WINWERKS & POWELL ELECTROCOAGULATION

Engineering Case Study

UCSD Can Decrease Cooling Tower Energy and Water Use for Improved Sustainability
Eliminate Makeup Water Purchases & Blowdown Wastewater Treatment - A Turnkey Solution

New uses and benefits from campus and city sanitary and storm sewers

Target: To develop a turnkey design build program for Cooling Tower (CT) make up water and blowdown at 3 campus plants: West Campus Central Utilities Plant, East Campus Hospital and Scripps Hillcrest Hospital to save money and increase sustainability.

Example: For UCSD campus recycle 126.5 MGY of sewer water as "SOFT" cooling tower makeup water (vs. use of "HARD" City of San Diego Potable or Recycled Water), increase the cycles of concentration from 6 to 46 and eliminate or significantly reduce blowdown wastewater discharge by > 60 MGY (95%). Eliminate water treatment chemical use to prevent scaling and biofouling.

Rationale: UCSD is growing with constrained budgets. Sustainability goals include "Zero waste by 2020, carbon neutrality by 2050 (emitting Net Zero greenhouse gases), 20 percent reduction in growth-adjusted potable water consumption by 2020 and 36 percent by 2025". , WinWerks uses the ***patented & proven Powell Electrocoagulation system to pretreat and recycle in street sewer water as makeup water, recycle and reduce blow down water by 95% to lower water use by 35%.*** Under proposed designs, minimize reclaimed water purchases and sanitary sewage discharge fees.

- **Wastewater Reclamation Physical Plants:** Equipment trains fits in small footprints, 2,500 sf buildings for the electrocoagulation machines plus outside area for water clarification and mulch loading.

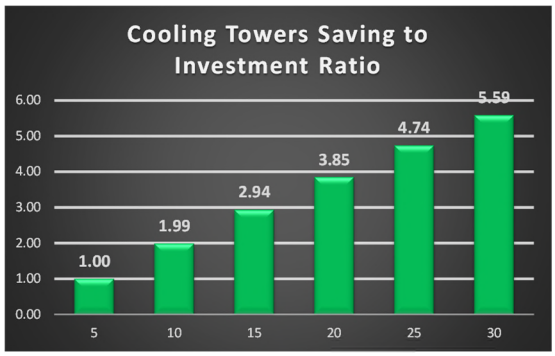
- **Electrocoagulation (EC)** technology, proven and patented, cleans water by coagulating pollutants and oxidizing toxic metals and chemicals to acceptable limits for industrial reuse. Kills 99.999 pathogens, removes heavy metals like Arsenic, Mercury, Cobalt and Vanadium, silicas, Fats, Oil, Grease (FOG) and phosphates.

- **Electrocoagulation meets** EPA requirements for Maximum Contaminant Level (MCL) limits.

- **Patented Technology**: Powell Water Systems has developed, patented and proven its wastewater Electrocoagulation system to *"electrocute dirty water clean"* and kill pathogens to log 5 standards (99.99%). EC operates on 175 sites across the world, from 1.5 to 1000 GPM systems, with Samsung, El Paso Electric, Chevron, Boeing, US Army, Intel and Tyson Foods representing its client list. Hydro, OK Wastewater Treatment Plant is a good site for tours.

- **Delivery by turnkey design build** with optional own and operate

Financial Projections: Shown in graph of Savings-to-Investment Ratio- Reclaimed Makeup Water purchased at $1.73/ HCF & Wastewater discharge at $4.55 HCF eliminated; Five-year 5% discounted payback, 30- year life



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UCSD Cooling Tower Electrocoagulation Wastewater Treatment – A Solution Description

WinWerks and Powell Water will and can provide the solution at all three campus cogeneration plants.

