Water Electrodialysis Reversal Pilot
DE-FE0032066

Matthew Heermann, PE (IL)
Sargent & Lundy, Water Treatment Consultant

U.S. Department of Energy
National Energy Technology Laboratory
Resource Sustainability Project Review Meeting
October 25 - 27, 2022

Agenda

- Project Overview
- Technology Background
- Technical Approach/Project Scope
- Progress and Current Status of Project
- Plans for Future Testing, Development, and Commercialization
- Project Summary

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Project Overview

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DE-FE0032066: Water Electrodialysis Reversal Pilot

- Overall Project Objective:
  - The objective of this project is to complete initial testing of a pilot-scale electrodialysis system to inform a conceptual industrial-scale design of an electrodialysis system for application at an existing coal-fired generation station.
- Budget:
  - Total: $1,025,000
  - DOE: $817,000
  - Nebraska Public Power District: $208,000
- Period of Performance:
  - July 2021 – April 2023

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Project Overview

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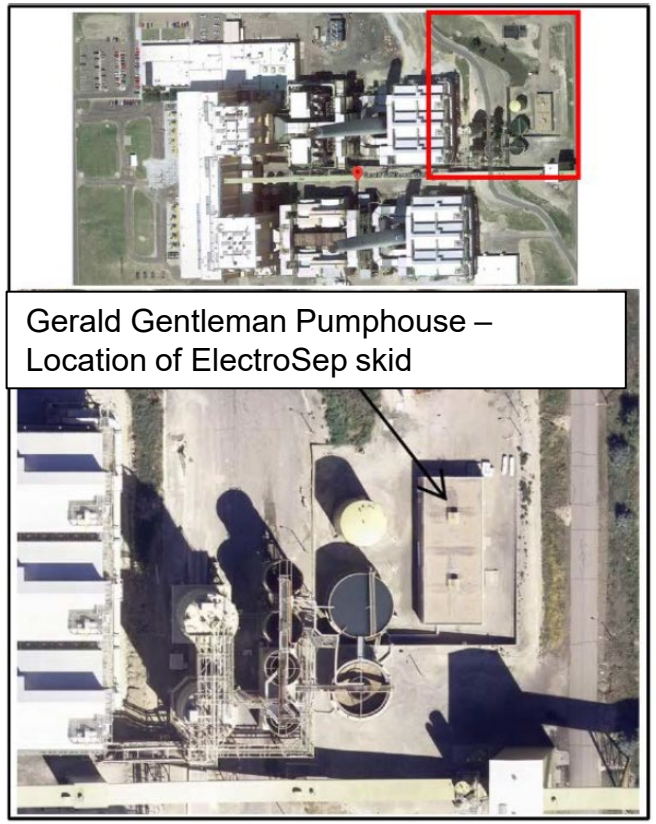
Nebraska Public Power District – Gerald Gentleman Station

- Location:
  - Sutherland, NE
- Facility Type:
  - 2 Pulverized Coal Steam Electric Generating Units
  - Fires Subbituminous Fuel
- Selected due to a desire to find a cost-effective technology to reduce wastewater flow to the existing evaporation pond



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Project Overview

Water Electrodialysis Reversal Pilot Team

U.S. Department of Energy
National Energy Technology Laboratory

ION Clean Energy
(Lead Institution)
- Project Management and Communication with all relevant stakeholders on status and results
- Complete DOE Deliverables: TEA, EH&S Risk Assessment, Technology Maturation Plan

ElectroSep, Inc.
(Subcontractor - EDR Technology Provider)
- Process design & costing for EDR pilot
- Fabrication of EDR pilot system

Sargent & Lundy, LLC
(Subcontractor - Engineering)
- Techno-economic Analysis
- Commercialization Plan

Nebraska Public Power District
(Host Site)
- Installation of EDR pilot and pretreatment system
- Operation support during test campaign
- Pilot stream sampling and analysis
- Decommissioning of the pilot system

