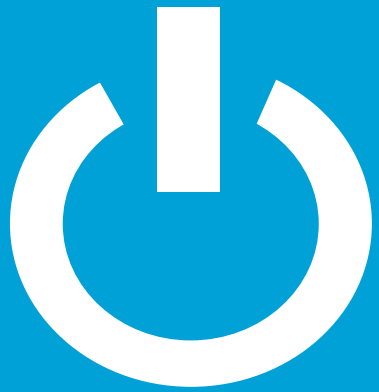
Startup Planning



April 27, 2018

Tina Hastings, P.E.

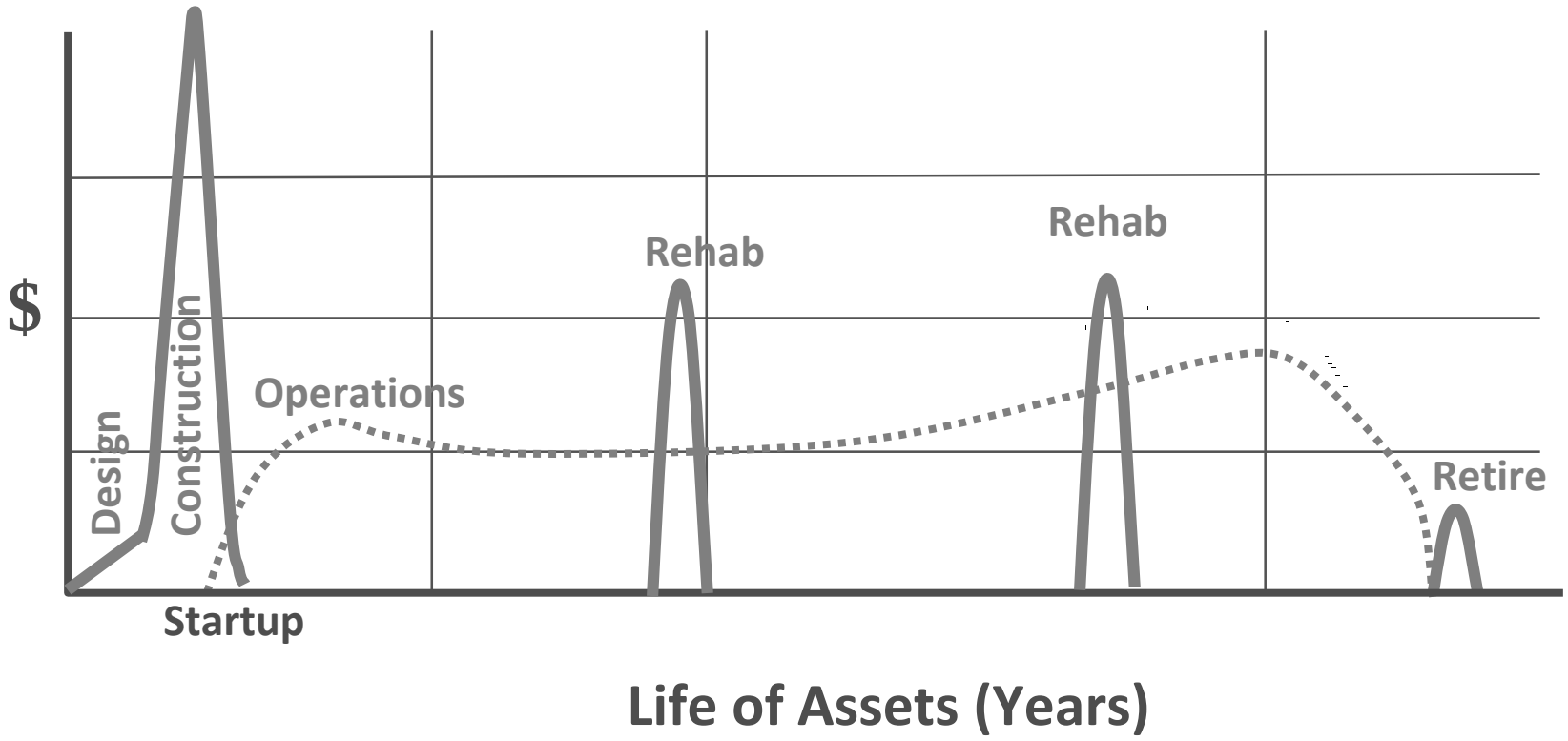
Butch Perry

JACOBS®

Agenda

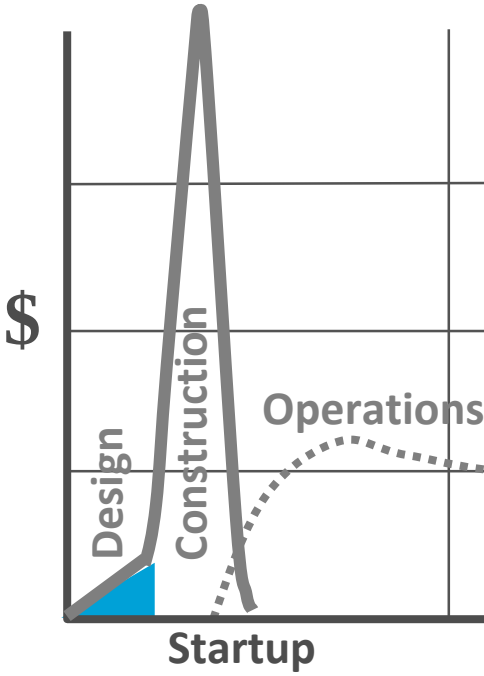
- Asset life Cycle
- Startup Phase Terminology
- Documentation
- Roles and responsibilities by Project Scale
- Planning Case Study

Asset Lifecycle

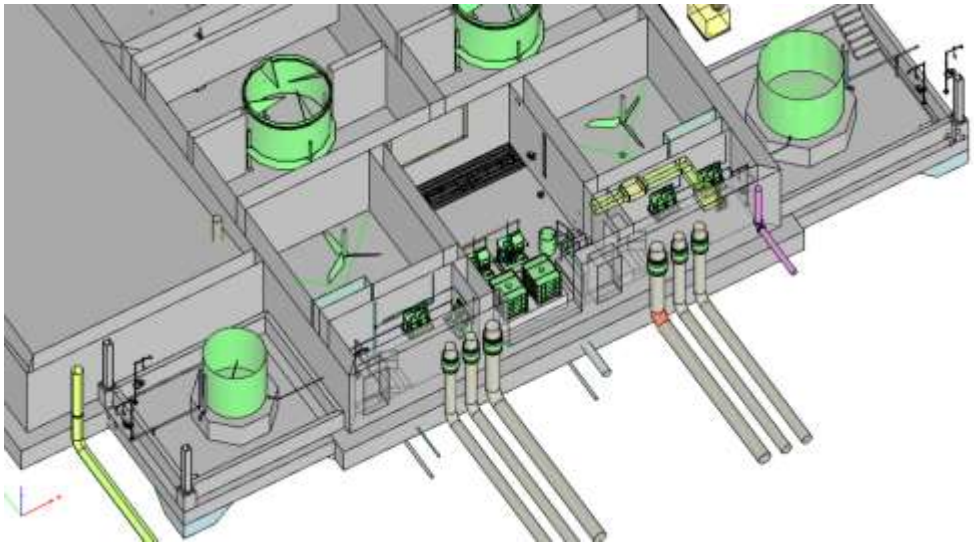


- Design and Construction
- Startup is transition from construction to operation
- Records
  - Startup Manuals and Test Plans including field notes
  - Record Drawings, O&M manuals, vendor manuals

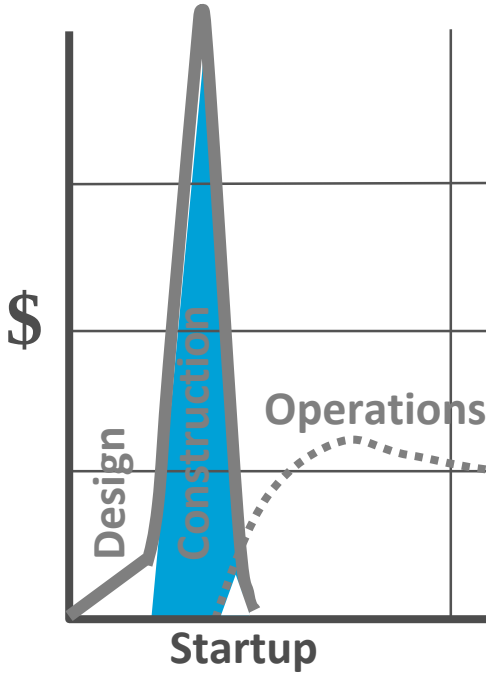
O&M Design Activities to support Startup during Design



- Pre-Design and Design (30, 60, 90)
- Drawing Review
  - Model review
    - 3D pdfs
    - Model walk-thru
    - Virtual or Augmented Reality
- Specification Review
  - Submittals: Review during construction
  - Materials: Spare Parts; Special Tools
  - Execution: Vendor support; Training
  - Warranty: Start dates (events) & duration
- Startup specification can be separate



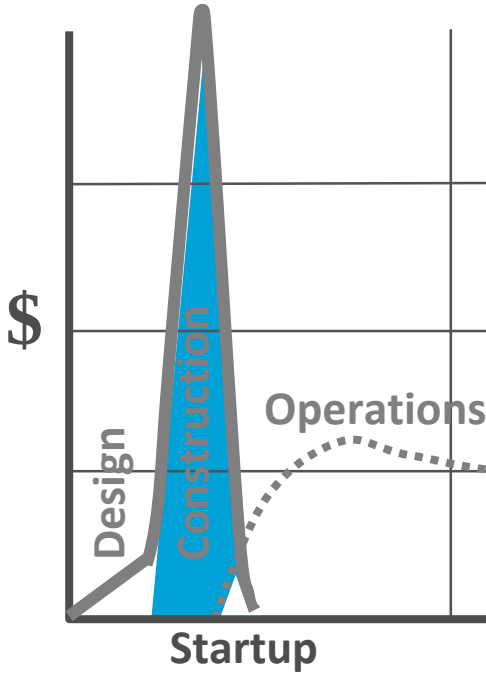
O&M Activities during Construction to support Startup



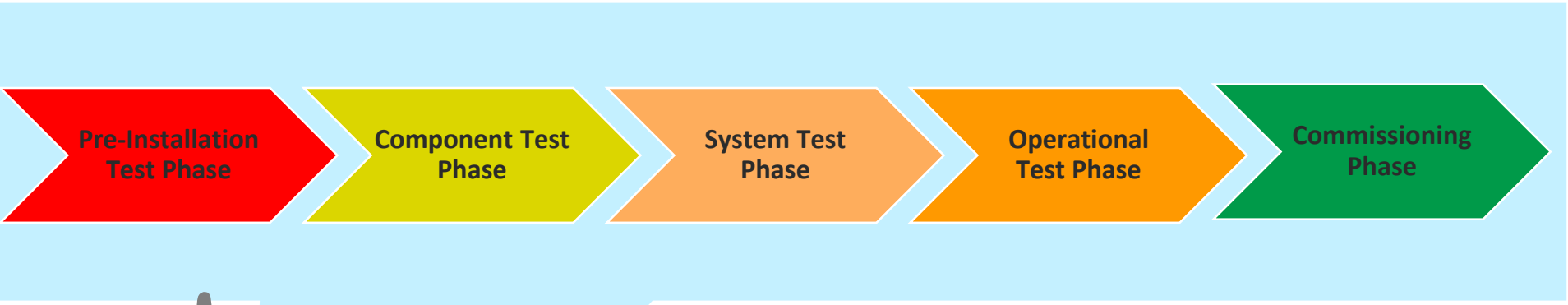
- Submittal Review
    - Engineer reviews for specification conformance
  - Spare Parts
  - Shop Drawings
  - Quality review
  - Materials check
  - “Or equal”
- Equipment
  - Delivery: Check for damage during shipment
  - Storage: maintenance per Mfr recommendation
  - Installation: alignment; field fit up pieces
- Training: Classroom and Field
- Participate in Startup Phases

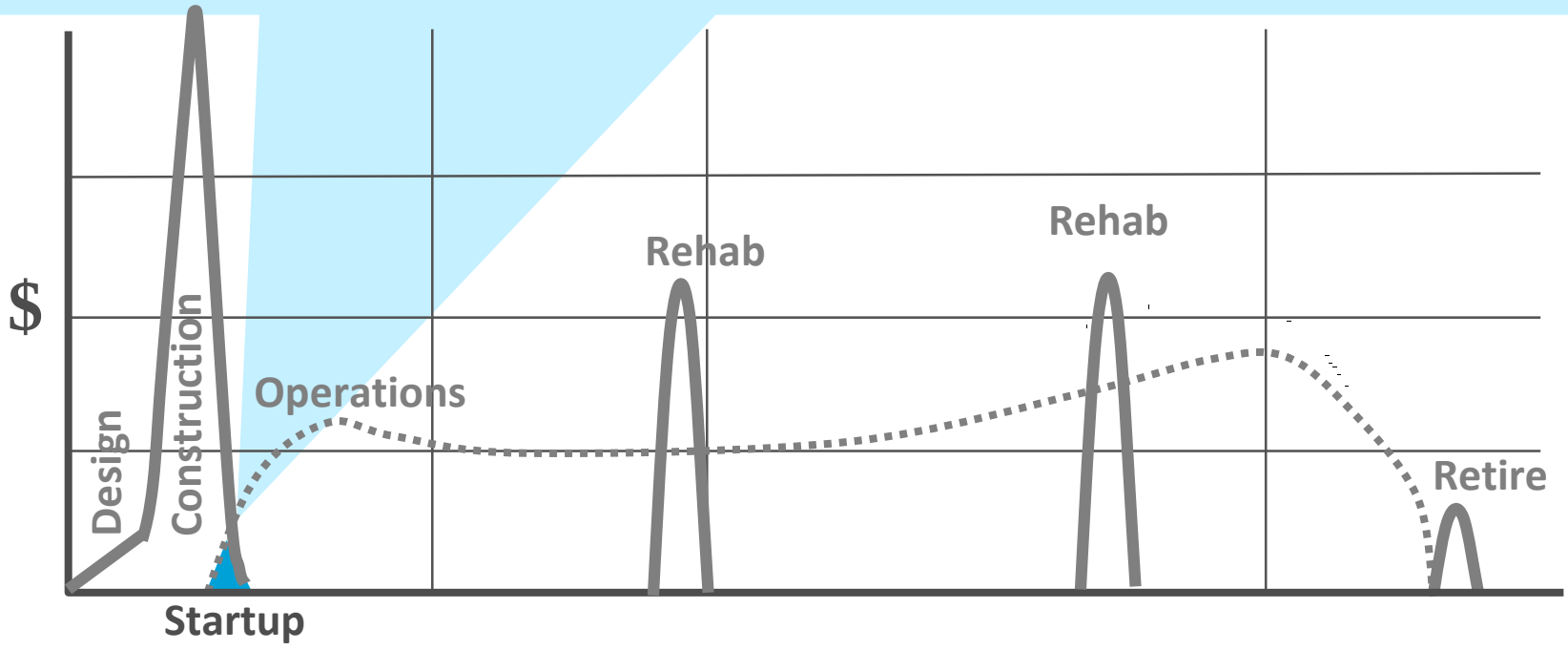
O&M Activities to support Submittal Review

- Review equipment submittals
  - Does the equipment contain everything needed?
  - Equipment materials and/or mounting material compatibility with use environment
  - Equipment manufacturer - spare parts availability
  - Critical spares provided
  - Special tools required
  - Training requirements
  - O&M manual, spare parts list, warranty
- Training content and coordination specific to discipline (Electrical, Mechanical, operations, etc…)
- Review System and Operational test plans
- Operation and Maintenance Manual review
  - Vendor O&M manual
  - Facility O&M Manual