Electrocoagulation System (EC) for Main Plant Cooling Towers

46 Cycles of Concentration vs. 3.1
Saves 36% of makeup water

600 GPM EC Machine
Treats water to xx

Clarifier Options – Makeup water and recycled solids to mulch

Saturated blowdown to storm sewer, mitigated NaCl

Electrocoagulation System Highlights for UCSD

Electrocoagulation

Over 175 locations, 35-year history

Patented and Proven

Electrocoagulation (EC) -

"Electrocutes dirty water, clean"

Meets 175 ppm MCL

Pretreat Water Inputs and Reclaim Water

Repurpose Wastewater Solids

Reduced chemicals and biocides

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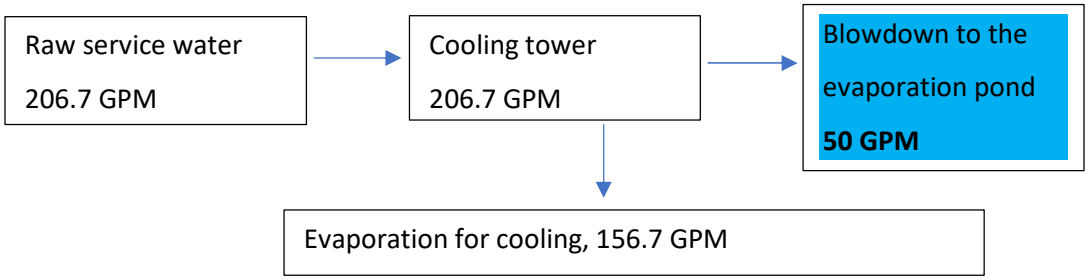
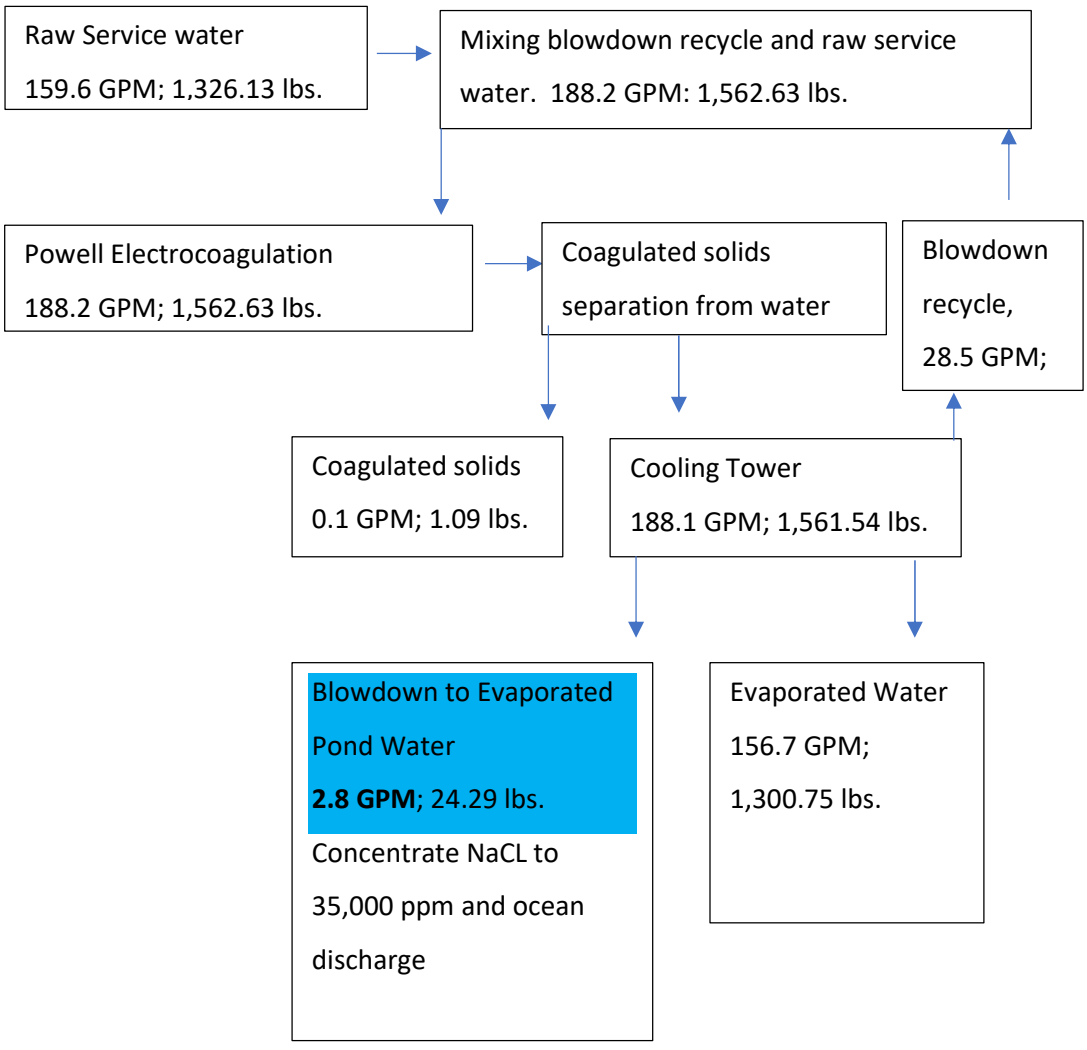
By treating the incoming water with Powell electrocoagulation, the process separates the silica, phosphate, calcium carbonate, and magnesium carbonate as coagulated solids before going to the cooling tower. With reduced scaling (hardness and silicas), the cooling tower cycles can increase from 3-4 to over 50 cycles and improves heat transfer.
Value= Recycled Water, lower blowdown disposal costs, no chemicals, and kills harmful legionella bacteria, the cause of Legionnaires' disease and microbial activity and slime. Extends cooling tower life and increases operating efficiencies.
Current example:



