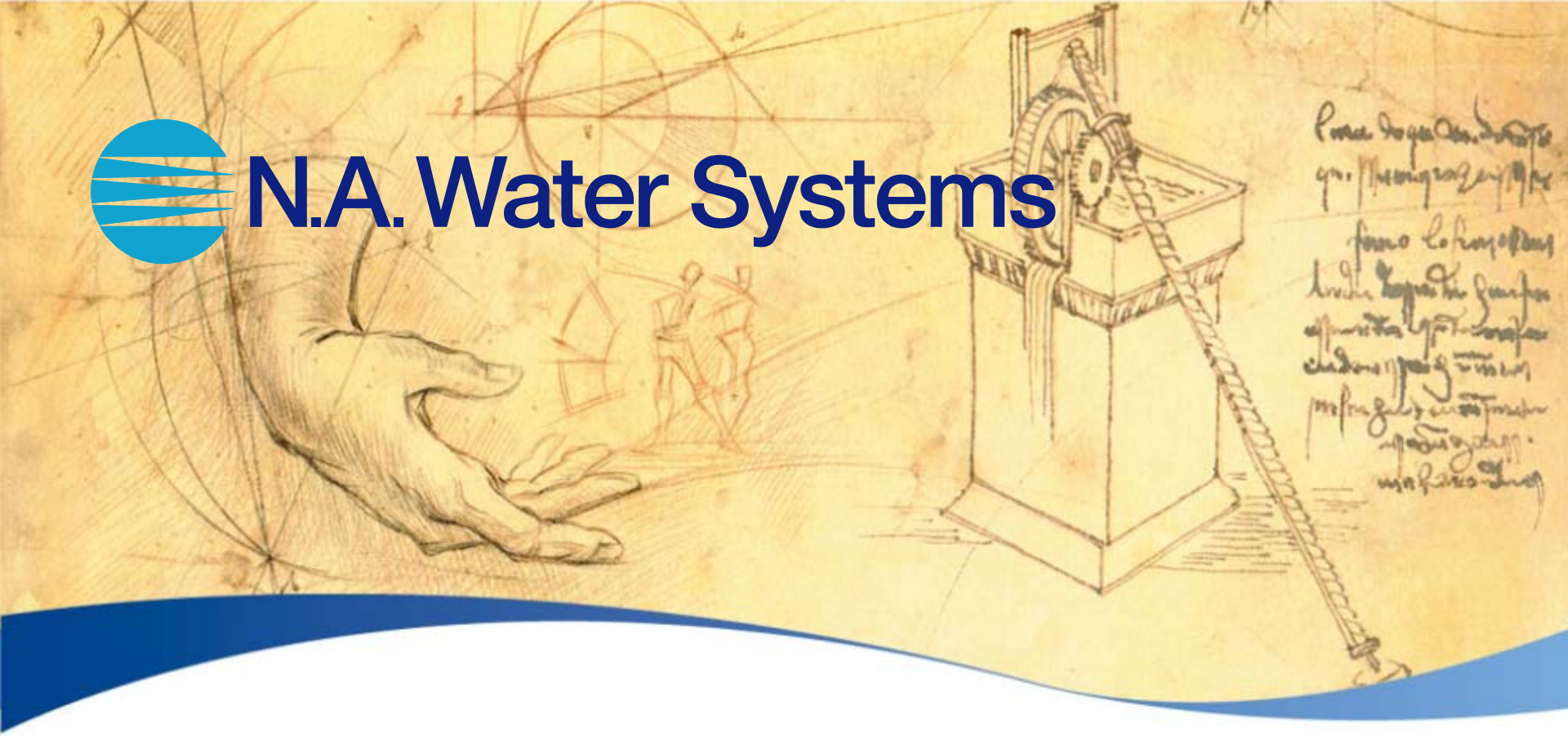

N.A. Water Systems

Treatment of Acidic Industrial Wastewaters using LowpHRO™ Technology

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LNSP Nagghappan

VEOLIA WATER
Solutions & Technologies

Acidic Wastewater

- Sources
  - Phosphate Manufacturing
  - Mining
  - Steel Mills
- Typical Acidic Wastewater
  - Hardness
  - Sulfates
  - Ammonia
  - Fluorides
  - Phosphates
  - Silica
  - Metals (Al, Fe, Mn, etc)
  - Total Dissolved Solids
- Disposal Options
  - Surface Water Discharge
  - Beneficial Re-use as Process Water/Plant Water
  - Off-site Disposal of Handling
  - Deep Well Injection

