NORTHEAST

WATER PURIFICATION PLANT EXPANSION

From 80 MGD to 400 MGD: Simulating Operation of a 320-MGD Water Treatment Plant

PNWS-AWWA Conference

May 1, 2019

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Central Harris County Regional Water Authority

City of Houston Texas

North Fort Bend Water Authority

North Harris County Regional Water Authority

West Harris County Regional Water Authority

carollo Engineers...Working Wonders With Water®

Houston Waterworks Team

Roles & acknowledgements

Design-Builder

Houston Waterworks Team

Joint-Venture of:

JACOBS

CDM Smith

listen. think. deliver.

Ownership Partners

(16%) City of Houston, Texas

(25.76%) West Harris County Regional Water Authority

(35.31%) North Harris County Regional Water Authority

(1.53%) Central Harris County Regional Water Authority

(21.41%) North Fort Bend Water Authority

Project Advisor/ Technical Consultant

carollo

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- SES Horizon Consulting Eng
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- United Engineers

Agenda

1	Project Background
2	Process Challenges & Solutions
3	Operational Model
4	Example Simulations
5	Staff Training

Operational modeling is a powerful tool for challenging projects:

- Useful at any stage of a project:
  - Planning, design, or operations
- Useful to the full range of stakeholders
  - Decision makers, plant managers, operations staff, and design engineers

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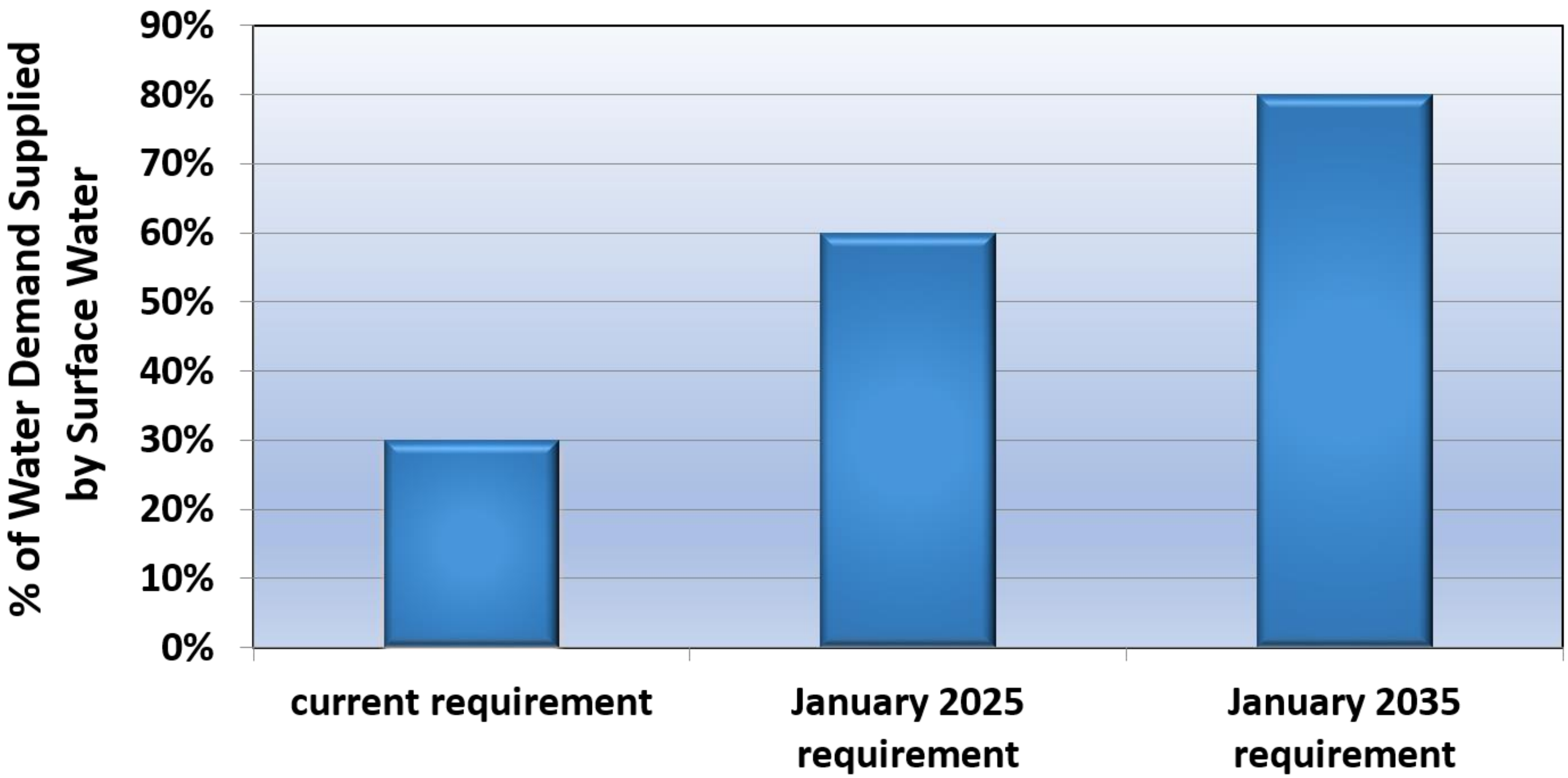
1 - Project Background

Subsidence regulations & growth drive need for expansion



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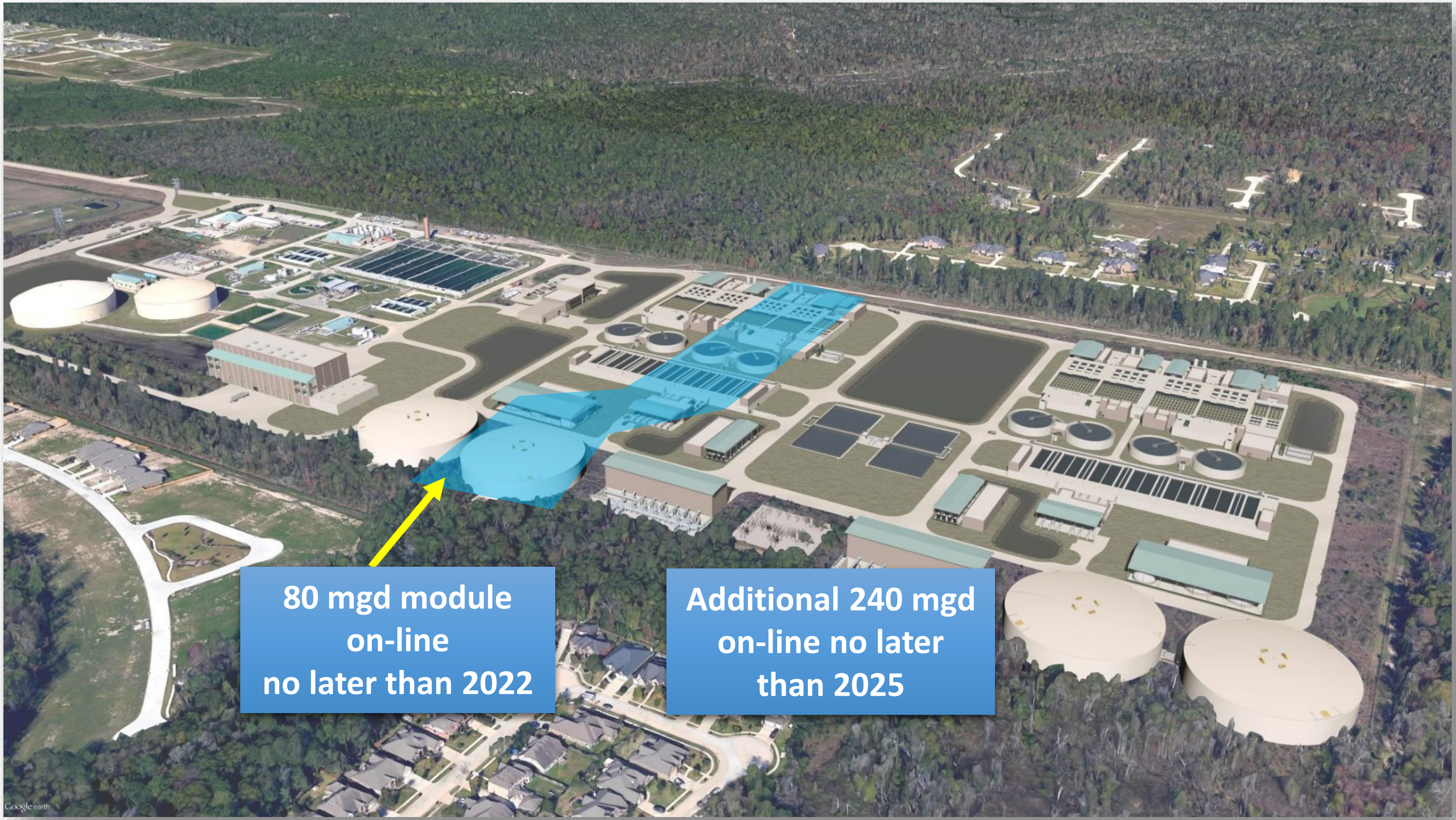
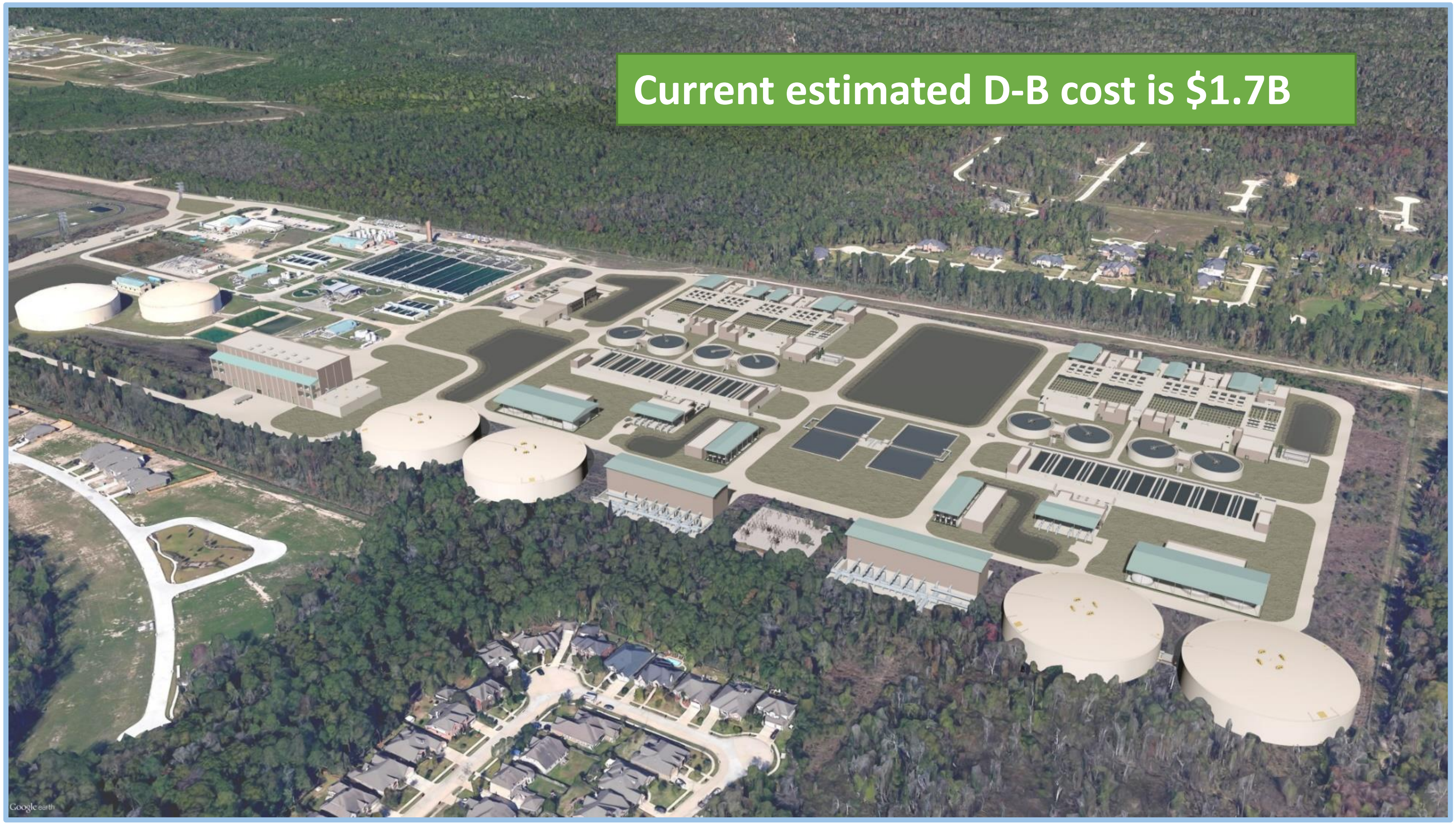
This 320 mgd expansion has an early 80 mgd milestone

