

Wafer Fab Water Recovery

Architects • Engineers • Constructors

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Manufacturing Requirements

- Ultrapure Water for Wafer Rinsing
 - Immersion Chemical Bath → Immersion Rinse and/or Spray
 - Process Flows
 - Standby Flows
 - Equipment Configuration
 - Drain Management
 - Multi-step Spray Tools
 - Chemical and Water Flows
 - Water efficiency
 - Typical Configuration
 - Drain Management

Manufacturing Requirements

(continued)

- Spin-on Tools
 - Chemical and Water Flows
 - Typical Configuration
 - Drain Management
- Chemical Mechanical Processing (CMP) / Polishing
 - Slurry Types
 - Typical Configuration
 - Drain Management
- Consumption Rates for Manufacturing
 - Industry Metrics
 - Utility Matrix

Utility Matrix

Sample

Tool	UPW Avg	UPW Peak	HF Drain	IWW Drain
AWS-1	10	15	–	15
AWS-2	5	25	–	25
MIRRA	0.2	0.6	1	2
FSI-A	2	6	0	6
FSI-B	1	3	3	3
Total	18.2	49.6	4	51

- Issues
 - Manufacturing connected load versus actual
 - Standby versus peak flows
 - Tool diversity

Manufacturing Requirements

(continued)

- Chemical Systems
 - Process Chemical Prep
 - Equipment Maintenance
- Parts Cleaning
- Miscellaneous Process Tool Support

Facilities Requirements

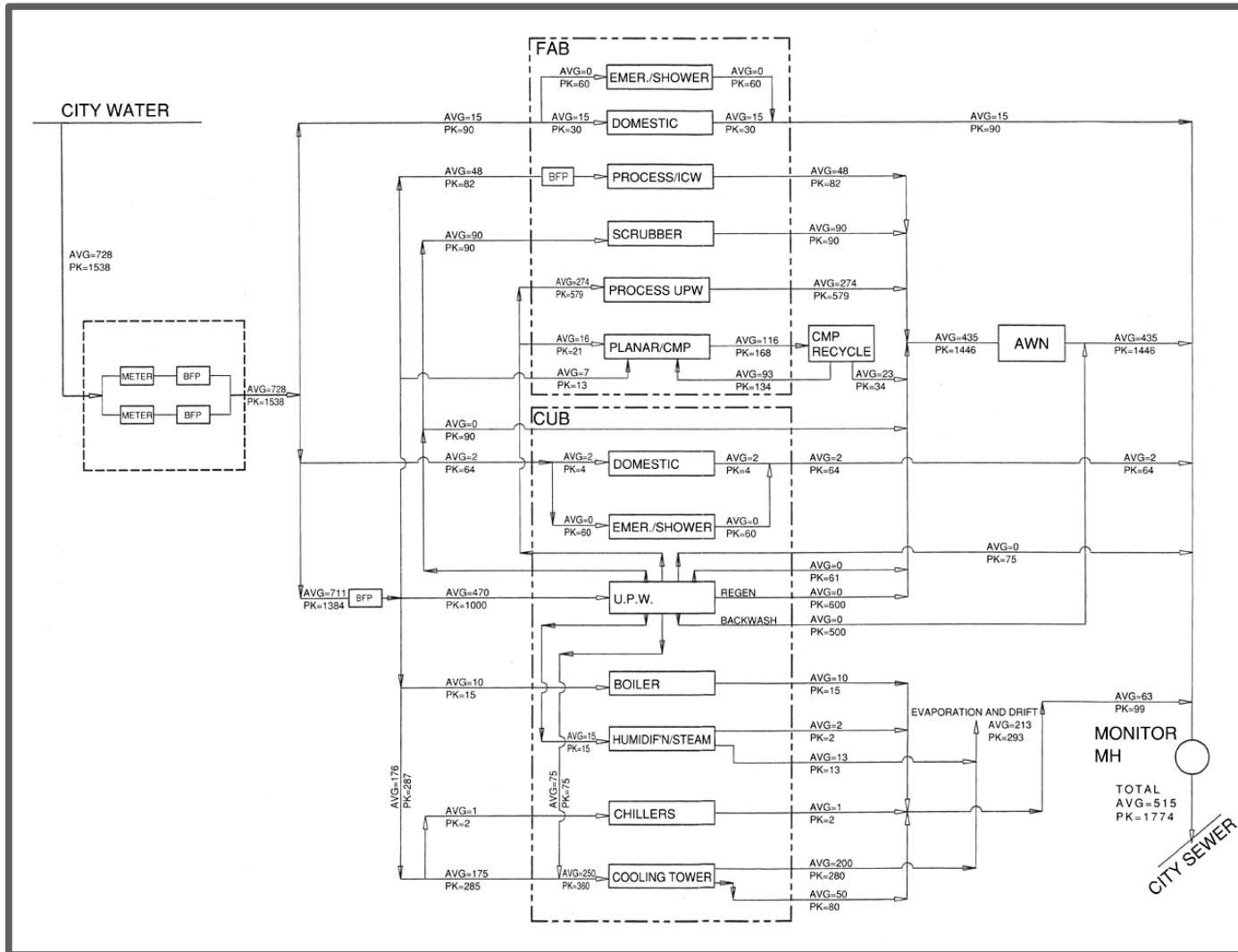
- Exhaust Fume Scrubbers
 - Central
 - Point-of-Use
 - Make-up/Discharge Options
- Evaporative Cooling Tower
 - Geographical Dependence
 - Seasonal Variation
 - Make-up Water Options
- Cleanroom Air Humidification
 - Steam
 - Mist