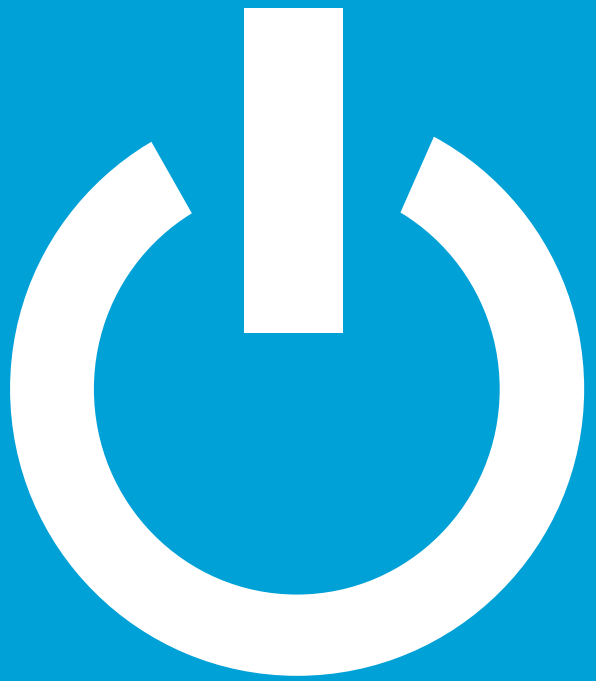


Project Startup Activities

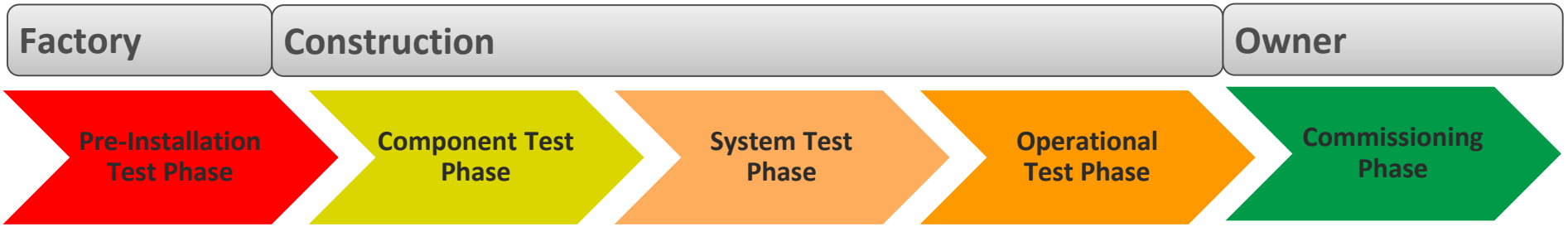




Startup Phases

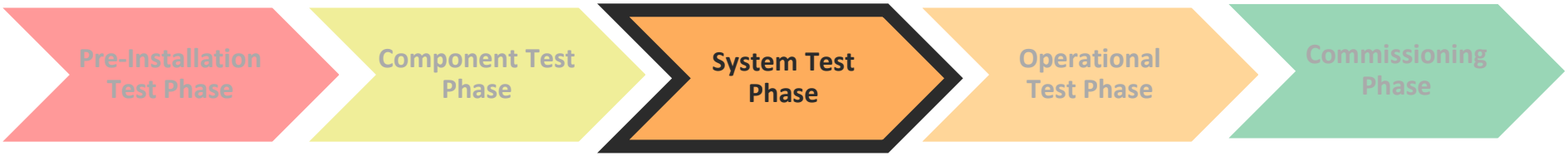


Test Phases



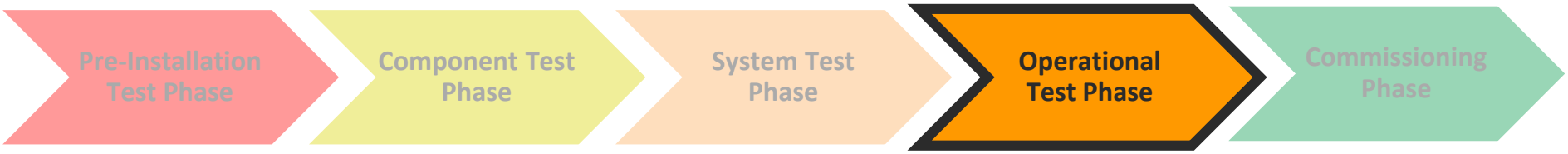
- **Pre-Installation:** Factory Acceptance Test (FAT); Test items at place of manufacture during or on completion of manufacture
- **Component Test:** Test the device (motor, valve actuator, etc…) Verify control signals to PLC and OIT graphics; System pressure testing and cleaning; alignment...
- **System Test:** Completely test equipment specified in Div 11-17 over entire range of operating conditions. Combined components that make up a system.
- **Operational Test Phase:** Water typically used as testing medium; Facility as a unit with Control system operating as designed over a full range of operation.
- **Commissioning:** Owner operates facility. Supported as needed by contractor for immediate assistance on any equipment failures.

System Test Phase



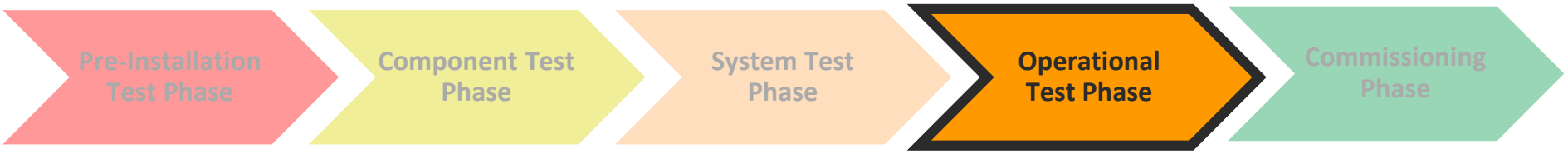
- Closed Loop recycle
  - Test full operational range; set points; alarms
- Consider impacts outside of project boundaries
    - Sufficient volume to start the test and sustain it without cycling
    - Where does the flow discharge
- System isolation done properly for the test
  - Screens/pancakes removed
  - Isolation valves
- Records: set point changes, etc

Operational Test Phase



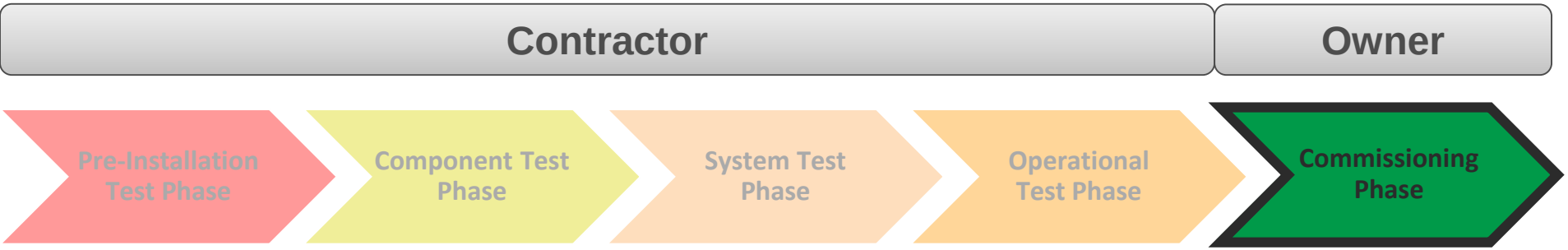
- All Systems working together
- Hydraulically run the facility as one coordinated system.
- Control strategies test interlocks and permissives between systems
  - Test failure scenarios and control system responses
  - Consider impacts outside of project boundaries Conveyance/Distribution system impacts
    - Failure Scenarios: is anything subject to a higher pressure than it was designed for?
    - Testing interlocks between systems

Operational Test Phase - continued



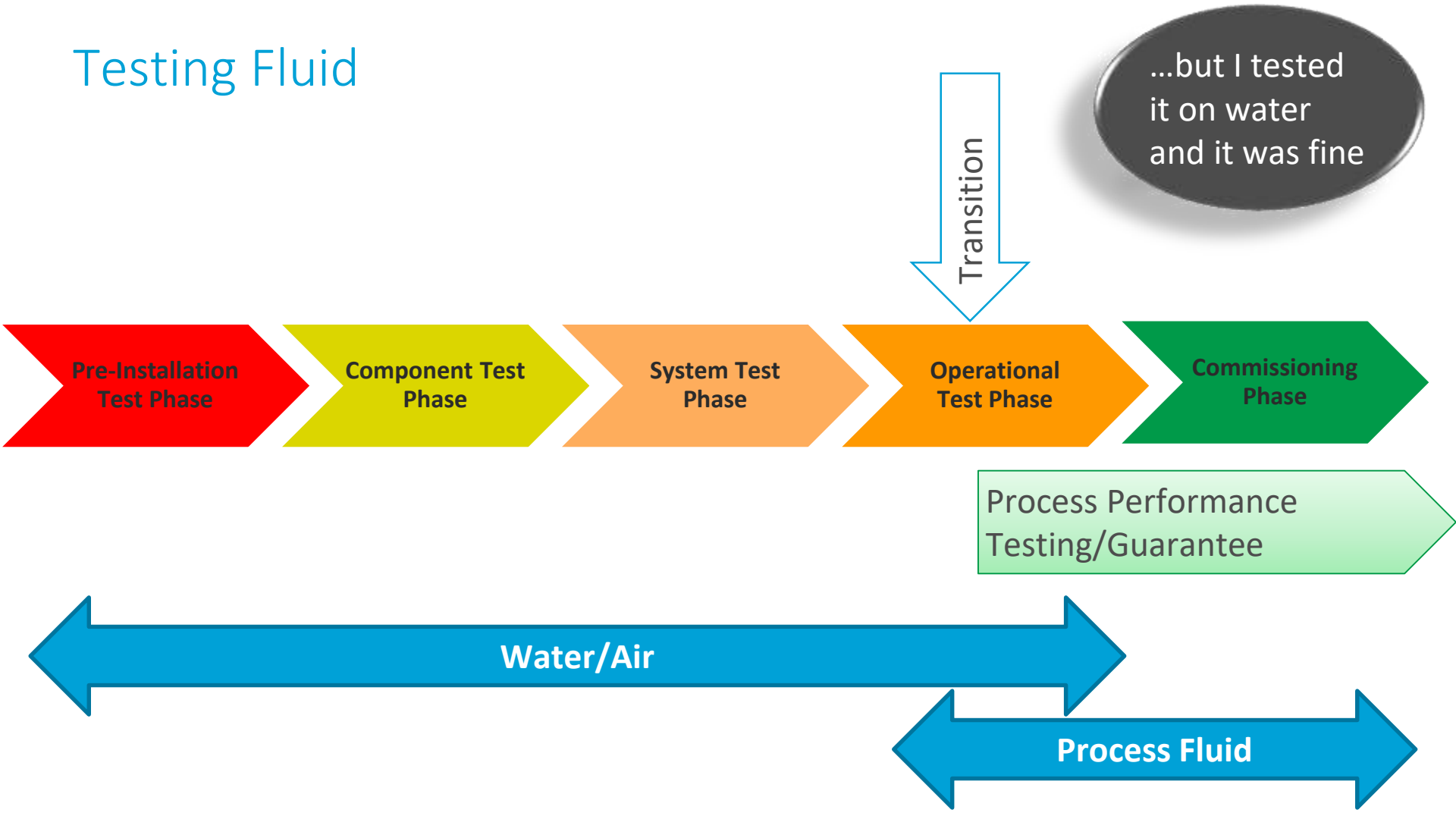
- Failures during test phase
    - Evaluated by startup team
    - May require retest or potential restart of Operational Test Phase
- Control system logs all operational data.
  - Trends used to evaluate operational data; changes typically made during the day with steady state operation at night.

Owner Commissioning



- Previous testing phase documentation and O&M Training complete
- O&M manuals and Spare Parts turned over to Owner
- Transfer fully functional facility to Owner for operation during commissioning period
- Contractor provide required support to Owner to ensure the facility maintains fully operational mode
- (X) (time period) continuous or full operation
- System operates as designed
- Contractor oncall during commissioning phase
- Equipment failures restart commissioning period

Testing Fluid



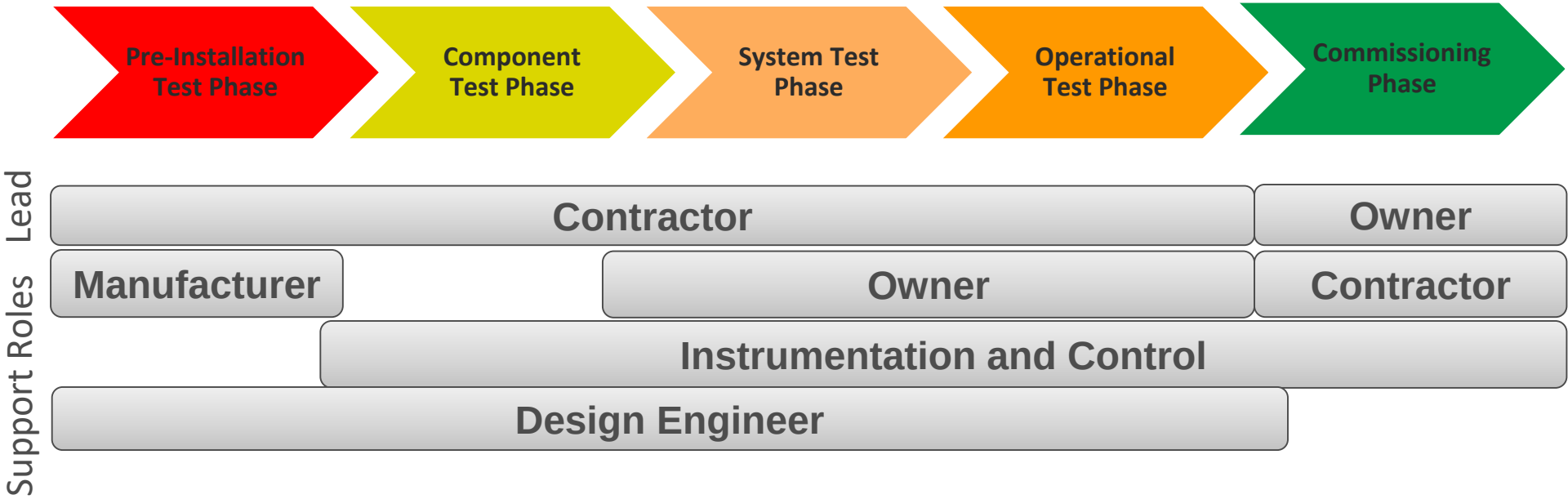
Operational changes can occur when operating with actual process fluid.