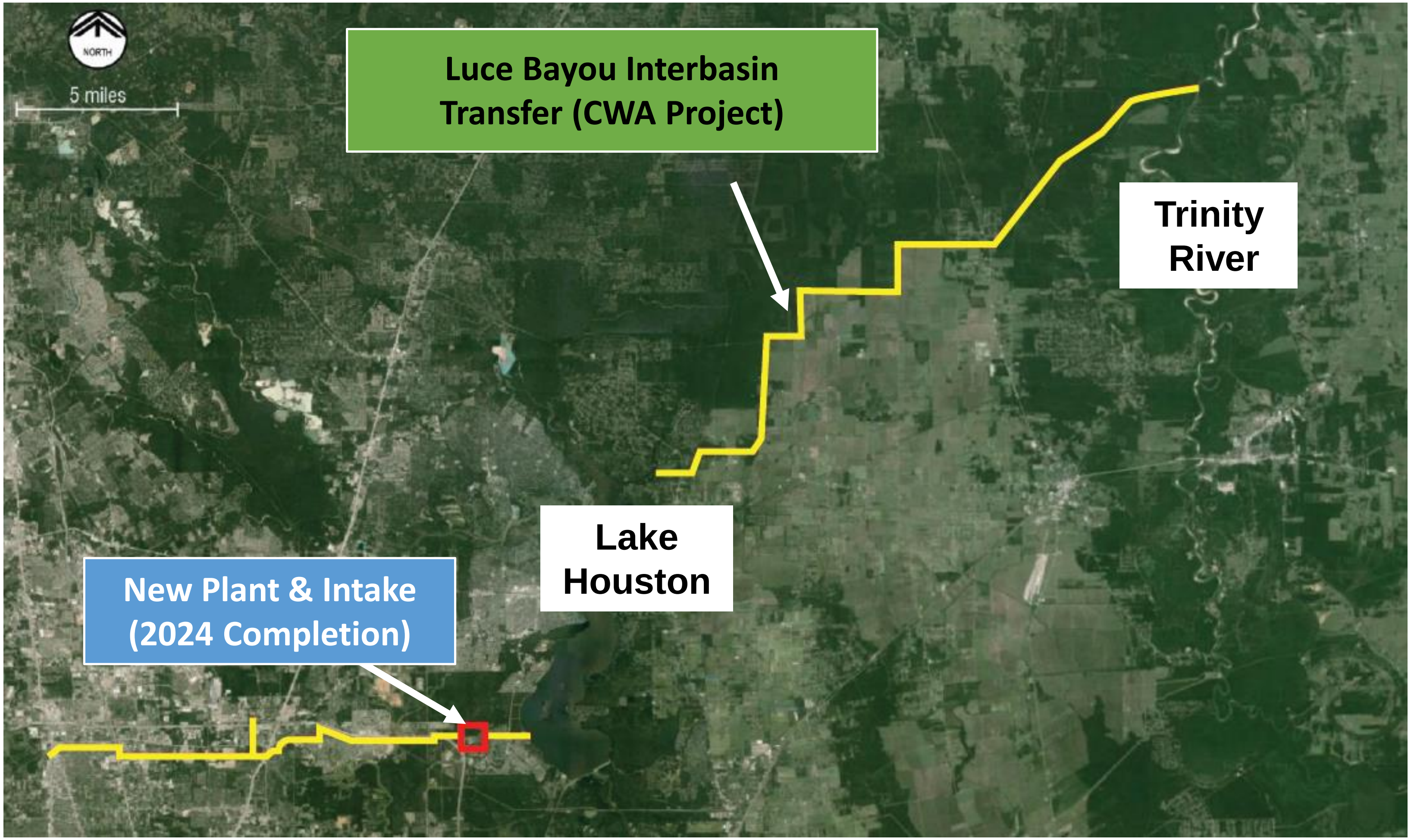


Design is at 90% completion milestone



2 - Process Challenges & Solutions

NEWPP will receive blend of Trinity River and Lake Houston water



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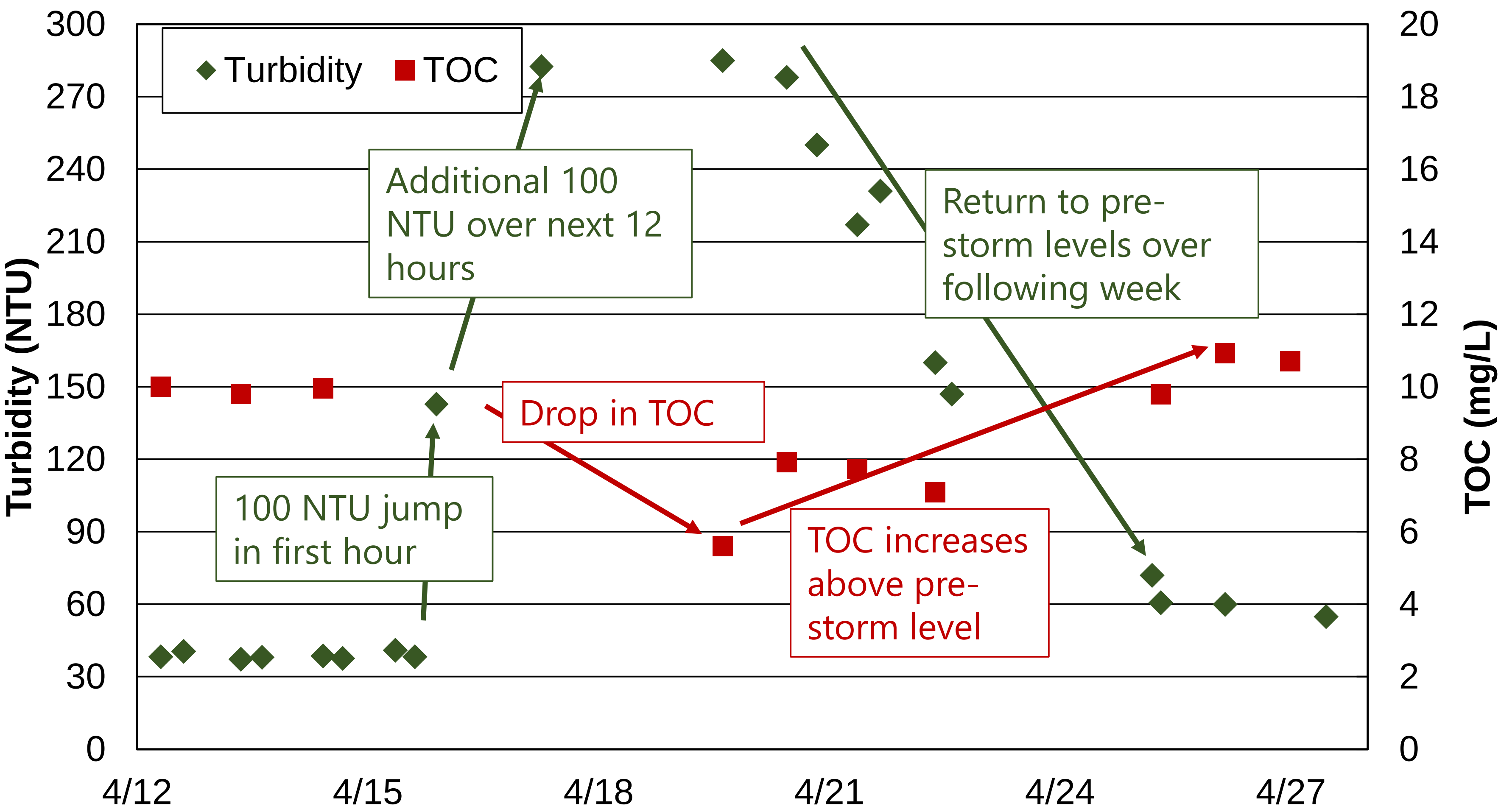
2016 April storm demonstrates water quality variability in Lake Houston water



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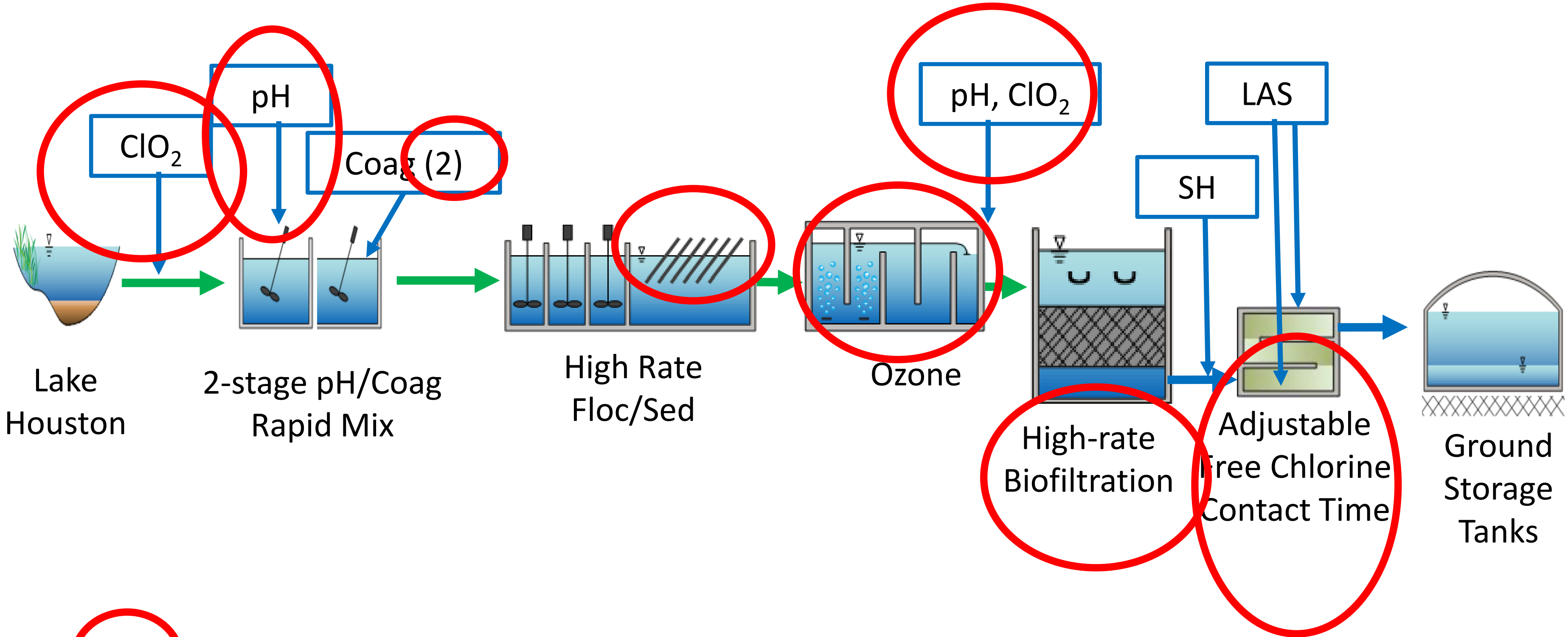
Design includes a multi-barrier approach, with treatment processes not in current WTP



Not in current WTP

HOW ARE WE GOING TO UNDERSTAND AND OPTIMIZE ALL THIS?

