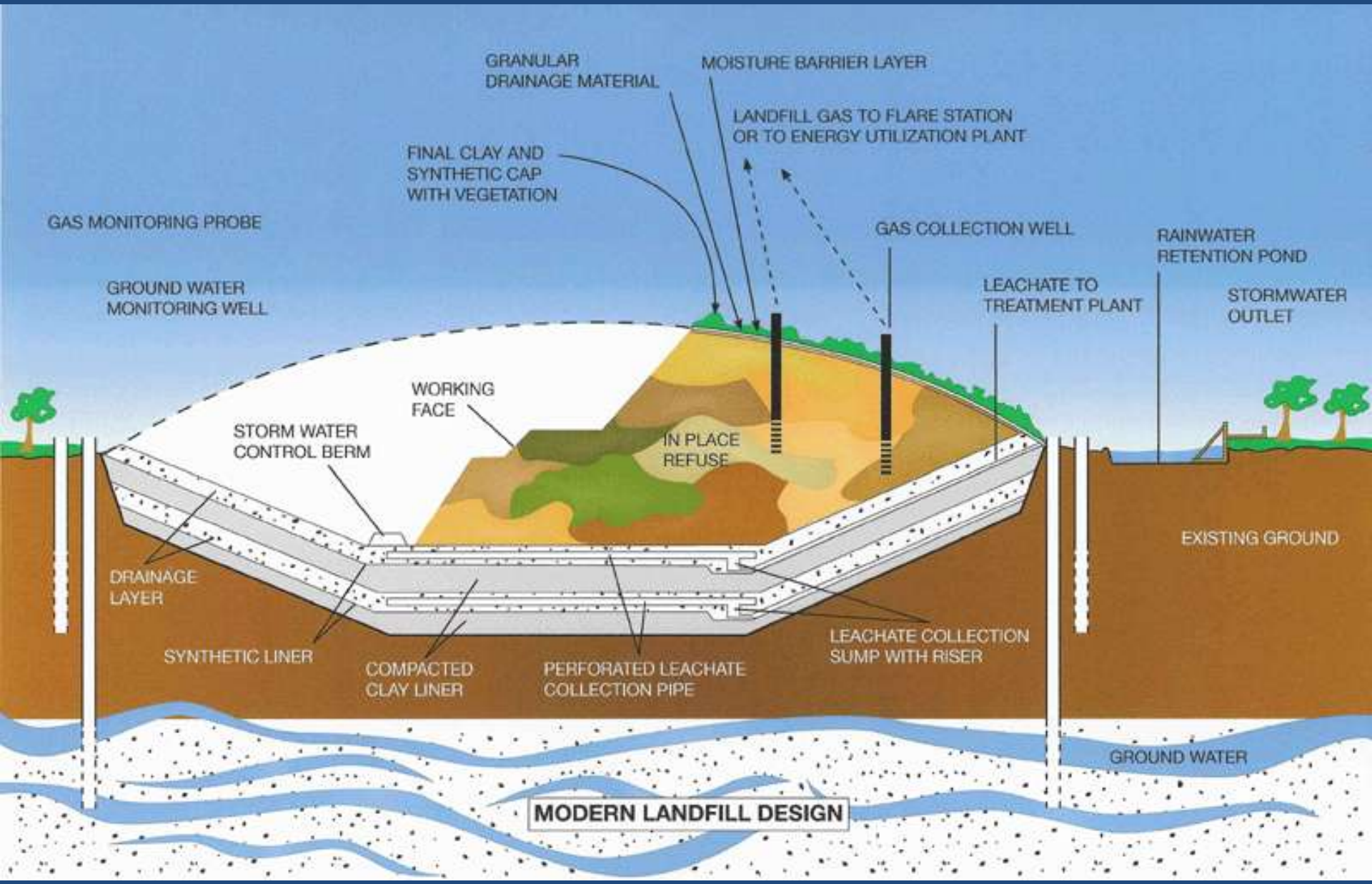
Algae & Water Hyacinth

Bioremediation potential for landfill leachate

Landfills

- Handle municipal solid waste (MSW), construction & demolition (C&D), and hazardous wastes.
- 1,754 reported US MSW landfills in 2007 received 137 million tons of waste
- Material & nutrient sinks
- Air & water pollution
    - CH_4, H_2S
    - Leachate