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Treatment Options

- Single/Double Liming Process
  - High Chemical Costs
  - High Solids Generation
  - Issues Associated with Sludge Management
  - Inability to meet Effluent Quality – Conductivity, Ammonia, etc
- Reverse Osmosis Technology
  - High Quality Effluent
  - Scaling & Fouling Concerns
  - Moderate CAPEX & OPEX Costs
  - Effective & Reliable Technology
- Evaporation Technology
  - High Quality Distillate
  - Scaling & Corrosion Concerns
  - High Capital Costs – Exotic Materials
  - High OPEX Costs – Power

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RO Technology Challenges

- Membrane Scaling Issues
  - Silica
  - Calcium Fluoride
  - Calcium Sulfate
  - Calcium Phosphate
  - Metals (Fe, Mn, Al, etc)
- Membrane Fouling Issues
  - Particulates
  - Biological
- Other Related Issues
  - Mechanical Pressure Limitation (Max: 1000 psig)
  - Membrane Salt Rejection Requirements (TDS, Total N, P, F, etc)
  - Membrane Life & Replacement Requirements
  - Reject Handling

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Our Approach:

- Utilize Reverse Osmosis at a Low pH
  - Potential Advantages:
    - Rejection of Ammonia as Ammonium Ion
    - Scale control by promotion of soluble chemical equilibrium to prevent calcium sulfate, calcium fluoride and silica scaling
    - Rejection of Phosphates as $H_3PO_4^0$ and $H_2PO_4^-$
  - Overall Technology Goals:
    - High Quality Permeate
    - High Recovery Rate
    - Limited Sludge Generation
    - Use of Reject in Production

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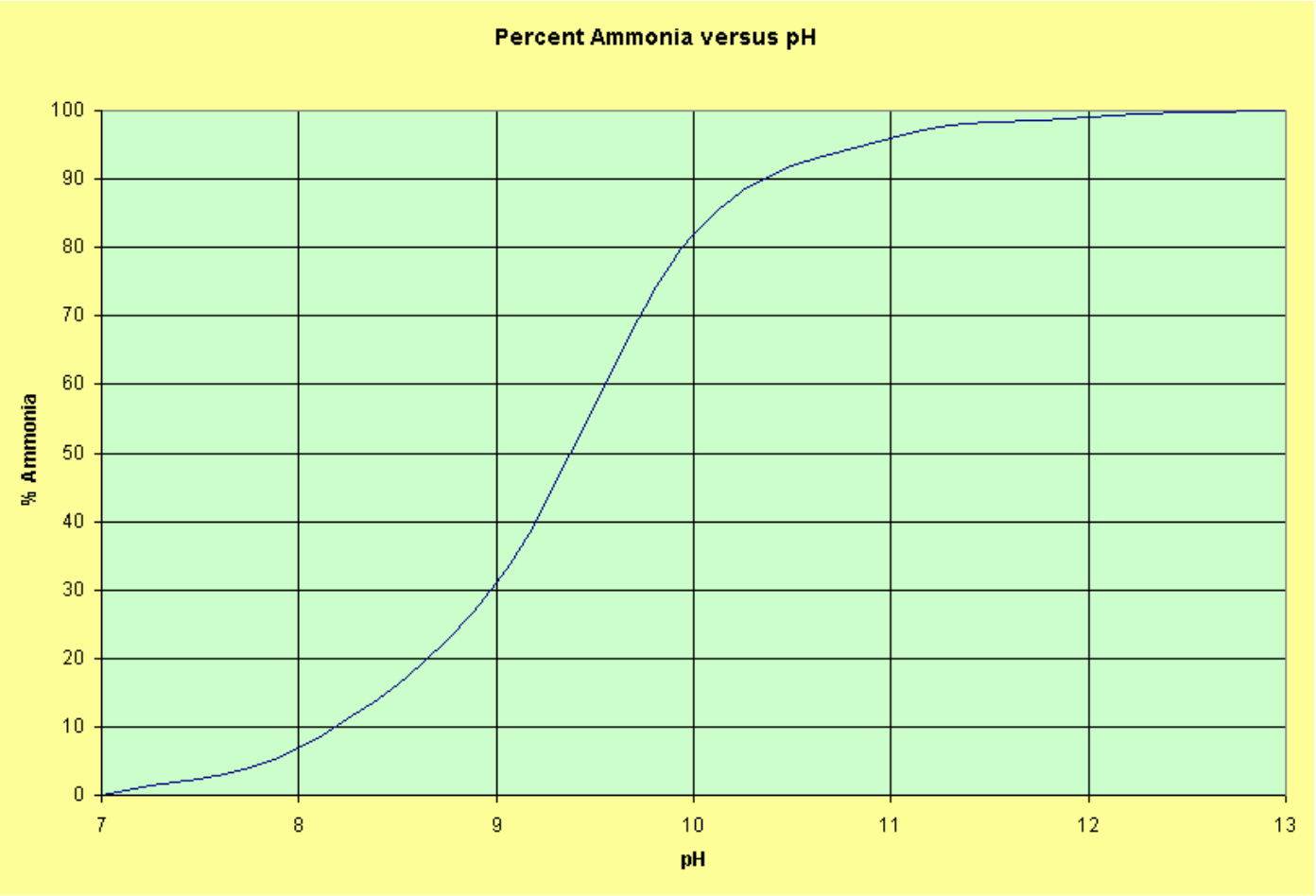
Free Ammonia / Ammonium Ion Equilibrium