3 - Operational Model

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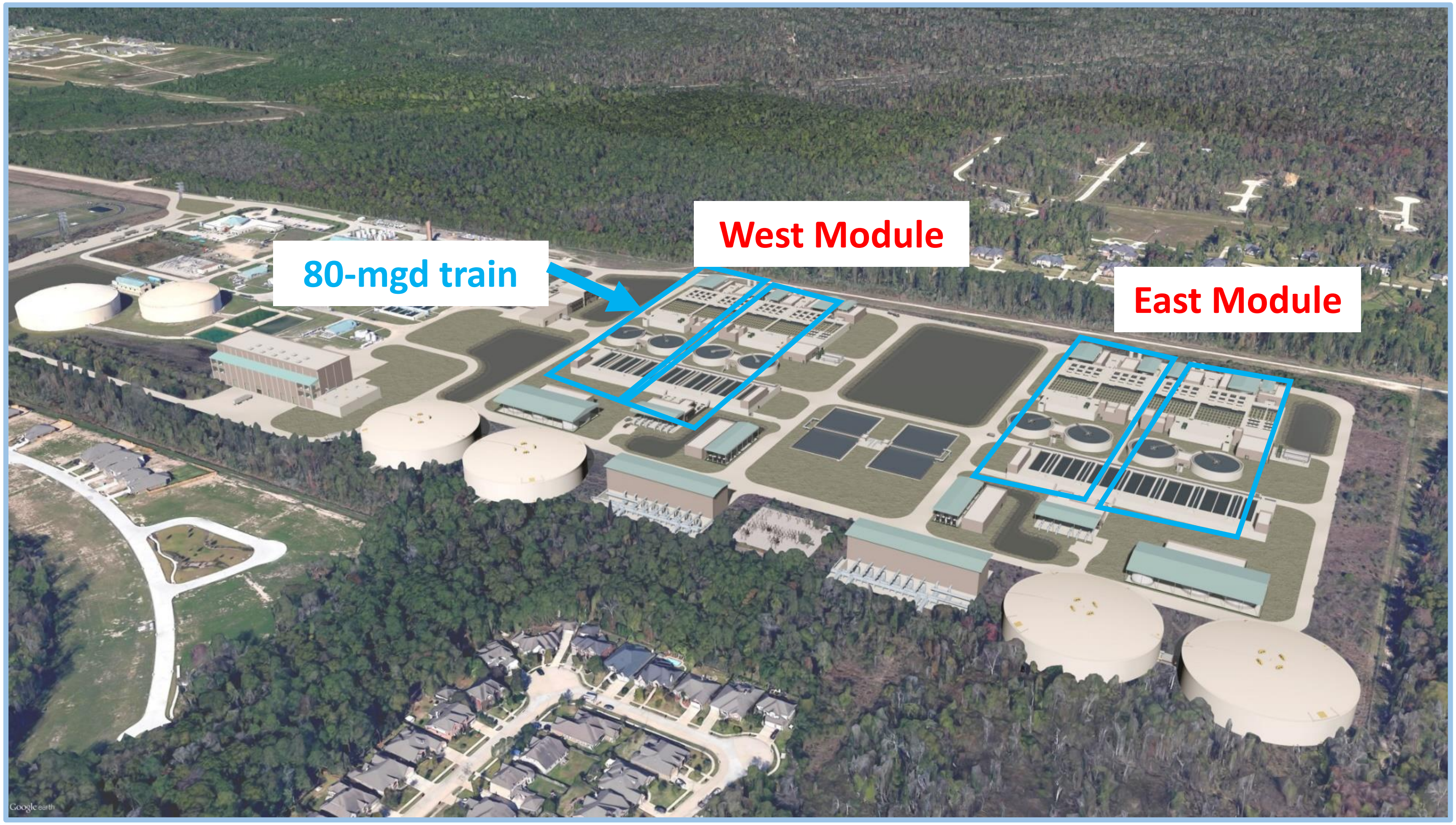
The model provides insight into how different scenarios impact plant performance

- Available to plant operators, plant supervisors, and managers
- Scenarios can be quickly modified for raw water quality, chemical feed strategy, plant production, and operating strategies
- Insight includes operating metrics (loading rates, run times), finished water quality, operating costs

The operations model simulates the entire treatment process



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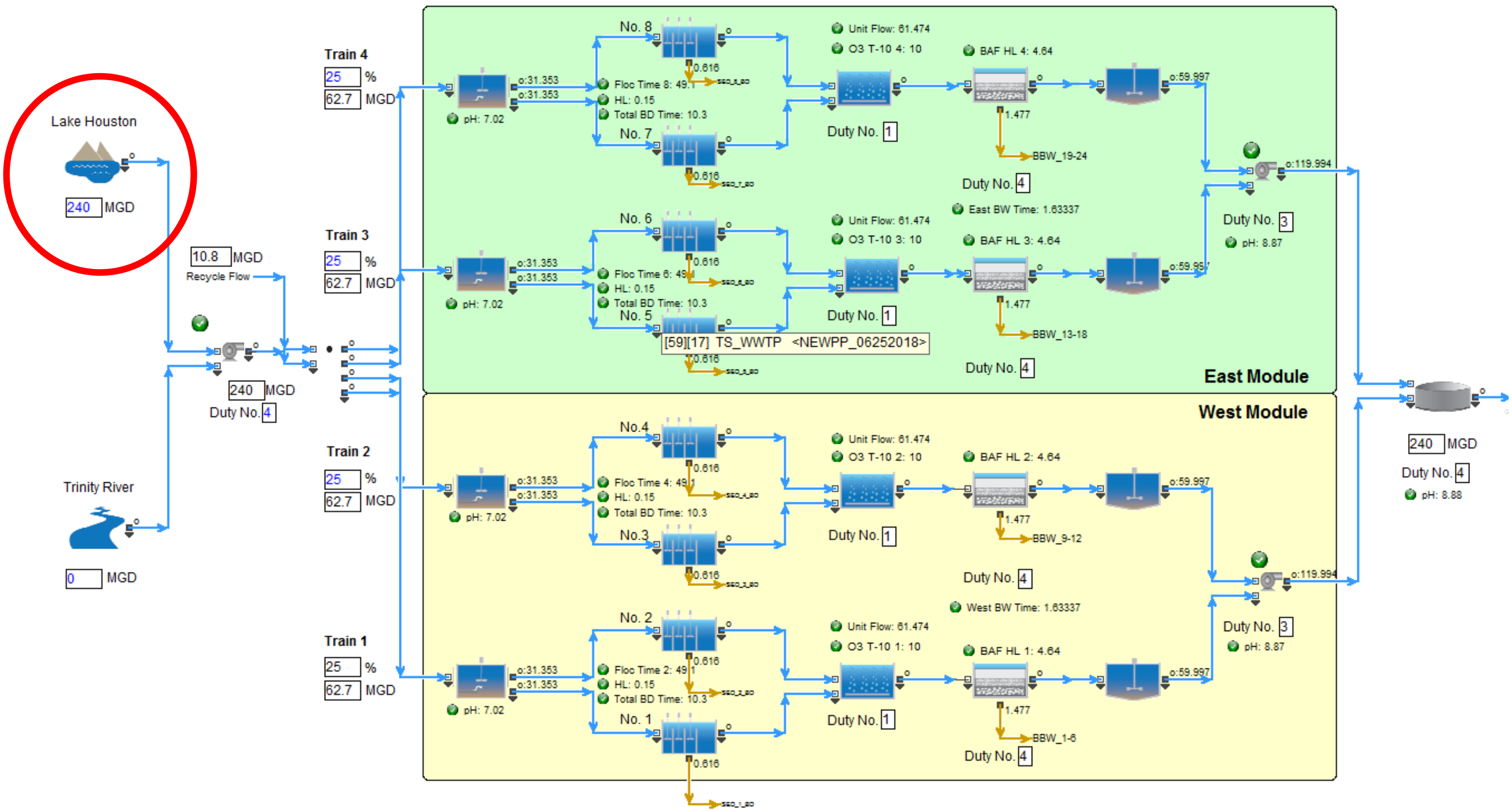
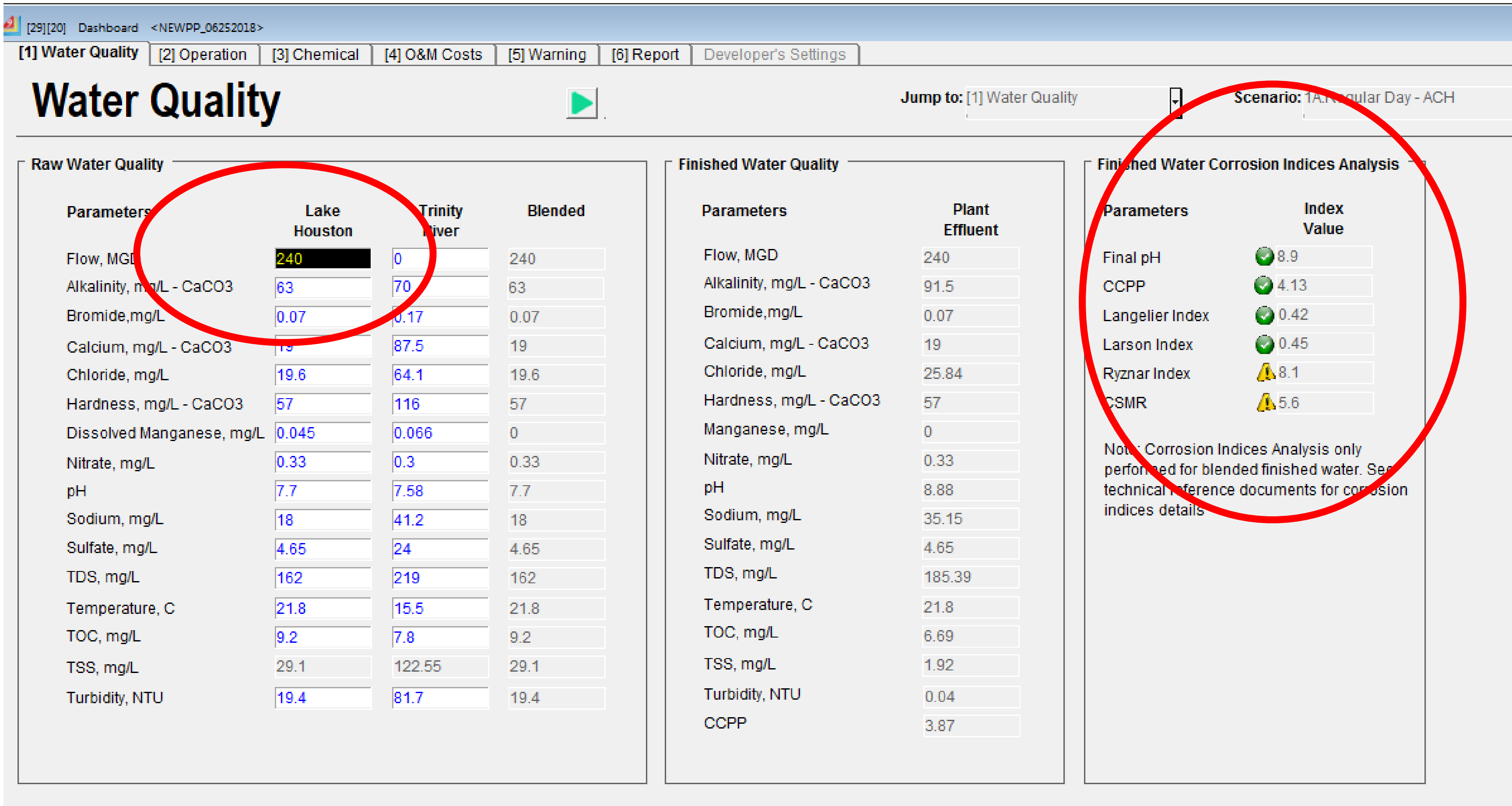
Graphical process flow diagrams mimic the actual facility and display input and output