Startup considerations

- Safety: LOTO; Job Hazard Analysis
- Hydraulics first; process and biology second
- Temporary accommodations to facilitate testing impacts to existing operations
  - Closed Loop
  - Discharge to storage tank; wet well
  - Simulate headloss (sleeve valve)
- Testing medium
  - Water/Air
  - Switching to actual medium
    - Chemicals
      - Specific Gravity changes
      - Corrosive problems may take time to show up

Start up Roles

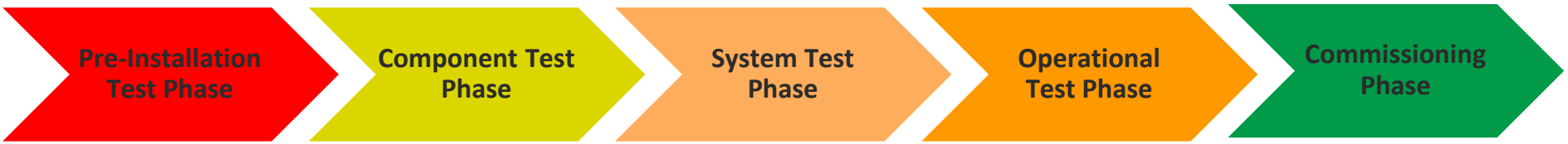
Startup Phase Roles and Responsibilities



- Roles and responsibilities change by Project Scale
  - PM, PE, CM-PR, CM-Inspector, O&M supervisor, operator, maintenance trade
  - Scale of startup activity (capital project vs in-house project)
  - Type of contracting method - hard bid, GCCM, on call
  - Value of contract – Capital, Contractor Work-Order, in-house Work-Order
  - Capital support for Operating budget projects

Scale of Projects

Test Phases: Pump Replacement



- Factory witness test of pump

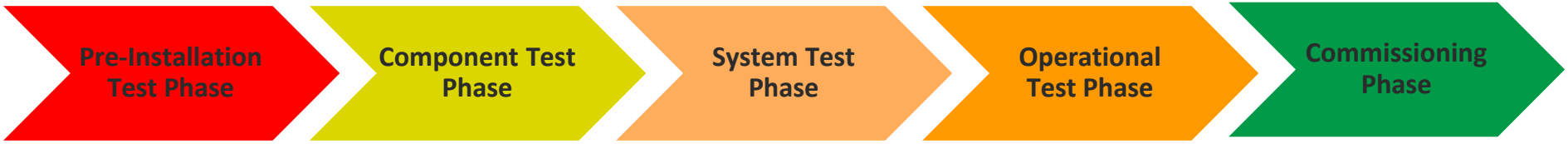
- Field device I/O
- Hydrostatic Test
- Alignment

- Range of Operations
  - Shutoff head
  - Lead / Lag
  - Operating point
  - Pumps operating alone, together
  - Provisions for Simulations
- Level Setpoints
- Alarms

- Test pumps with any existing systems

- Run for X days with contractor/vendor on-call

Test Phases: Treatment Plant



- Factory witness test of vendor packages; specialized equipment

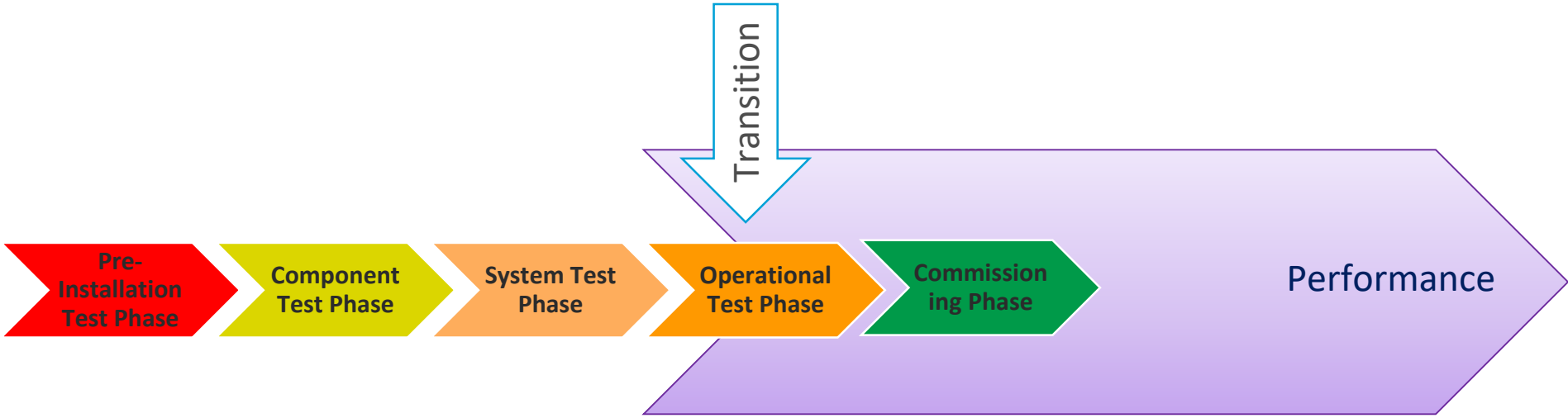
- Field device I/O
- Hydrostatic Test
- Alignment

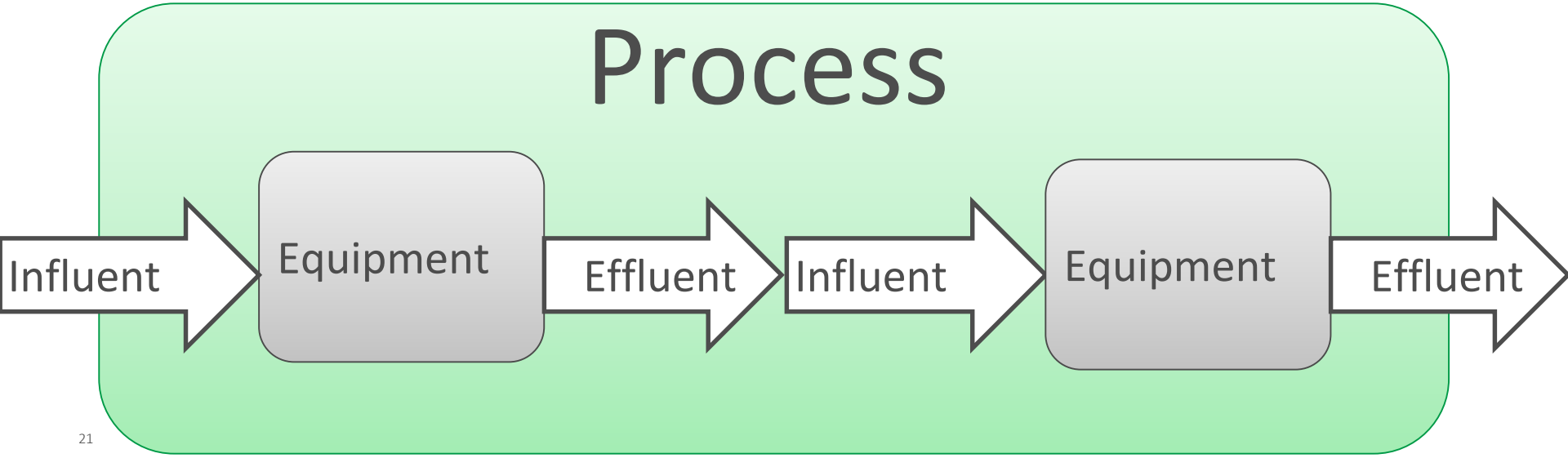
- Range of Operations
  - Operating points
  - Units operating alone, together within a system
  - Provisions for Simulations
- Level Setpoints
- Alarms

- Test systems operating together
- Fully test operating ranges and scenarios
- Document all changes

- Run for X days with contractor/vendor on-call

Performance: Process Optimization (Treatment Plant)

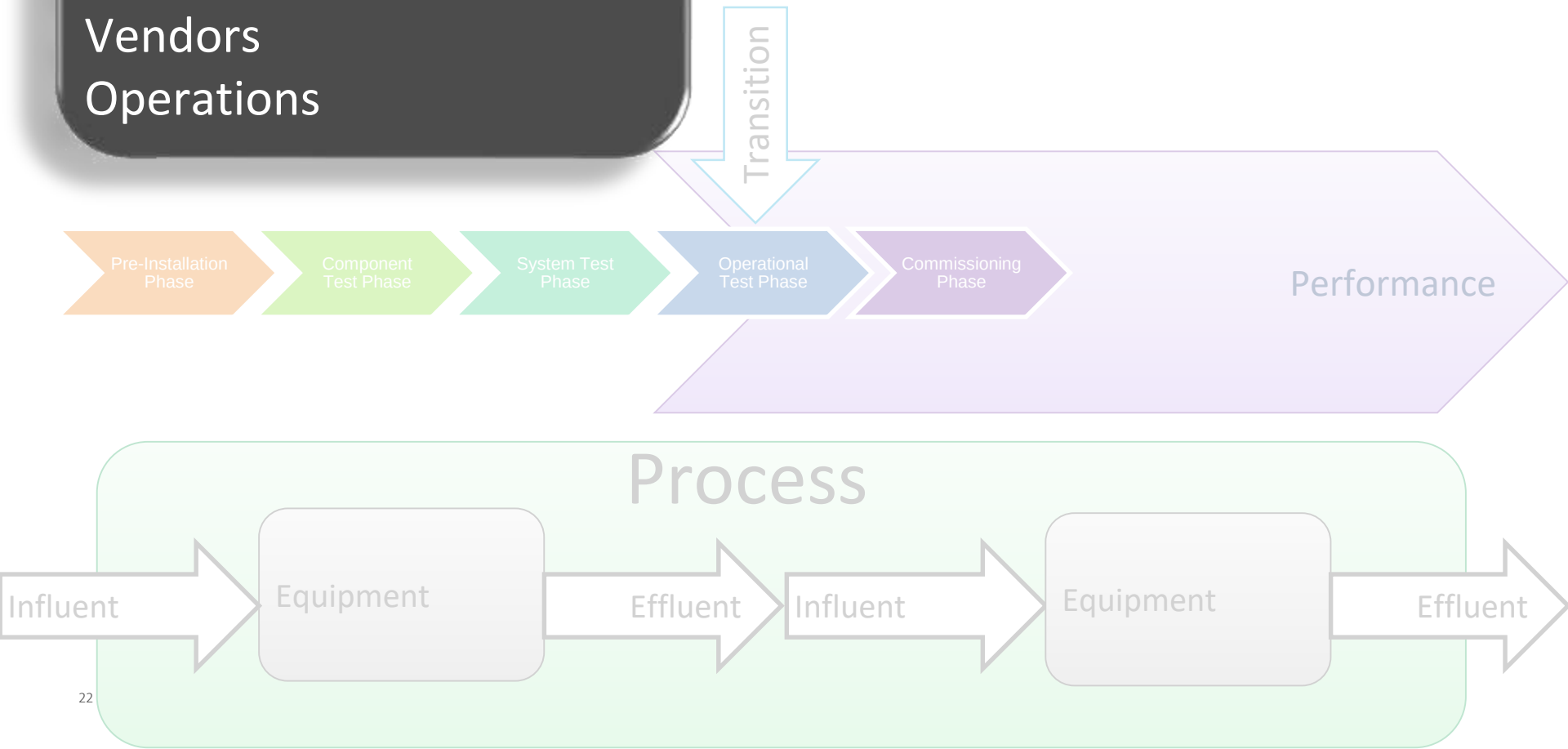




Team Collaboration

Owner
Design
Construction Management
Contractor
Vendors
Operations

We're all in this together



Startup Plan

Startup Test Plan Content

1. Control Strategy
2. P&ID Drawings
3. Related Specifications
4. Manufacturer and Instrument Drawings
5. Pressure and Leak Tests
6. Electrical Wire and Cable Pre-Component Tests
7. I&C Wire and Cable Pre-Component Tests
8. Factory Tests and Installation
9. Electrical and I&C Component Tests
10. Mechanical Equipment Startup and Component Tests
11. Equipment Vibration, Sound and Capacity Tests
12. Startup Plan and Job Hazard Analyses
13. Training Records
14. System Tests
15. Maintenance Forms and Records
16. Deficiencies, Punch lists and Corrections

Content of final Startup test plan documents everything that happened during startup testing

Legend

- Support information
- Pre-installation phase
- Component
- System
- Operational
- Commissioning

Startup Test Plan Content

1. Control Strategy
2. P&ID Drawings
3. Related Specifications
4. Manufacturer and
5. Pressur
6. E
7. I&
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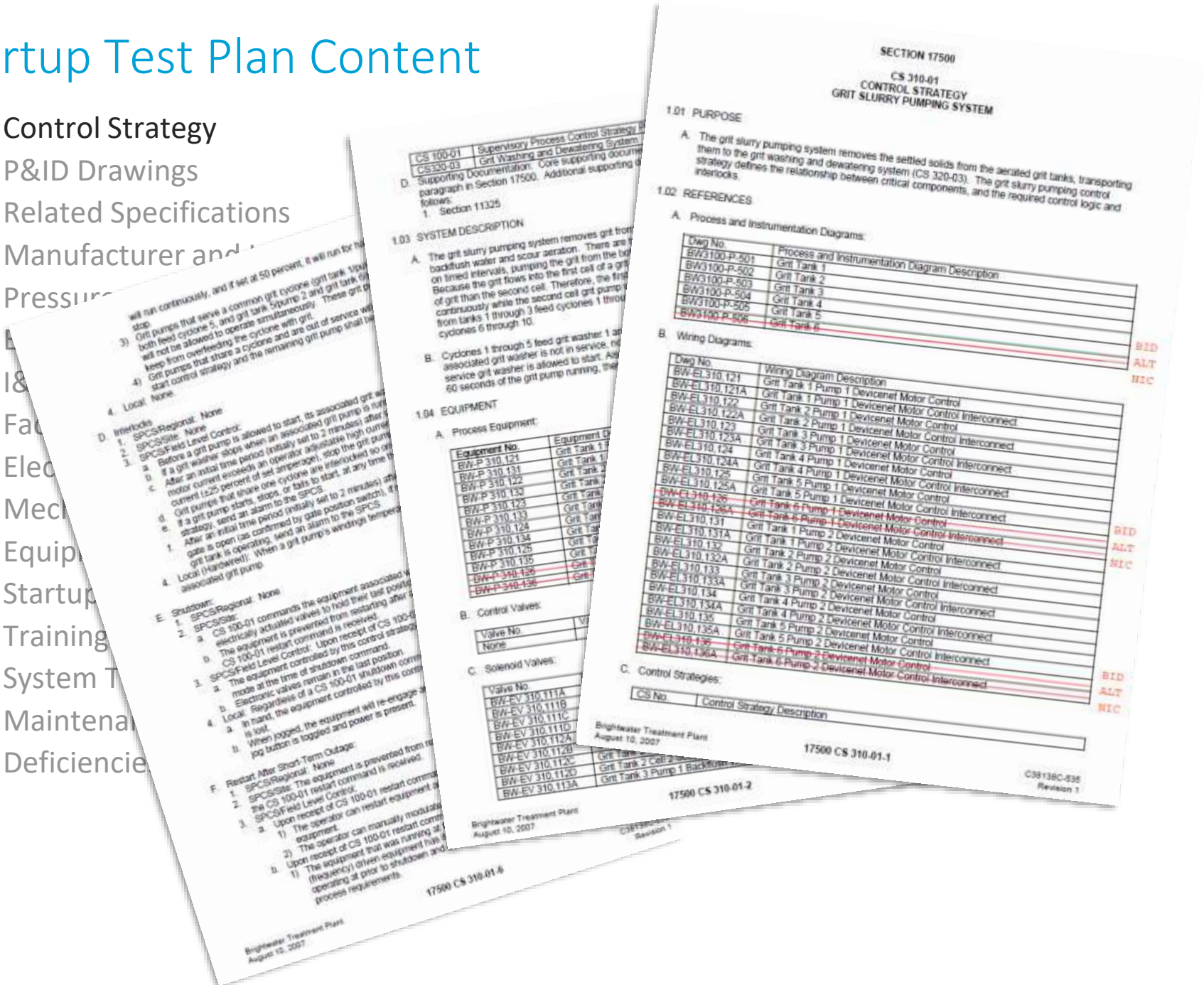
9. Elec
10. Mec
11. Equip
12. Startup
13. Training
14. System T
15. Maintena
16. Deficiencie