Facilities Requirements

(continued)

- Mechanical Systems
 - Boiler Make-up
 - Closed Loop Cooling Water (PCW) Make-up
 - Vacuum Pump Seal Water
- Domestic Use
 - Drinking Water
 - Water Closets
 - Cafeterias
 - Safety Showers
- Irrigation

Typical Site Water Balance Diagram



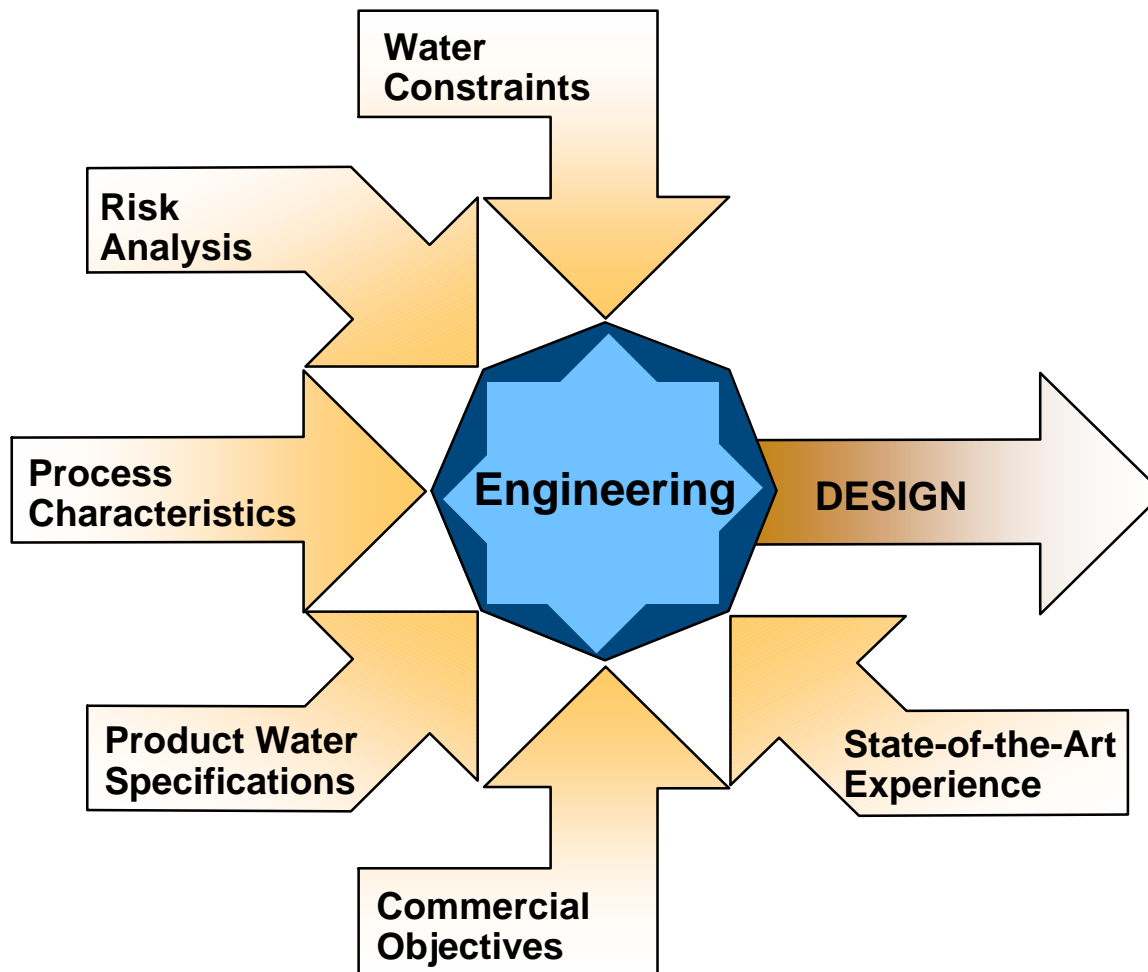
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Water Reclaim Engineering Analysis

General Framework



- Administrative Controls
- Segregation
- Detection/ Diversion
- Process Steps for Protection/ Reprocessing