GRANULAR
DRAINAGE MATERIAL
MOISTURE BARRIER LAYER
LANDFILL GAS TO FLARE STATION
OR TO ENERGY UTILIZATION PLANT
FINAL CLAY AND
SYNTHETIC CAP
WITH VEGETATION
GAS MONITORING PROBE
GAS COLLECTION WELL
RAINWATER
RETENTION POND
GROUND WATER
MONITORING WELL
LEACHATE TO
TREATMENT PLANT
STORMWATER
OUTLET
WORKING
FACE
STORM WATER
CONTROL BERM
IN PLACE
REFUSE
EXISTING GROUND
DRAINAGE
LAYER
LEACHATE COLLECTION
SUMP WITH RISER
SYNTHETIC LINER
COMPACTED
CLAY LINER
PERFORATED LEACHATE
COLLECTION PIPE
GROUND WATER
MODERN LANDFILL DESIGN

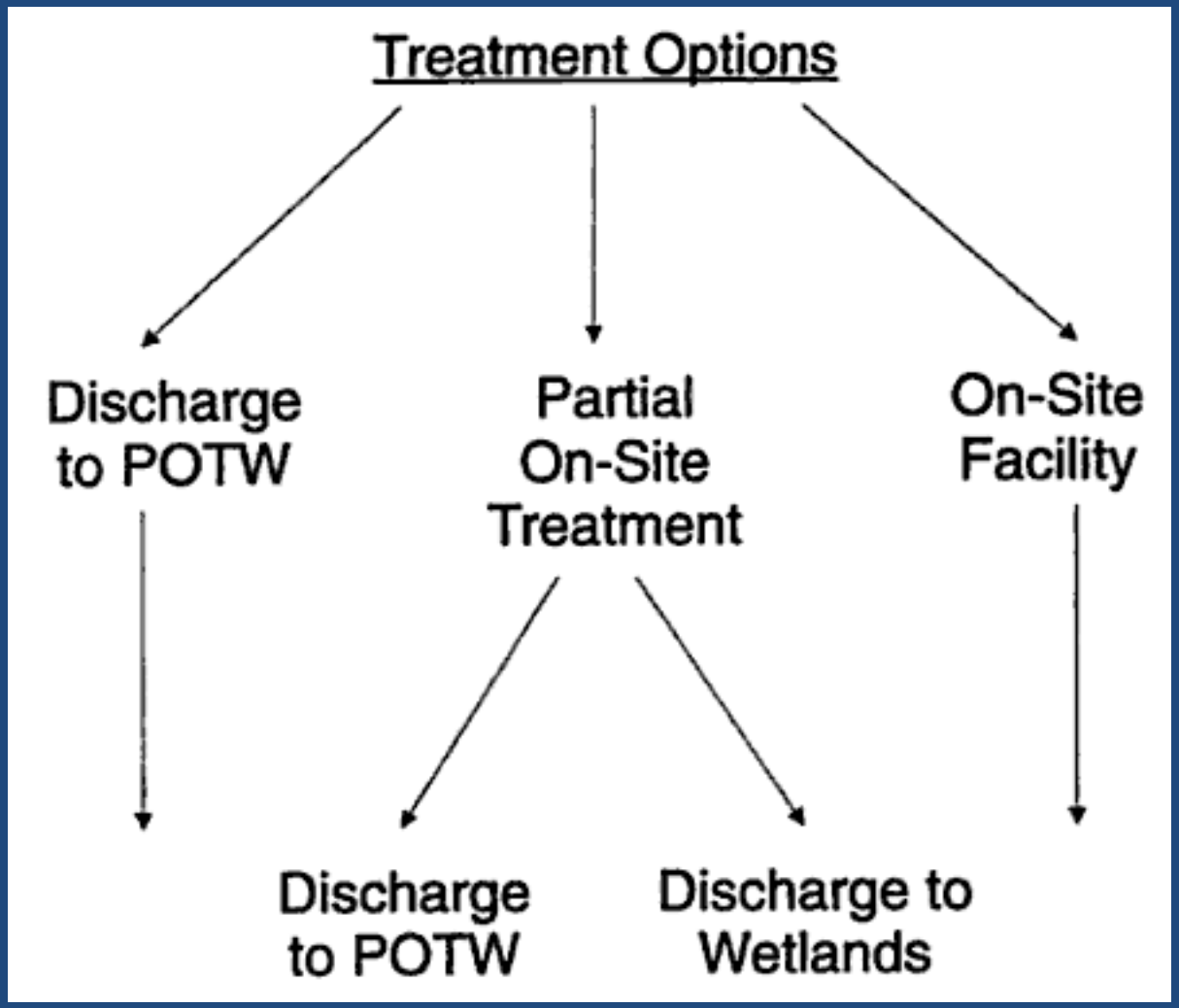
Landfill Leachate

- Every landfill has leachate
- Leachate from MSW
  - High NH3-N, BOD, Dissolved Solids, Suspended solids, heavy metals
- Unconfined landfills → groundwater pollution
- Many US landfills are now lined and fitted with pump systems

Leachate Contents

Compound	Concentration
Arsenic	60.2µg/L
Chromium	77.4µg/L
Iron	6410µg/L
Potassium	574mg/L
Sodium	2290mg/L
Ammonia as N	1300mg/L
Ammonium as N	1200mg/L
COD	2100mg/L
Electroconductivity	1800µS/cm
pH	7.6
Orthopohsophorus	19mg/L

Leachate Treatment Paths



Adapted from (Mulamoottil et al)

What to do with leachate?

- Conventional leachate treatment
  - Trucked to wastewater treatment facilities
    - High ammonia levels creates problems for facilities
    - Cost is High
- Treatment ranges from ponds to electrochemical oxidation
- Treatment Cost is often prohibitive and highly energy consumptive causing difficulties