Proposed Powell electrocoagulation example:



WINWERKS & POWELL ELECTROCOAGULATION

"30 Years of EFFECTIVE, RELIABLE, SAFE Wastewater Applications"

Treating Cooling Tower make-up and blowdown water with Electrocoagulation (electrocuting wastewater streams) offers a very safe, economical and environmentally qualified water treatment for meeting discharge standards and compliance requirements. Recover water, capital and operating costs by eliminating discharge fees, increasing cycles of concentration to conserve water, and significantly reducing water replacement costs. No maintenance chemicals needed. Send treated wastewater to storm drains and capture NaCl for industrial reuse.

Design Build & P3 Delivery

Contaminants Removed	Percentage of Removal
TSS (Clay, silt, silica, etc.)	99%+
Bacteria	99%
BOD 5	98%+
Viruses like Legionnaires	99%+
Fats, Oils, Grease	93-99%+
Heavy Metals	95-99%+
Phosphates	99%+
Water from Sludge	50-80%+

1.5 GPM to 60 M+ GPD

System Capabilities

Removes heavy metals and pass TCLP
Removes suspended and colloidal solids & silicas
Destroys & removes bacteria, viruses, and cysts
Breaks oil emulsions in water
Removes fats, oil, and grease
Increase Cycles of Concentration, up to 15 times
Processes multiple contaminants, simultaneously
Flexible to meet changing influent water
Designed to meet discharge standards
Recycled water enhances overall water use efficiency

Facts & Benefits

- Turnkey delivery, single point of responsibility
- Extend cooling tower life, substantially
- Recognized green building practice
- Over 150 electrocoagulation installs: consistent and reliable results
- Proven; University & Case Studies, White Papers
- Low operating and maintenance costs
- Low power requirements & minimal operator attention
- No chemical or biocides
- Handles a wide variation in the waste streams
- Sustainability; reduce sludge, energy and landfill use
- Treats multiple contaminants & concentrates NaCL (salts)
- Water reuse- resulting in near zero liquid discharge