On-site Water Recovery/Reuse

Opportunities

- Focus on Major Users
- Stream Matching of “Wastes” to Demands
- Used UPW Back to UPW plant
 - Spent UPW Contains Process Chemicals Much Different from City Water
 - Cleans: NH_4OH , HCl , H_2O_2 , H_2SO_4
 - Etches: HF , NH_4F , HNO_3 , H_3PO_4 , Silicates
 - Strips: Solvents, Polymers, H_2SO_4 , Metals
 - Develops: TMAH, KOH, Resist
 - CMP: Slurries, NH_4OH , HF

UPW Product Quality

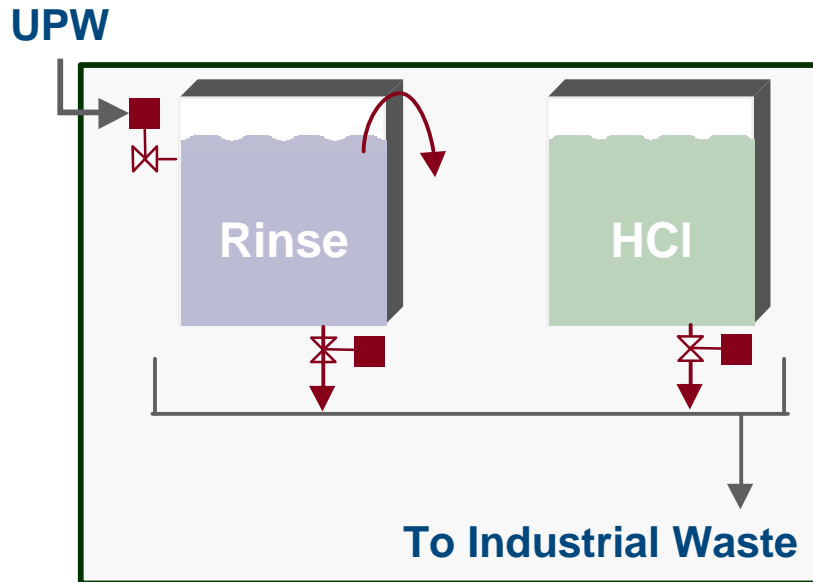
Typical Specifications

Parameter	Specification
Resistivity In-Line Cell	> 18.2 MOhm-cm
Total Oxidizable Carbon (TOC) UV/Resistivity	< 2 ppb
Bacteria, 48-Hour Culture	< 1 cfu/Liter
Reactive Silica	< 1 ppb
Dissolved Oxygen	1 to 20 ppb
Particles–Laser Cell	
> 0.05 Micron	< 500/Liter
> 0.10 Micron	< 50/Liter
> 0.50 Micron	< 1/Liter
Sodium, IC	50 ppt
Chloride, IC	50 ppt
Metals, Each, ICPMS	50 ppt
Metals, Total, ICPMS	< 1 ppb

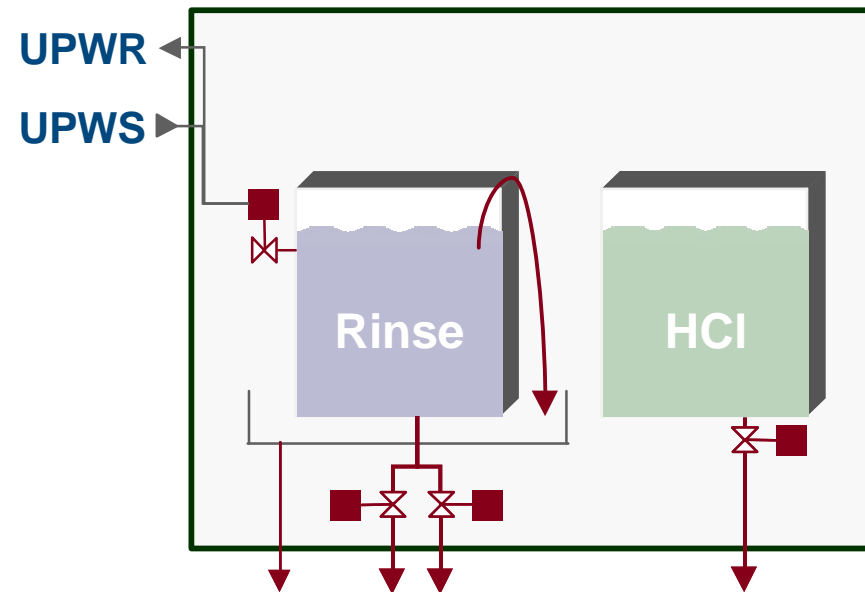
UPW Reclaim Analysis

Process	Chemistry	Reclaim Viability
Cleaning	HF NH ₄ OH / H ₂ O ₂ HCl / H ₂ O ₂	Hi Volumes Predictable Contaminants
Post Strip	H ₂ SO ₄ / PDSA	Moderate Volume Moderate Risk (Organics)
Planar / CMP		High Volume
Oxide	Misc. Slurry	High Solids Variable Chemistry
Metal		Changing Slurries
Post Clean	NH ₄ OH HF	Consistent but Challenging
Resist Develop	TMAH	Low Volumes High Risk
Co/Ti Strip	HCl / H ₂ O ₂	Low Volumes High Risk (Metals)
Oxynitride Strip	HF	Low Volumes Moderate Risk of Chemistry