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Technology Background

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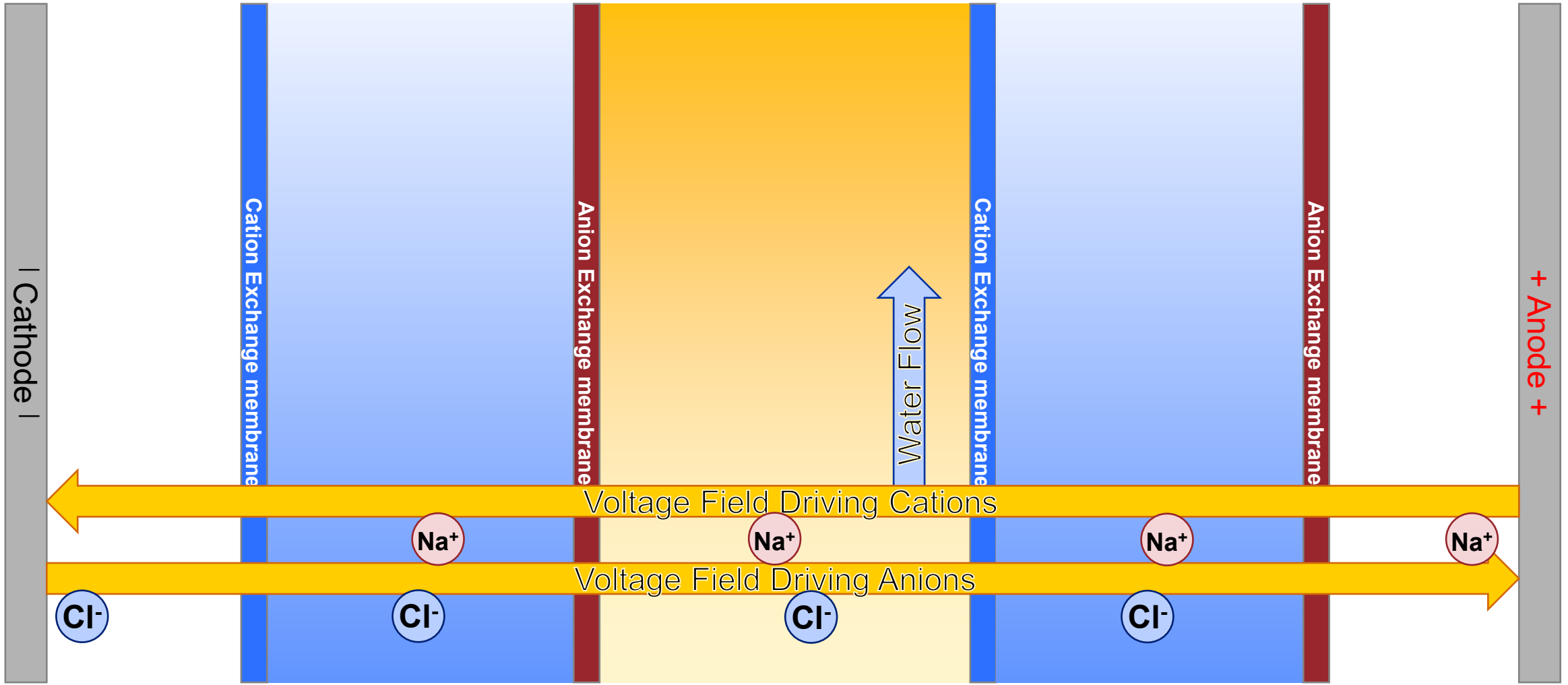
Water Electrodialysis Reversal