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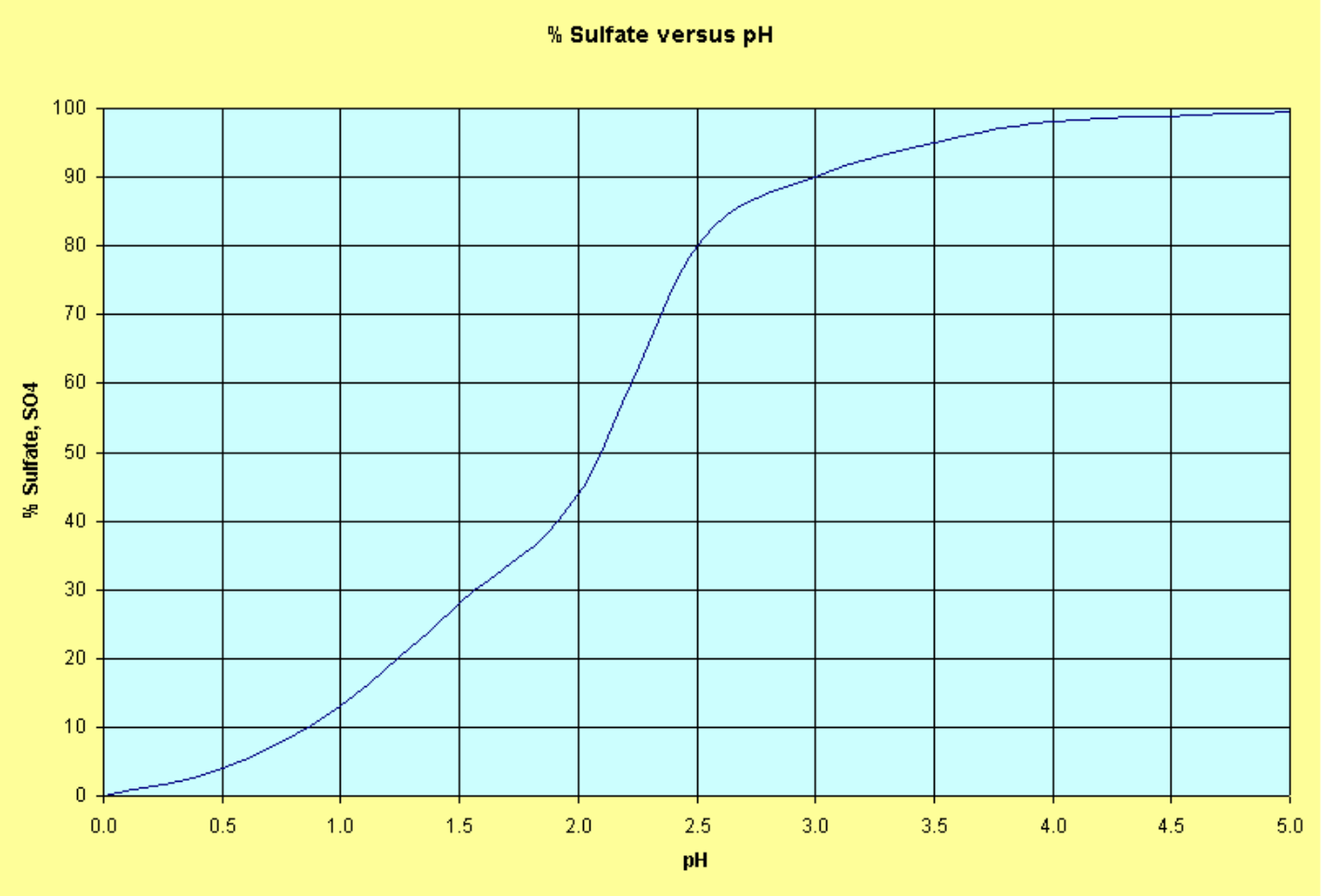
Sulfate/Bisulfate Equilibrium



