Converting Sioux City WWTP to Modified Ludzak-Ettinger Process *(MLE)*

AWWA & KWEA Joint Annual Meeting

Presented by:

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September 2, 2009

CDM

listen. think. deliver.

Presentation Outline

- Project Background
- Hydraulic Considerations
- Nitrogen Removal Basics
- MLE Conversion Design
- Questions

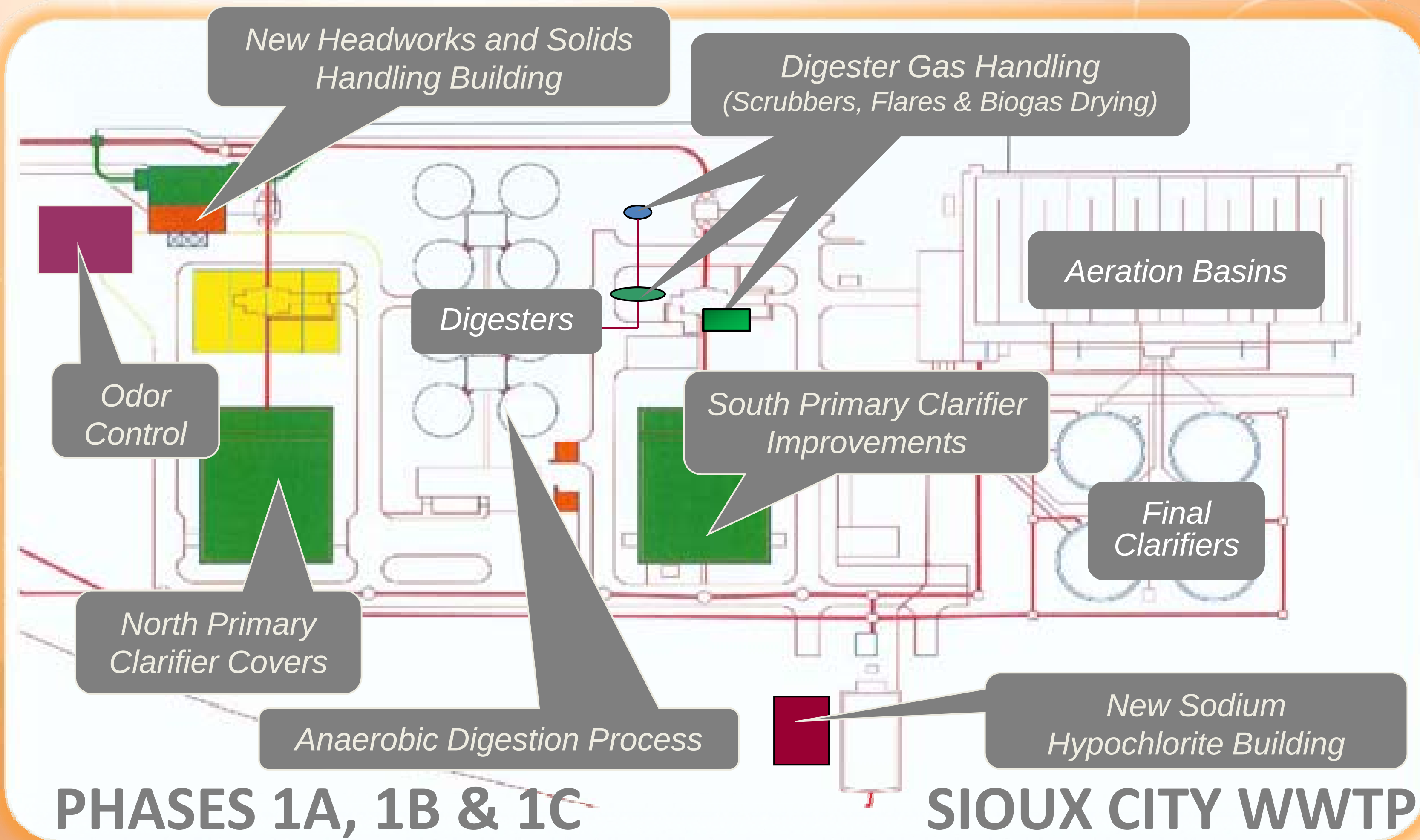
Project Background

- City Owns One Regional WWTP
  - *11 Pump Stations*
  - *320 Miles of Sewers*
- WWTP Highly Visible
- Original WWTP Constructed in 1961
- Major Upgrade in 1978
- Since Then, Only Minor Upgrades and Aging Infrastructure