Technology Background

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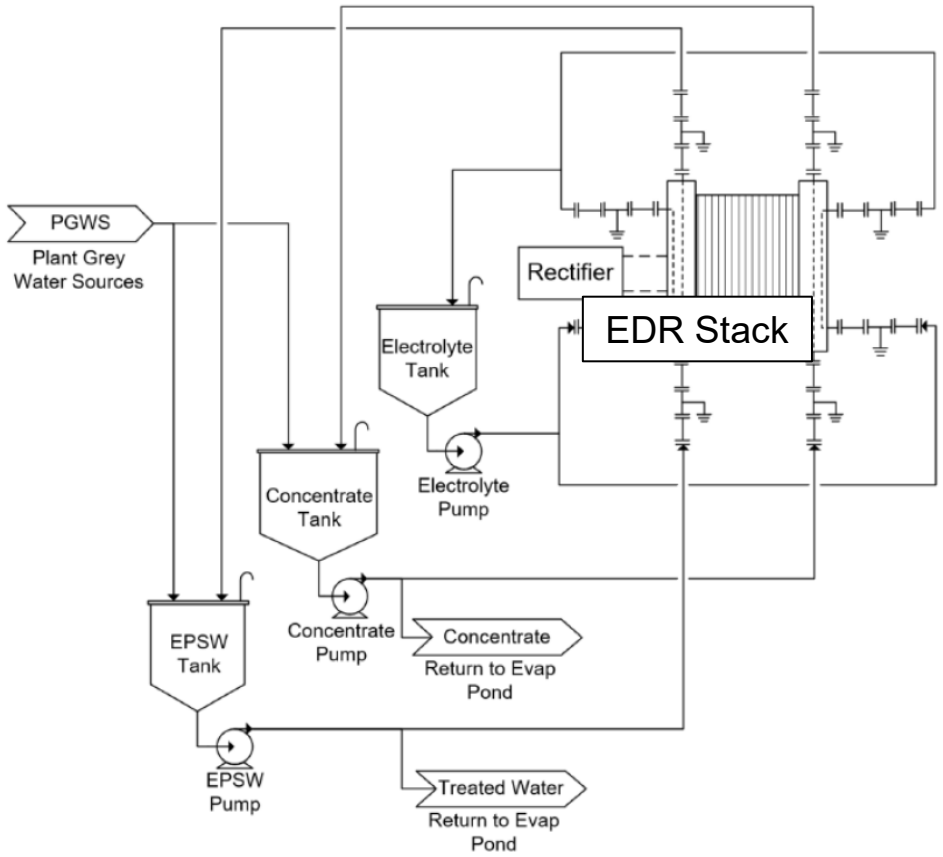
Water Electrodialysis Reversal

- Ions are moved from the product stream to the concentrate stream inside the stack.
- This process concentrates the wastewater and recovers purified water in a manner that does not require the energy of thermal distillation.
- Advantages:
  - Lower energy requirement than thermal desalination
  - More tolerant to scale than reverse osmosis
  - Higher maximum concentrate concentration and water recovery than reverse osmosis
- Challenges:
  - Not optimized for lower feed conductivity (driver for pilot testing)
  - Cannot remove non-ionic species (such as dissolved gases)
  - Water softening may be required due to the precipitation of calcium at high concentrations



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Technology Background

Water Electrodialysis Reversal Compared to Thermal Desalination

- Electrodialysis Reversal
  - Water does not change phase
    - Lower energy cost per unit volume purified
  - The voltage reversal step mitigates the deposition of scale on membrane surface
    - Lower maintenance due to scale
  - Materials of construction do not have to contend with high TDS and Temperature
    - Lower Capital Cost
- Thermal Brine Concentrator
  - Water is vaporized
    - High energy cost of heat of vaporization
  - Local conditions within the concentrator may be above saturation (scaling)
    - Requires greater maintenance labor for cleaning
  - Materials of construction must be suitable for high TDS and Temperature
    - Higher Capital Cost

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Technical Approach/Project Scope

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Technical Approach/Project Scope

Project Scope and Key Milestones

- Prepare Preliminary TEA, and Technology Maturation Plan
- Develop Test Plan
- Develop EDR Pilot Conceptual Plan
- Install and commission pretreatment system
- Install and commission EDR pilot
- Operate pilot test and record data
- Final data evaluation and reporting
- Develop Final TEA, Technology Gap Assessment, and Commercialization Plan

Milestone Title / Description	Completion Date
Kickoff Meeting	07-14-2021
EDR Pilot Factory Pre-test	07-22-2022
Pretreatment System Installation	09-02-2022
EDR System Installation	09-09-2022
Pilot Operation Start	09-19-2022
Pilot Operation End	10-28-2022
Technology Gap Assessment	12-30-2022
Technoeconomic Analysis	01-26-2023
Commercialization Plan	04-20-2023

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Progress and Current Status of Project