Bath-Type Wet Benches

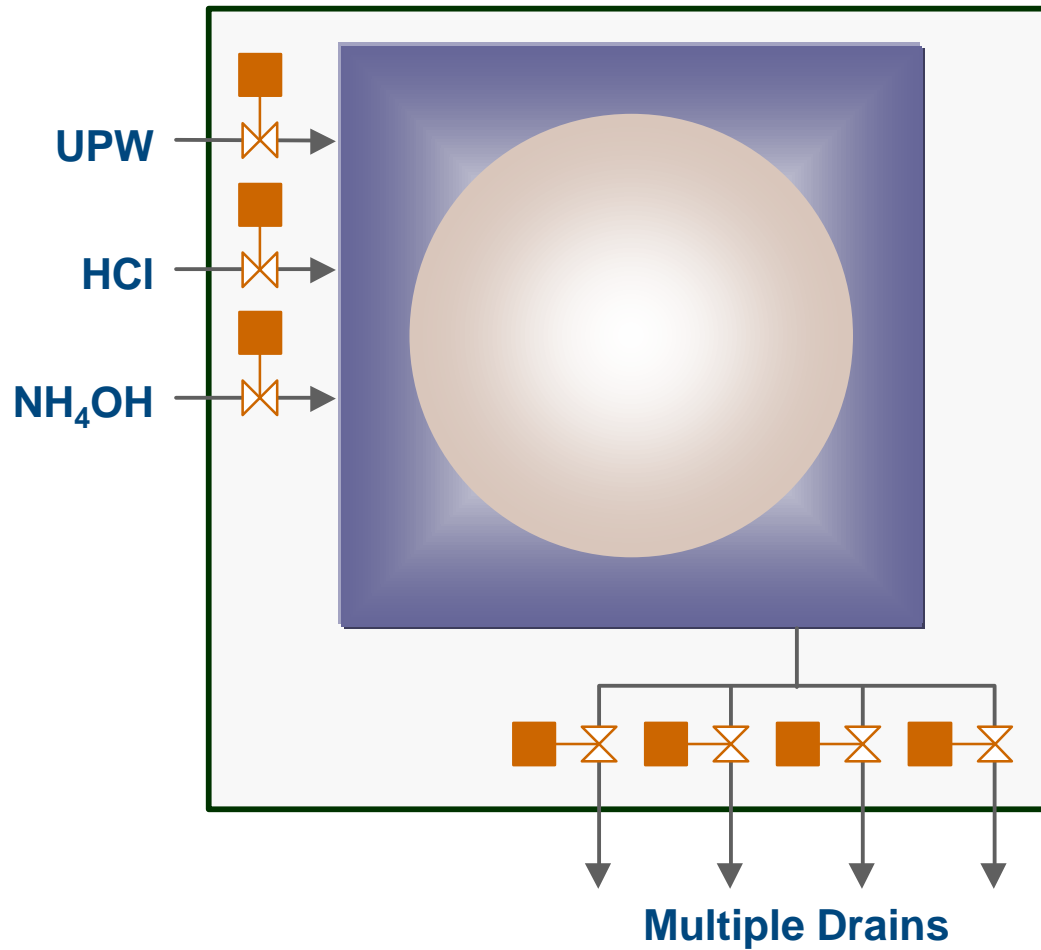


Old Style with Common Plenum



With Segregation and Diversion

Spray-Type Wet Station

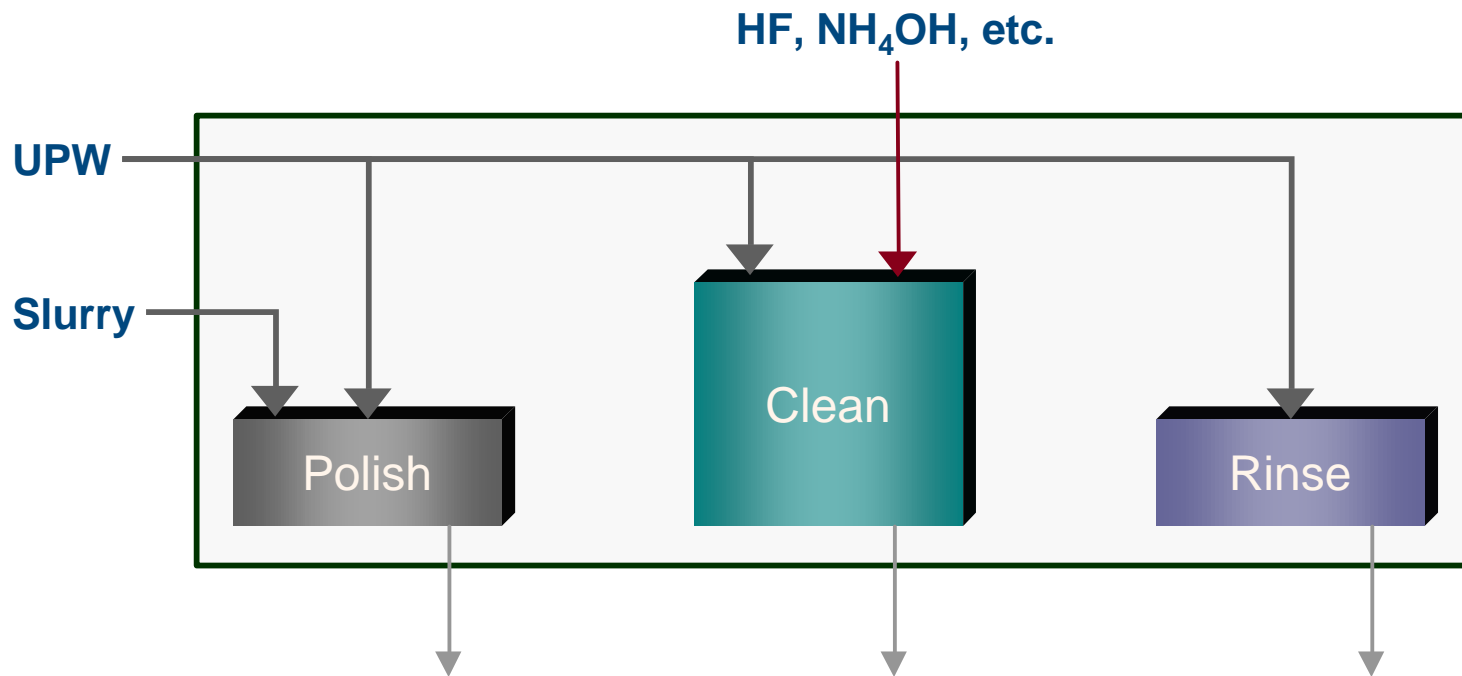


On-site Water Recovery/Reuse

Opportunities (continued)

- Difficult to Detect and Remove Chemistries
 - TMAH
 - Solvents
 - Concentrated Acids / Bases / Slurries
- Strict Controls Required
 - Drain Management
 - Chemical Change Management
 - Quality Monitoring

CMP Wet Station



CMP Water Reclaim Challenges

- Potentially Very High Volumes of UPW