The PFDs are linked to dashboard tabs to convey all input, output, and warnings


[29][20] Dashboard <NEWPP_06252018>

[1] Water Quality | [2] Operation | [3] Chemical | [4] O&M Costs | [5] Warning | [6] Report | Developer's Settings

Water Quality

Jump to: [1] Water Quality

Scenario: 1A Regular Day - ACH

Raw Water Quality

Parameters	Lake Houston	Trinity River	Blended
Flow, MGD	240	0	240
Alkalinity, mg/L - CaCO3	63	70	63
Bromide,mg/L	0.07	0.17	0.07
Calcium, mg/L - CaCO3	19	87.5	19
Chloride, mg/L	19.6	64.1	19.6
Hardness, mg/L - CaCO3	57	116	57
Dissolved Manganese, mg/L	0.045	0.066	0
Nitrate, mg/L	0.33	0.3	0.33
pH	7.7	7.58	7.7
Sodium, mg/L	18	41.2	18
Sulfate, mg/L	4.65	24	4.65
TDS, mg/L	162	219	162
Temperature, C	21.8	15.5	21.8
TOC, mg/L	9.2	7.8	9.2
TSS, mg/L	29.1	122.55	29.1
Turbidity, NTU	19.4	81.7	19.4

Finished Water Quality

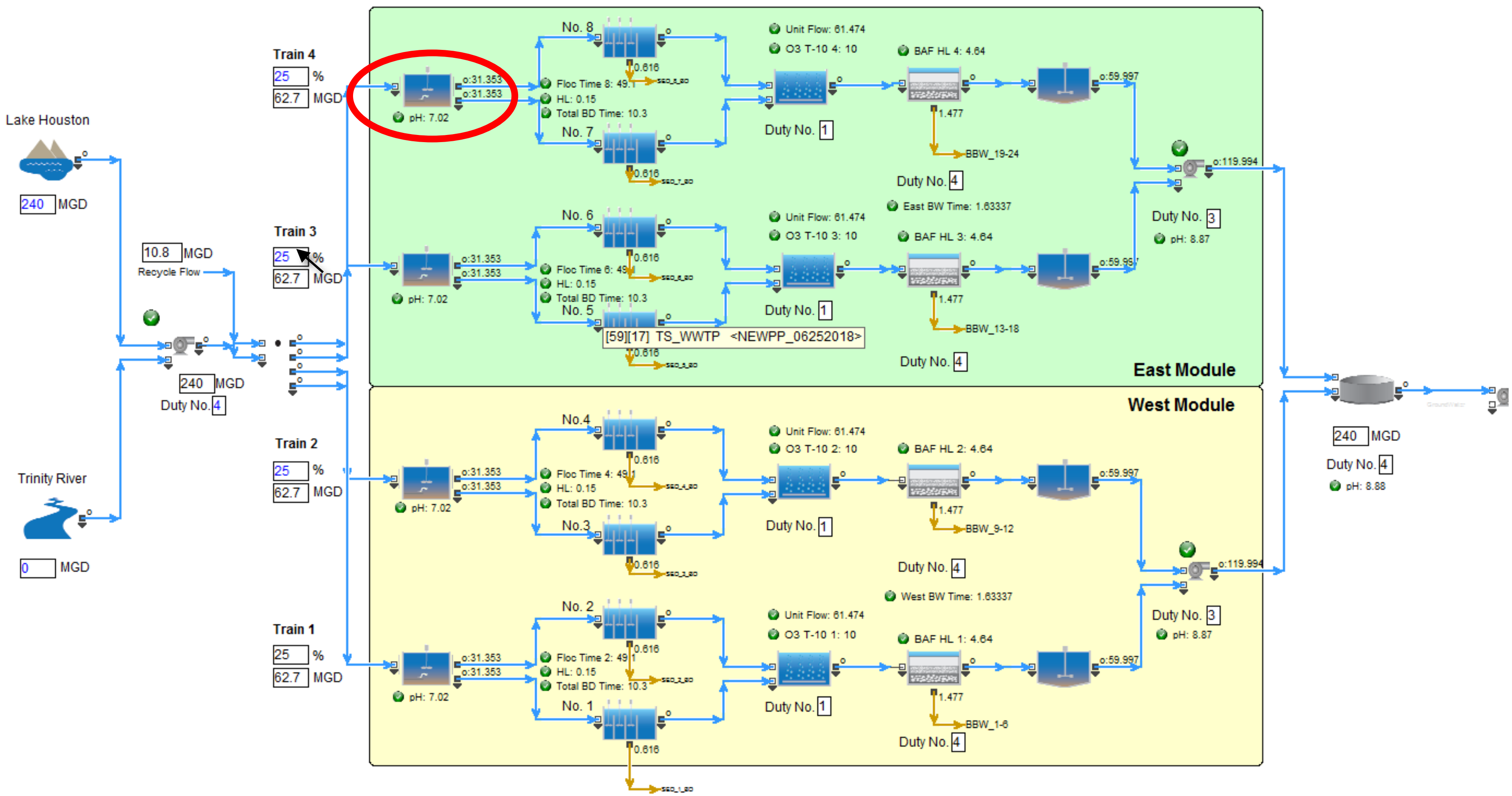
Parameters	Plant Effluent
Flow, MGD	240
Alkalinity, mg/L - CaCO3	91.5
Bromide,mg/L	0.07
Calcium, mg/L - CaCO3	19
Chloride, mg/L	25.84
Hardness, mg/L - CaCO3	57
Manganese, mg/L	0
Nitrate, mg/L	0.33
pH	8.88
Sodium, mg/L	35.15
Sulfate, mg/L	4.65
TDS, mg/L	185.39
Temperature, C	21.8
TOC, mg/L	6.69
TSS, mg/L	1.92
Turbidity, NTU	0.04
CCPP	3.87

Finished Water Corrosion Indices Analysis

Parameters	Index Value
Final pH	8.9
CCPP	4.13
Langelier Index	0.42
Larson Index	0.45
Ryznar Index	8.1
CSMR	5.6

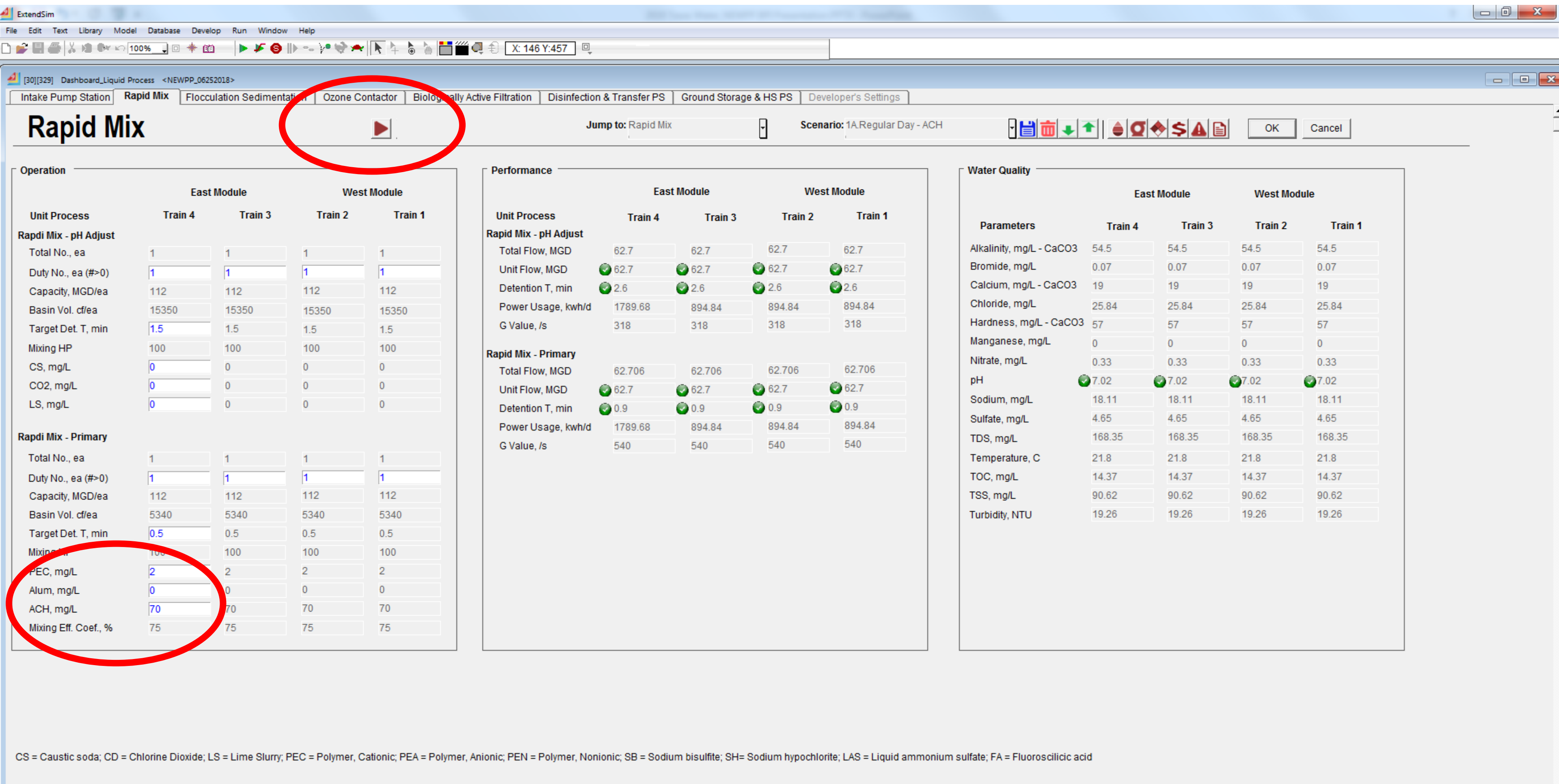
Note: Corrosion Indices Analysis only performed for blended finished water. See technical reference documents for corrosion indices details

Operational decisions can be quickly changed to determine plant-wide impacts



NORTHEAST WATER PURIFICATION PLANT EXPANSION

Operational decisions can be quickly changed to determine plant-wide impacts



Operation

Unit Process	East Module Train 4	East Module Train 3	West Module Train 2	West Module Train 1
Rapdi Mix - pH Adjust				
Total No., ea	1	1	1	1
Duty No., ea (#>0)	1	1	1	1
Capacity, MGD/ea	112	112	112	112
Basin Vol. cf/ea	15350	15350	15350	15350
Target Det. T, min	1.5	1.5	1.5	1.5
Mixing HP	100	100	100	100
CS, mg/L	0	0	0	0
CO2, mg/L	0	0	0	0
LS, mg/L	0	0	0	0
Rapdi Mix - Primary				
Total No., ea	1	1	1	1
Duty No., ea (#>0)	1	1	1	1
Capacity, MGD/ea	112	112	112	112
Basin Vol. cf/ea	5340	5340	5340	5340
Target Det. T, min	0.5	0.5	0.5	0.5
Mixing HP	100	100	100	100
PEC, mg/L	2	2	2	2
Alum, mg/L	0	0	0	0
ACH, mg/L	70	70	70	70
Mixing Eff. Coef., %	75	75	75	75