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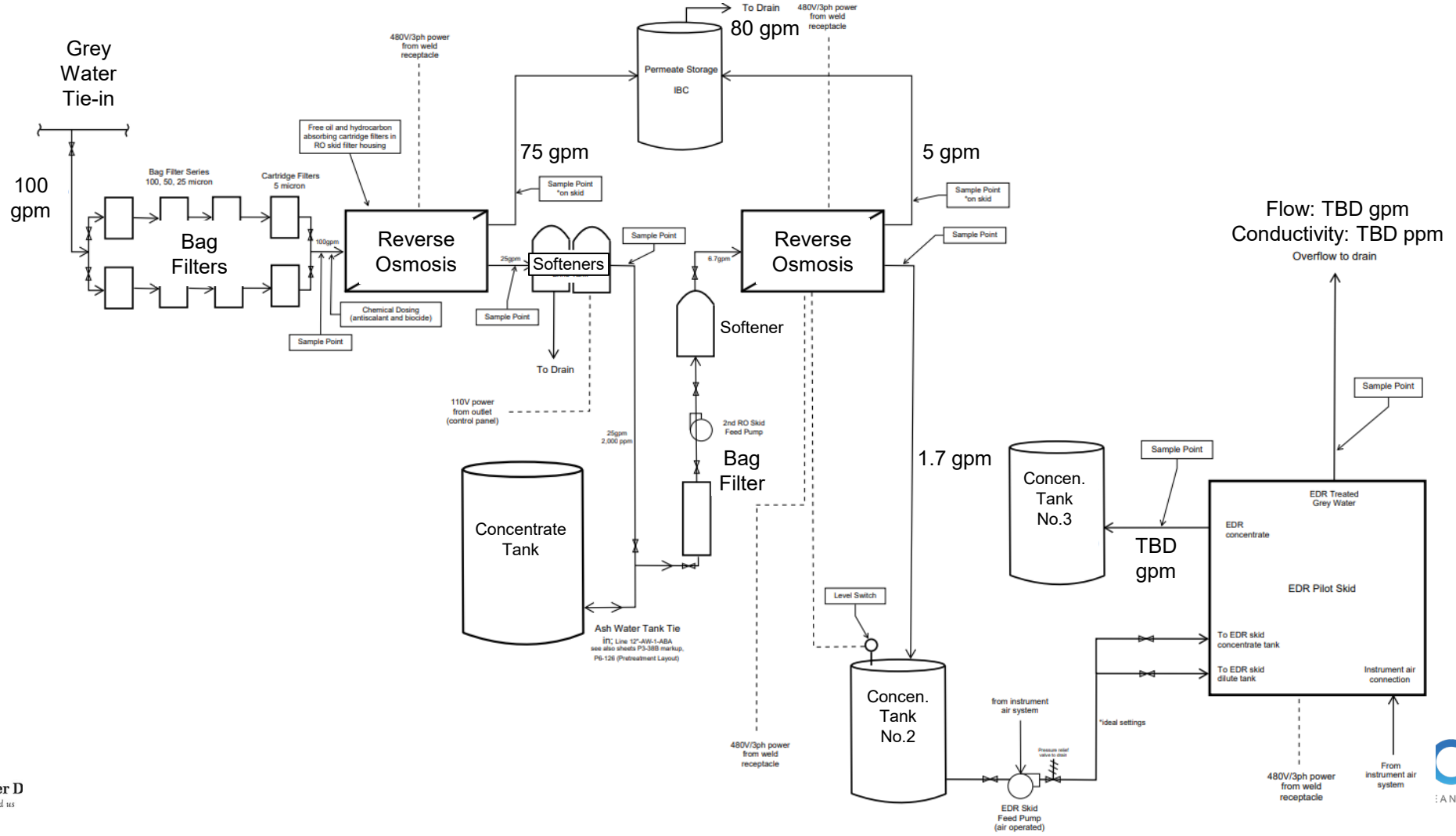
Pilot System Process Flow Diagram