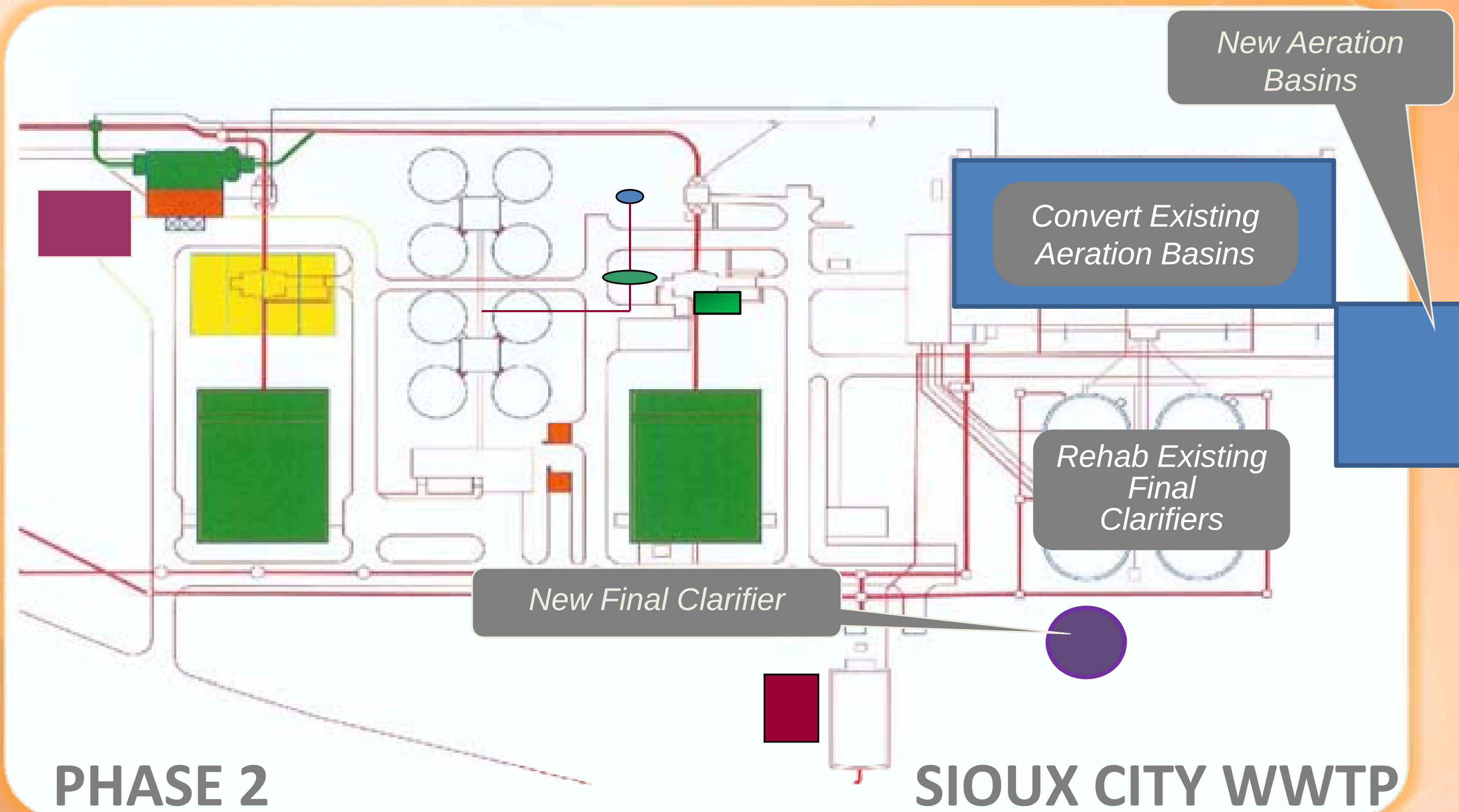
Project Background

- Unique Features of Sioux City WWTP Project
  - *Design / Operate: American Water / CDM Team*
  - *Significant high strength industrial flow*
    - *BOD >600 mg/L and TKN >100 mg/L*
  - *Odor Control Guarantee*
  - *Project Phasing: 1A, 1B/1C, 2*

Phases 1A,1B & 1C Project Treatment Processes *(anticipated completion Fall 2009)*



Phase 2 Project Treatment Processes *(anticipated completion Spring 2011)*



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Hydraulic Considerations

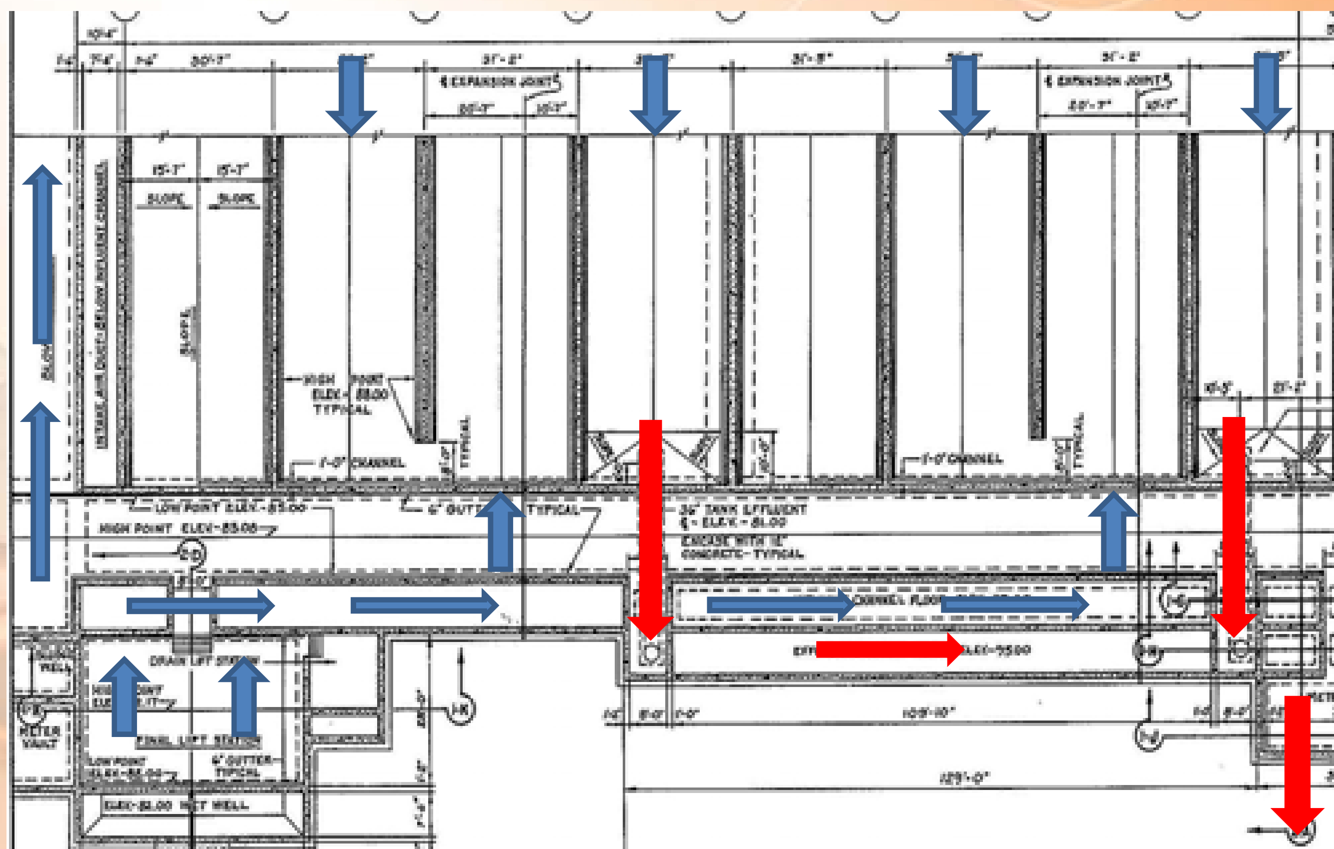
- Design Flows to Sioux City WWTP
  - *Significant increase in peak flow capacity*