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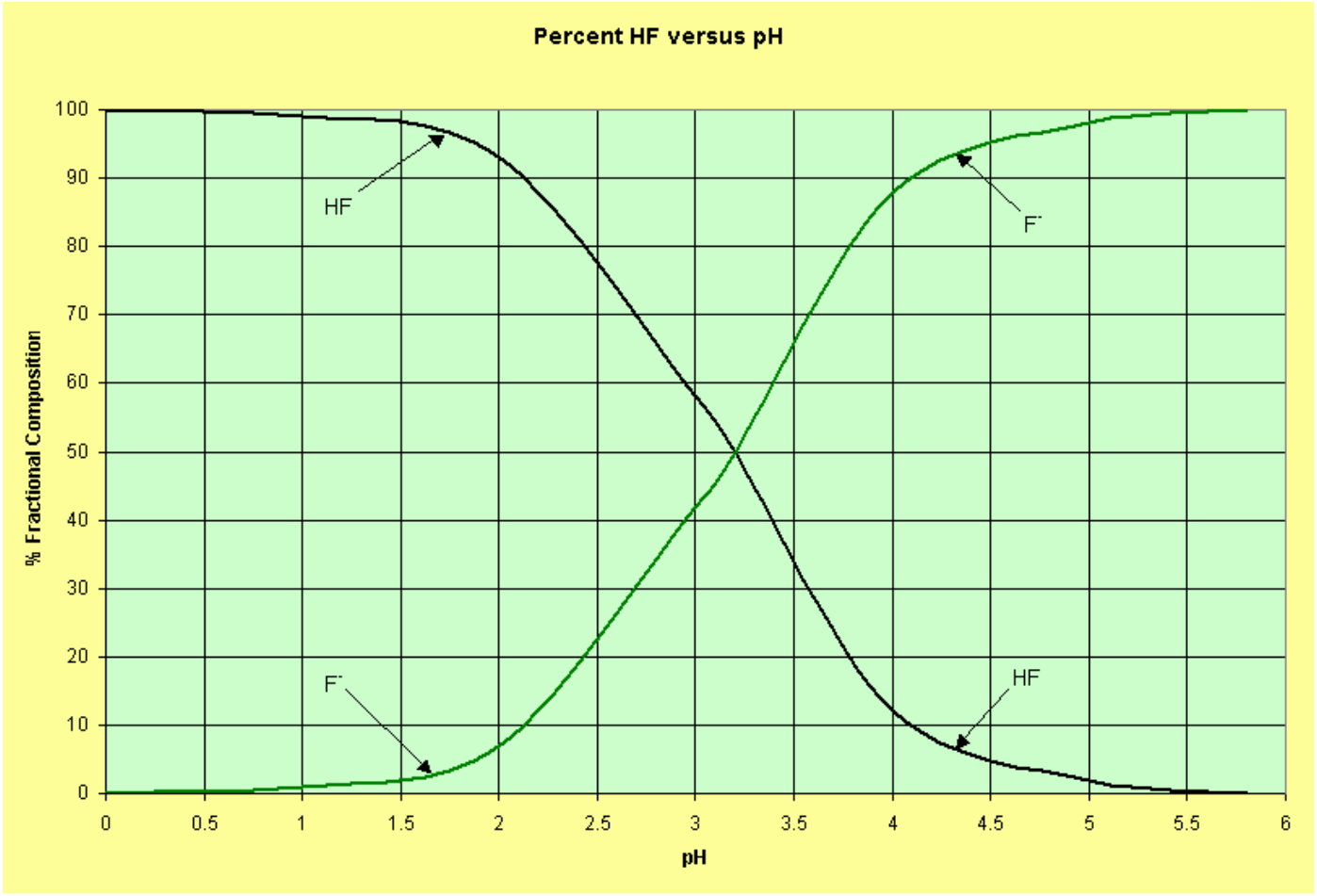
Hydrofluoric Acid / Fluoride Equilibrium