Performance

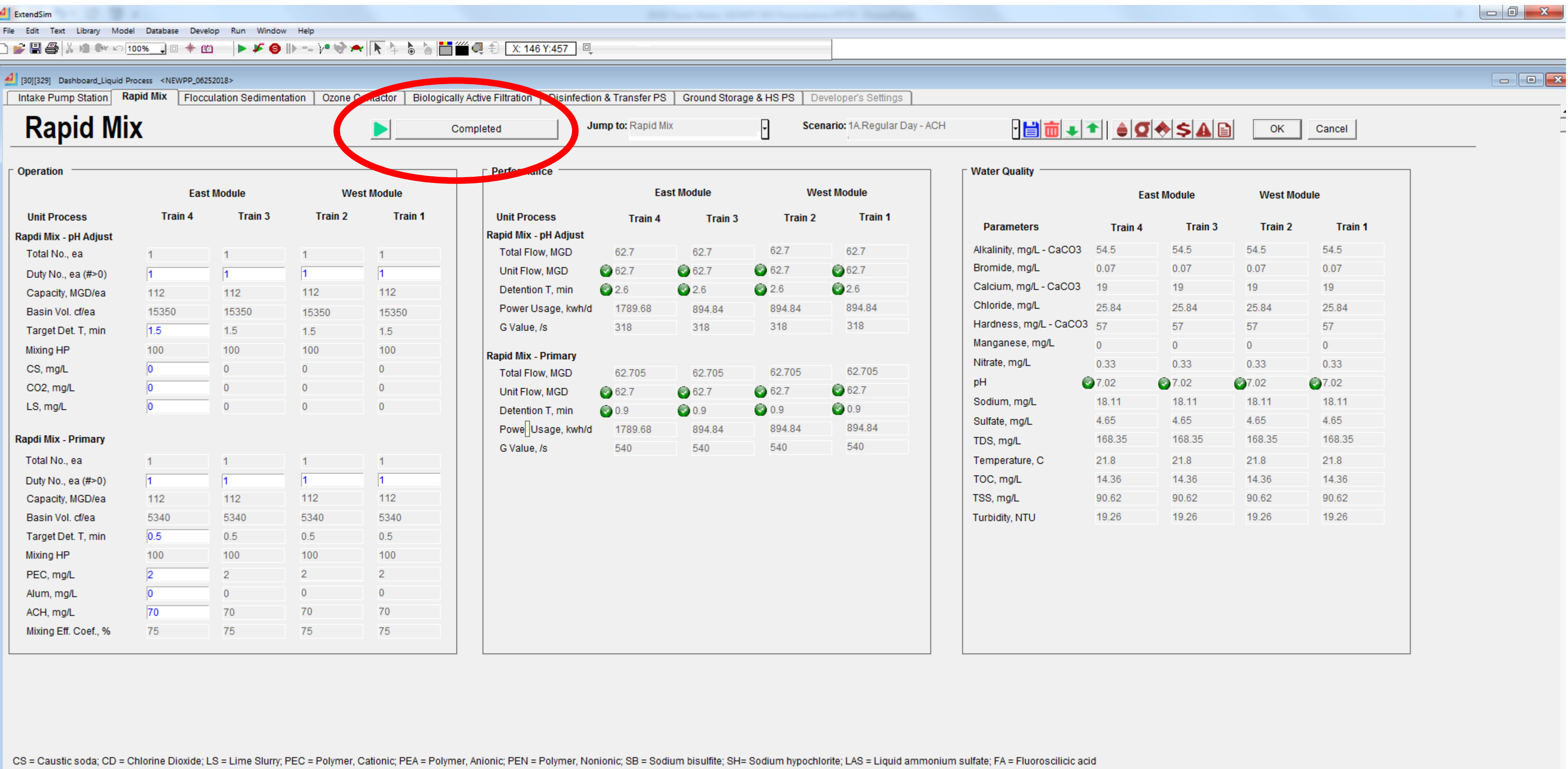
Unit Process	East Module Train 4	East Module Train 3	West Module Train 2	West Module Train 1
Rapid Mix - pH Adjust				
Total Flow, MGD	62.7	62.7	62.7	62.7
Unit Flow, MGD	62.7	62.7	62.7	62.7
Detention T, min	2.6	2.6	2.6	2.6
Power Usage, kwh/d	1789.68	894.84	894.84	894.84
G Value, /s	318	318	318	318
Rapid Mix - Primary				
Total Flow, MGD	62.706	62.706	62.706	62.706
Unit Flow, MGD	62.7	62.7	62.7	62.7
Detention T, min	0.9	0.9	0.9	0.9
Power Usage, kwh/d	1789.68	894.84	894.84	894.84
G Value, /s	540	540	540	540

Water Quality

Parameters	East Module Train 4	East Module Train 3	West Module Train 2	West Module Train 1
Alkalinity, mg/L - CaCO3	54.5	54.5	54.5	54.5
Bromide, mg/L	0.07	0.07	0.07	0.07
Calcium, mg/L - CaCO3	19	19	19	19
Chloride, mg/L	25.84	25.84	25.84	25.84
Hardness, mg/L - CaCO3	57	57	57	57
Manganese, mg/L	0	0	0	0
Nitrate, mg/L	0.33	0.33	0.33	0.33
pH	7.02	7.02	7.02	7.02
Sodium, mg/L	18.11	18.11	18.11	18.11
Sulfate, mg/L	4.65	4.65	4.65	4.65
TDS, mg/L	168.35	168.35	168.35	168.35
Temperature, C	21.8	21.8	21.8	21.8
TOC, mg/L	14.37	14.37	14.37	14.37
TSS, mg/L	90.62	90.62	90.62	90.62
Turbidity, NTU	19.26	19.26	19.26	19.26

CS = Caustic soda; CD = Chlorine Dioxide; LS = Lime Slurry; PEC = Polymer, Cationic; PEA = Polymer, Anionic; PEN = Polymer, Nonionic; SB = Sodium bisulfite; SH= Sodium hypochlorite; LAS = Liquid ammonium sulfate; FA = Fluoroscilicic acid

Operational decisions can be quickly changed to determine plant-wide impacts



4 - Example Simulation: Solids Handling

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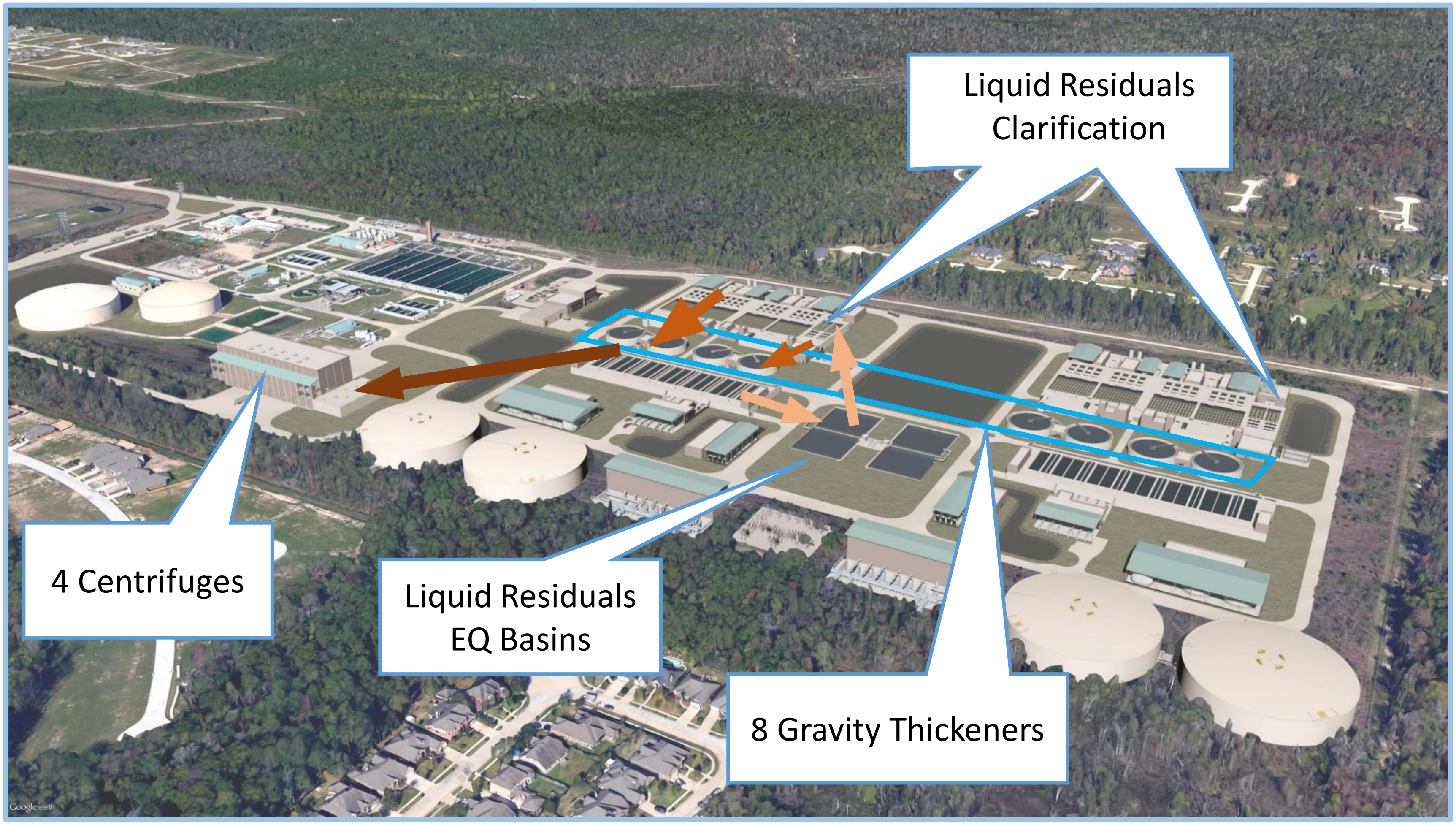
Solids handling system is a new addition to operations



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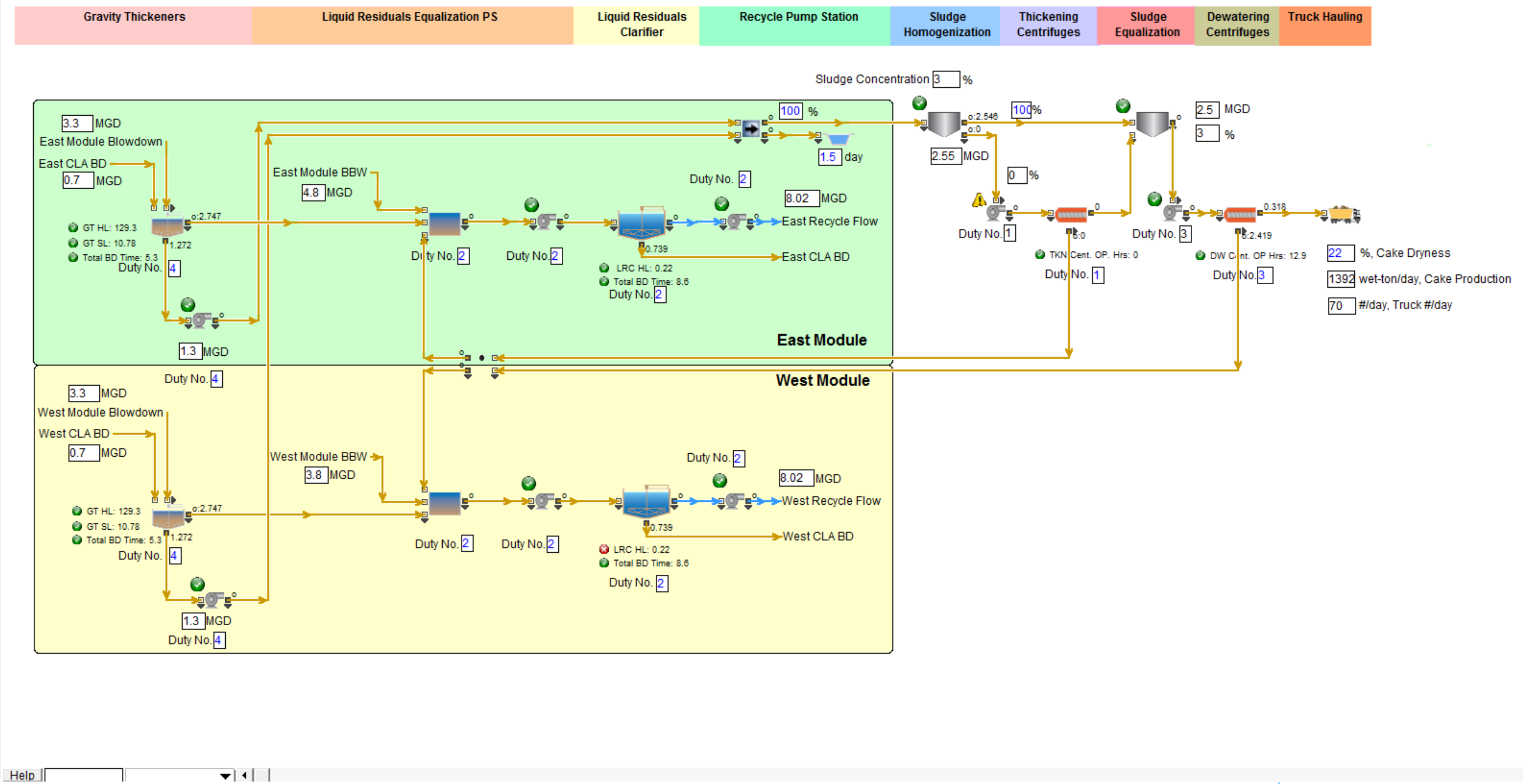
The model for the solids handling system confirms operations under the design condition