	Existing Flows (MGD)	Design Flows (MGD)	Difference
Average Daily (ADW)	12.0	16.0	33% increase
Maximum Monthly (AWW)	N/A	17.6	- - -
Peak (PHWW)	28.0	56.5	102% increase

- IDNR Requirements
  - *Minimum 18-inch freeboard at peak flows*
  - *No weir submergence at peak flows*

Hydraulic Considerations (cont.)

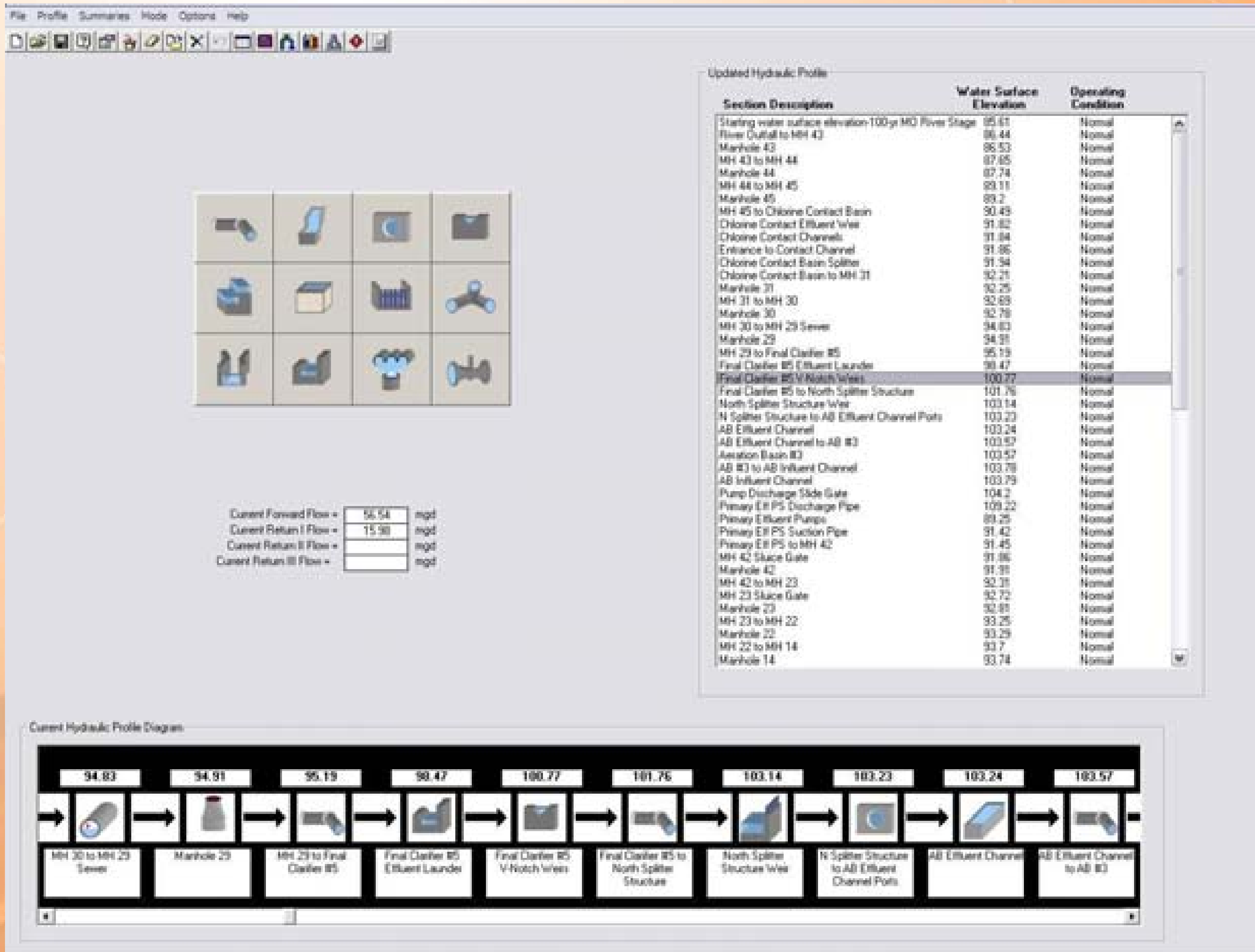
- Retrofitting Existing Structures
  - *Converting 4 existing step feed Aeration Basins to MLE*
  - *Avoid adding wall height*
- Proper Flow Splitting
  - *Replace throttling valves that split flow to Final Clarifiers*