- Polishing vs Post Polish Cleaning
- Changing Processes
- Changing Chemistries
 - Slurries
 - Cleaners
- UPW Supply Quality Limits?

UPW Reclaim Strategies

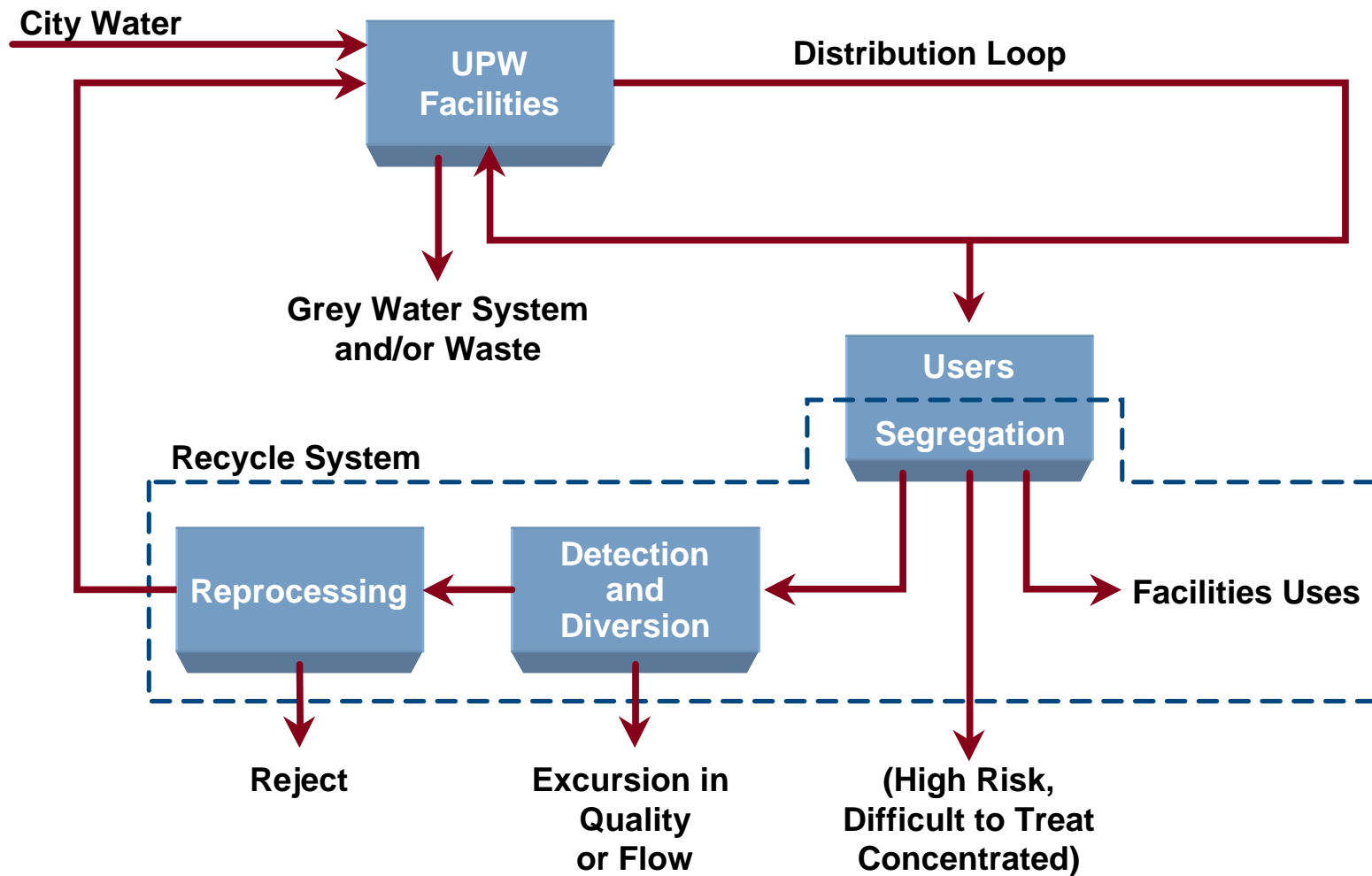
- Incorporate Segregated Connections on Wet Process Tools
- Develop Dedicated Drain Networks
- Pre-Qualify Each Source Prior to Connection
- Provide Highly Reliable Analytical Detection/Diversion
- Provide Appropriate Re-treatment
- Consider Point of Re-introduction to UPW System
 - Front End as Raw Water Equivalent
 - Downstream of Primary Treatment