- Efficient treatments transfer energy cost to environment and sacrifice time

The Ecological Approach

- Increasing interest in environmentally driven systems
  - Lower energy costs
  - On site treatment
- Algae
  - Associated with polluted water
  - Vast biodiversity
- Water Hyacinth
  - Hardiness to nutrients and electroconductivity
  - Easy to harvest
  - Potential for anaerobic digestion

Research

- Water Hyacinth batches removed 24%-80% of heavy metals from serial concentrations in leachate (El-Gendy, 2008)
  - Fast initial adsorption at roots
  - Slower long-term uptake driven by vascular system
- Water Hyacinth batches removed >90% of total nitrogen and phosphorous in diary farm effluent (Sooknah and Wilkie)
- Significant uptake of heavy metals from solution, survival in solutions ~3mg/L total metals (Soltan and Rashed, 2001)
- Potential for biofuel production and nutrient recycle with anaerobic digestion of Water Hyacinth (Wilkie and Evans, 2010)
- Water Hyacinth utilized in stormwater/leachate pond at Escambia County landfill (Mulamoottil et al, 1999)

Experiments

- Water Hyacinths placed in 20 gallon batches of 5, 10, 20, & 50% leachate dilutions to test survival
- 250 gallon batches of 10% leachate; one containing Water Hyacinth the other left alone
  - Conductivity, pH, orthophosphorus, NH_3-N, and cell counts monitored
- 2 liter batches of 25, 50, & 75% dilutions of leachate
  - 3 replicates of each dilution; one dilution allowed to grow algae before use the other using fresh leachate