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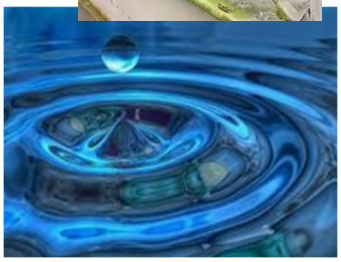
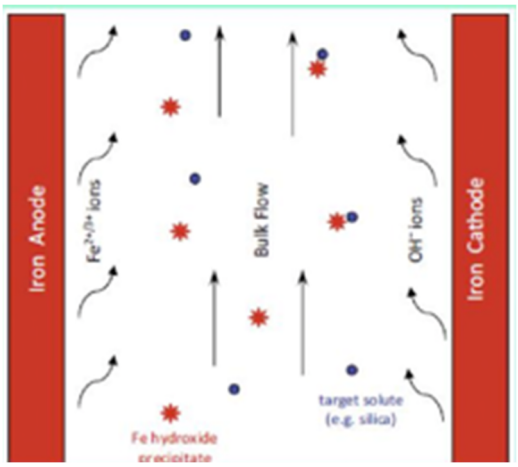
Cooling Tower Makeup and Blowdown Water Technology Process

www.winwerksipd.com/electrocoagulation-facts

Electrocoagulation (EC) has been in existence for decades with the first patent issued in 1906. However, only during the past 30 years has the process been fully commercialized as a result of Powell Water technological advancements to overcome the deficiencies of previous systems. Treating cooling tower (CT) makeup water and blowdown water with Powell electrocoagulation prevents scaling by separating the silica, phosphate, calcium carbonate, and magnesium carbonate as coagulated solids before going through the cooling tower. Cooling tower cycles of concentration can increase from 3 or 4 to 20 -60 times more cycles. Salts can be concentrated to 35,000 ppm and eventually sent down storm drains to the sea or sanitary sewer. Kills Legionella bacteria, the cause of Legionnaires' disease.
Extends Cooling Tower life increases cooling efficiency and lowers maintenance costs.



Electrocoagulation] utilizes direct current to cause sacrificial electrode ions. to remove undesirable contaminants either by chemical reaction and precipitation or by causing colloidal materials to coalesce and then removed by electrolytic flotation. Powell's patented and proven electrochemical system copes with a variety of wastewaters. These waters can originate from cooling towers, coal utility plants, paper pulp mill waste, metal plating, tanneries, canning factories, steel mill effluent, slaughterhouses, or PWWTP. Silicas, sand, chromate, boron, arsenic, lead and mercury laden effluents, as well as domestic sewage are treated. These wastewaters become clear, clean, odorless and reusable water, often better than the raw water."[1]



In the Electrocoagulation process, the electrical current is introduced into water via parallel plates constructed of various metals that are selected to optimize the removal process. The two most common plate materials are iron and aluminum. In accordance with Faraday's Law, metal ions will be split off or sacrificed into the liquid medium. 'these metal ions tend to form metal oxides that electromechanically attract to the contaminants that have been destabilized.
The unit also contains an air purge system to fluidize precipitates, polarity reversing to extend blade life and prevent contaminants from coating the blades, and an automated clean-in–place system. The acid solution used in the automated cleaning cycle is recycled and, when exhausted, it is routed through the EC system for final disposal. Frequency, every 4-6 hours, 20-minute cycle or less.

No chemicals are required for the treatment process. Solids are removed by filters or clarifiers with water available for reuse or discharge.

EC System Footprint

EC Train Options:
10 GPM - 24' long x 8' wide x 8' high trailer with clarifier
50 GPM - 7' x 7' x 7' skid
600 GPM -17' long x 12' wide x 20' high Mezzanine

(1) Eckenfelder, W.W. and Cecil, L.K. "Applications of New Concepts of Physical-Chemical Wastewater Treatment." Vanderbilt University; Nashville, TN: Pergamon Press, Inc.