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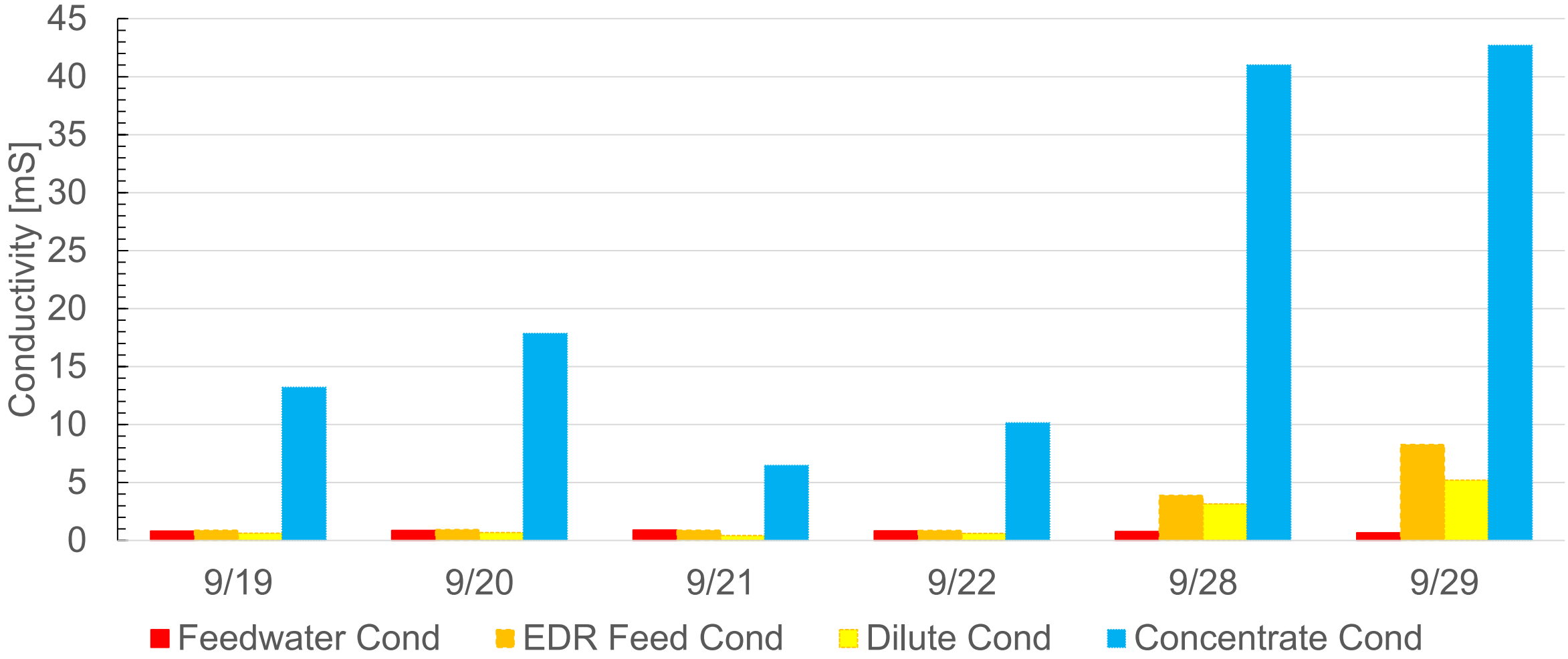
Progress and Current Status of Project