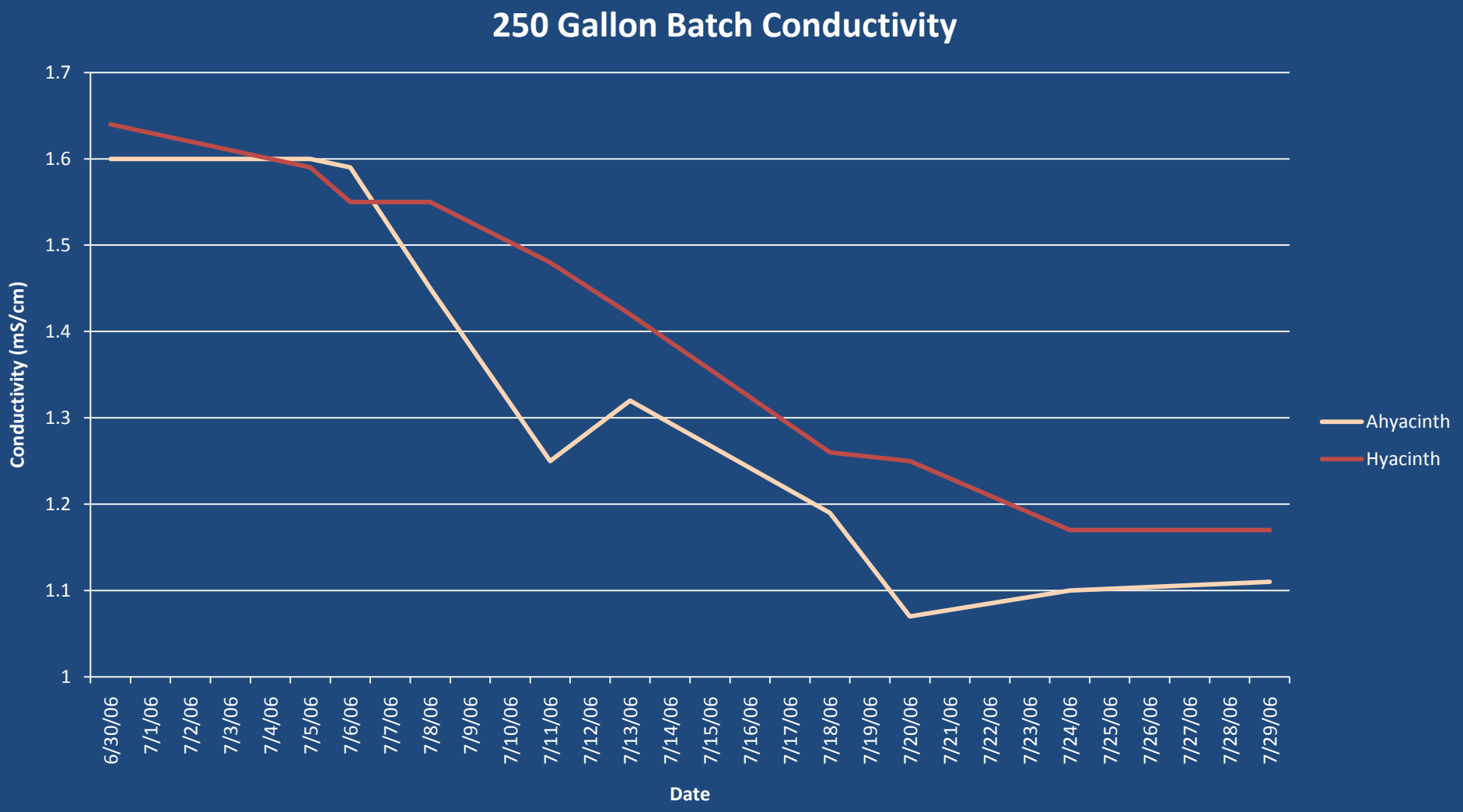
Survival of Hyacinths in Leachate Dilutions