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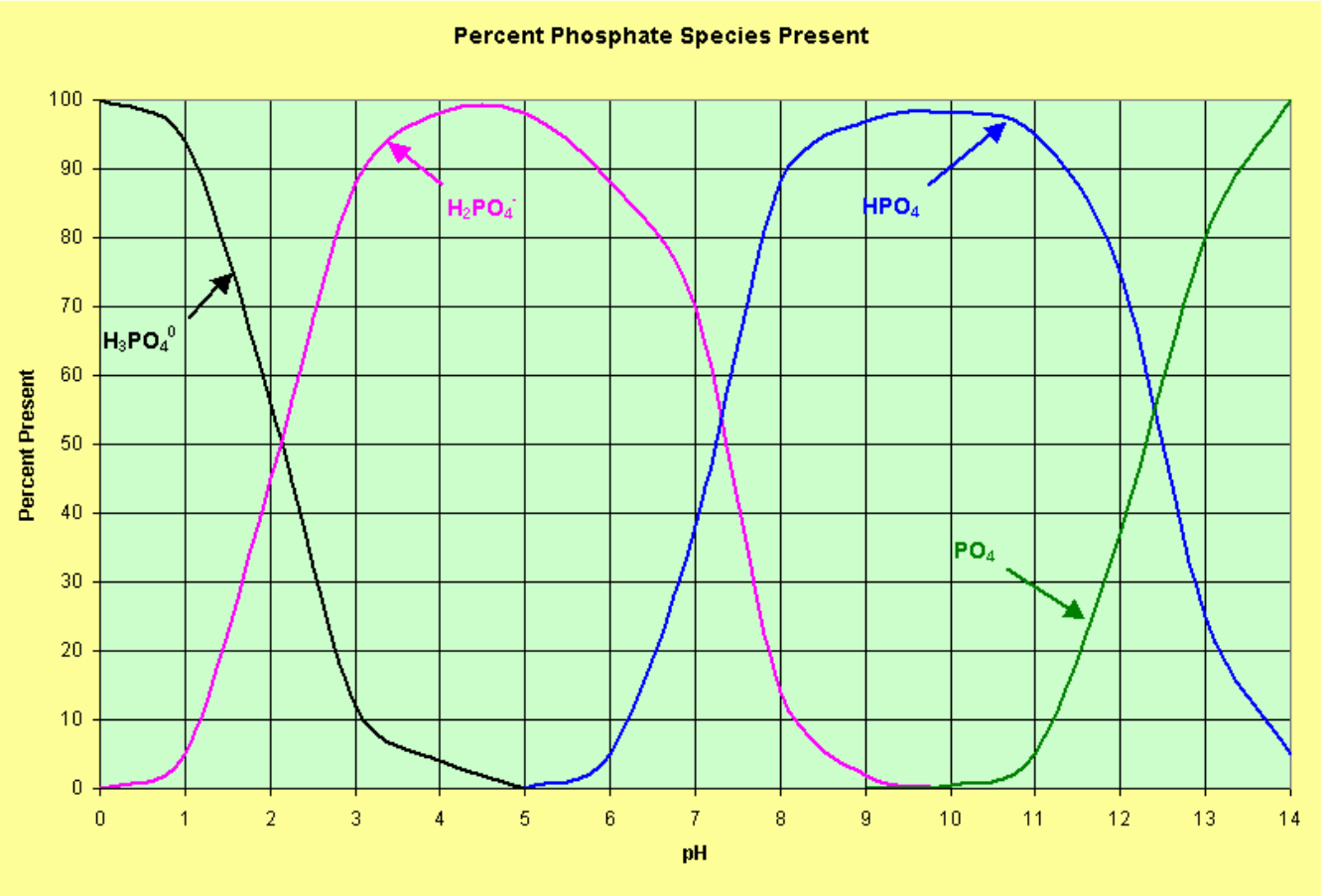
Phosphoric Acid / Phosphate Equilibrium