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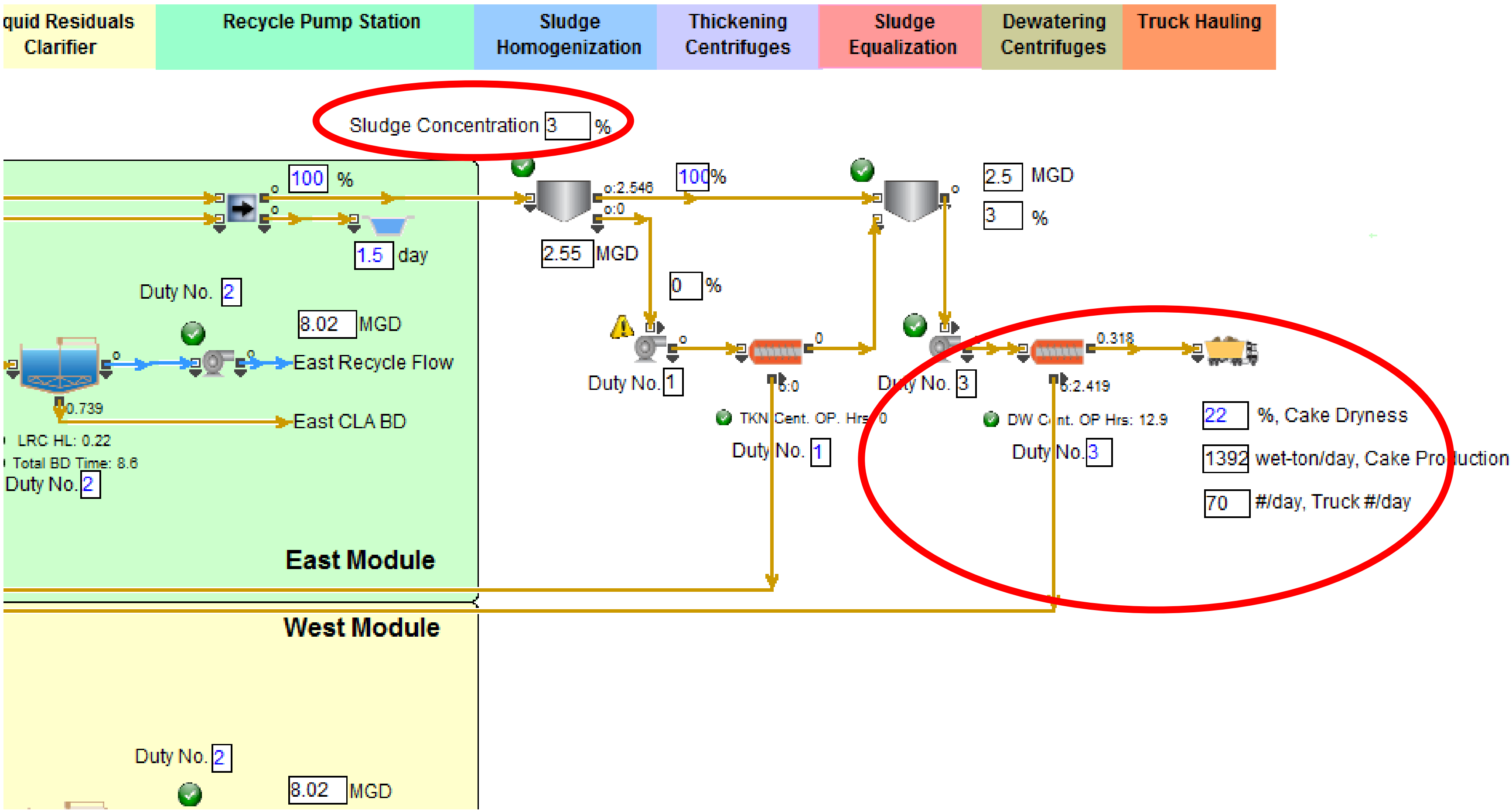
NORTHEAST WATER PURIFICATION PLANT EXPANSION

The model for the solids handling system confirms operations under the design condition



But what happens if there is a process upset at the thickeners?

[31][166] Dashboard_Solids Process <NEWPP_06252018>

Gravity Thickener | Sludge EQ & TK Centrifuge | Dewatering Centrifuge | Liquid Residual EQ Basin | Liquid Residual Clarifier | Developer's Settings

Gravity Thickener

Jump to: Gravity Thickener **Scenario:** 2A Design Peak Solids - ACH OK Cancel

Operation

Unit Process	East Module	West Module
Gravity Thickener		
Total Number, ea	4	4
Duty Number, ea (#>0)	4	4
GT Diameter, feet	100	100
Design SL*, lb/d/sf	11	11
Design HL*, gpd/sf	266	266
Solids Capture, %	95	95
Sludge Blanket %	1.5	1.5
Sludge Blanket D, feet	6	6
CS Dosage, mg/L	0	0
PEA Dosage, lbs/dry-ton	5	5
PEC Dosage, lbs/dry-ton	0	0
Gravity Thickener Blowdown		
BD Conc., %	1.5	1.5
BD Time, min/BD	30	30
BD Flow, gpm	1000	1000
Thickened Sludge PS		
Total Number, ea	6	6
Duty #, ea (#>0)	4	4
Capacity, MGD/ea	0.72	0.72
Discharge Head, ft	150	150
Horsepower, HP/ea	40	40

Performance

Unit Process	East Module	West Module
Gravity Thickener		
Floc/Sed BD, mgd	3.3	3.3
Clarifier BD, mgd	0.7	0.7
Total Feed Flow, mgd	0	4.019
Unit Flow, mgd	1	1
Total Solids L, lb/day	335,082	335,082
Unit Solids L, lb/day	83,771	83,771
Feed Conc., %	0.99969	0.99969
Hydraulic L, gpd/sf	129.3	129.3
Solids L, lb/d/sf	10.78	10.78
Days of Sludge Storage	0.5	0.5
Gravity Thickener Blowdown		
Daily BD, ea/day/GT	11	11
BD Time, hrs/d/GT	5.3	5.3
BD Flow, mgd	1.27	1.27
BD Solids, dry-lb/BD	30,024	30024
Thickened Sludge PS		
Total Flow, mgd	1.3	1.3
Unit Flow, mgd	0.3	0.3
Power Usage, kwh/d	781	781

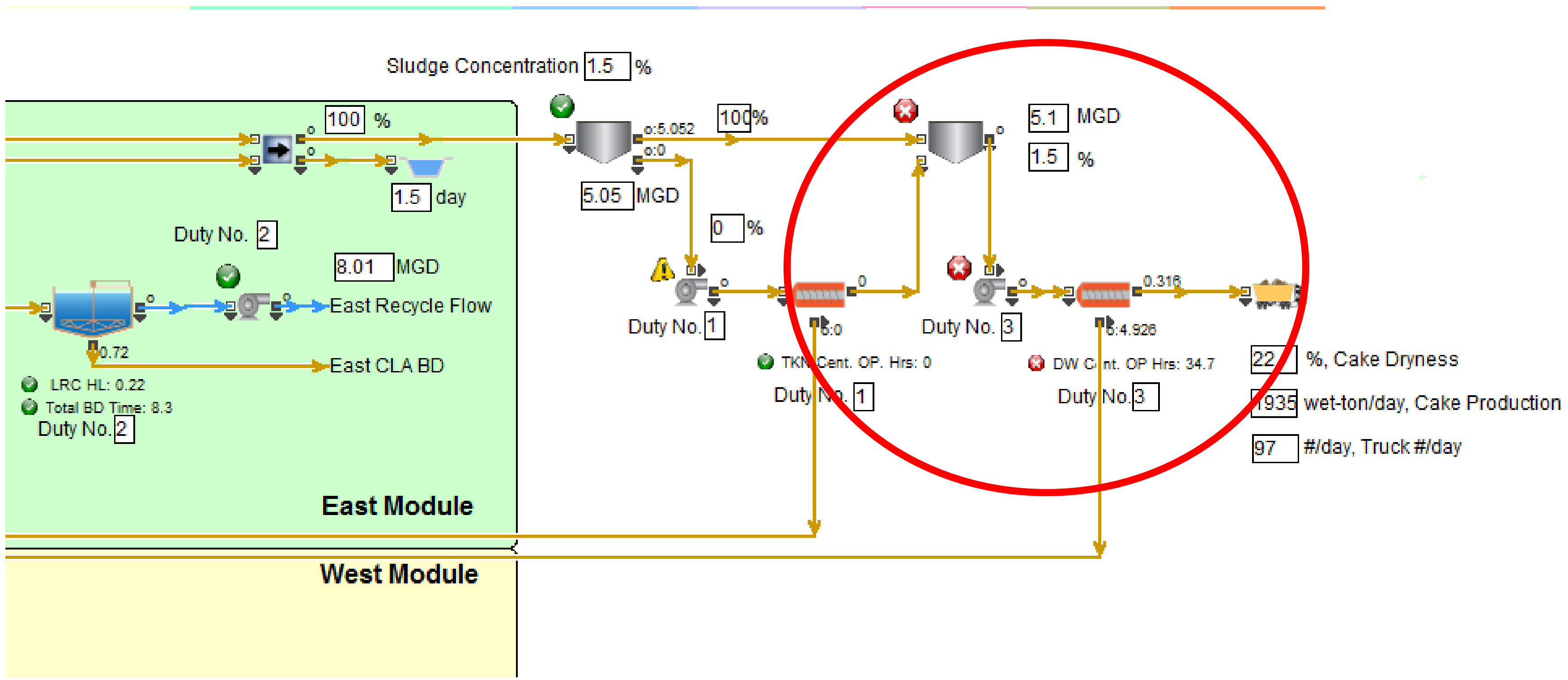
Water/Sludge Quality

Parameters	East Module	West Module
Decant Flow, mgd	2.747	2.747
Decant TSS, mg/L	731	731
Decant pH	6.77	6.77
Decant Solids, lb/day	16,754	16,754
BD TSS, mg/L	30,007	30,007
BD pH	6.77	6.77
BD Solids, lb/day	318,328	318,328

*Max allowable SL = 11.09 lb/d/sf, Max allowable HL = 265.8 gpd/sf.