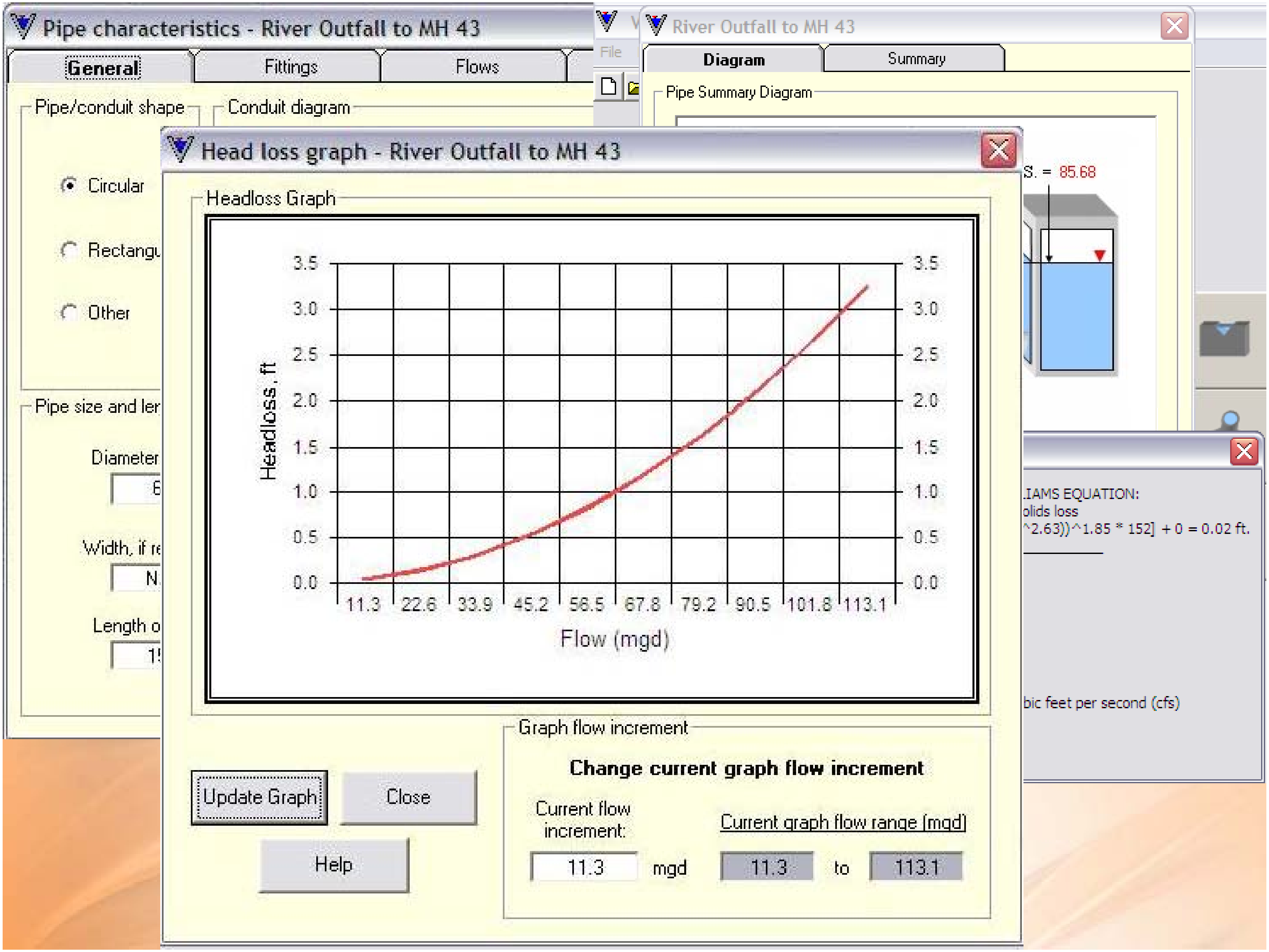


Hydraulic Profile Development

- Utilized Visual Hydraulics Software
  - *Graphical interactive interface*
  - *Allows user to build profiles by components*
    - *Pipes, channels, fittings, junctions*
    - *Weirs, gates, orifices, flumes*
    - *Pumps, screens, filters, tank launders*
  - *Enter main forward flow, plus return flows*
  - *Uses standard hydraulic equations*
    - *Hazen-Williams, Manning's, Darcy-Weisbach*
    - *Critical depth step method*
    - *Weir, orifice, other equations*
  - *Standard fitting minor loss table - customizable*

Visual Hydraulics Software




Pipe characteristics - River Outfall to MH 43
General
Fittings
Flows
Pipe/conduit shape
Conduit diagram
Circular
Other
River Outfall to MH 43
Diagram
Summary
Pipe Summary Diagram
Head loss graph - River Outfall to MH 43
Headloss Graph
Headloss, ft
Flow (mgd)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
11.3
22.6
33.9
45.2
56.5
67.8
79.2
90.5
101.8
113.1
85.68
bic feet per second (cfs)
Graph flow increment
Change current graph flow increment
Current flow increment:
11.3
mgd
Current graph flow range (mgd)
11.3
to
113.1
Update Graph
Close
Help

Software Benefits/Limitations

- Benefits
  - *Easy to change parameters, add components – automatic profile update*
  - *Operating condition status: normal, submerged, etc.*
  - *Analyze flow splits & taking units off-line*
  - *Eliminates spreadsheet incorrect cell references*
  - *Various graphs, reports available*
  - *Consistency of results between projects*
- Limitations
  - *Static hydraulic condition, not a dynamic model*
  - *Open channel versus pressure pipe – must manually check conditions*

Hydraulic Solutions

- New Splitter Structures
  - *Attached to Aeration Basin effluent channel*
  - *36-inch orifices to eliminate pipe losses*
  - *20-foot wide weir gates*
- Aeration Basin Retrofit
  - *Designed anoxic zone baffles to limit headloss*
  - *Increased influent pipe diameter*
- IDNR Variance
  - *Freeboard at peak flows:*
    - *14.5 inches in Aeration Basin Influent Channel*
    - *11/17 inches in Aeration Basins (internal/external walls)*