Water Treatment Unit

Typical Operations and Technologies

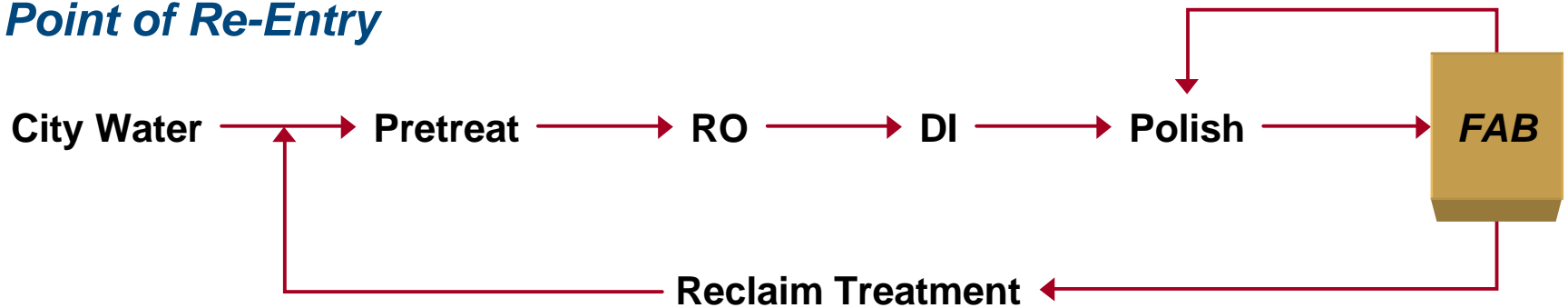
- Reverse Osmosis (RO)
- Ion-Exchange (IX)
- Continuous Electrodeionization (CEDI)
- Ozone (O₃)
- Ultraviolet (UV) Units
- Activated Carbon (AC)
- Multimedia Filters (MMF)
- Membrane Cartridge
- Filters
- Ultrafilters (UF)
- Heat Exchangers
- Chemical Injection
- Clarifiers
- Filter Presses