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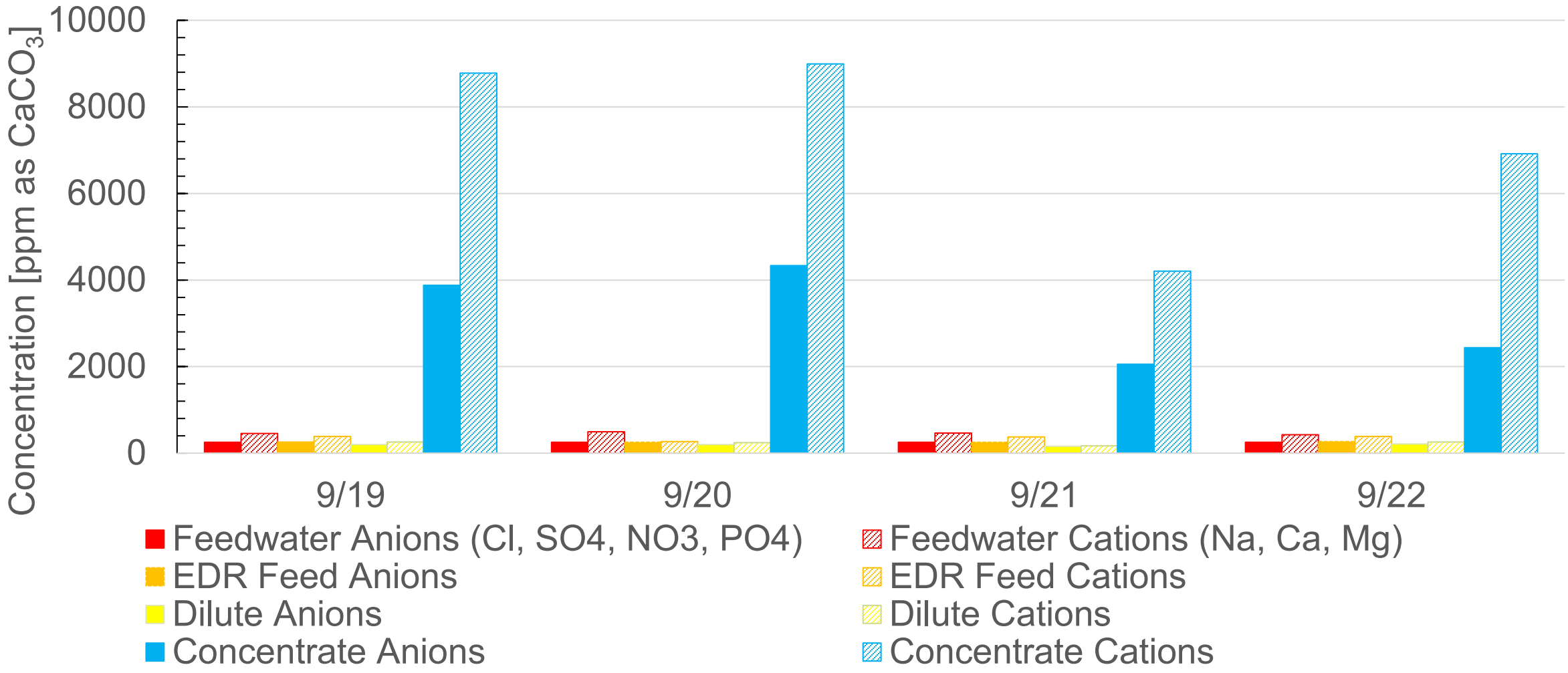

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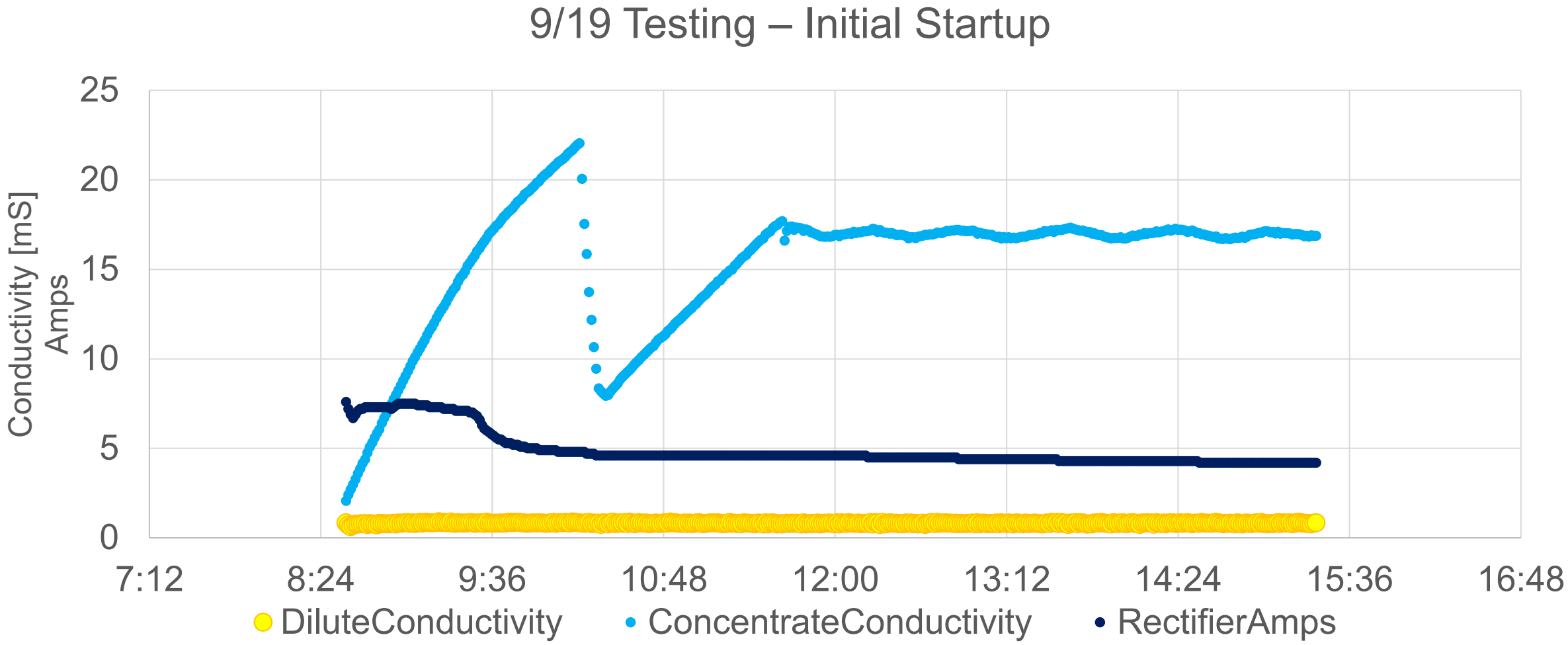