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Nitrogen Removal Basics

Ammonia Removal (*Nitrification*) – Required

- Ammonia compliance schedule August 2011
  - *Monthly Average 26 to 92 mg/L*
  - *Daily Maximum 53 to 97 mg/L*
- Phase 2 Design ~ 5 mg/L Effluent Ammonia-N

Nitrogen Removal (*Denitrification*) – Not Required

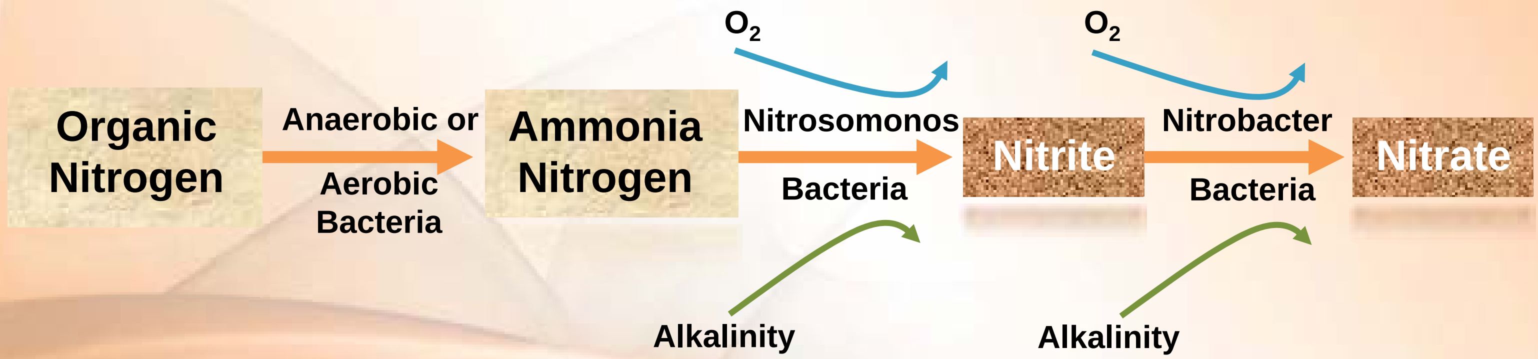
- Benefits to Environment
- Benefits to Plant Operation

Why Remove Nitrogen?

- Ammonia is highly toxic to aquatic life
- Ammonia exerts high oxygen demand in surface waters
- Ammonia increases chlorine demand
- Nitrates interfere with biological P removal
- Nitrogen stimulates growth of aquatic plants and algae

Environmental Conditions for Biological Nitrification

Adequate oxygen and alkalinity will result in ammonia conversion to Nitrate



Results of Nitrification

- TKN → NO_3^- (Nitrate)
- O_2 demand ≅ 4.5 mg O_2 /mg Ammonia
- Alkalinity demand ≅ 7.1 mg CaCO3 /mg Ammonia
- Nitrification contributes little to waste biosolids
  - *BOD solids yield ≅ 0.7 mg /mg BOD*
  - *Nitrifier solids yield ≅ 0.1- 0.15 mg /mg Ammonia*

Environmental Conditions for Biological Denitrification

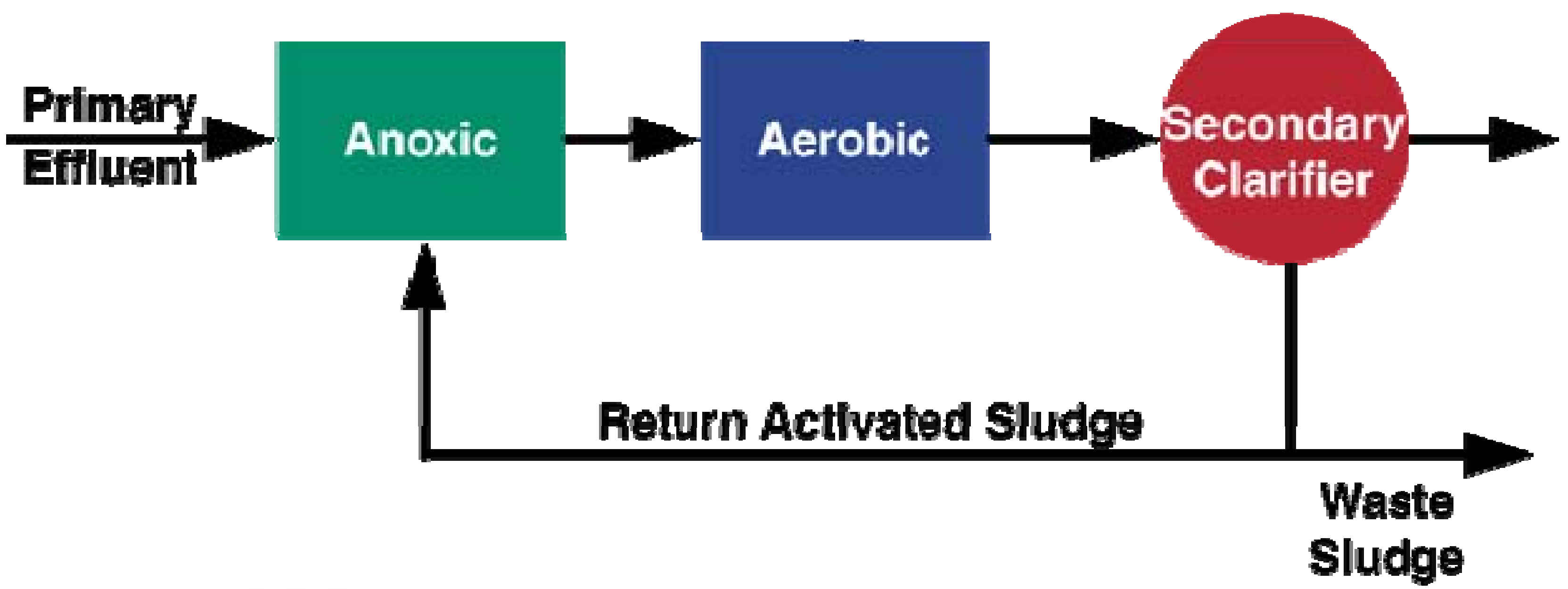
- Occurs in the absence of molecular oxygen
  - *Anoxic Zones*
- NO_3 used instead of O_2 as an electron acceptor
- Carbon source is required for denitrification
- Anoxic contact time (2 to 4 hours)
- Mixing