CS = Caustic soda; CD = Chlorine Dioxide; LS = Lime Slurry; PEC = Polymer, Cationic; PEA = Polymer, Anionic; PEN = Polymer, Nonionic; SB = Sodium bisulfite; SH= Sodium hypochlorite; LAS = Liquid ammonium sulfate; FA = Fluoroscilicic acid

The model highlights the resulting bottleneck: the centrifuges are hydraulically overloaded



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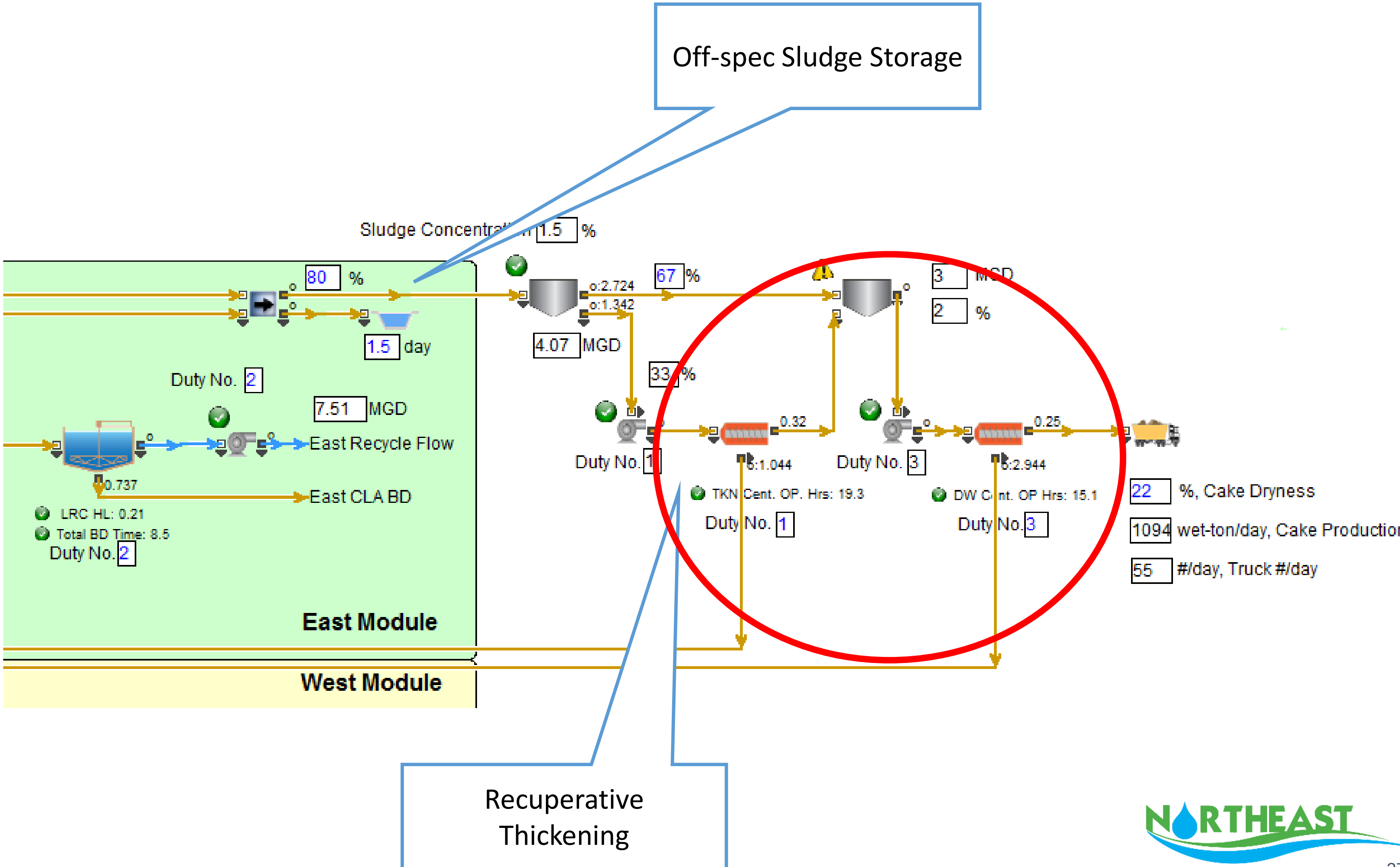
The model provides the operator with a tool to identify the solution



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4 - Example Simulation: Traffic

Daily truck traffic for chemical delivery and sludge hauling can exceed 160 trucks/day

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A site management operations team will help coordinate activities

- Transportation oversite and coordination
- Truck scale operation
  - Dual inbound and outbound scales
- Solids hauling coordination
- Chemical inventory and delivery coordination

- Team is on high alert when traffic volumes are high

But when is that?

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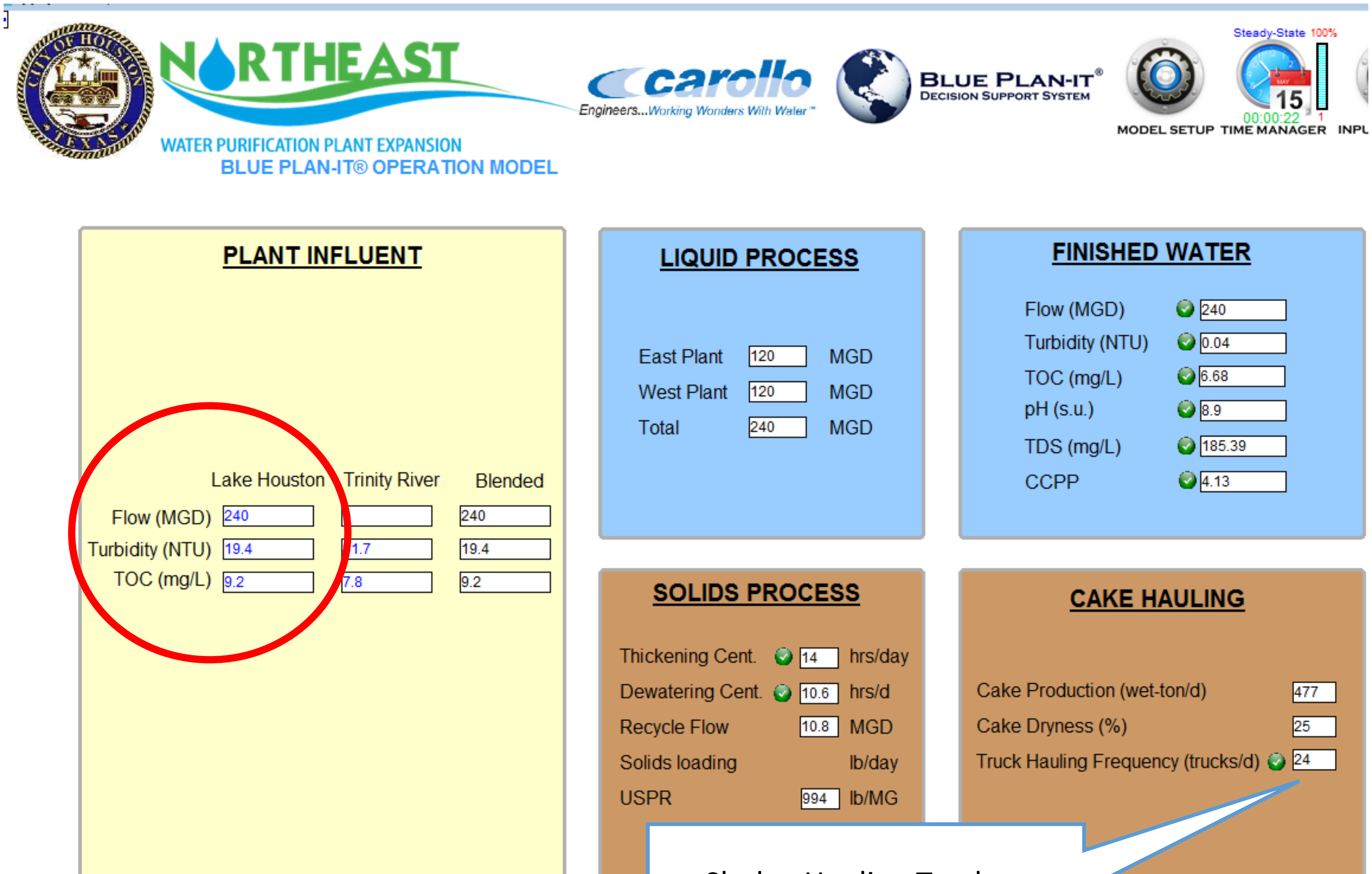
Under normal operations, the truck traffic is manageable



Sludge Hauling Trucks = 24/day

The model shows increased traffic with higher flows and challenging conditions

320 MGD, challenging water quality, ACH as primary coagulant

[29][20] Dashboard <NEWPP_06252018>

[1] Water Quality | [2] Operation | [3] Chemical

Operation

Water Treatment Process Operation

Unit Process	Total No.	Duty No.	Unit Flow, MGD
Intake Pump Station	6	5	64
Rapid Mix - 1	1	1	0
Rapid Mix - 2	1	1	111.1
Rapid Mix - 3	1	1	111.1
Rapid Mix - 4	1	1	114.5
Floc./Sed. 1 & 2	2	2	0
Floc./Sed. 3 & 4	2	2	55.5
Floc./Sed. 5 & 6	2	2	55.5
Floc./Sed. 7 & 8	2	2	57.2
O3 Contactor - 1	1	1	0
O3 Contactor - 2	1	1	108.9
O3 Contactor - 3	1	1	108.9
O3 Contactor - 4	1	1	56.1
BAF #1-6	6	5	0
BAF #7-12	6	5	21.8
BAF #13-18	6	5	21.8
BAF #19-24	6	5	22.4
Post-Fltr Chemical - 1	1	1	0
Post-Fltr Chemical - 2	1	1	105.6
Post-Fltr Chemical - 3	1	1	105.6
Post-Fltr Chemical - 4	1	1	108.7
Transfer PS #1-6	6	4	26.4
Transfer PS #7-12	6	4	53.6
HS Pump - Large	4	4	75
HS Pump - Medium	2	2	50
HS Pump - Small	2	2	25

Solids Handling Process Operation

Unit Process	Total No.	Duty No.	Unit Flow, MGD
Gravity Thickener 1-4	4	4	0.7
Gravity Thickener 5-8	4	4	1.3
TKN Sludge PS 1-6	6	4	0.2
TKN Sludge PS 7-12	6	4	0.4
Off-Spec Sludge Tank	2	1	2.5
Sludge EQ Tank	2	2	1.3
TKN Cent Feed PS	2	1	0
TKN Centrifuges	2	1	0
DW Cent Feed PS	3	3	0.8
DW Centrifuges	4	3	0.8
LR EQ - East	2	2	5.8
LR EQ PS - East	3	2	5.8
LR Clarifier - East	2	2	5.8
Recycle PS - East	3	2	5.4
LR EQ - West	2	2	3.2
LR EQ PS - West	3	2	3.2
LR Clarifier - West	2	2	3.2
Recycle PS - West	3	2	2.9

Solids Production and Hauling

Operation Parameters	Value
Solids Production, dry-lb/day	613000.1
Cake Production, wet-ton/day	1393
Cake Dryness, %	22
Truck Hauling Capacity, ton/ea	20
Hauling Frequency, # trucks/day	70
USPR, lb/MG	1914

Chemical Delivery

Chemicals	Usage, gal/d	Delivery, gal/truck		
Hydrochloric Acid	1113	4400	[illegible]	[illegible]
Sodium Chlorite	1460	4400	[illegible]	[illegible]
Sodium Hypochlorite	23368	4400	[illegible]	[illegible]
Carbon Dioxide	6314	4400	1000	[illegible]
Caustic Soda	37490	4400	[illegible]	[illegible]
Fluorosilicic Acid	0	4400	[illegible]	[illegible]
Liquid Ammo. Sulfate	3199	4400	[illegible]	15
Lime Slurry	0	4400	[illegible]	0
Oxygen	8686	4400	[illegible]	3.5
Alum	0	4400	[illegible]	0
ACH	20637	4400	[illegible]	5.2
Polymer, Anionic	3003	4400	5875	2
Polymer, Cationic	675	4400	12975	19.2
Polymer, Unionic	97	4400	3300	34.1
Sodium Bisulfite	390	4400	6016	15.4
Chemical Del., # trucks/day		24.2		

Chemical Trucks = 24/day

Sludge Hauling Trucks = 70/day

CS = Caustic soda; CD = Chlorine Dioxide; LS = Lime Slurry; PEC = Polymer, Cationic; PEA = Polymer, Anionic; PEN = Polymer, Nonionic; SB = Sodium bisulfite; SH= Sodium hypochlorite; LAS = Liquid ammonium sulfate; FA = Fluoroscilicic acid