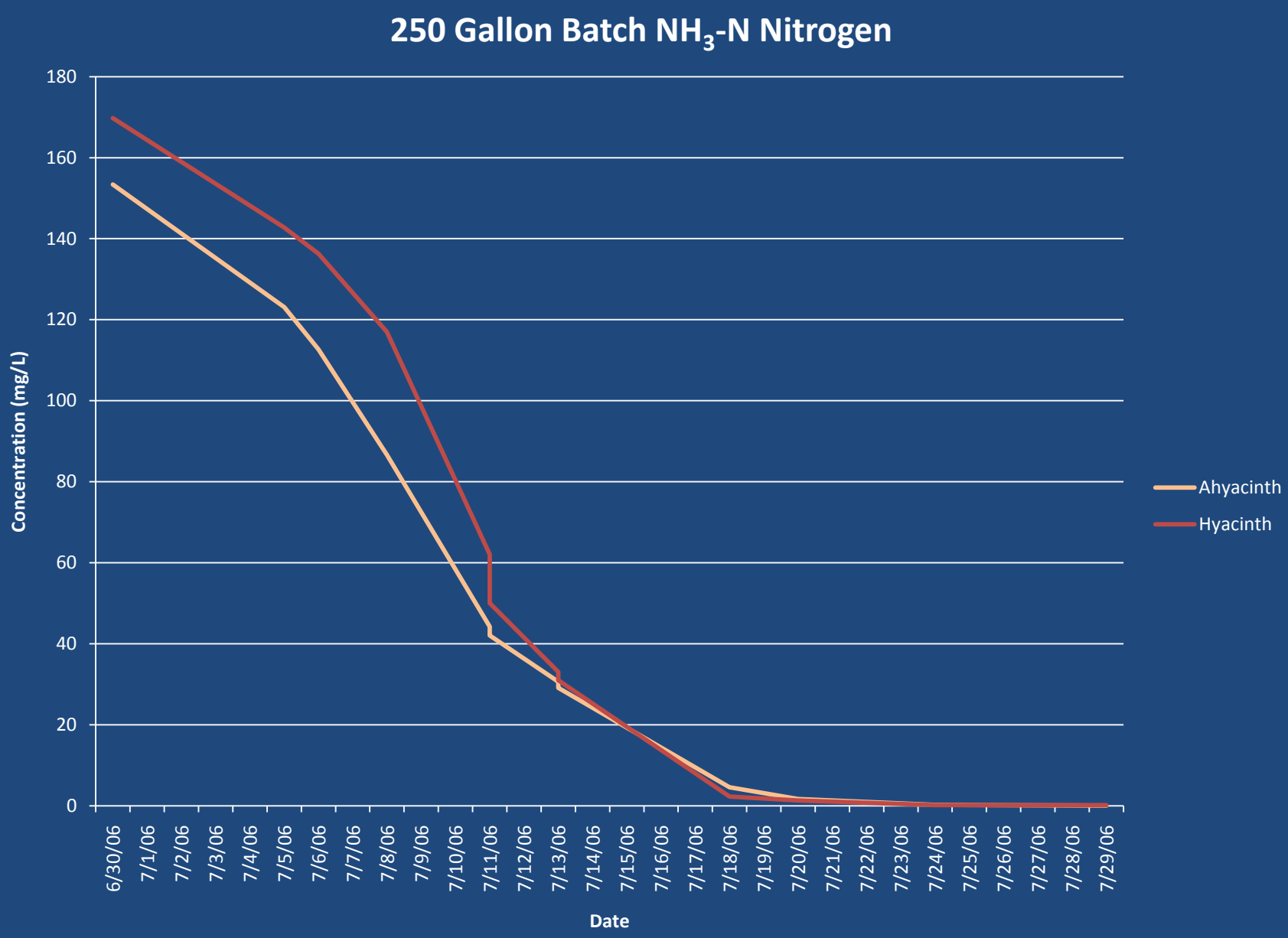
5% Leachate

10% Leachate

20% Leachate

50% Leacahte


250 Gallon Batch Conductivity
Conductivity (mS/cm)
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
6/30/06
7/1/06
7/2/06
7/3/06
7/4/06
7/5/06
7/6/06
7/7/06
7/8/06
7/9/06
7/10/06
7/11/06
7/12/06
7/13/06
7/14/06
7/15/06
7/16/06
7/17/06
7/18/06
7/19/06
7/20/06
7/21/06
7/22/06
7/23/06
7/24/06
7/25/06
7/26/06
7/27/06
7/28/06
7/29/06
Date
Ahyacinth
Hyacinth