Results of Denitrification

- Nitrate NO_3^- → Nitrogen Gas
- O_2 recovery ≅ 2.8 mg O_2 /mg NO_3^- reduced
- Alkalinity recovery ≅ 3.0 mg $CaCO_3$ /mg NO_3^-
- Solids yield ≅ 0.4 mg VSS / mg COD removed

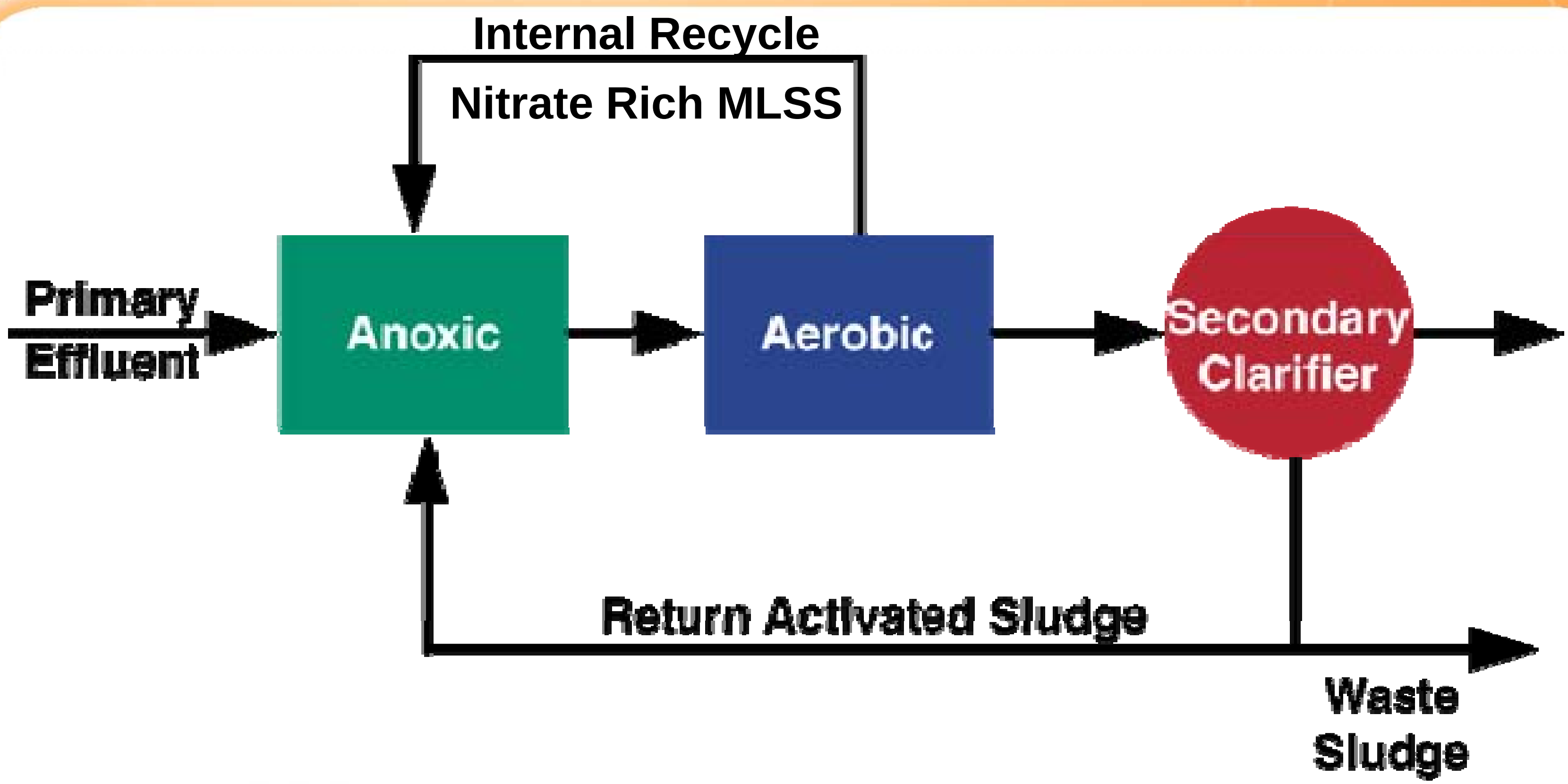
Ludzack-Ettinger (1962)

First pre-anoxic Biological Nutrient Removal (BNR) concept



Modified Ludzack-Ettinger (1973)

MLE



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MLE Conversion Design (Phase 2)
Secondary Treatment Facilities

- Ammonia compliance schedule August 2011
- Facility Plan Updated, 2008 (Veenstra & Kimm, Inc.)
- MLE Selected
  - *Lowest capital cost alternative*
  - *Meet ammonia scheduled effluent permit limits*
  - *Minimize future projects by meeting possible total nitrogen limits*
  - *Lower oxygen use and power cost (compared to nitrification alone)*