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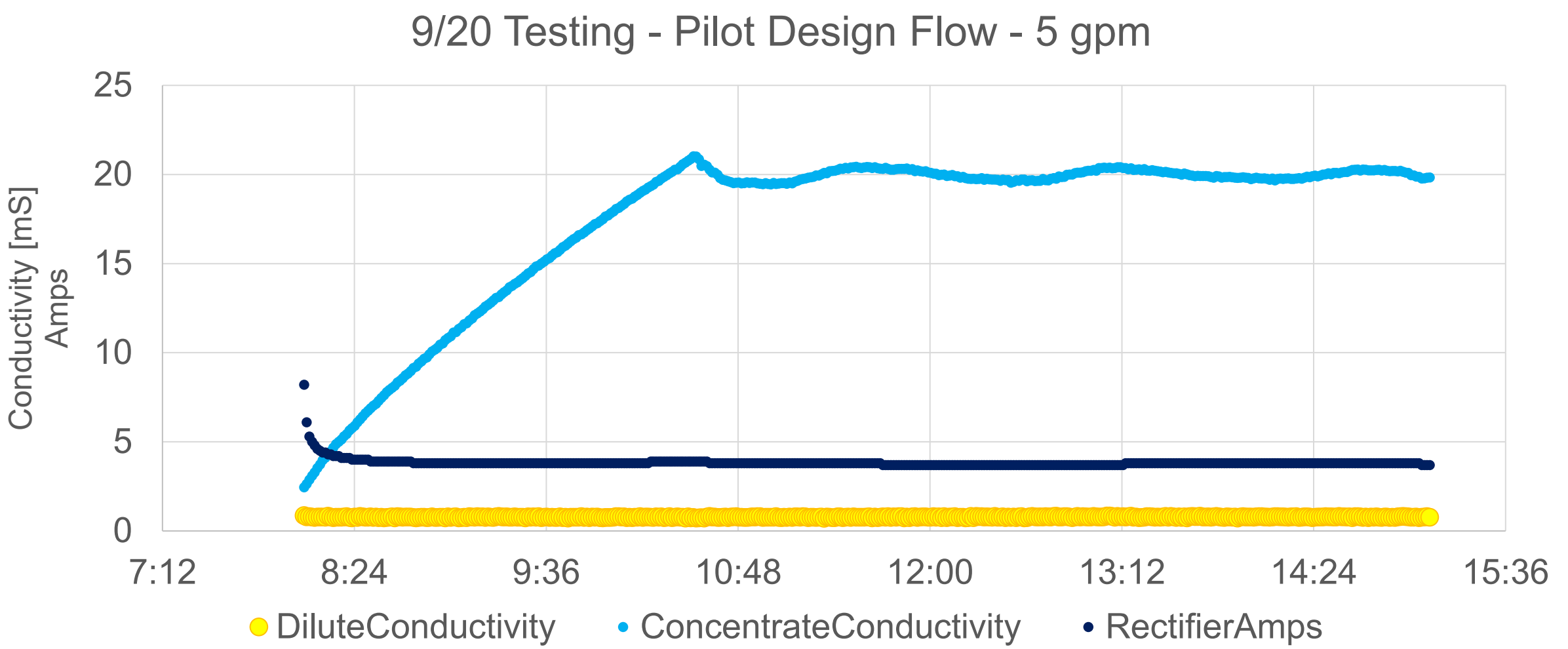