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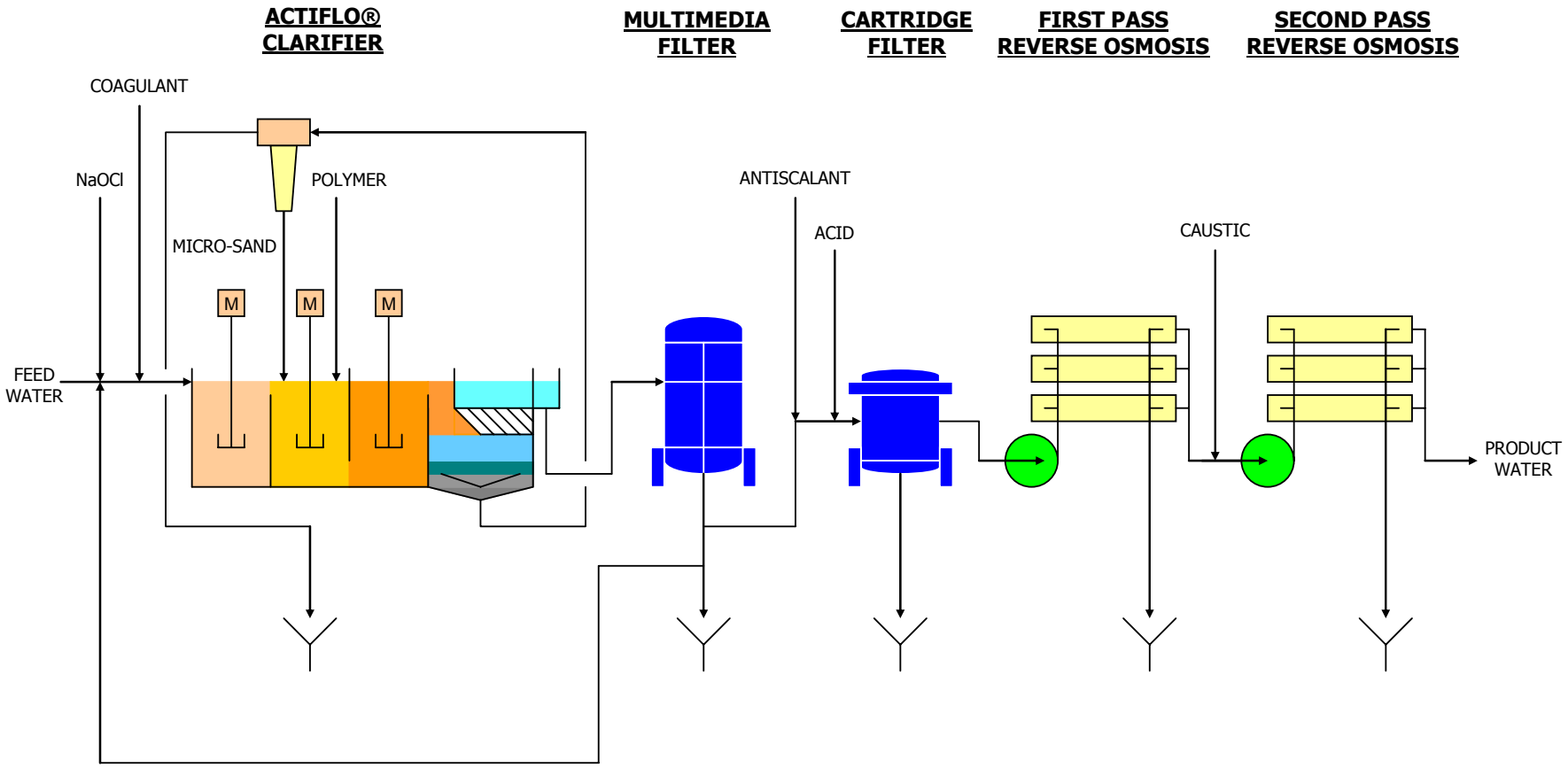
LowpHRO™ Technology *PATENT PENDING PROCESS*



