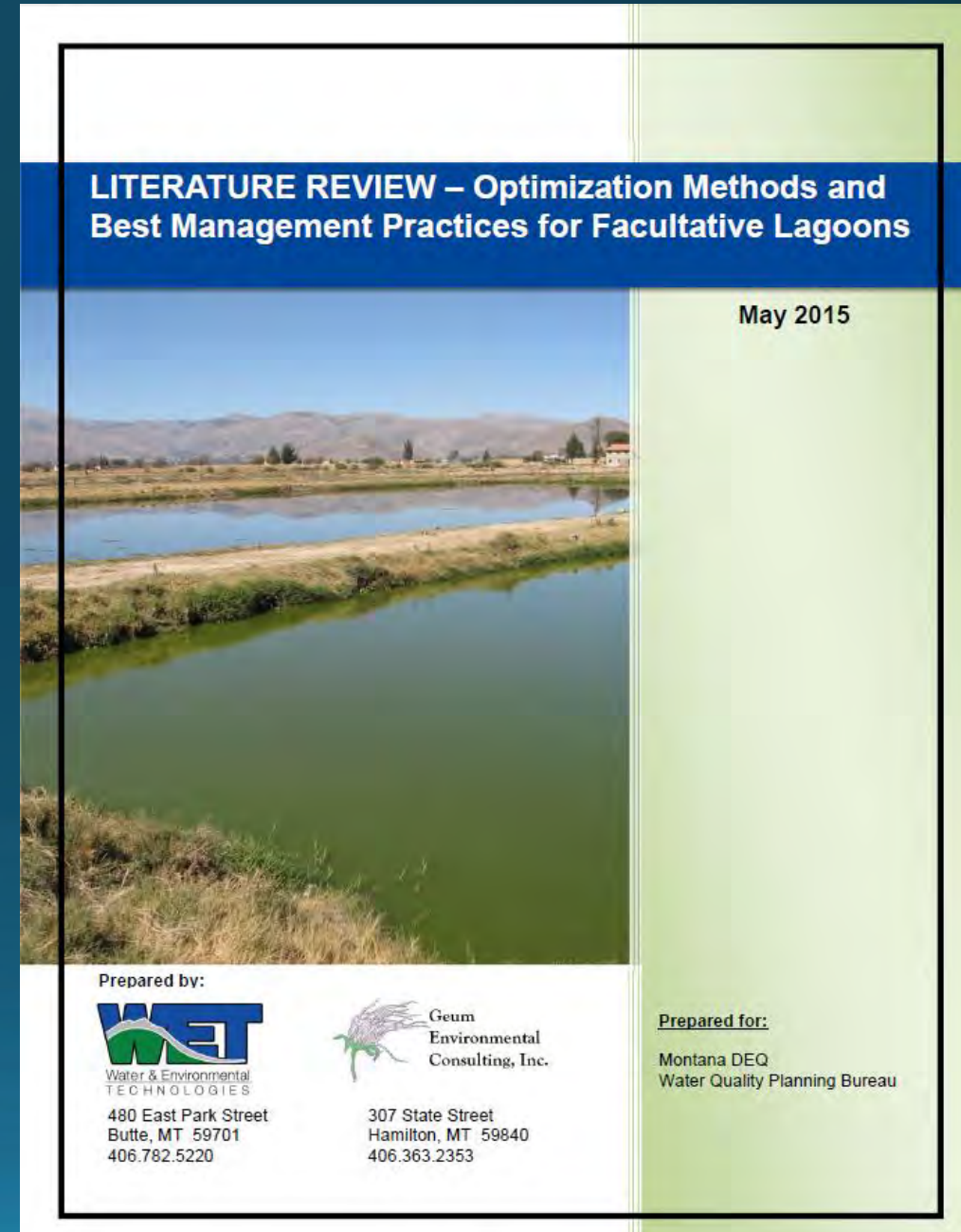
- Chemicals
- Cost effective
- Less maintenance
- Ancillary benefits



LITERATURE REVIEW – Optimization Methods and Best Management Practices for Facultative Lagoons