Help | Portfolio | Default View

Model quantifies the operational impacts across the plant of process decisions

[31][166] Dashboard_Solids Process <NEWPP_06252018>

[29][20] Dashboard <NEWPP_06252018>

[1] Water Quality | [2] Operation | [3] Chemical

OK | Cancel

Operation

320 MGD, challenging water quality, alum as primary coagulant

Water Treatment Process Operation

Unit Process	Total No.	Duty No.	Unit Flow, MGD
Intake Pump Station	6	5	64
Rapid Mix - 1	1	1	0
Rapid Mix - 2	1	1	112.2
Rapid Mix - 3	1	1	112.2
Rapid Mix - 4	1	1	112.6
Floc./Sed. 1 & 2	2	2	0
Floc./Sed. 3 & 4	2	2	56.1
Floc./Sed. 5 & 6	2	2	56.1
Floc./Sed. 7 & 8	2	2	56.3
O3 Contactor - 1	1	1	0
O3 Contactor - 2	1	1	109.9
O3 Contactor - 3	1	1	109.9
O3 Contactor - 4	1	1	55.1
BAF #1-6	6	5	0
BAF #7-12	6	5	22
BAF #13-18	6	5	22
BAF #19-24	6	5	22
Post-Fltr Chemical - 1	1	1	0
Post-Fltr Chemical - 2	1	1	106.5
Post-Fltr Chemical - 3	1	1	106.5
Post-Fltr Chemical - 4	1	1	106.8
Transfer PS #1-6	6	3	35.5
Transfer PS #7-12	6	5	42.7
HS Pump - Large	4	4	75
HS Pump - Medium	2	2	50
HS Pump - Small	2	2	25

Solids Handling Process Operation

Unit Process	Total No.	Duty No.	Unit Flow, MGD
Gravity Thickener 1-4	4	4	0.7
Gravity Thickener 5-8	4	4	1.4
TKN Sludge PS 1-6	6	4	0.2
TKN Sludge PS 7-12	6	4	0.4
Off-Spec Sludge Tank	2	1	2.7
Sludge EQ Tank	2	2	1.4
TKN Cent Feed PS	2	1	0
TKN Centrifuges	2	1	0
DW Cent Feed PS	3	4	0.7
DW Centrifuges	4	4	0.7
LR EQ - East	2	2	6
LR EQ PS - East	3	2	6
LR Clarifier - East	2	2	6
Recycle PS - East	3	1	10.9
LR EQ - West	2	2	3.3
LR EQ PS - West	3	1	6.7
LR Clarifier - West	2	2	3.3
Recycle PS - West	3	1	6.1

Solids Production and Hauling

Operation Parameters	Value
Solids Production, dry-lb/day	650424.4
Cake Production, wet-ton/day	2070
Cake Dryness, %	22
Truck Hauling Capacity, ton/ea	20
Hauling Frequency, # trucks/day	103
USPR, lb/MG	2035

Chemical Delivery

Chemicals	Usage, gal/d	Delivery, gal/truck		
Hydrochloric Acid	1113	4400		
Sodium Chlorite	1461	4400		
Sodium Hypochlorite	23368	4400		
Carbon Dioxide	4181	4400	[illegible]	
Caustic Soda	25622	4400	67682	
Fluorosilicic Acid	0	4400	1692	
Liquid Ammo. Sulfate	3199	4400	[illegible]	
Lime Slurry	48922	4400	[illegible]	3
Oxygen	8685	4400		3.5
Alum	94773	4400		3.6
ACH	0	4400	[illegible]	0
Polymer, Anionic	3187	4400	[illegible]	1.8
Polymer, Cationic	677	4400	12975	19.2
Polymer, Unionic	97	4400	3300	34
Sodium Bisulfite	390	4400	6016	15.4

Chemical Del., # trucks/day: 49

Chemical Trucks = 49/day

Sludge Hauling Trucks = 103/day

CS = Caustic soda; CD = Chlorine Dioxide; LS = Lime Slurry; PEC = Polymer, Cationic; PEA = Polymer, Anionic; PEN = Polymer, Nonionic; SB = Sodium bisulfite; SH= Sodium hypochlorite; LAS = Liquid ammonium sulfate; FA = Fluoroscilicic acid

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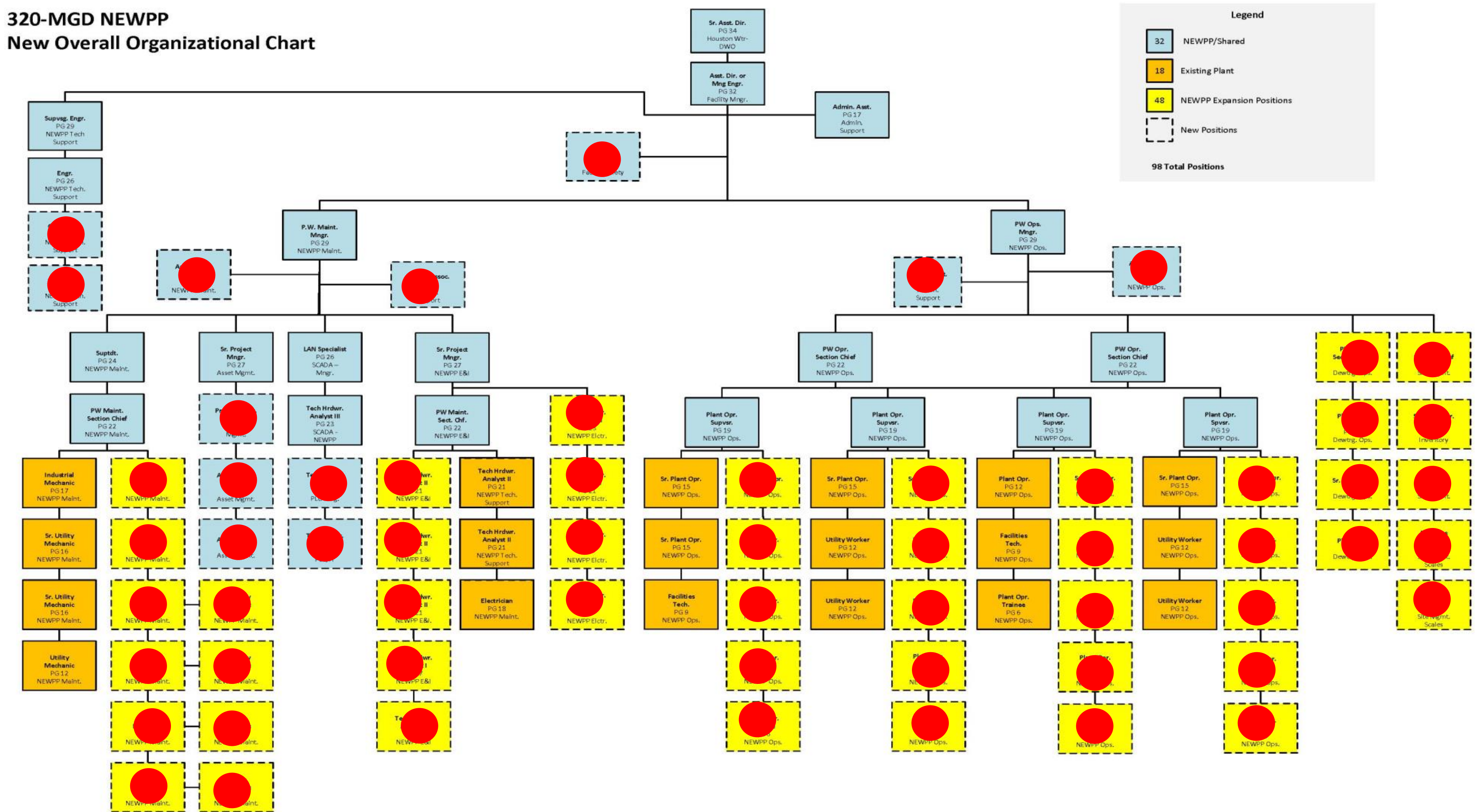
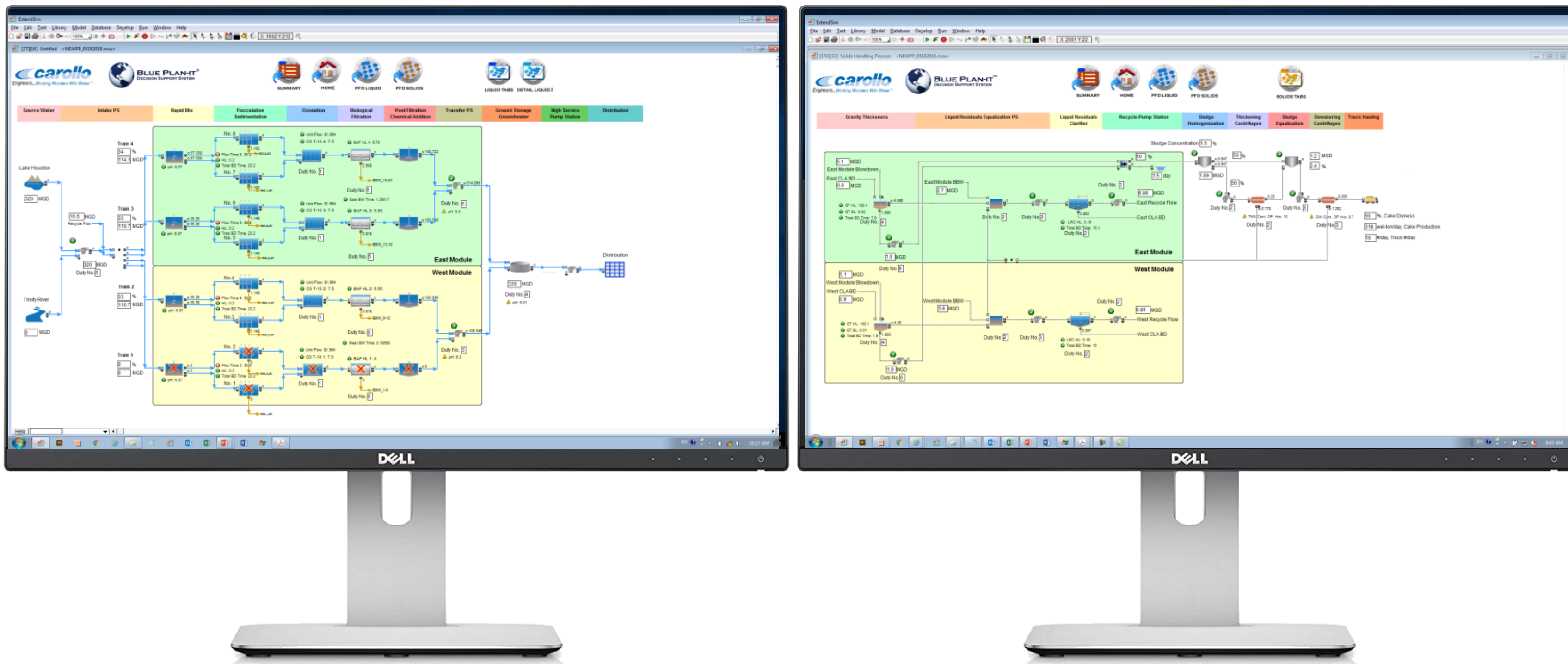
NORTHEAST WATER PURIFICATION PLANT EXPANSION

5 - Staff Training

Plant staff will increase from 38 to 98 people, a total of 60 new positions



The operational model will be critical to train new staff in operations and optimization



The operational model will be critical to train new staff in operations and optimization

![NORTHEAST WATER PURIFICATION PLANT EXPANSION]

What does it all mean?

NORTHEAST
WATER PURIFICATION PLANT EXPANSION

Conclusions

- Challenging raw water quality requires rapid operational response.
- Plant encompasses a lot of flexibility, which creates a lot of complexity.
- That flexibility is only valuable if:
  - Plant staff understand it
  - Plant staff are empowered to experiment.

Operations simulation modeling assists with both of these!!

NORTHEAST

WATER PURIFICATION PLANT EXPANSION

From 80 MGD to 400 MGD: Simulating Operation of a 320-MGD Water Treatment Plant

PNWS-AWWA Conference

May 1, 2019

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Central Harris County Regional Water Authority

City of Houston Texas

North Fort Bend Water Authority

North Harris County Regional Water Authority

West Harris County Regional Water Authority

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