Elements of a Recycle System



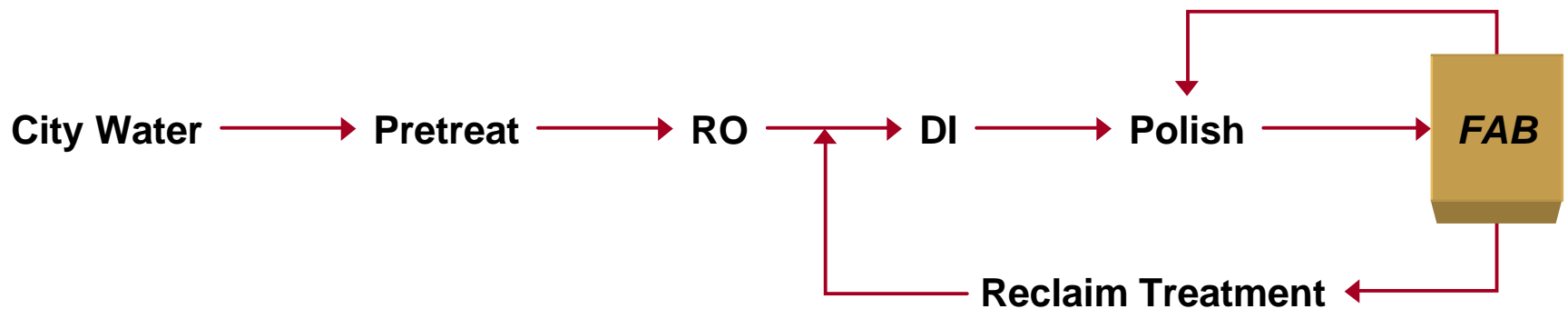
UPW Reclaim

Point of Re-Entry



Pros: Full System Sized for CW Makeup Most Re-Treatment of Reclaim

Cons: Reclaimed Water Quality Higher Than CW (Over-Treat)



Pros: Re-Entry Quality Closely Matched (Efficiency)

Cons: RO Sizing/Redundancy w/CW; Higher Risk of Recalcitrants

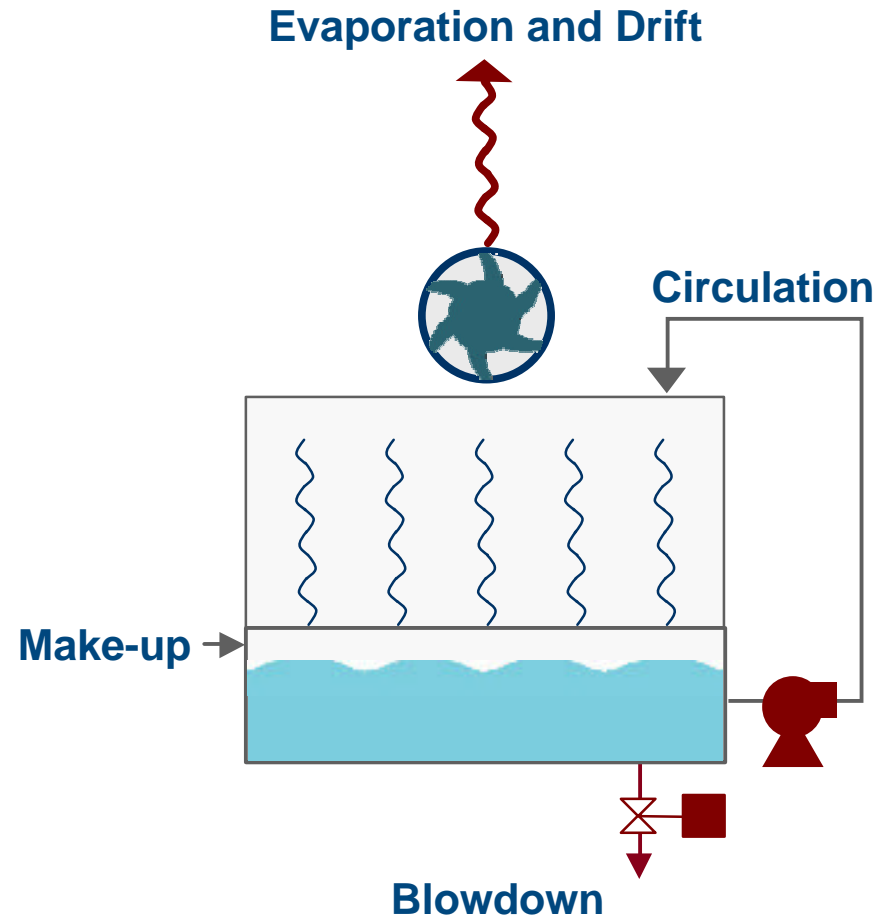
On-site Water Recovery/Reuse

Opportunities (continued)

- Cooling Tower and Scrubber Make-Up
 - High Potential for “Low Grade” Water Re-use
 - RO Reject from UPW Plant
 - Treated Industrial Wastewater
 - “Off-spec” UPW Reclaim
 - Must Consider
 - Seasonal (Load) Effects
 - Biological, organic, and inorganic fouling

Cooling Towers

- Cycles of Concentration
$$\frac{\text{(Make-up)}}{\text{(Drift + Blowdown)}} @ 5 - 7$$
- Determined by Maximum Contaminant Concentration
 - Hardness
 - Silicates
 - LSI
 - Ammonia
 - Chloride
 - Sulfate



Potential Off-site Solutions

Treated Fab Wastewater Disposition

- Community Wastewater Reclamation: Irrigation (Agricultural and Non-Agricultural Applications)
- Community Wastewater Reclamation: Industrial Makeup Water for Cooling, Fire Protection, Community Potable Water (Aquifer Recharge, Lakes)
- Wetland Restoration, Stream Flow Enhancement
- Makeup Water for Large Utility/Industrial Users (Boilers, Power Plants)
- Makeup Water for Large Developments (Water Features, Golf Courses)