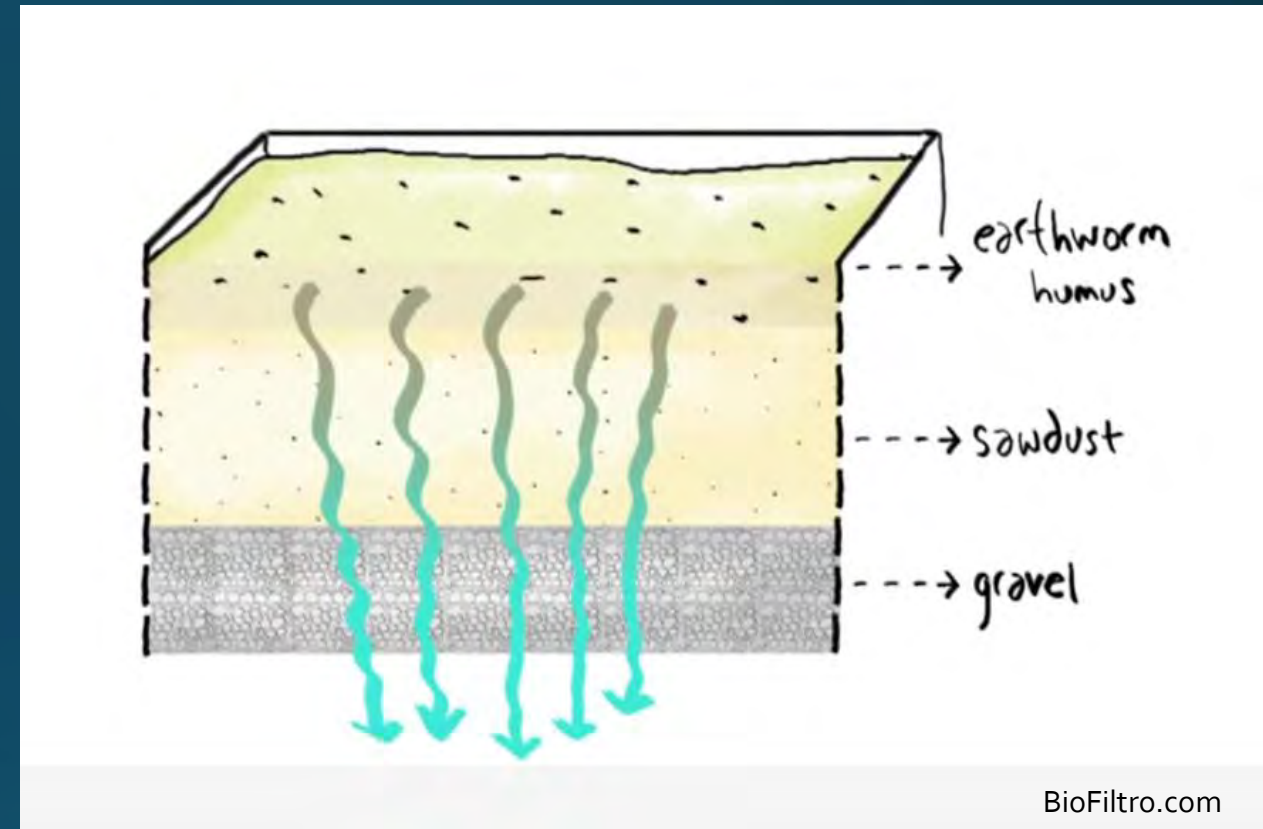
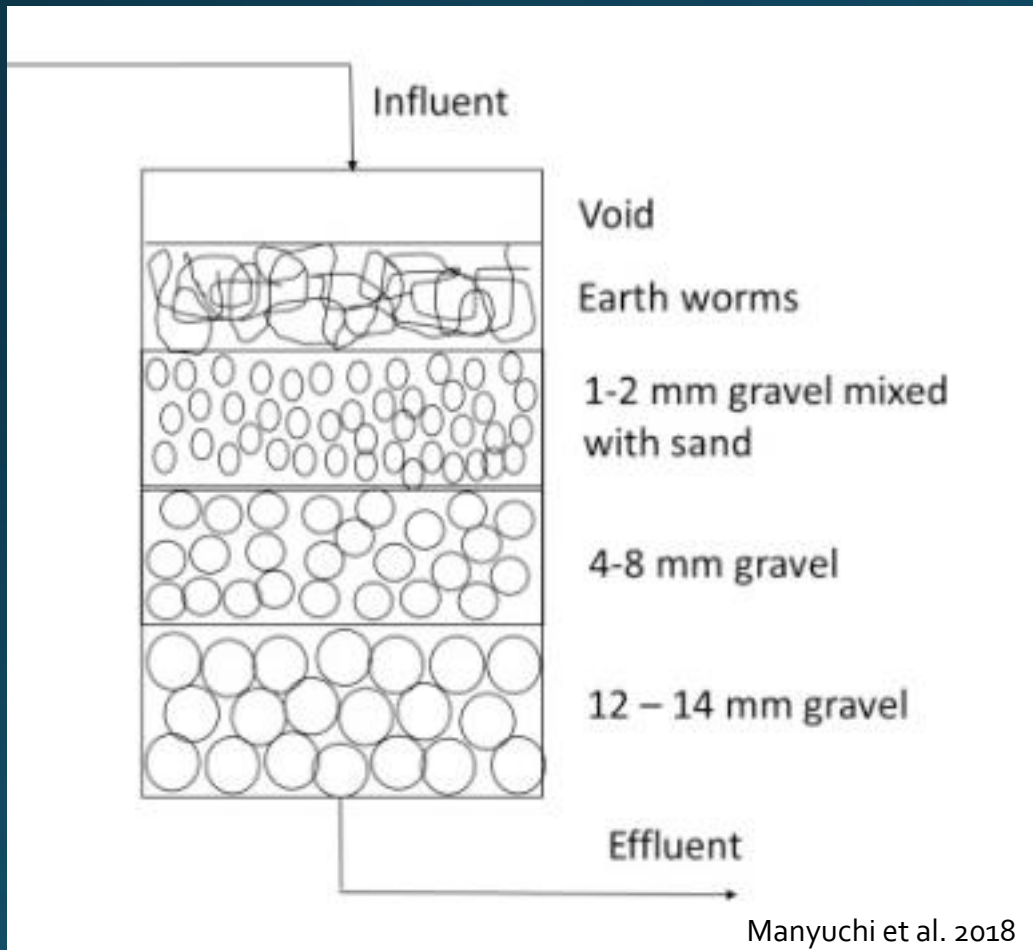
<https://deq.mt.gov/Portals/112/Water/TFAB/WPCSRF/pdf/FacultativeLagoonLiteratureReviewFINAL5292015.pdf>