Startup Test Plan Content

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7. I&C Wire and Cable
8. Factory
9. Electric
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11. Equipr
12. Startu
13. Traini
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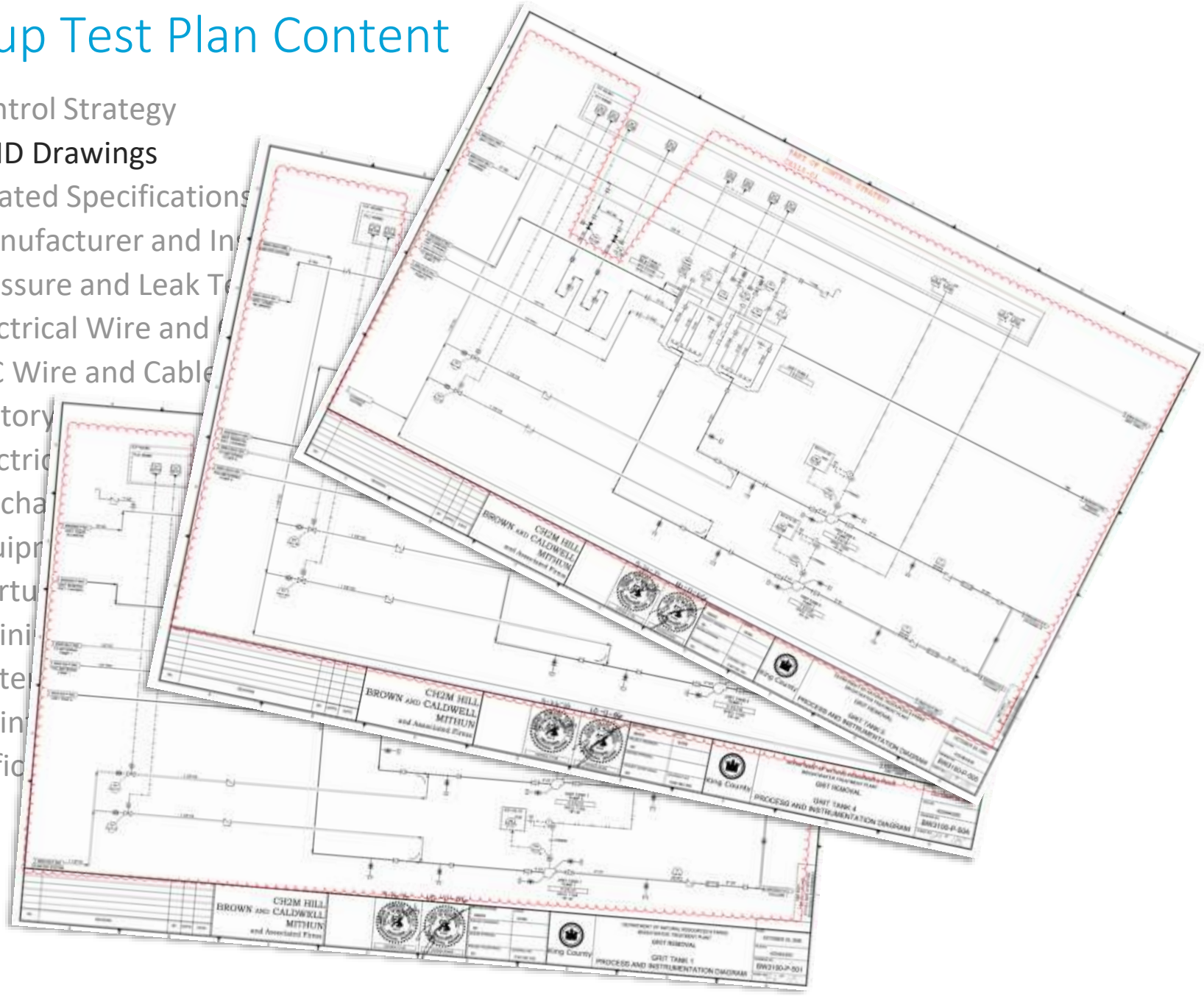
15. Main
16. Defic



Startup Test Plan Content

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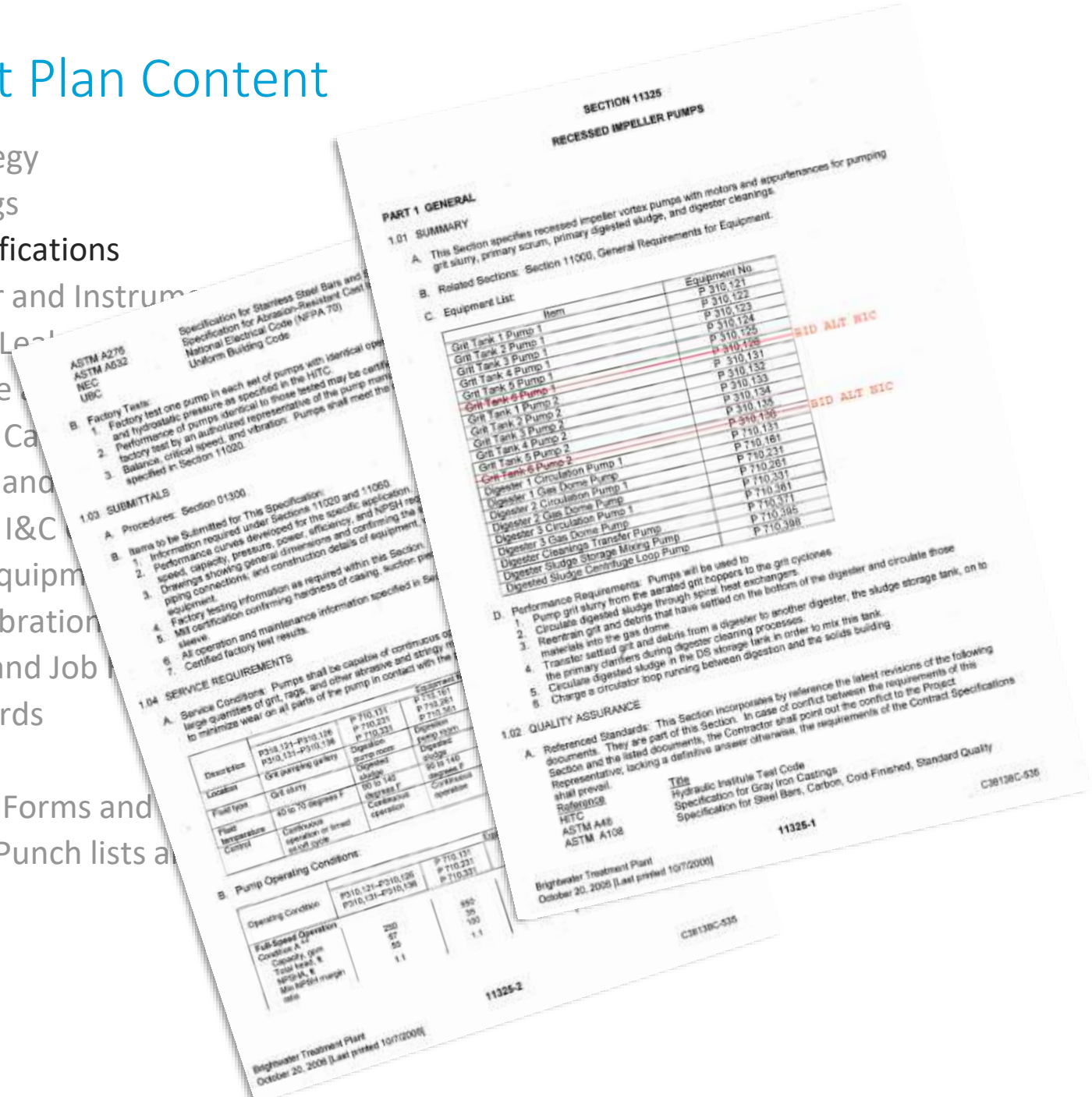
5. Pressure and Le
6. Electrical Wire
7. I&C Wire and Ca
8. Factory Tests and
9. Electrical and I&C
10. Mechanical Equipm
11. Equipment Vibration
12. Startup Plan and Job
13. Training Records
14. System Tests
15. Maintenance Forms and
16. Deficiencies, Punch lists a



SECTION 11325

RECESSED IMPELLER PUMPS

PART 1 GENERAL

1.01 SUMMARY

A. This Section specifies recessed impeller vortex pumps with motors and appurtenances for pumping grit slurry, primary scrum, primary digested sludge, and digester cleanings.

B. Related Sections: Section 11000, General Requirements for Equipment.

C. Equipment List:

Item	Equipment No.
Grit Tank 1 Pump 1	P 310,121
Grit Tank 2 Pump 1	P 310,122
Grit Tank 3 Pump 1	P 310,123
Grit Tank 4 Pump 1	P 310,124
Grit Tank 5 Pump 1	P 310,125
~~Grit Tank 6 Pump 1~~	~~P 310,126~~ BID ALT #1C
Grit Tank 1 Pump 2	P 310,131
Grit Tank 2 Pump 2	P 310,132
Grit Tank 3 Pump 2	P 310,133
Grit Tank 4 Pump 2	P 310,134
Grit Tank 5 Pump 2	P 310,135
~~Grit Tank 6 Pump 2~~	~~P 310,136~~ BID ALT #1C
Digester 1 Circulation Pump 1	P 710,131
Digester 1 Gas Dome Pump	P 710,161
Digester 2 Circulation Pump 1	P 710,231
Digester 2 Gas Dome Pump	P 710,261
Digester 3 Circulation Pump 1	P 710,331
Digester 3 Gas Dome Pump	P 710,361
Digester Cleanings Transfer Pump	P 710,371
Digester Sludge Storage Mixing Pump	P 710,395
Digested Sludge Centrifuge Loop Pump	P 710,398

D. Performance Requirements: Pumps will be used to
1. Pump grit slurry from the aerated grit hoppers to the grit cyclones
2. Circulate digested sludge through spiral heat exchangers
3. Reentrain grit and debris that have settled on the bottom of the digester and circulate those materials into the gas dome
4. Transfer settled grit and debris from a digester to another digester, the sludge storage tank, on to the primary clarifiers during digester cleaning processes.
5. Circulate digested sludge in the DS storage tank in order to mix this tank.
6. Charge a circulator loop running between digestion and the solids building

1.02 QUALITY ASSURANCE

A. Referenced Standards: This Section incorporates by reference the latest revisions of the following documents. They are part of this Section. In case of conflict between the requirements of this Section and the listed documents, the Contractor shall point out the conflict to the Project Representative; lacking a definitive answer otherwise, the requirements of the Contract Specifications shall prevail.

Reference	Title
HITC	Hydraulic Institute Test Code
ASTM A48	Specification for Gray Iron Castings
ASTM A108	Specification for Steel Bars, Carbon, Cold-Finished, Standard Quality

C3813IC-536

11325-1

Brightwater Treatment Plant
October 20, 2008 [Last printed 10/7/2008]

ASTM A276
ASTM A532
NEC
UBC

Specification for Stainless Steel Bars and
Specification for Abrasion-Resistant Cast
National Electrical Code (NFPA 70)
Uniform Building Code

B. Factory Tests:
1. Factory test one pump in each set of pumps with identical ope
2. Performance of pumps identical to those tested may be certifi
3. Balance, critical speed, and vibration: Pumps shall meet the
specified in Section 11020.

1.03 SUBMITTALS

A. Procedures: Section 01300.

B. Items to be Submitted for This Specification:
1. Information required under Sections 11020 and 11060.
2. Performance curves developed for the specific application
3. Drawings showing general dimensions and confirming the
piping connections; and construction details of equipment.
4. Factory testing information as required within this Section
5. Mill certification confirming hardness of casing, suction pie
sleeve.
6. All operation and maintenance information specified in Se
7. Certified factory test results.

1.04 SERVICE REQUIREMENTS

A. Service Conditions: Pumps shall be capable of continuous o
large quantities of grit, rags, and other abrasive and stringy m
to minimize wear on all parts of the pump in contact with the

Description	P310,121–P310,126 P310,131–P310,136	P 710,131 P 710,231 P 710,331	P 710,161 P 710,261 P 710,361
Location	Grit pumping gallery	Digestion pump room	Digestion pump room
Fluid type	Grit slurry	Digested sludge	Digested sludge
Fluid temperature	45 to 70 degrees F	90 to 140 degrees F	90 to 140 degrees F
Control	Continuous operation or timed on/off cycle	Continuous operation	Continuous operation

B. Pump Operating Conditions:

Operating Condition	P310,121–P310,126 P310,131–P310,136	P 710,131 P 710,231 P 710,331	
Full-Speed Operation			
Condition A			
Capacity, gpm	250	950	
Total head, ft	67	35	
NPSHA, ft	55	100	
Min NPSH margin ratio	1.1	1.1	

11325-2

Brightwater Treatment Plant
October 20, 2008 [Last printed 10/7/2008]

C3813IC-535

Startup Test Plan Content

1. Control Strategy
2. P&ID Drawings
3. Related Specifications
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5. Pressure and Leak Tests
6. Electrical Wire and Cable Pre
7. I&C Wire and Cable Pre-Comp
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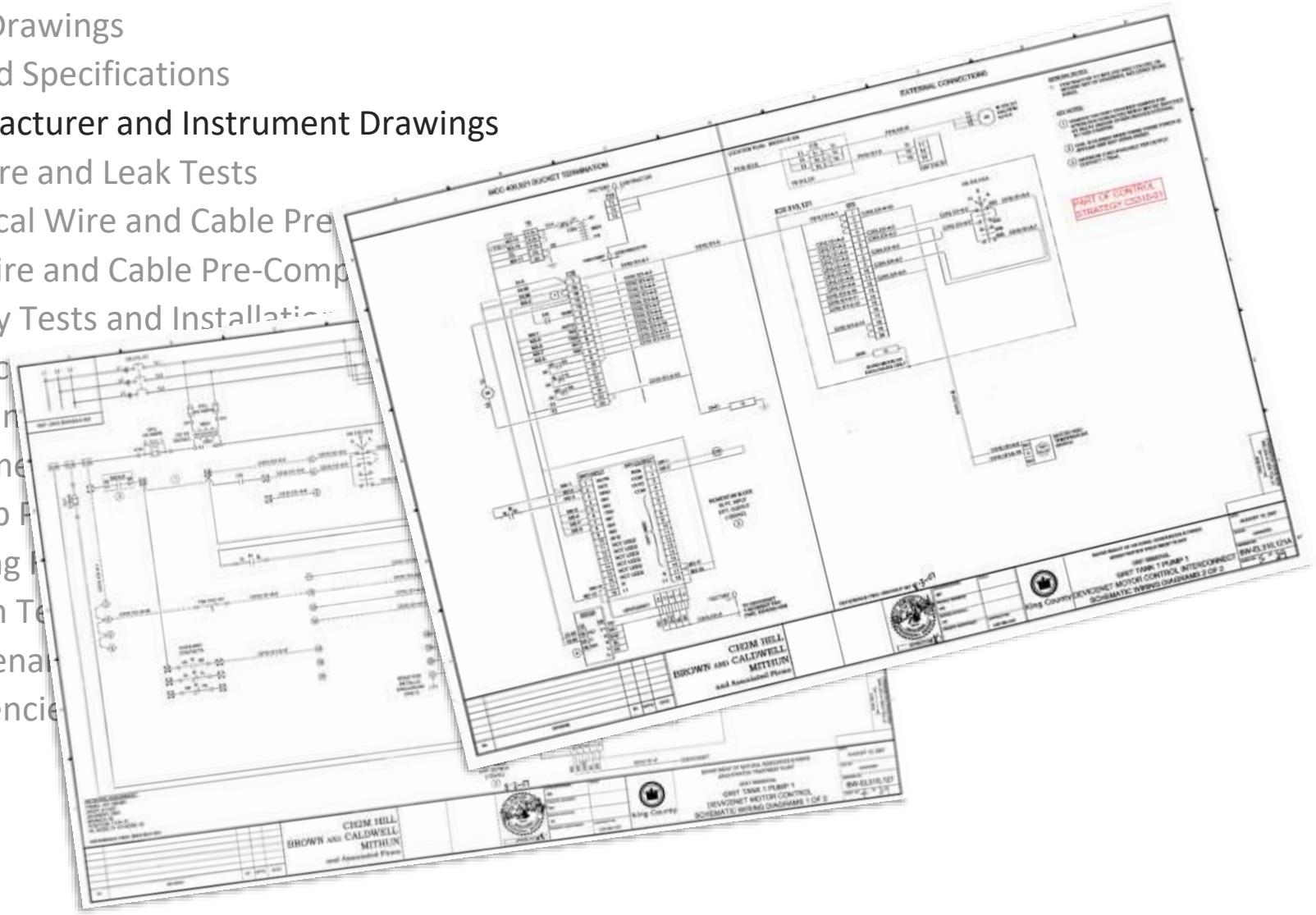
9. Electric
10. Mechan
11. Equipme
12. Startup P
13. Training P
14. System Te
15. Maintena
16. Deficiencie