Potential Off-site Solutions

Reuse, Recycle, Reclaim

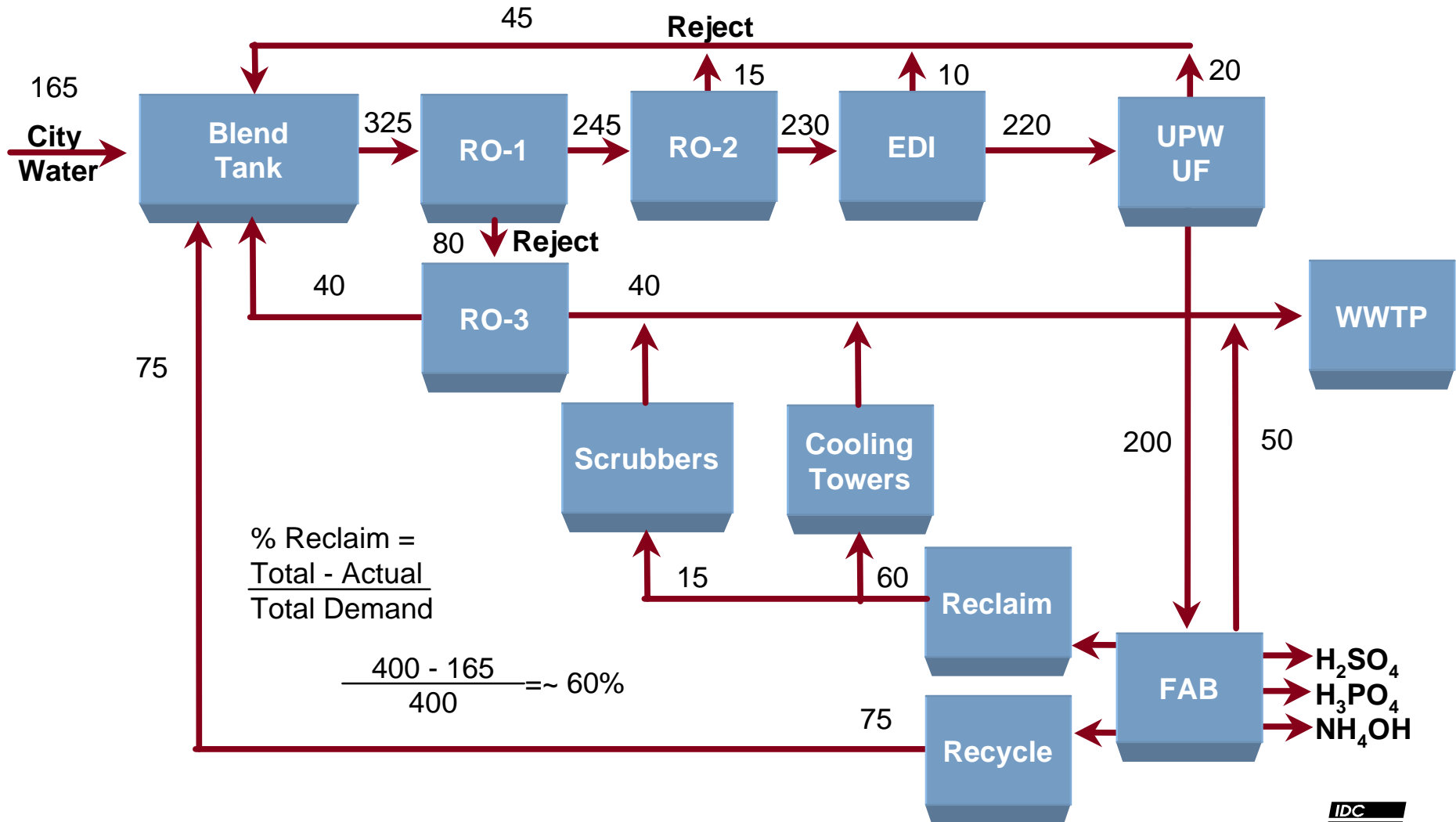
- Surface Water Reclamation Facilities (POTW Effluent Used for Landscaping and Agricultural Irrigation)
- Dedicated Industrial Wastewater Treatment in Combination Existing Wastewater Reclamation Facility (Reclaimed Water Returned to Industrial User for Cooling Tower Makeup, or Used Within Community for Irrigation, Fire Protection or Aquifer Recharge)
- Dedicated Pretreated Industrial Wastewater Pipelines Connected to POTW System, but Downstream of Head Works

Environmental Impacts

- Increasing reuse onsite results in more concentrated wastewater streams.
- Segregation of concentrated chemicals for reclamation/resale or disposal
 - H_2SO_4
 - H_3PO_4
 - NH_4OH

Typical Water Balance

with Reclamation



Summary

- Up To 70 Percent “Reclaim” Readily Feasible
- Process Tool Design and Installation is Key
- Process Automation and Operator Training Required
- Environmental Factors Influence Opportunities
- New Processes Require Thorough Analysis
- Matching Stream Quality/Quantity for Efficiency