<https://deq.mt.gov/Portals/112/Water/TFAB/WPCSRF/pdf/FacultativeLagoonUserGuideFINAL5292015.pdf>



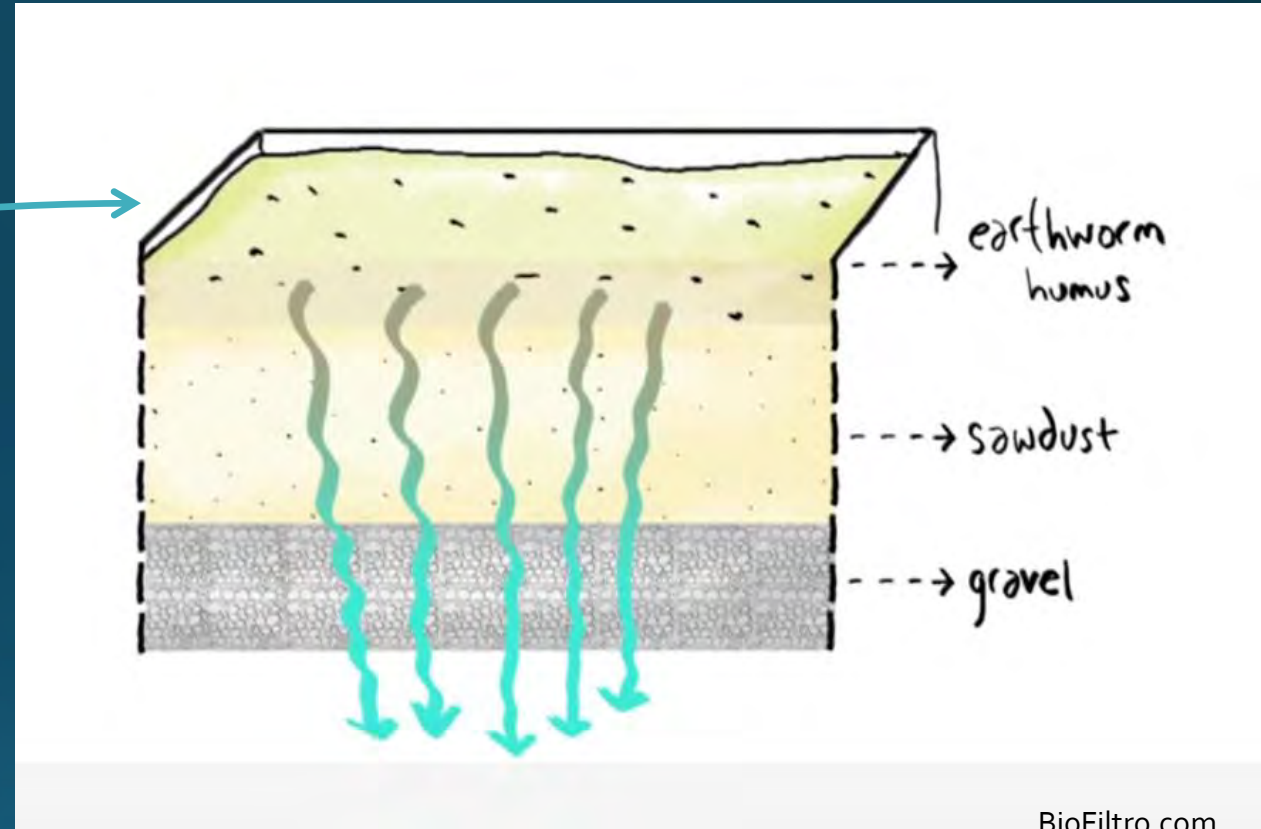
VERMICULTURE

- Vermifiltration
- Vermicompost



VERMICULTURE

- Vermifiltration
- Vermicompost



- Best at: Nitrogen removal and BOD reduction
- Waste can be used as bio-fertilizer

VERMICULTURE

- Worms breakdown organic matter
- More microbes = improved water and soil quality

Table 10. Summarize water quality parameters. Adapted from Sinha and others (2008).

Water quality parameter	Average Influent (mg/L)	Average effluent with worms (mg/L)	Average effluent without worms (mg/L)
BOD	298	3.7	68.4
COD	273.4	132.8	225
TSS	381.4	25.2	167.4