250 Gallon Batch NH3-N Nitrogen
Concentration (mg/L)
180
160
140
120
100
80
60
40
20
0
6/30/06
7/1/06
7/2/06
7/3/06
7/4/06
7/5/06
7/6/06
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7/10/06
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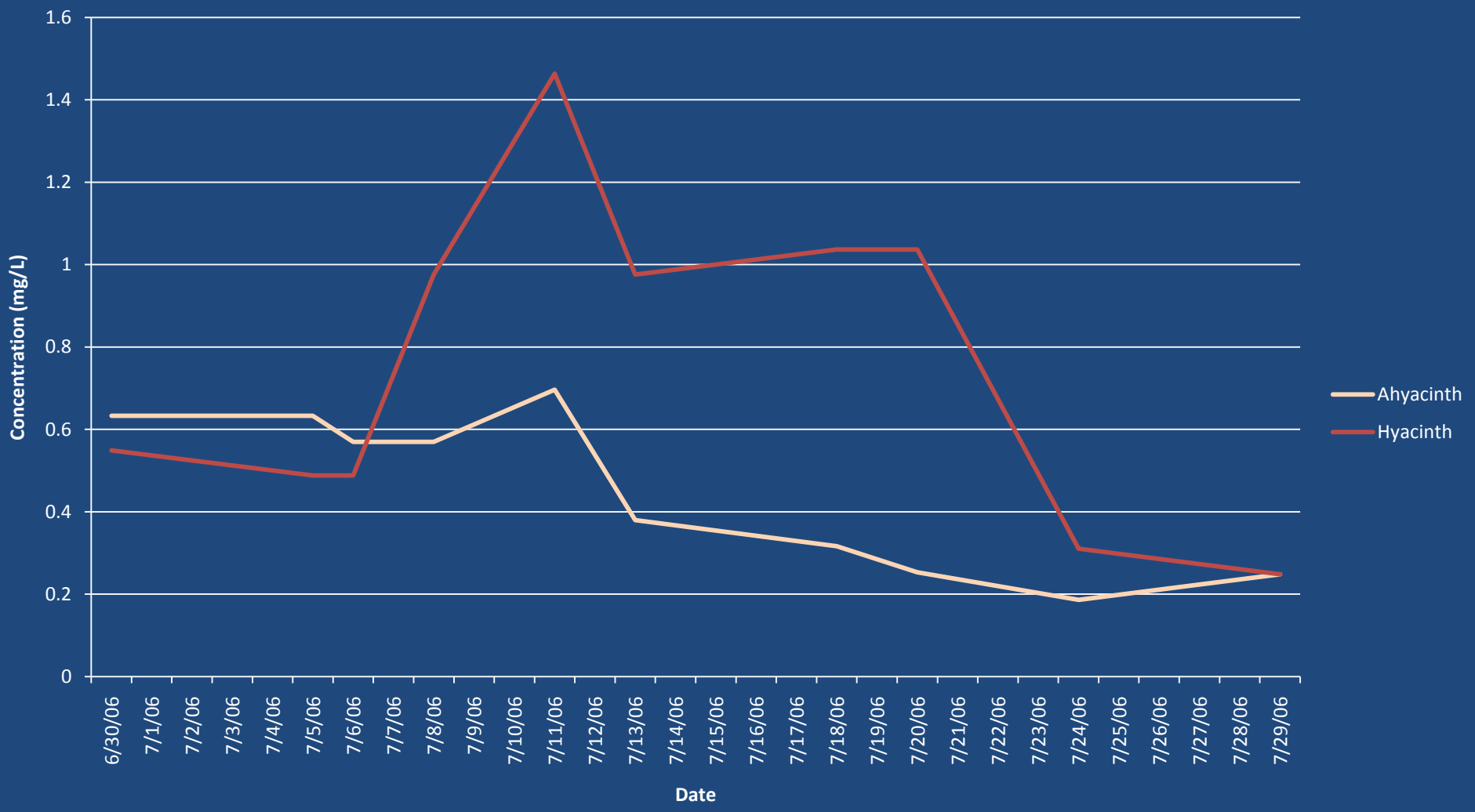
Date
Ahyacinth
Hyacinth