Powell Water Systems Installations
WinWerks IPD Contact Development Services

EC Efficacy: Metals, Ions, Solids, Hardness, Bacteria, Radioisotopes, and Turbidity

Contaminant	Before (mg/l)	After (mg/l)	Removal Rate %
Aldrin (pesticide)	0.063	ND (0.001)	**98**
Aluminium	224	ND (0.7)	**99+**
Ammonia	49	19.4	**60**
Arsenic	0.076	ND (<0.002)	**97**
Barium	0.014	ND (<0.001)	**93**
Benzene	90.1	0.36	**99+**
BOD5	1,050	14	**98**
Boron	4.86	1.41	**70**
Cadmium	0.125	ND (<0.004)	**96**
Calcium	1,321	21.4	**98**
Chlorpyriphos	5.87	ND (0.03)	**99+**
Chromium	139	ND (<0.1)	**99+**
Cobalt	0.1238	0.0214	**82**
Copper	0.7984	ND (<0.0020)	**99+**
Cyanide (free)	723	ND (<0.02)	**99+**
Cypermethrin	1.3	0.07	**94**
DDT	0.261	0.002	**99+**
Diazinon	34	0.21	**99+**
Ethyl Benzene	428	0.372	**99+**
Fluoride	1.1	0.415	**62**
Gold	5.72	1.38	**75**
Iron	68.34	0.19	**99+**
Lead	0.59	0.0032	**99+**
Lindane	0.143	ND (0.001)	**99+**
Magnesium	13.15	0.04	**99+**
Manganese	1.061	0.018	**98**
Mercury	0.72	ND (<0.003)	**98**
Molybdenum	0.35	0.029	**91**
MP-Xylene	41.6	0.057	**99+**
MTBE	21.58	0.0462	**99+**
Nickel	183	0.07	**99+**
Nitrate	11.7	2.6	**77**
Nitrite	21	12	**42**
Nitrogen TKN	1,118	59	**94**
NTU	35.38	0.32	**99**
O-Xylene	191	0.416	**99+**
PCB	0.0007	ND (<0.0001)	**85**
Petro Hydrocarbons	72.5	ND (<0.2)	**99+**

Contaminant	Before (mg/l)	After (mg/l)	Removal Rate %
Phosphate	28	ND (0.2)	**99+**
Platinum	4.4	0.68	**84**
Potassium	200	110	**45**
Propetamphos	80.87	0.36	**99+**
Selenium	68	38	**44**
Silicon	21.07	ND (0.10)	**99+**
Sulfate	104	68	**34**
Silver	0.0081	0.0006	**92**
Tin	0.213	ND (<0.020)	**90**
Toluene	28,480	0.227	**99+**
TSS	1,560	8	**99+**
Vanadium	0.262	ND (<0.002)	**99+**
Zinc	221	0.140	**99+**

Bacteria	Before (cfu)	After (cfu)	Removal Rate %
Bacteria	110,000,000 cfu	2,700 cfu	**99+**
Coliform	318,000,000 cfu	ND (<1) cfu	**99+**
E. coli	>2,419.2 mpn	ND (<0.01) mpn	**99+**
Enterococcus	83 mpn	ND (<10.) mpn	**82**
Total Coliform	>2,419.2 mpn	ND (<0.1) mpn	**99+**

Radioisotopes	Before (pCi/L)	After (pCi/L)	Removal Rate %
Americium-241	71.99 pCi/L	0.57 pCi/L	**99+**
Plutonium-239	29.85 pCi/L	0.29 pCi/L	**99+**
Radium	1093.pCi/L	0.10 pCi/L	**99+**
	Before mg/L	**After mg/L**	
Uranium	0.13 mg/L	0.0002 mg/L	**99+**

Dyes	Before (NTU)	After (NTU)	Removal Rate %
Ref. 006-691	125.1	12.1	**90**
Ref. 006-692	129.4	2.2	**98**
Ref. 006-854	68.30	0.68	**99+**
Ref. 006-851	2,340	4.5	**99+**

Notes: ND = Not Detected at the Reporting Limit mg/l = milligram per liter or part per million pCi/L = picocuries per liter