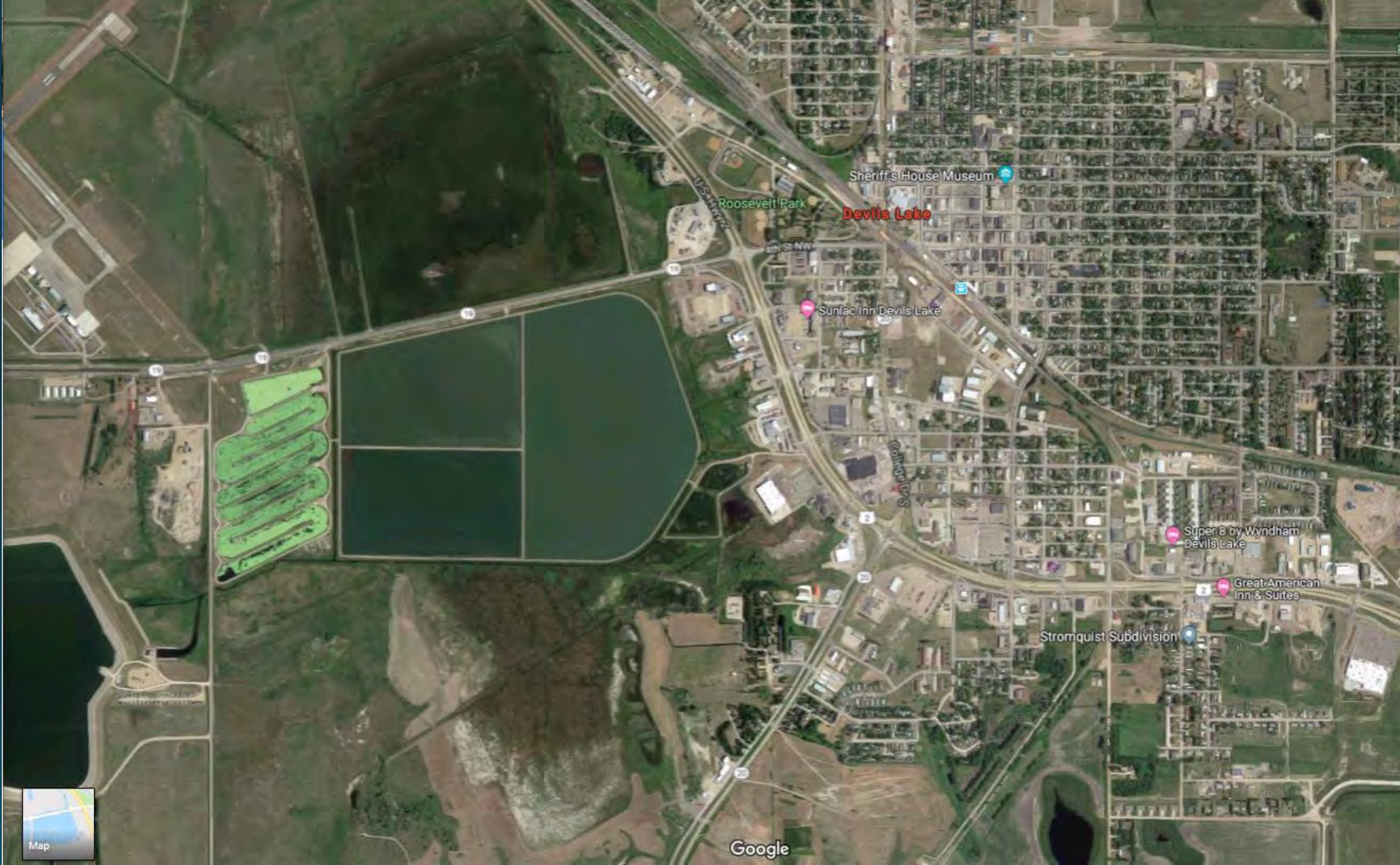
VEGETATION HARVESTING

- Algae and duckweed – use N and P for growth
- Harvest and use for compost, feed, biofuels



Devils Lake,
North Dakota





Sheriff's House Museum

Roosevelt Park

Devils Lake

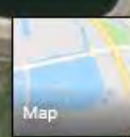
Sunlac Inn Devils Lake

Super 8 by Wyndham
Devils Lake

Great American
Inn & Suites

Stromquist Subdivision

Google



VEGETATION HARVESTING

- Metal tolerance
- Growth rate

Pollutant	Uptake Rate (g/m ² ·a)	Uptake Rate (lb/acre/yr)
Aluminum (Al)	260	2300
Arsenic (As)	0.6	5
Calcium (Ca)	600	5000
Chloride (Cl)	100	940
Chromium (Ch)	0.6	5
Copper (Cu)	0.1	1
Iron (Fe)	80.0	710
Magnesium (Mg)	80.0	700
Manganese (Mn)	9	80
Mercury (Hg)	0.1	1
Nitrogen (N)	611	5450
Phosphorous (P)	80	700
Potassium (K)	252	2250
Sodium (Na)	39	350
Sulfur (S)	65	580
Zinc (Zn)	0.7	6

TERRESTRIAL APPLICATION

- Soil aquifer treatment – No vegetation
- Overland flow – Not permitted in MT
- Slow rate system – Economic use



- Best at ammonia removal
- Water quantity management

TERRESTRIAL APPLICATION



12/26/2018 11:54



© 2018 Google

Google Earth

Imagery Date: 7/21/2016 46°52'49.09" N 114°03'09.28" W elev 3147 ft eye alt 11409 ft