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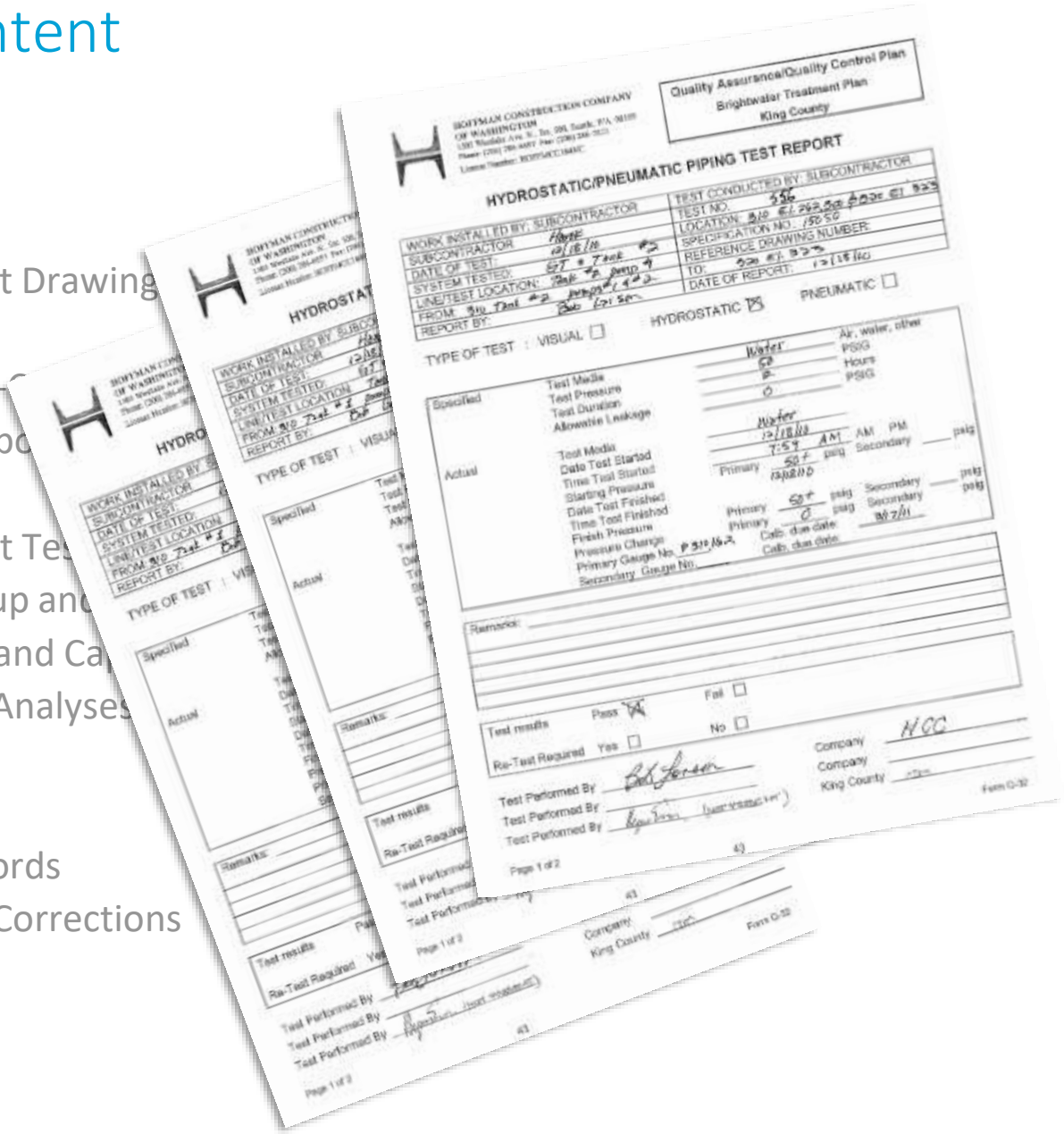

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13. Traini
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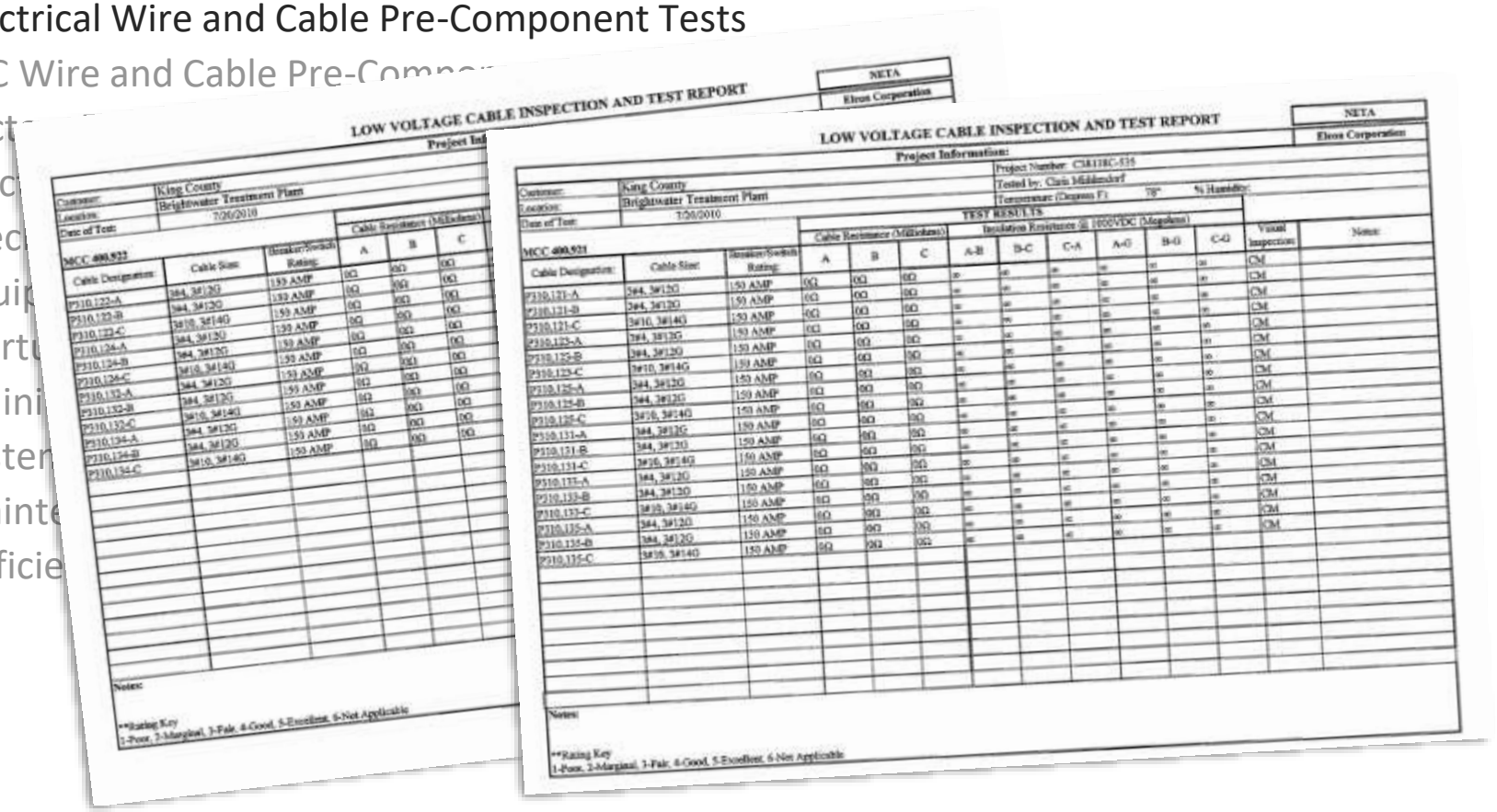
LOW VOLTAGE CABLE INSPECTION AND TEST REPORT

NETA
Elton Corporation

Project Information:

Customer: King County
Location: Brightwater Treatment Plant
Date of Test: 7/26/2010
Project Number: CSR11EC-036
Tested by: Chris Middendorf
Temperature: (Degrees F): 78° % Humidity:

MCC 400.S21

TEST RESULTS

Cable Designation:	Cable Size:	Breaker/Switch Rating:	Cable Resistance (Milliohms) A	B	C	Insulation Resistance @ 1000VDC (Megohms) A-B	B-C	C-A	A-G	B-G	C-G	Visual Inspection:	Notes:
P310.121-A	3#4, 3#12G	150 AMP	0Ω	0Ω	0Ω	∞	∞	∞	∞	∞	∞	OM	
P310.121-B	3#4, 3#12G	150 AMP	0Ω	0Ω	0Ω	∞	∞	∞	∞	∞	∞	OM	
P310.121-C	3#10, 3#14G	150 AMP	0Ω	0Ω	0Ω	∞	∞	∞	∞	∞	∞	OM	
P310.123-A	3#4, 3#12G	150 AMP	0Ω	0Ω	0Ω	∞	∞	∞	∞	∞	∞	OM	
P310.123-B	3#4, 3#12G	150 AMP	0Ω	0Ω	0Ω	∞	∞	∞	∞	∞	∞	OM	
P310.123-C	3#10, 3#14G	150 AMP	0Ω	0Ω	0Ω	∞	∞	∞	∞	∞	∞	OM	
P310.125-A	3#4, 3#12G	150 AMP	0Ω	0Ω	0Ω	∞	∞	∞	∞	∞	∞	OM	
P310.125-B	3#4, 3#12G	150 AMP	0Ω	0Ω	0Ω	∞	∞	∞	∞	∞	∞	OM	
P310.125-C	3#10, 3#14G	150 AMP	0Ω	0Ω	0Ω	∞	∞	∞	∞	∞	∞	OM	
P310.131-A	3#4, 3#12G	150 AMP	0Ω	0Ω	0Ω	∞	∞	∞	∞	∞	∞	OM	
P310.131-B	3#4, 3#12G	150 AMP	0Ω	0Ω	0Ω	∞	∞	∞	∞	∞	∞	OM	
P310.131-C	3#10, 3#14G	150 AMP	0Ω	0Ω	0Ω	∞	∞	∞	∞	∞	∞	OM	
P310.133-A	3#4, 3#12G	150 AMP	0Ω	0Ω	0Ω	∞	∞	∞	∞	∞	∞	OM	
P310.133-B	3#4, 3#12G	150 AMP	0Ω	0Ω	0Ω	∞	∞	∞	∞	∞	∞	OM	
P310.133-C	3#10, 3#14G	150 AMP	0Ω	0Ω	0Ω	∞	∞	∞	∞	∞	∞	OM	
P310.135-A	3#4, 3#12G	150 AMP	0Ω	0Ω	0Ω	∞	∞	∞	∞	∞	∞	OM	
P310.135-B	3#4, 3#12G	150 AMP	0Ω	0Ω	0Ω	∞	∞	∞	∞	∞	∞		
P310.135-C	3#10, 3#14G	150 AMP	0Ω	0Ω	0Ω	∞	∞	∞	∞	∞	∞		

Notes:

**Rating Key
1-Poor, 2-Marginal, 3-Fair, 4-Good, 5-Excellent, 6-Not Applicable

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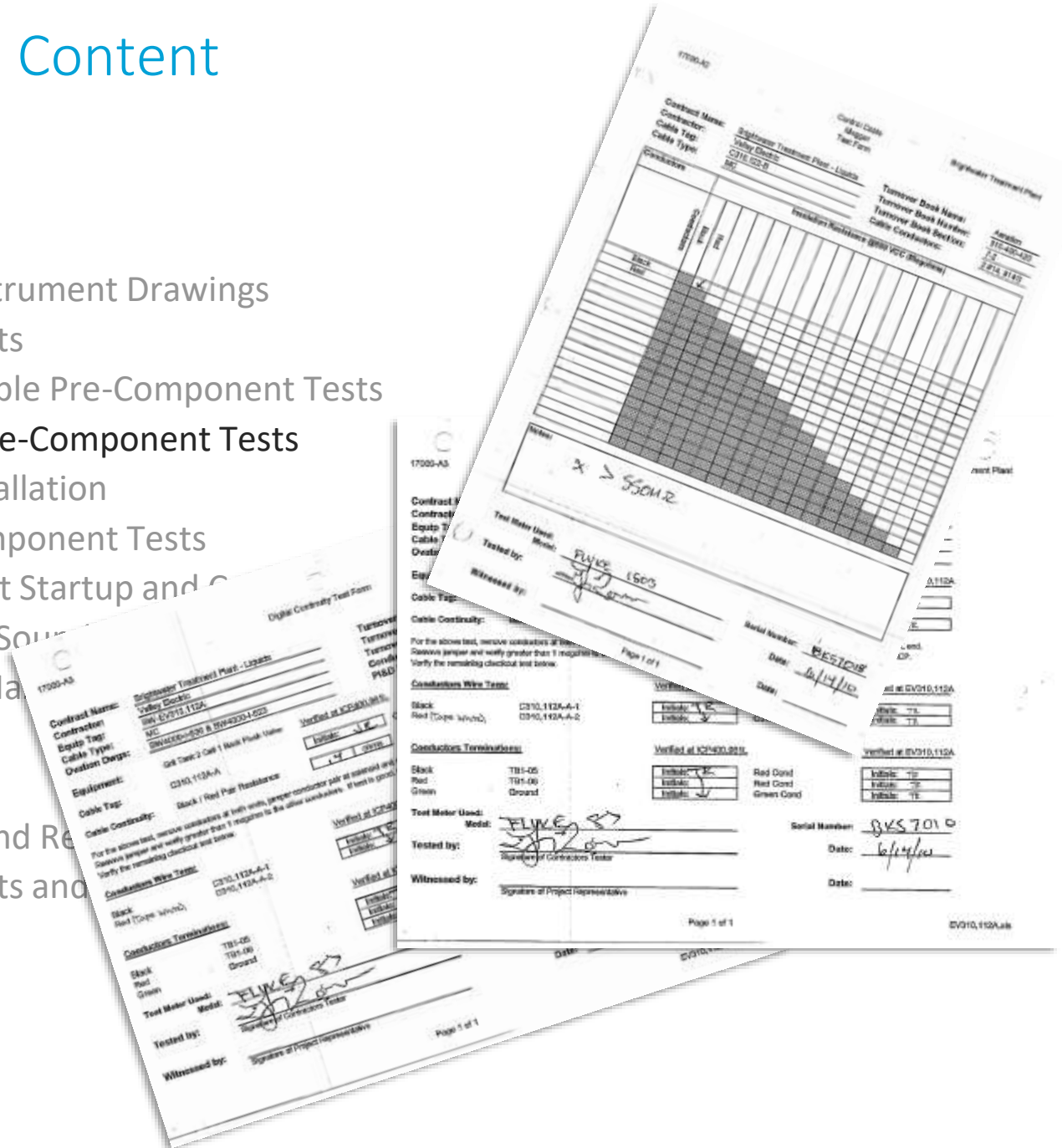