Design Flows and Loadings

FLOWS

ADW: 16.0 MGD

AWW: 17.6 MGD

MWW: 28.7 MGD

PHWW: 56.5 MGD

LOADINGS

BOD: *74,000 – 90,000 ppd*

~600 mg/L

TSS: *52,000 – 75,000 ppd*

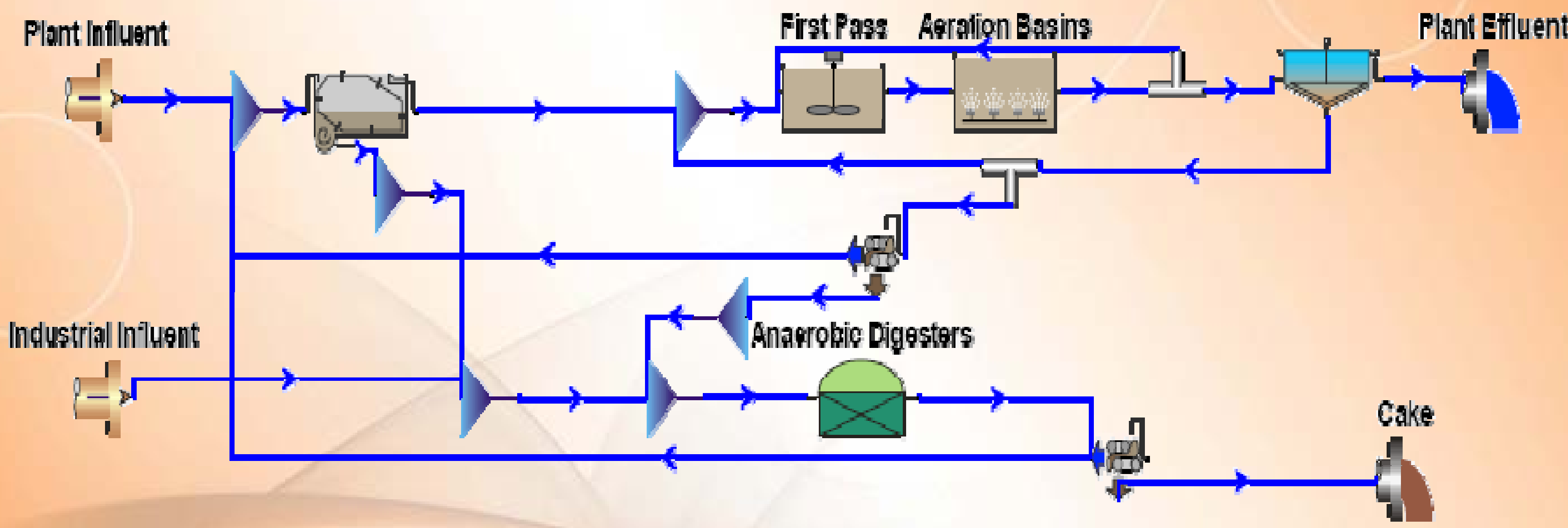
~450 mg/L

Total Kjeldahl Nitrogen:

10,000 – 12,400

~ 100 mg/L

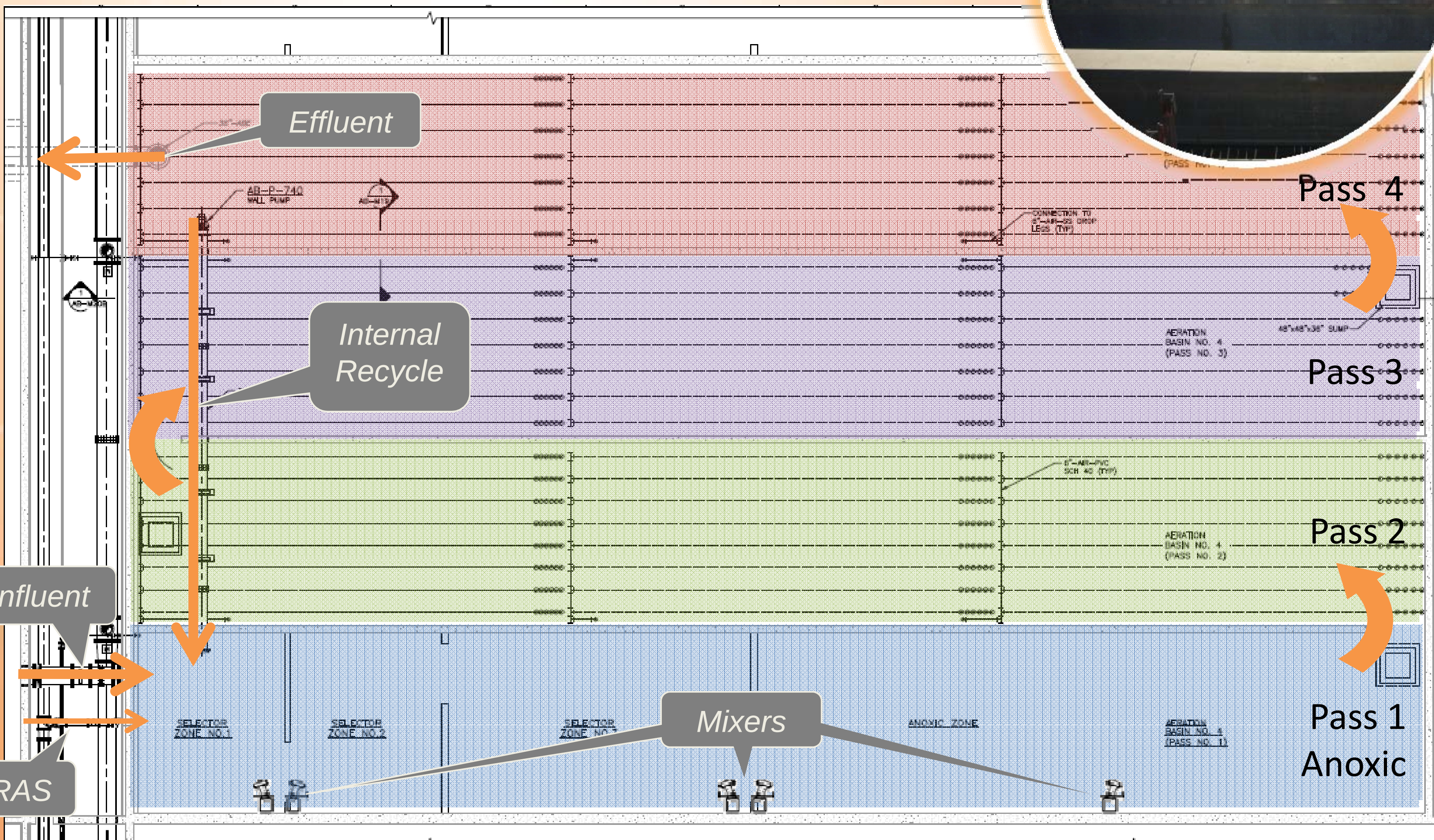
BioWin Process Flow Chart



BioWin Simulation Results

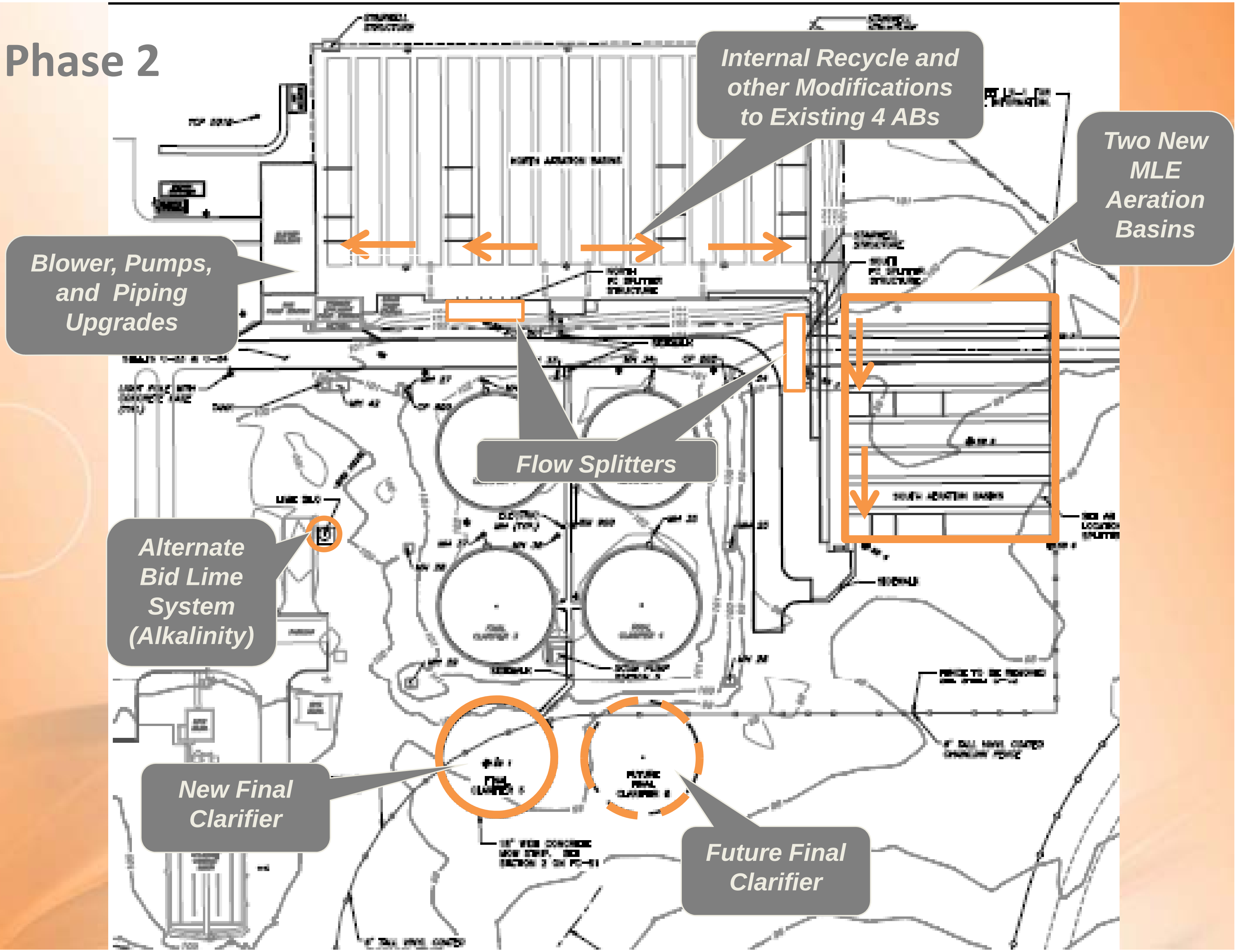
Flow SRT		BOD mg/L	TSS mg/L	Ammonia – N mg/L	TKN mg/L
16.0 MGD 7.8 days	Influent	550	400	55	73
	Effluent	2.7	5.0	0.9	16.9
	% Removal	**99.5**	**98.8**	**98.4**	**77**
17.6 MGD 6.8 days	Influent	690	560	73.5	98
	Effluent	2.9	5.7	1.0	22.3
	% Removal	**99.6**	**99.0**	**98.7**	**77**
28.73 MGD 6.8 days	Influent	376	312	55.5	74
	Effluent	4.5	10.3	0.1	29.6
	% Removal	**98.8**	**96.7**	**99.7**	**60**

Sioux City MLE Process Aeration Basins



Existing Aeration Basin

Phase 2



Internal Recycle and other Modifications to Existing 4 ABs
Two New MLE Aeration Basins
Blower, Pumps, and Piping Upgrades
Flow Splitters
Alternate Bid Lime System (Alkalinity)
New Final Clarifier
Future Final Clarifier

Design Challenges

- Existing Facility
  - *Geometry of ABs is fixed*
  - *Hydraulic constraints*
- Construction scheduling and maintaining plant in operation during 20 month construction period
- Concurrent construction
  - *Phase 1A*
  - *Phase 1B/1C*
  - *Phase 2*

Questions

CDM

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