TERRESTRIAL APPLICATION

- Cold weather alternative → SNOW

Concentrations after terrestrial application

	BOD (mg/L)	TSS (mg/L)	TN (mg/L)	TP (mg/L)
Slow Rate	<2	<2	<3	<0.1



ECO-MACHINES

- Very specific, patented design from Vermont

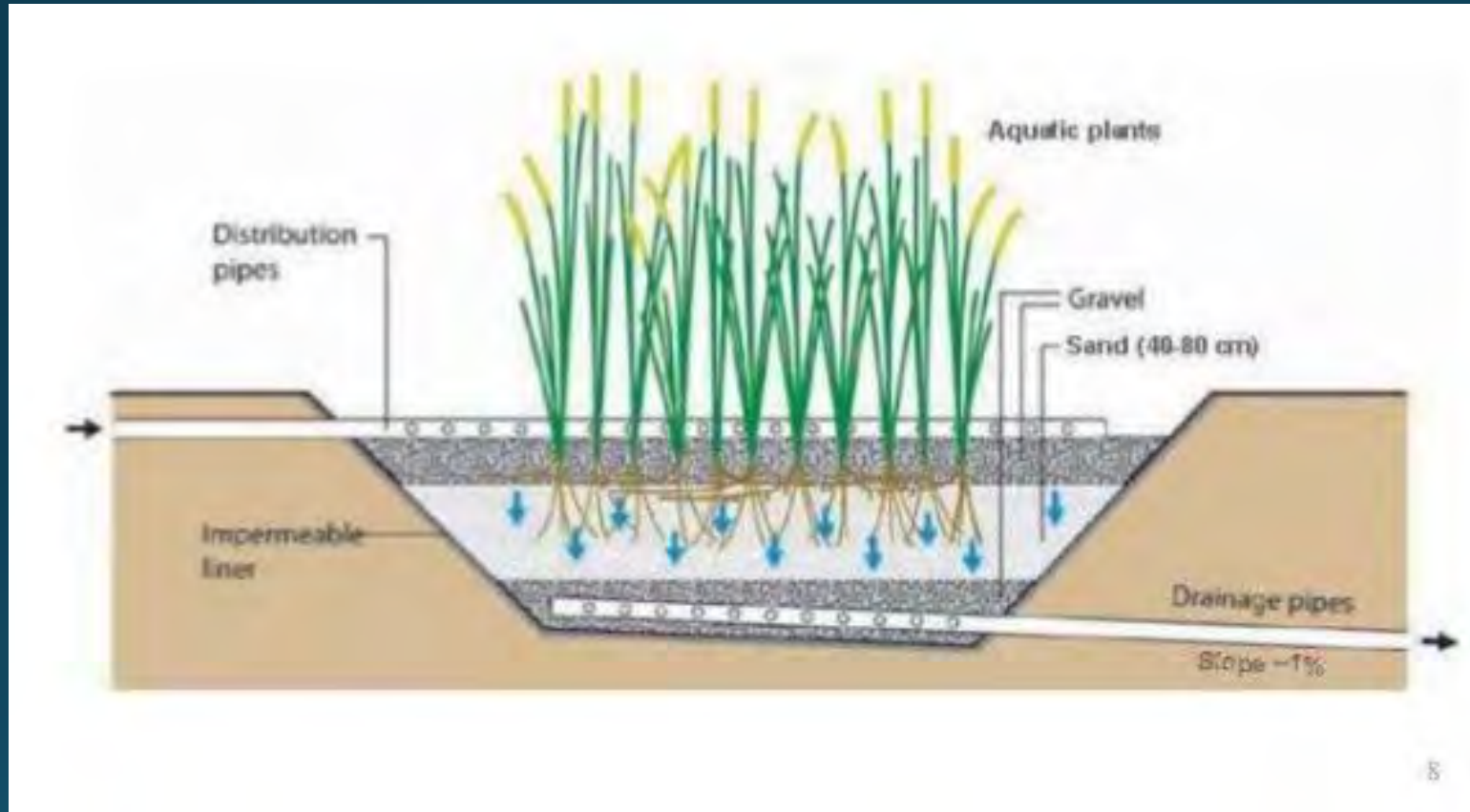


WETLANDS

- Vertical Wetlands
- Horizontal/Subsurface Flow Wetlands
- Surface Wetlands



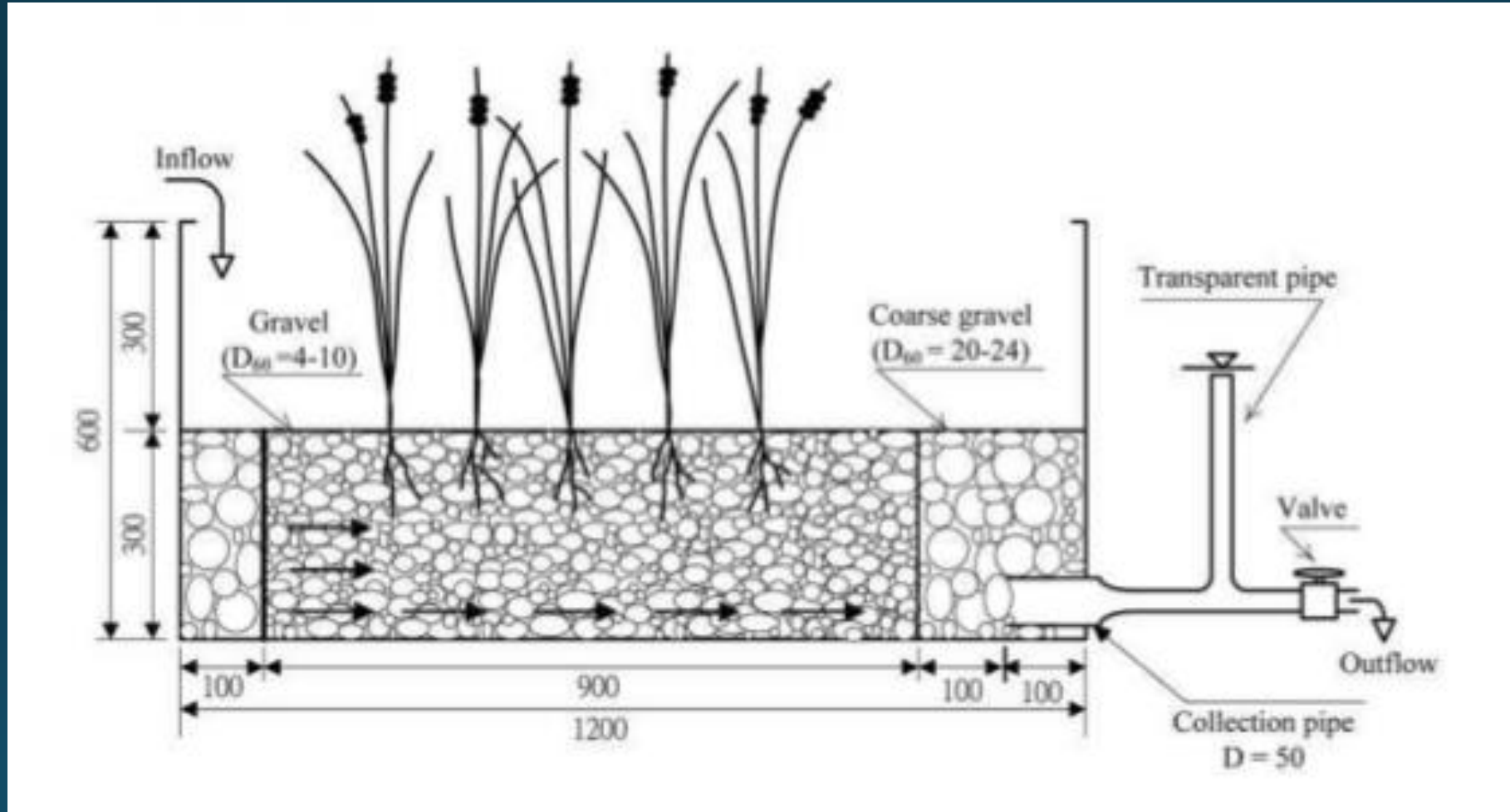
VERTICAL WETLANDS



Best at removing ammonia

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SUBSURFACE FLOW WETLANDS

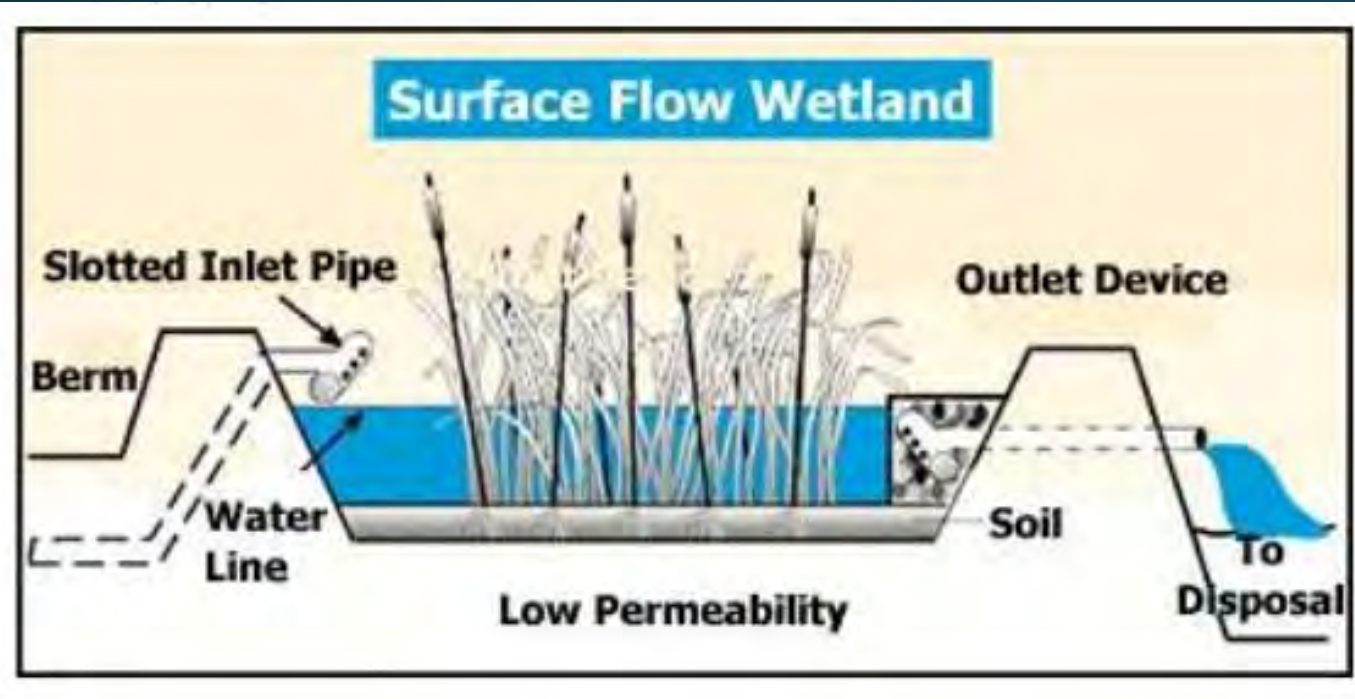


Best at removing nitrates

	IWA 2000			IWA 2000			Kadlec and Knight 1996		