250 Gallon Batch Orthophosphorus Concentration
Concentration (mg/L)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
6/30/06
7/1/06
7/2/06
7/3/06
7/4/06
7/5/06
7/6/06
7/7/06
7/8/06
7/9/06
7/10/06
7/11/06
7/12/06
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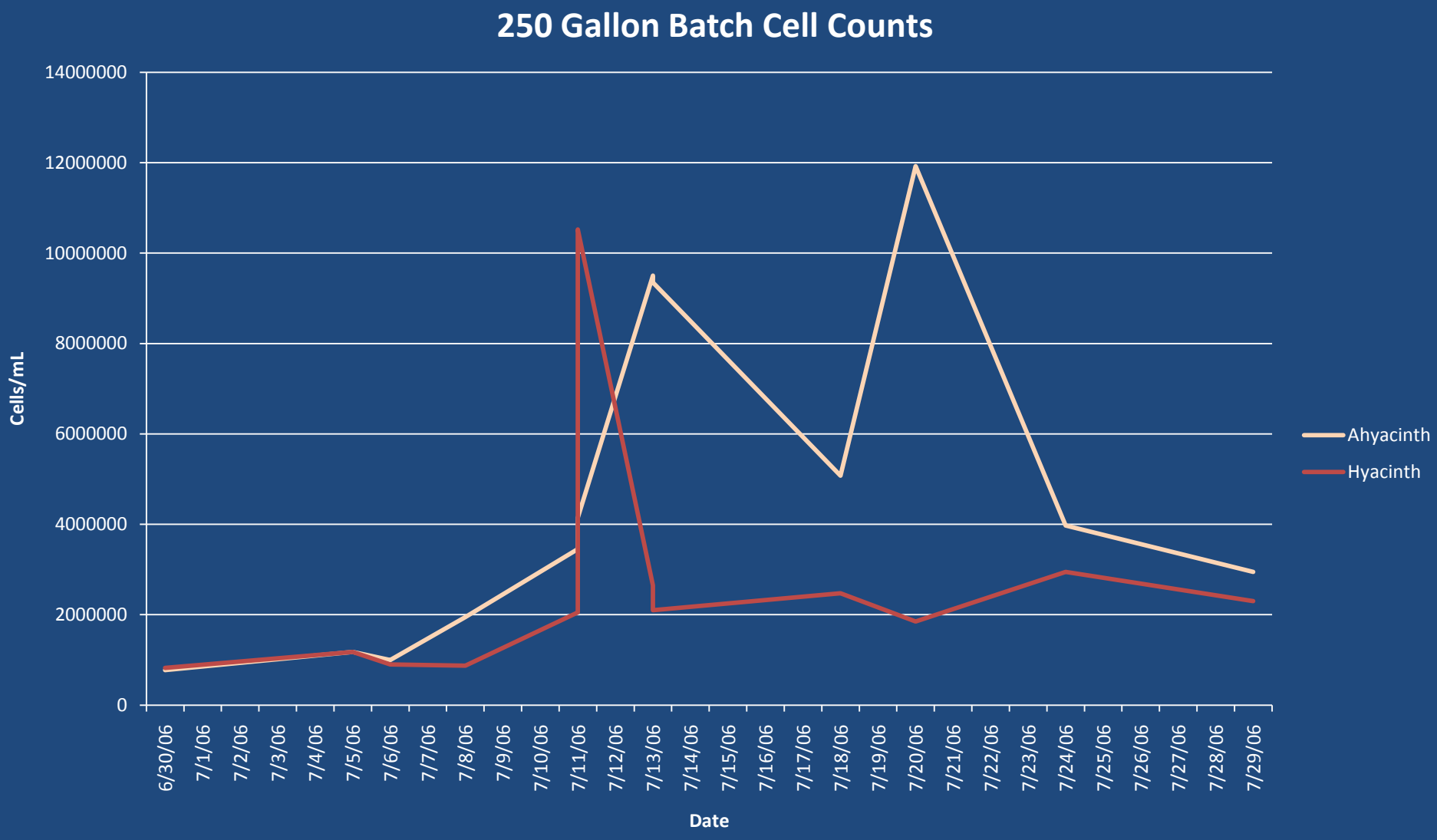
Date
Ahyacinth
Hyacinth


250 Gallon Batch Cell Counts
14000000
12000000
10000000
8000000
6000000
4000000
2000000
0
Cells/mL
6/30/06
7/1/06
7/2/06
7/3/06
7/4/06
7/5/06
7/6/06
7/7/06
7/8/06
7/9/06
7/10/06
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7/26/06
7/27/06
7/28/06
7/29/06
Date
Ahyacinth
Hyacinth

2-L Batch Results

Sample	Initial Conductivity (mS/cm)	Final Conductivity (mS/cm)	Survival (# of Specimens)
25% Leachate w/ Algae	2.45	1.88	6 of 6
25% Fresh Leachate	4.44	2.86	0 of 6
50% Leachate w/ Algae	3.84	2.88	6 of 6
50% Fresh Leachate	7.88	5.23	0 of 6
75% Leachate w/ Algae	5.46	4.12	6 of 6
75% Fresh Leachate	11.31	7.81	0 of 6

2 Liter Batch Experiment
Day 1

2 Liter Batch Experiment
Day 4

Conclusions

- Change in conductivity similar between Hyacinths and native Algae
- Major removal of NH_3-N appears non-biological despite uptake by Hyacinth and Algae
- Phosphorus appears to cycle within decreasing trend
  - Possibly influenced by outside sources (animal waste, grass clippings)
- Water Hyacinth grown in leachate dilutions containing algae has greater survivability than in fresh diluted leachate
  - Possibility for two stage treatment utilizing lower volume of clean/treated water
- Investigate utilization of water hyacinth biomass after cultivation in leacahte

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