Powell Water Systems Installations
WinWerks IPD Contact Development Services

Alcan–Canada • Alcan International Limited–Canada • Alfa Appliance Service–Colorado • Anadarko Petroleum–Wyoming • Apex Processing Systems–Australia • Aquamanzi–California • Associated Plating–California • AWES–Colorado • BacTee Systems–North Dakota • Barreto Manufacturing–Oregon • BASX Systems–Colorado • Beckley Water Company–West Virginia • Beijing Wall Investment–China • Ben Gerker Company–Missouri • Boeing–Arizona • Brian Collins–United Kingdom • Burlington Engineering–California • Carige Water Technology–Puerto Rico • Chautauqua Hardware–New York • Chevron Energy Technology Company–California • Christ Water USA–Intel–Washington • CleanWaters LTD–Korea • Colorado Energy Management–New Mexico • Compañía Chilena de Tabacos S.A.–Chile • Conoco Phillips–Oklahoma • Consolidated Meats Group–Australia • Dong Lim Industrial–Korea • Doosan Industrial Development–Korea • E.A.R.T.H / I.M.S.E (Division) - Kingdom of Saudi Arabia • Ethan Allen Coachworks–Vermont • EC System (Thailand) Co–Bangkok • EC&P–Korea • Eco Dewell International–Arizona • EcoGeo International–South Korea • El Paso Electric Company–Texas • Electro Chemical Finishing–Michigan • Emerald Performance Materials–Wyoming • Environmental Solutions & Products–Indiana • ES3–Utah • Fontaniva Bonifico –Italy • Flagship Ecosystems Pte Ltd–Singapore • George A. Bull, Jr–Illinois • Gerber Pumps International–Florida • Golden Star Technology–California • Golder Associates Inc – Colorado • Hyannis Car Wash–Massachusetts • I G B Vetsch AG–Switzerland • Ilen Seafoods–Ireland • Indland Empire Oilseeds–Washington • Integralsa SA–Mexico • Intel–Oregon • International Dehydrated Foods–Missouri • J C Engineering Consultant–Taiwan • Joe's Plating–California • Joyner's Die Casting & Plating–Minnesota • Kent Troup–New York • KVF–Quad–Illinois • Lawrence Livermore National Labs–California • LIG–Korea • Metal Preparations Co–New York • Natural Environmental Systems–Missouri • Natural Systems–California • NEAT Environmental Inc–Canada • New Century Water–California • New China Limited–Texas • Newalta Corporation–Canada • Office of Naval Research–Virginia • Peagasus Environmental Group–Washington • Piedras Negras–Mexico • Production Plating–Washington • Quantum Ionics–Florida • RAK Gas Commission–UAE • REW Nukem–South Carolina • Rhapsody Environmental–California • Rich–Aqua Environmental–Taiwan • Sam–Chang Foundry–Korea • Sammis Oil and Gas–Canada • Samsung SDI Cheonan–Korea • Samsung SDI Pusan–Korea • San Antonio Trade Group–Texas • Santa Clara Waste Water–California • Separation Process Technologies–Japan • Shihlin Electric & Engineering Corp–Taiwan • Southern California Water Company– California • Spence Electro Plating–California • SUMCO Oregon Corp–Oregon • Sumco USA Cincinnati Division– Ohio • Sustainable Industrial Development–Pakistan • Tecprosol International C. A. • Ted Bozarth–Texas • Terra–Magic–Oregon • The Art Alliance–Florida • Tom Beckwith International–California • Troop Environmental Alternatives–New York • TSS Filtration Services–Texas • Tyson Fresh Meats–South Dakota • U S Army Research–Pennsylvania • UCO–California • Ultra Wheel Company–California • United States Navy–California • Universal Systems–Oregon • Uxmal–Mexico • Vermont Organics Reclamation–Vermont • Wastech International–New Hampshire • Wastewater Treatment Associates–Colorado • Water & Power Technologies Inc–Utah • Water Solutions–Oregon • Water Systems Integrators–Colorado • Western Finance & Lease–North Dakota • William Long Sales–Michigan • WMC Corp–Ontario • World Water Works–New York

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