SUB-SURFACE FLOW	INFLUENT (mg/L)	EFFLUENT (mg/L)	PERCENT REMOVAL (%)	INFLUENT (mg/L)	EFFLUENT (mg/L)	PERCENT REMOVAL (%)	INFLUENT (mg/L)	EFFLUENT (mg/L)	PERCENT REMOVAL (%)
Notes	SOIL BASED			GRAVEL BASED			GRAVEL BASED		
NO ₃ ⁻	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NO ₂ ⁻	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NH ₄ ⁺	N/A	N/A	N/A	N/A	N/A	N/A	5.98	4.51	24.6
TN	28.5	18.0	36.8	46.1	27.6	40.1	18.92	8.41	55.5
TKN	N/A	N/A	N/A	N/A	N/A	N/A	14.21	7.16	49.6
PO ₄ ⁻³	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
TP	8.6	6.3	26.7	6.4	3.1	51.6	4.41	2.97	32.7
BOD	97.0L	13.1	86.5	87.4	11.9	86.4	27.5	8.6	68.7
COD	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
TSS	98.6 mg/L (N=77)	13.6	86.2	71.9 (N=37)	10.8	85.0	48.2	10.3	78.6

	IWA 2000			IWA 2000			Kadlec and Knight 1996		
SUB-SURFACE FLOW	INFLUENT (mg/L)	EFFLUENT (mg/L)	PERCENT REMOVAL (%)	INFLUENT (mg/L)	EFFLUENT (mg/L)	PERCENT REMOVAL (%)	INFLUENT (mg/L)	EFFLUENT (mg/L)	PERCENT REMOVAL (%)
Notes	SOIL BASED			GRAVEL BASED			GRAVEL BASED		
NO ₃ ⁻	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NO ₂ ⁻	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NH ₄ ⁺	N/A	N/A	N/A	N/A	N/A	N/A	5.98	4.51	24.6
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SURFACE WETLANDS