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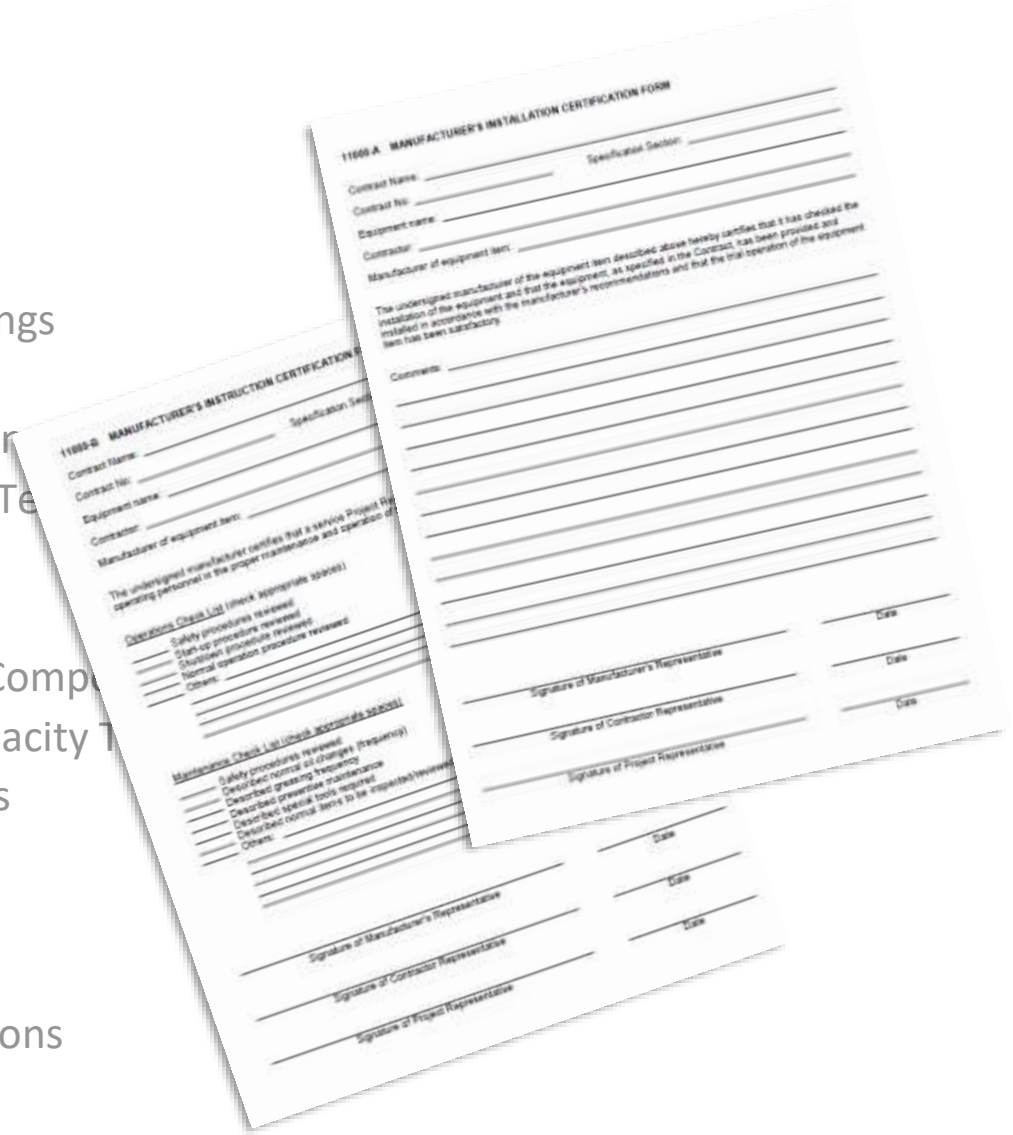

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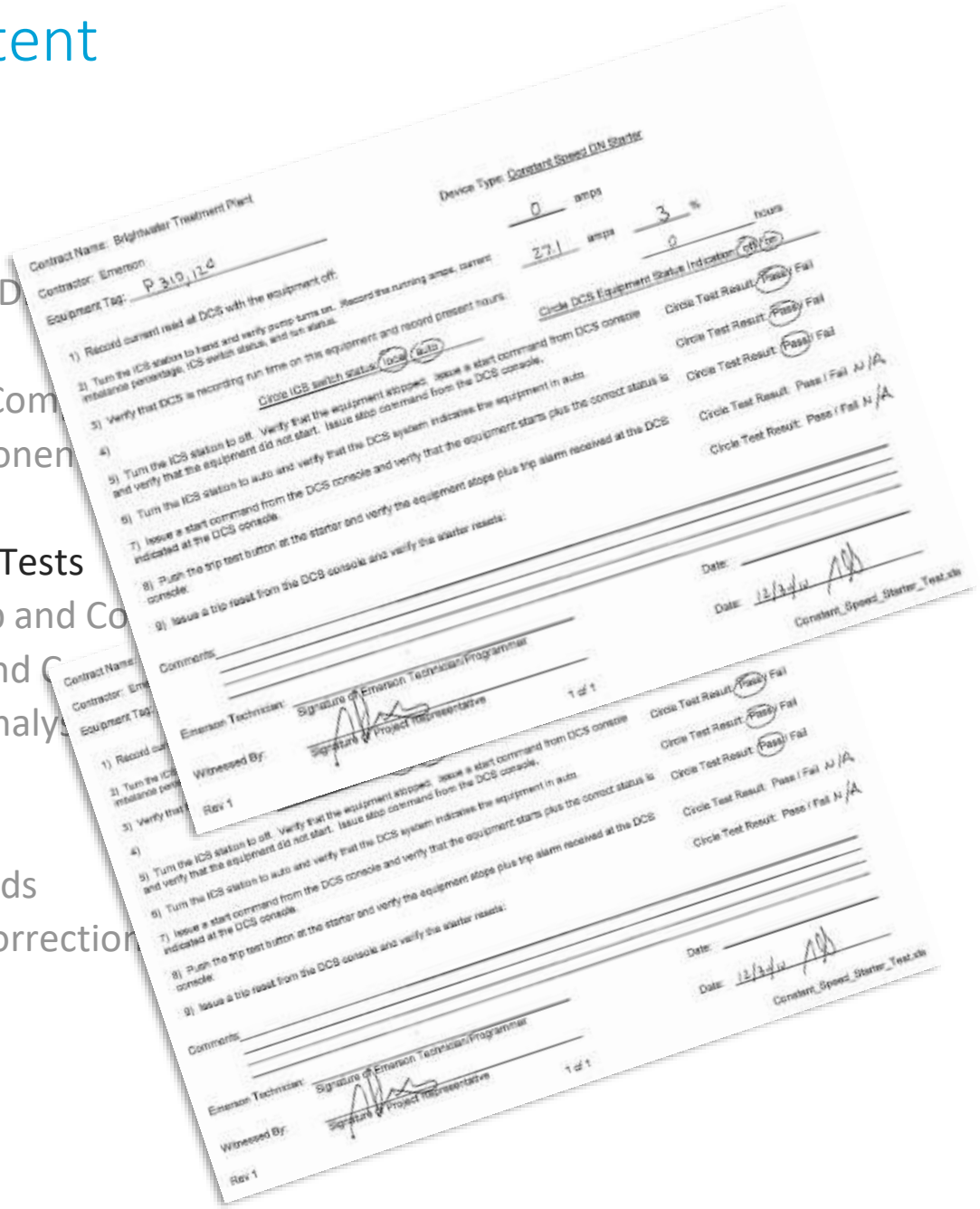

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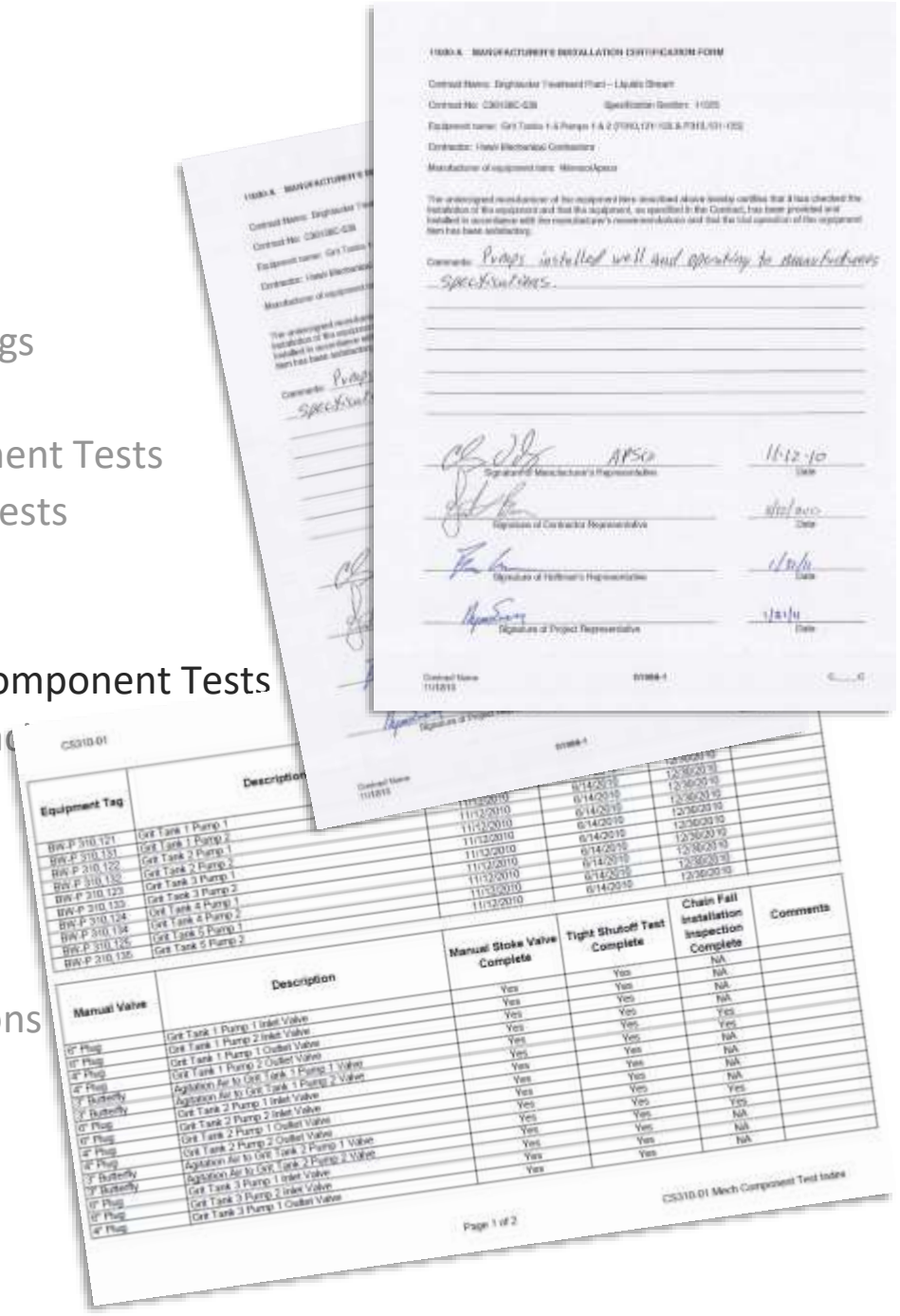

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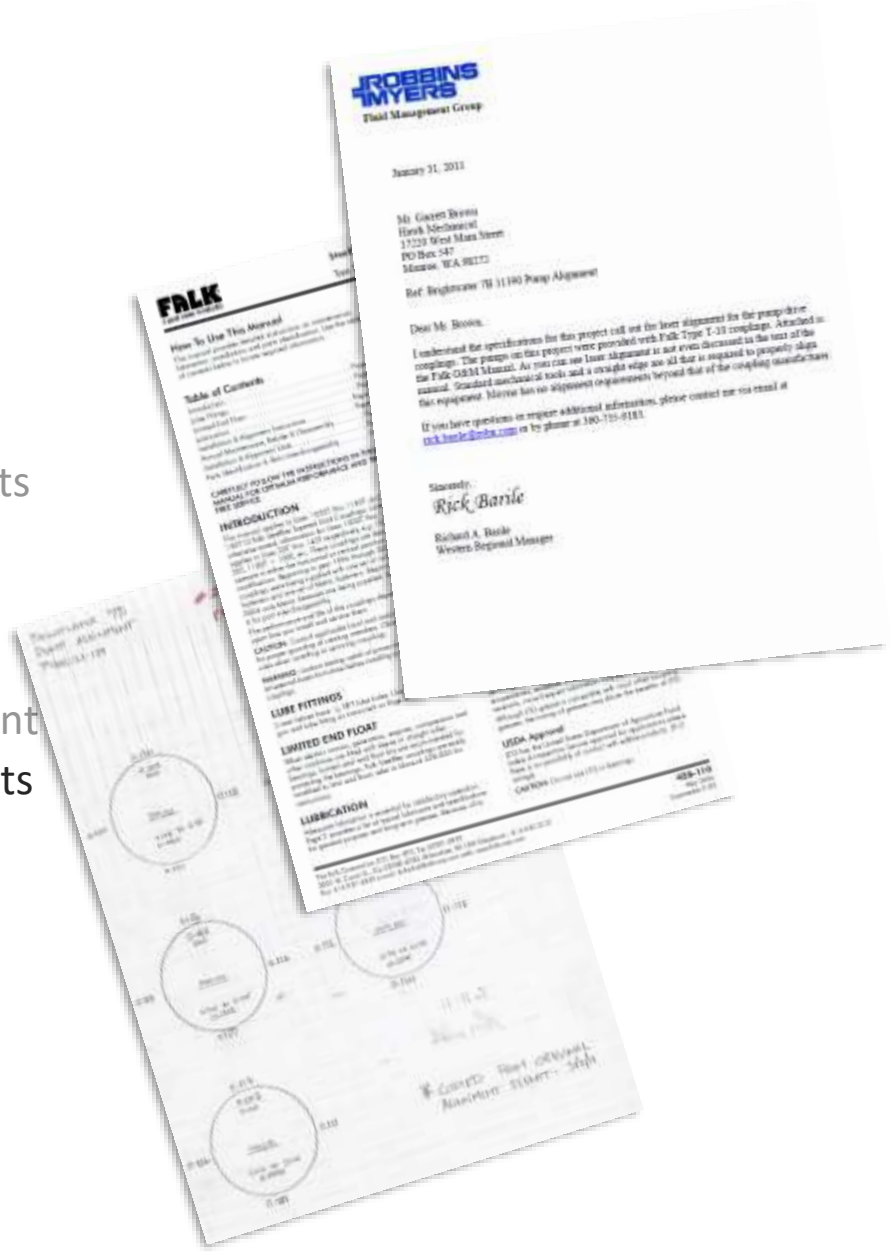

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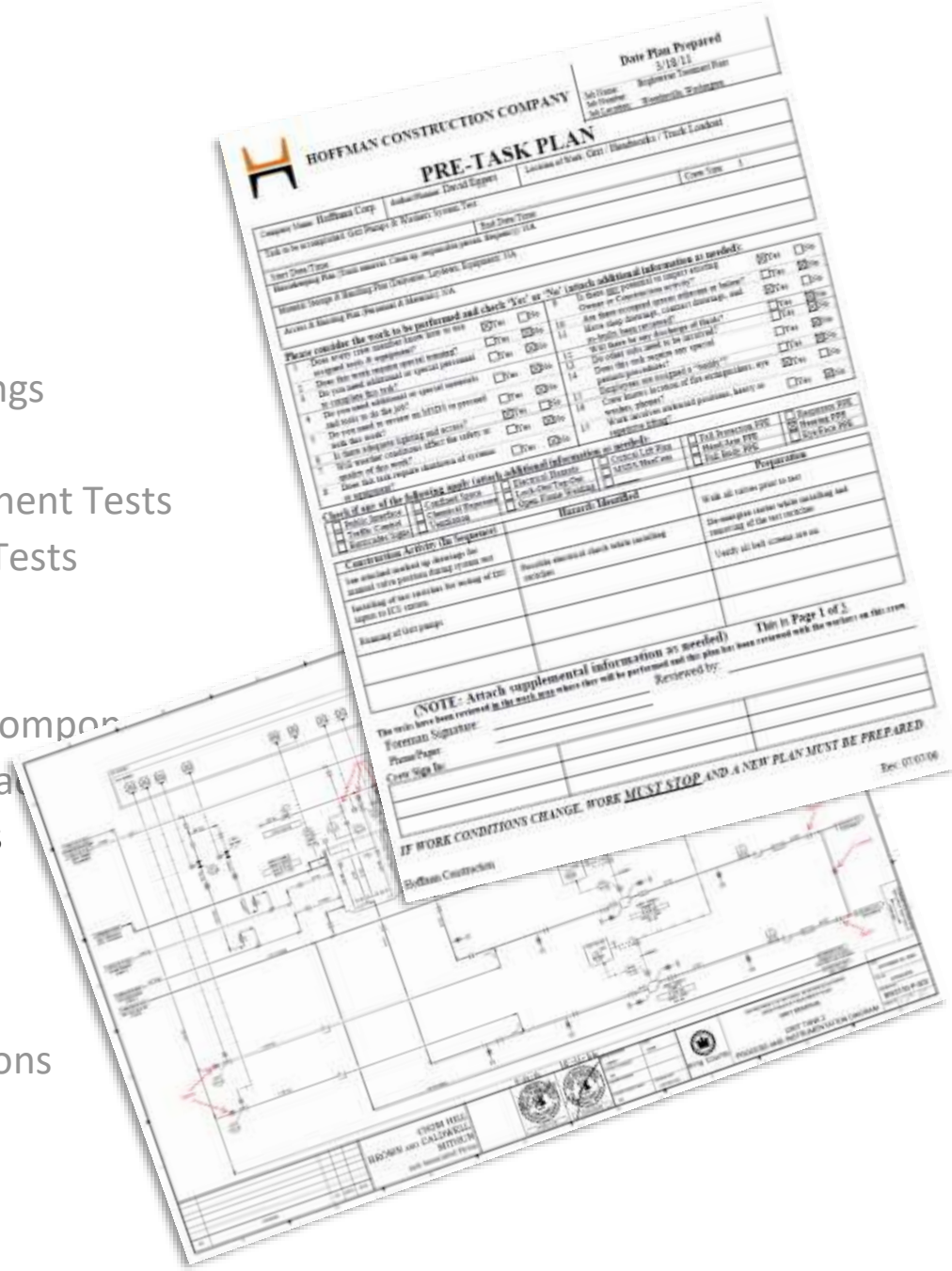