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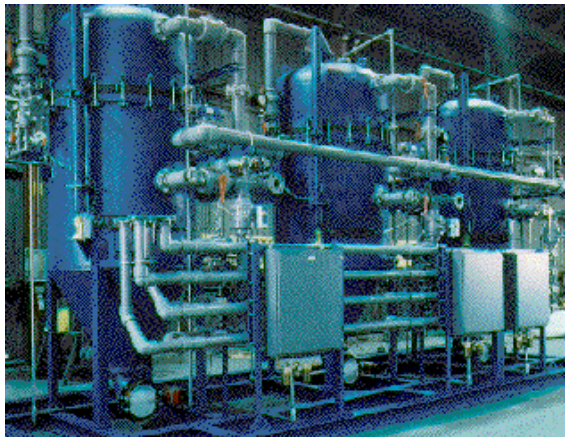
LowpHRO™ Technology Discription

> Technology Discription

- > Proprietary Low pH Coagulation Process
- > High Rate Pretreatment Process
  - Actiflo® Clarification
  - Multimedia & Cartridge Filtration
- > Effective Scaling Control
  - Proprietary Antiscalant Addition
  - Soluble Chemical Equilibrium Promotion
  - 1st Pass RO Operation @ pH < 3.5
  - Interstage Caustic Addition
  - 2nd Pass RO Operation @ pH > 6.0
- > Effective Fouling Control
  - Particulate Fouling
  - Bio-Fouling



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LowpHRO™ Technology Discription

- Technology Discription (cont'd):
  - High Salt Rejection
    - Ammonia > 99%
    - Fluorides > 99.1%
    - Phosphates > 99.9%
    - Sulfates > 99.1%
  - Less CAPEX & OPEX Costs than Double Liming Process
    - 90 ~ 95% Less Alkali Demands
    - 90 ~ 95% Less Solids Generation

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Case Study 1

- Project Location – Florida
- Source Water – Phosphate Pond Water
- Project Discharge Requirements
  - Surface Water Discharge
  - Conductivity < 1,275 µS
  - Ammonia < 30 mg/l
  - Phosphate < 15 mg/l
  - Fluoride < 10 mg/l
- Project Objectives
  - Low Chemical Demand
  - Low Solids Generation
  - High Salt Rejection
  - Low Life Cycle Cost

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Case Study 1 - Influent Quality

CATIONS	CONCENTRATION
CALCIUM, mg/l	716
MAGNESIUM, mg/l	303
SODIUM, mg/l	1,360
POTASSIUM, mg/l	149
ALUMINUM, mg/l	112
BARIUM, mg/l	1.0
STRONTIUM, mg/l	21.0
AMMONIUM, mg/l	101.6

ANIONS	CONCENTRATION
BICARBONATES, mg/l	-
CARBONATES, mg/l	-
HYDROXIDES, mg/l	-
SULFATES, mg/l	4,523
CHLORIDES, mg/l	143
PHOSPHATES, mg/l	18,642
NITRATES, mg/l	5.0
FLUORIDES, mg/l	4,782

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Case Study 1 - Influent Quality

CONSTITUENT	CONCENTRATION
pH, standard units	1.9
TEMPERATURE, deg F	77
T. ALKALINITY, as $CaCO_3$	-
T. Ammonia, as N	130.7
IRON, mg/l	**117.0**
MANGANESE, mg/l	**11.6**
SILICA, mg/l	**1,270**
BORON, mg/l	-

CONSTITUENT	CONCENTRATION
TDS, mg/l	33,063
Conductivity, µS	24,800
TSS, mg/l	**210**
TURBIDITY, NTU	-
TOC, mg/l	**132**
COD, mg/l	-
Total Sulfides, mg/l	-
Total Oil & Grease, mg/l	-

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Case Study 1 - Treatment Challenges

- Membrane Scaling Issues
  - Silica
  - Calcium Fluoride
  - Calcium Sulfate
  - Calcium Phosphate
  - Metals (Fe, Mn, Al, etc)
- Membrane Fouling Issues
  - Particulates (High TSS)
  - Organics (High TOC)
- Salt Rejection Requirements
  - TDS
  - Ammonia
  - Fluoride
  - Phosphate