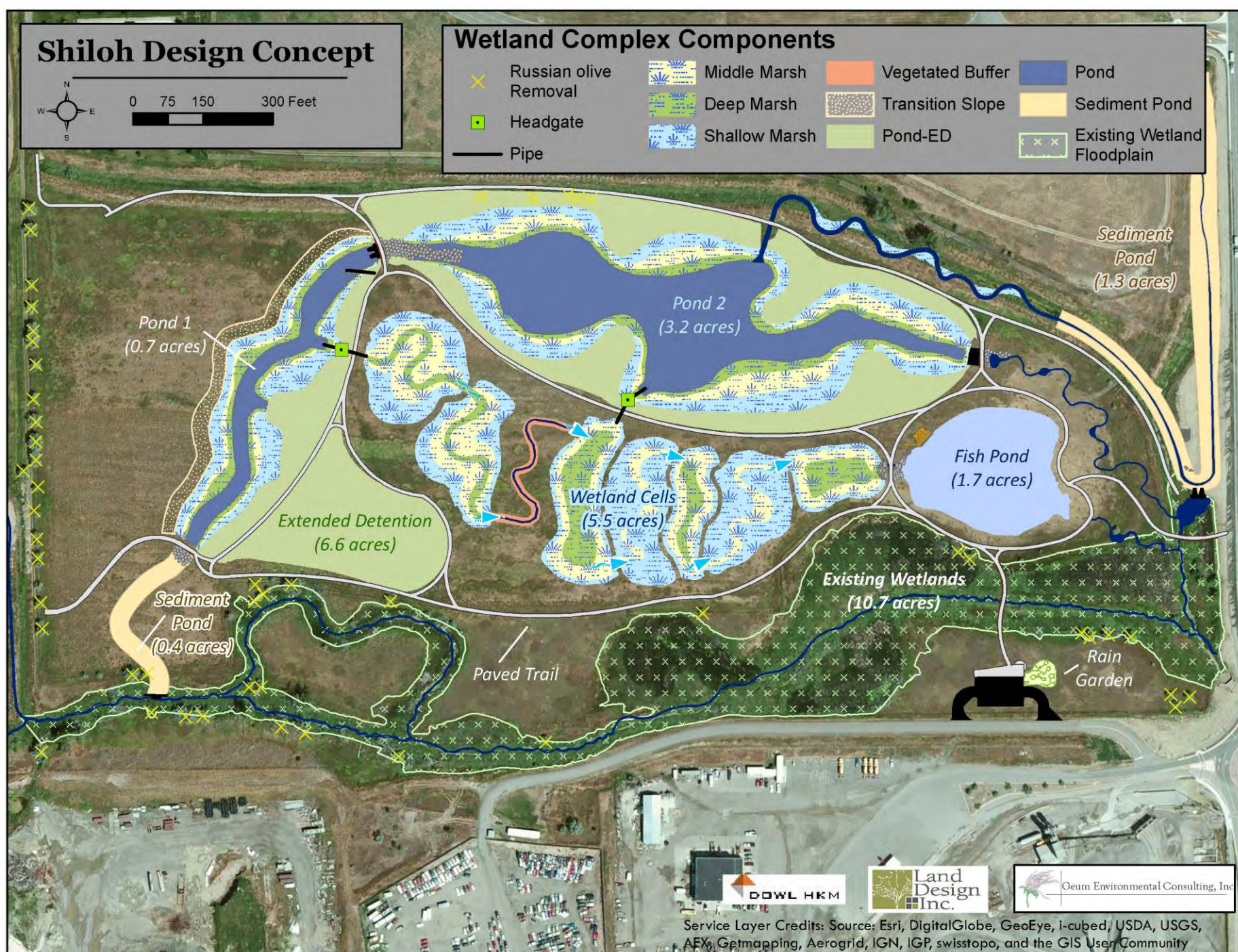


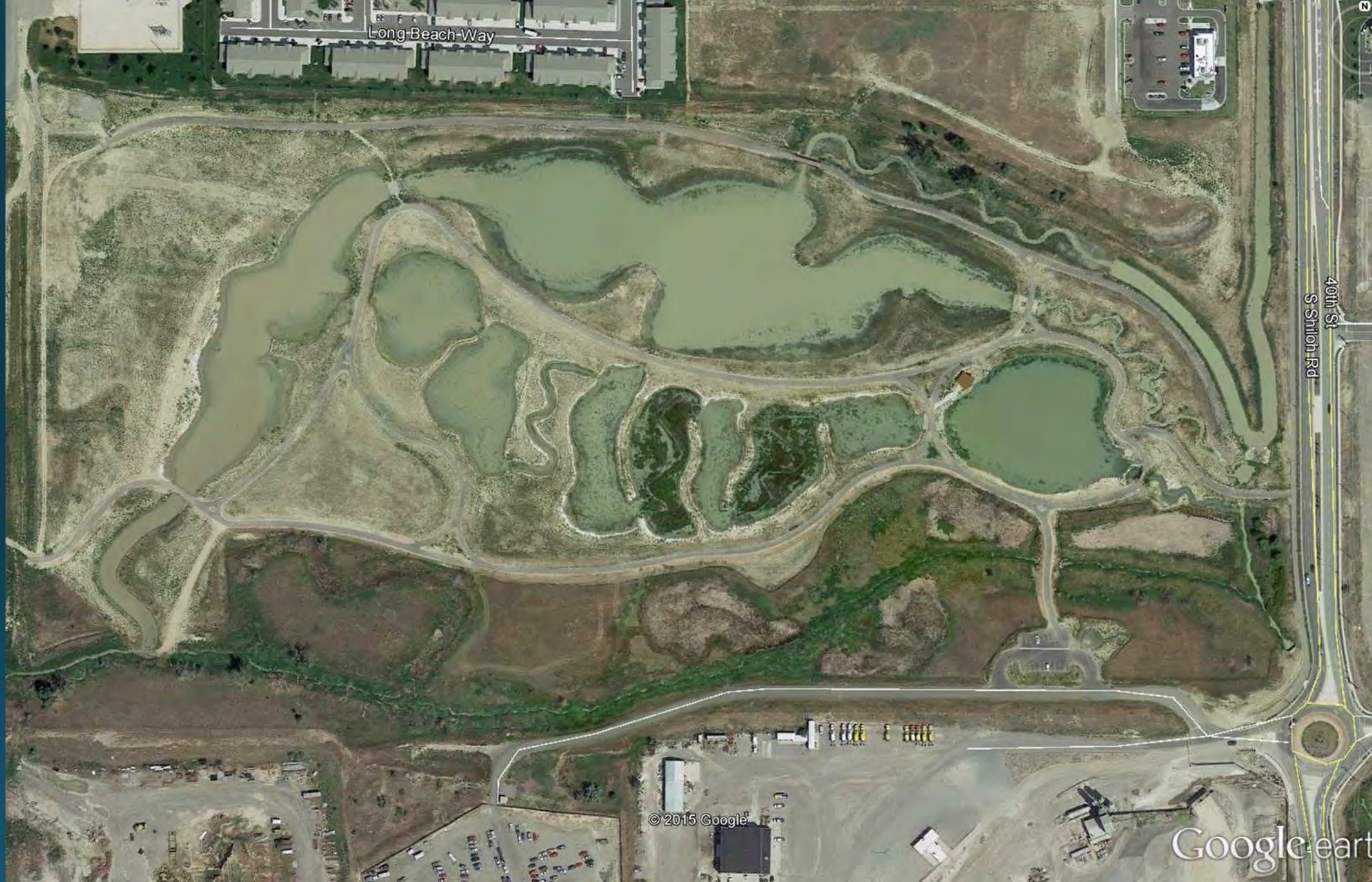
Rathor (2014)

- Primarily anoxic = nitrates
- Variability (water depth, substrate)



SURFACE WETLAND





Long Beach Way

40th St
S. Shiloh Rd

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Google earth