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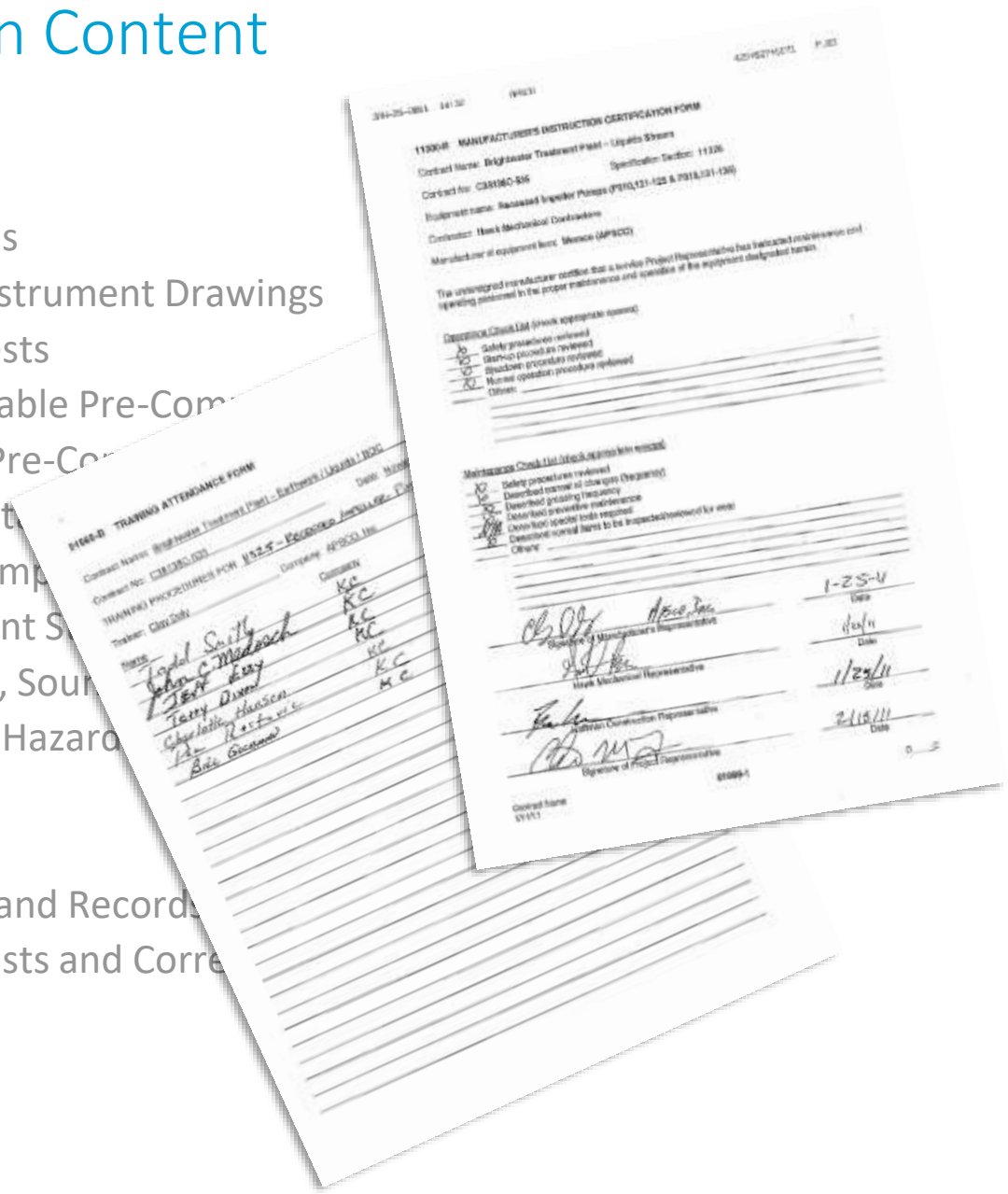

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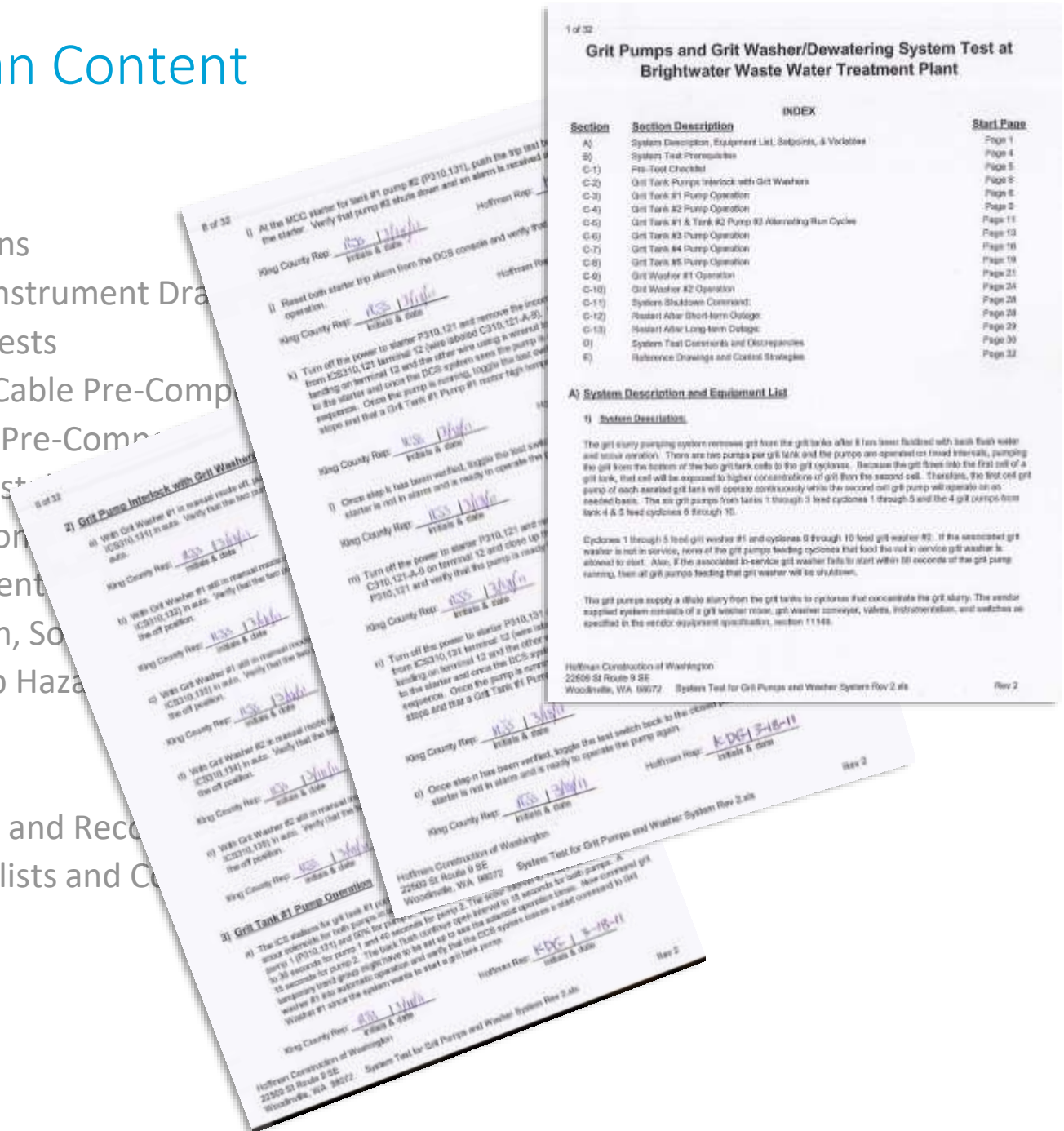
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Grit Pumps and Grit Washer/Dewatering System Test at Brightwater Waste Water Treatment Plant

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A) System Description and Equipment List

1) System Description:

The grit slurry pumping system removes grit from the grit tanks after it has been flushed with fresh flush water and scour aeration. There are two pumps per grit tank and the pumps are operated on timed intervals, pumping the grit from the bottom of the two grit tank cells to the grit cyclones. Because the grit flows into the first cell of a grit tank, that cell will be exposed to higher concentrations of grit than the second cell. Therefore, the first cell grit pump of each aerated grit tank will operate continuously while the second cell grit pump will operate on an needed basis. The six grit pumps from tanks 1 through 3 feed cyclones 1 through 5 and the 4 grit pumps from tank 4 & 5 feed cyclones 6 through 10.

Cyclones 1 through 5 feed grit washer #1 and cyclones 6 through 10 feed grit washer #2. If the associated grit washer is not in service, none of the grit pumps feeding cyclones that feed the not in service grit washer is allowed to start. Also, if the associated in-service grit washer fails to start within 60 seconds of the grit pump running, then all grit pumps feeding that grit washer will be shutdown.

The grit pumps supply a dilute slurry from the grit tanks to cyclones that concentrate the grit slurry. The vendor supplied system consists of a grit washer mixer, grit washer conveyer, valves, instrumentation, and switches as specified in the vendor equipment specification, section 11148.

Hoffman Construction of Washington
22505 St Route 9 SE
Woodinville, WA 98072 System Test for Grit Pumps and Washer System Rev 2.xls Rev 2

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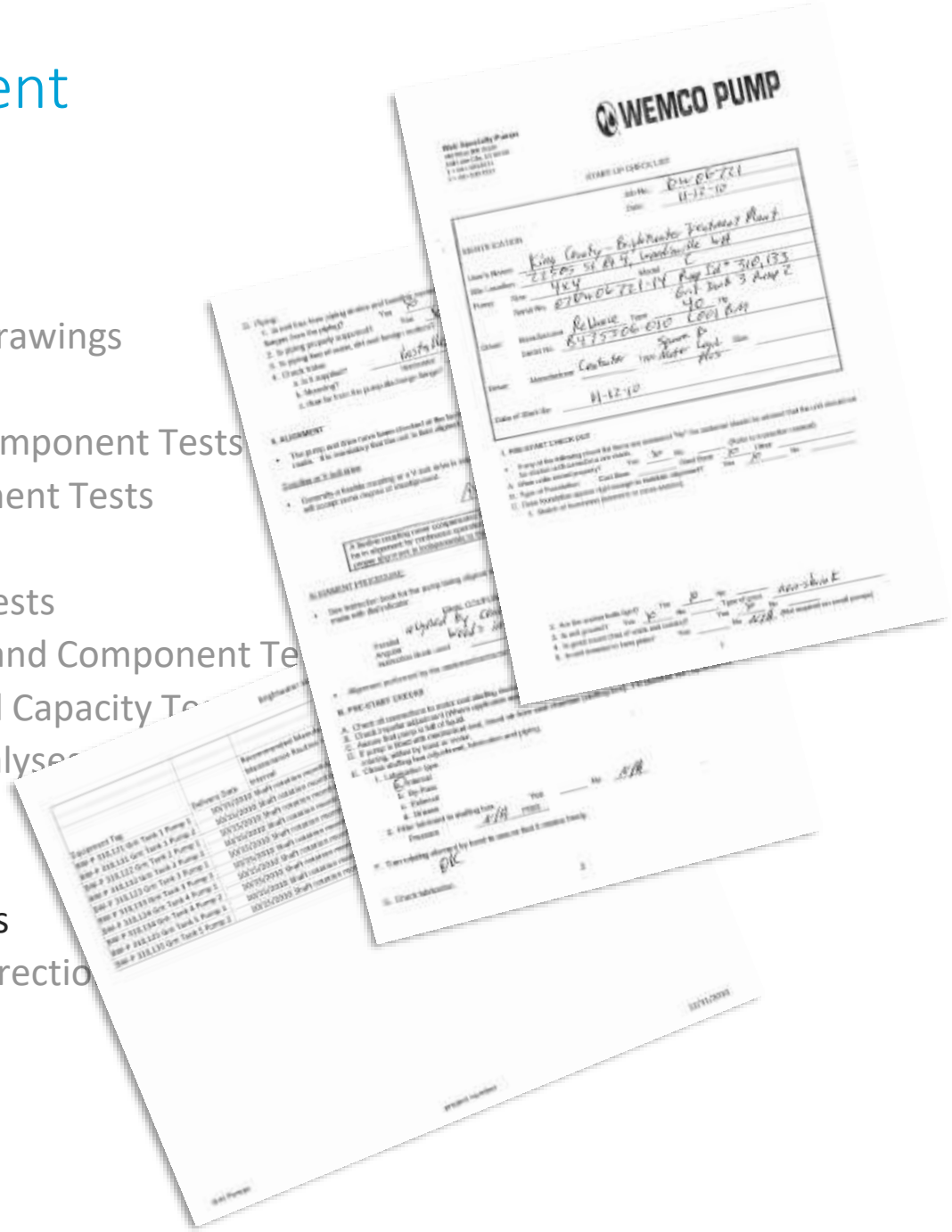