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Case Study 1 - LowpHRO™ Technology Performance

Constituent	Feed Water	First Pass RO Permeate	Second Pass RO Permeate
TDS, mg/l	33,063	562	< 25
Conductivity, µS	24,800	1,850	< 50
Ammonia, mg/l	102	5.3	< 0.5
Phosphates, mg/l	18,641	208	< 5.0
Fluorides, mg/l	4,782	185	< 5.0
Sulfates, mg/l	4,523	70	< 1.0
Silica, mg/l	1,270	13	< 0.3
Calcium, mg/l	716	7.7	< 0.2
pH, standard units	1.9	2.7	6.5 ~ 7.5

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Case Study 2

- Project Location – South Africa
- Source Water – Coal Mine Water
- Project Discharge Requirements
  - Potable Water Reuse
  - Total Dissolved Solids < 450 mg/l
  - Calcium < 80 mg/l
  - Magnesium < 30 mg/l
  - Sodium < 100 mg/l
  - Chloride < 100 mg/l
  - Sulfate < 200 mg/l
- Project Objectives
  - Low Chemical Demand
  - Low Solids Generation
  - High Salt Rejection
  - Low Life Cycle Cost

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Case Study 2 – Influent Quality

CATIONS	CONCENTRATION
CALCIUM, mg/l	550
MAGNESIUM, mg/l	192
SODIUM, mg/l	108
POTASSIUM, mg/l	11
ALUMINUM, mg/l	33
BARIUM, mg/l	-
STRONTIUM, mg/l	-
AMMONIUM, mg/l	5

ANIONS	CONCENTRATION
BICARBONATES, mg/l	-
CARBONATES, mg/l	-
HYDROXIDES, mg/l	-
SULFATES, mg/l	2,896
CHLORIDES, mg/l	35
PHOSPHATES, mg/l	-
NITRATES, mg/l	10
FLUORIDES, mg/l	1

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Case Study 2 – Influent Quality

CONSTITUENT	CONCENTRATION
pH, standard units	2.7
TEMPERATURE, deg F	71
T. ALKALINITY, as $CaCO_3$	-
T. Ammonia, as N	6.0
IRON, mg/l	**175**
MANGANESE, mg/l	**29**
SILICA, mg/l	**25**
BORON, mg/l	-

CONSTITUENT	CONCENTRATION
TDS, mg/l	4,072
Conductivity, µS	6,000
TSS, mg/l	**475**
TURBIDITY, NTU	-
TOC, mg/l	4
COD, mg/l	-
Total Sulfides, mg/l	-
Total Oil & Grease, mg/l	-

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Case Study 2 - Treatment Challenges

- Membrane Scaling Issues
  - Calcium Sulfate
  - Aluminum Precipitates
  - Iron Precipitates
  - Manganese Precipitates
- Membrane Fouling Issues
  - Particulate (High TSS)
- Salt Rejection Requirements
  - TDS
  - Ammonia
  - Fluoride
  - Phosphate

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Case Study 2.0 - LowpHRO™ Technology Performance

Constituent	Feed Water	Single Pass RO Permeate
TDS, mg/l	4,072	< 90.0
Calcium, mg/l	550	< 8.0
Magnesium, mg/l	192	< 3.0
Sodium, mg/l	108	< 5.0
Chloride, mg/l	35	< 3.5
Sulfate, mg/l	2,896	< 61
Ammonia, mg/l	5.0	< 0.05

N.A. Water Systems

Merits of LowpHRO™ Technology

- High Salt Rejection
  - TDS > 98%
  - Ammonia > 99%
  - Fluorides > 99.1%
  - Phosphates > 99.9%
  - Sulfates > 99.1% %
- Less OPEX Costs than Double Liming Process
  - 90 ~ 95% Less Alkali Demand
  - 90 ~ 95% Less Sludge Generation
- Effective Pretreatment Process for Fouling Control
  - Proprietary LowpH Coagulation Process
  - Effective Removal of Particulates
- Effective Scaling Control
  - Promotion of Soluble Chemical Equilibrium
  - Proprietary Antiscalant Addition
- Reject Waste Re-use for Active Facilities

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