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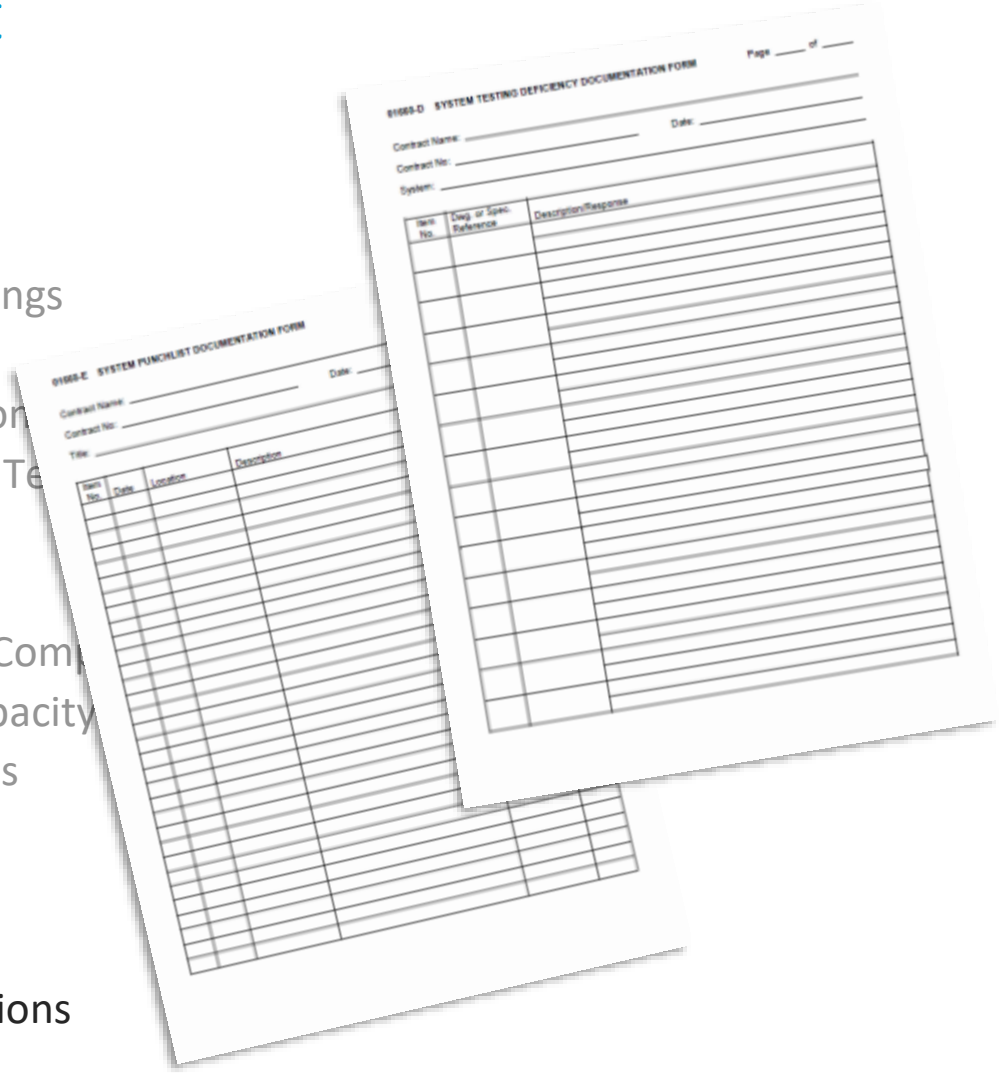


Case Studies

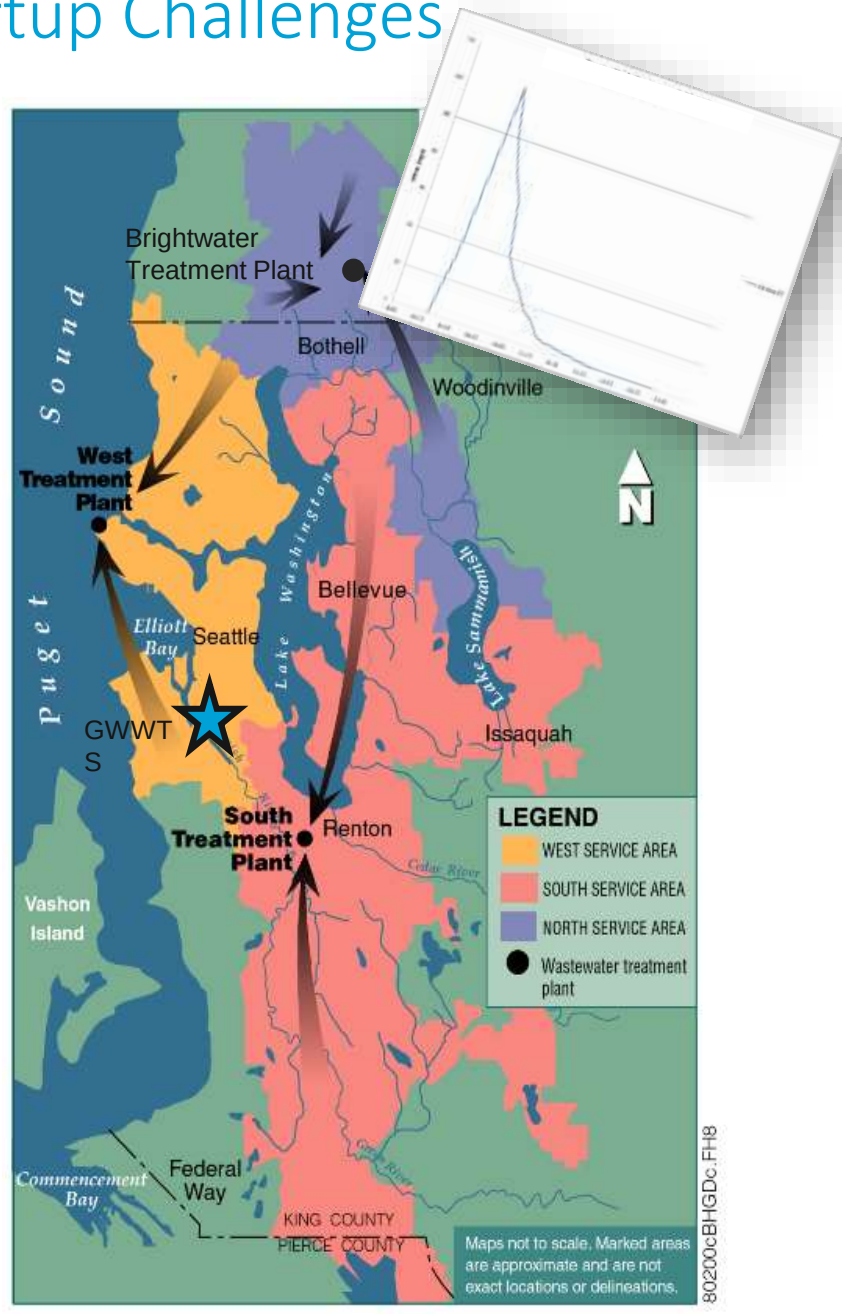
GWWTS Overview

- 70 MGD treatment capacity
  - Screening – 115 MGD
  - Equalization – 1.1 MG
  - Conveyance storage counted in the model
  - Ballasted Sedimentation – 70 MGD
  - UV disinfection – 70 MGD
  - River outfall – 70 MGD

- Peak event volume – 85 MG
- Average annual treated volume – 67 MG/year
- Average number of events – 20+
- Events are a few hours to a few days long

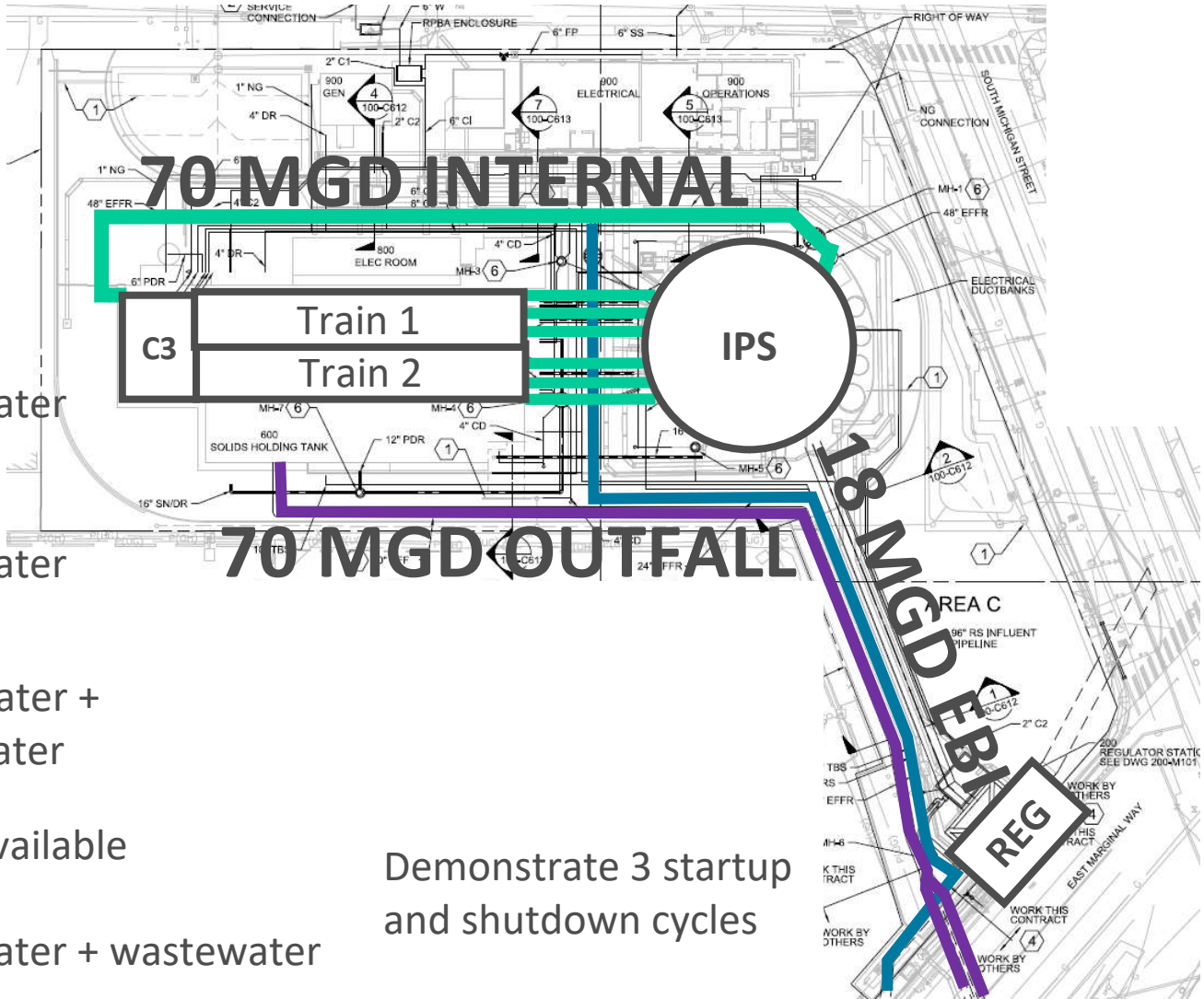
Intermittent Operations and Startup Challenges

Challenges
Satellite facility (not located at an existing 24/7 WWTP, not staffed full time)
Ready to start – must react quickly as levels rise quickly
Start and Stop automatically
Shutdown after event
Shutdown after season
Startup Testing – sufficient water to hydraulically test
Performance Testing – achieve a meaningful test, since storms cannot be scheduled.

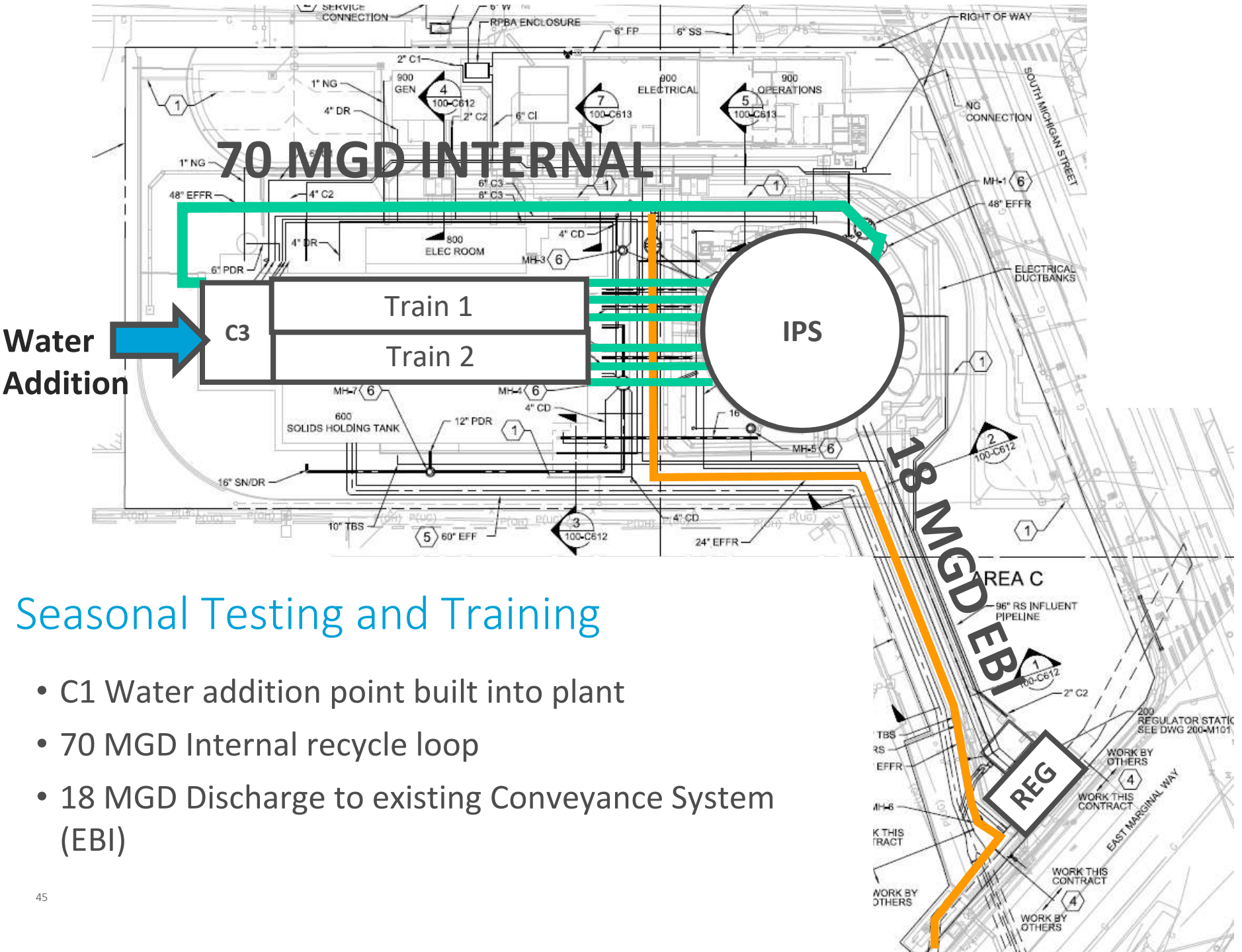


Georgetown Wet Weather Treatment Station Start-up

- **Pre-Installation Test Phase**
- **Component Test Phase**
- **System Test Phase** — Clean water
- **Operational Test Phase Part 1** — Clean water
- **Operational Test Phase Part 2** — Clean water + wastewater
- **Commissioning Phase** — CSO if available OR Clean water + wastewater



Demonstrate 3 startup and shutdown cycles



Seasonal Testing and Training

- C1 Water addition point built into plant
- 70 MGD Internal recycle loop
- 18 MGD Discharge to existing Conveyance System (EBI)

Recurring themes

- Ozone threads leak
- Hypo systems leak
- Diffusers leak
- If process fails, confirm mechanical
  - Valves open/actuator open
  - Pumps delivering specified flow
- Vendor supplied package system may not fully understand process outside of package
- Material compatibility
- Startup screens left in place
- Surge issues during testing
- Nuisance alarms are not always nuisances

Thank you

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Jacobs
Project Manager/Water Engineer
425.233.3058 Desk
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Butch Perry
King County
Infrastructure Coordinator
Harold.Perry@KingCounty.gov

Boston Water Treatment Plant

- Ozone disinfection, storage tank(s) conveyance tunnel
- Design allowed for future filtration facility
- Connecting structure flooded
- Ozone contractor vacuum relief minimal
- Post event forensics

Tolt

- Does the design match upstream and downstream conditions?
- Post construction - are all hatches/covers clean gasketed and secured?
- Control System
  - Alarm criticality assigned?
  - Nuisance alarms cleared?
- Post startup all systems should be visually inspected frequently and monitored for alarm condition continuously
- Unusual activities detected by smell, sound, visually or by the control system should be checked immediately and problem corrected or system disabled until craft is available to investigate.

Cambridge

- Consider failure modes and isolation points
- Access to isolation devices
- Changes allowed during construction - Don’t assume, consider impact
- Power failure resulted in surge
- Could not isolate flow into plant
- Flow isolated at tank over a mile away - no vacuum relief