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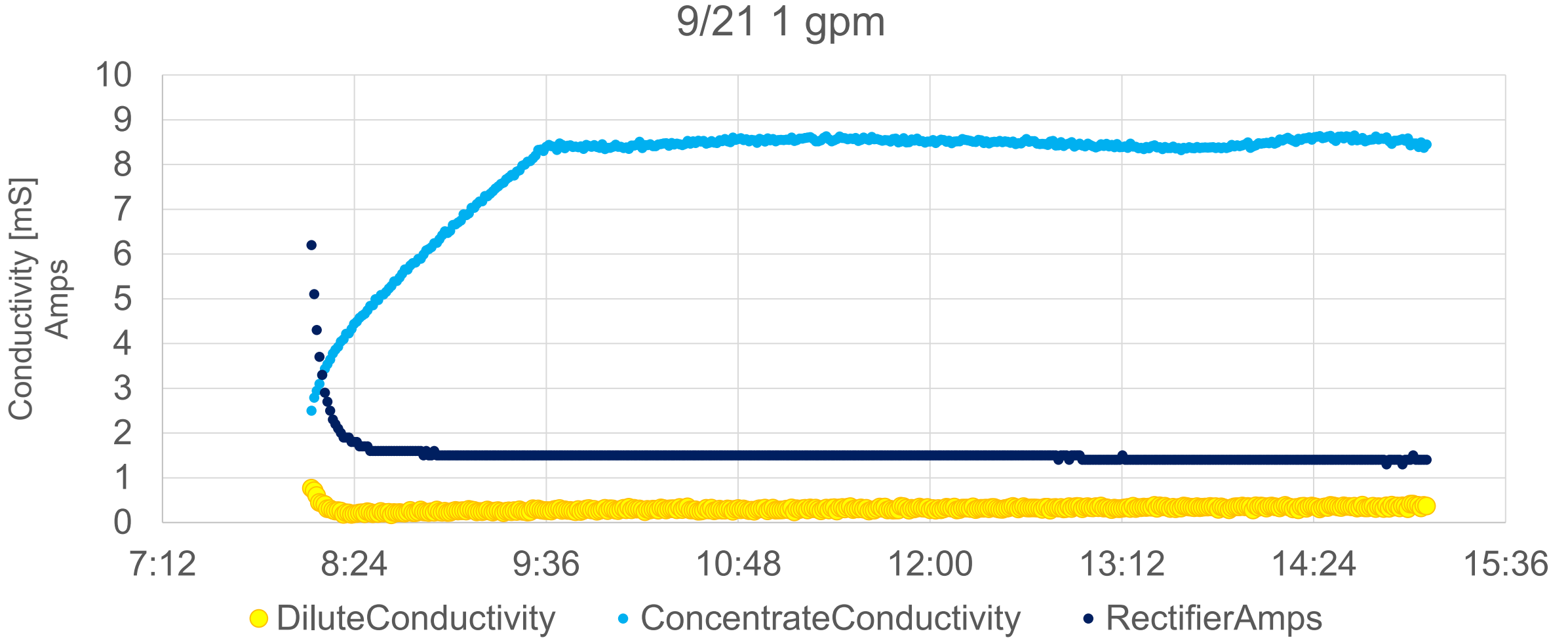

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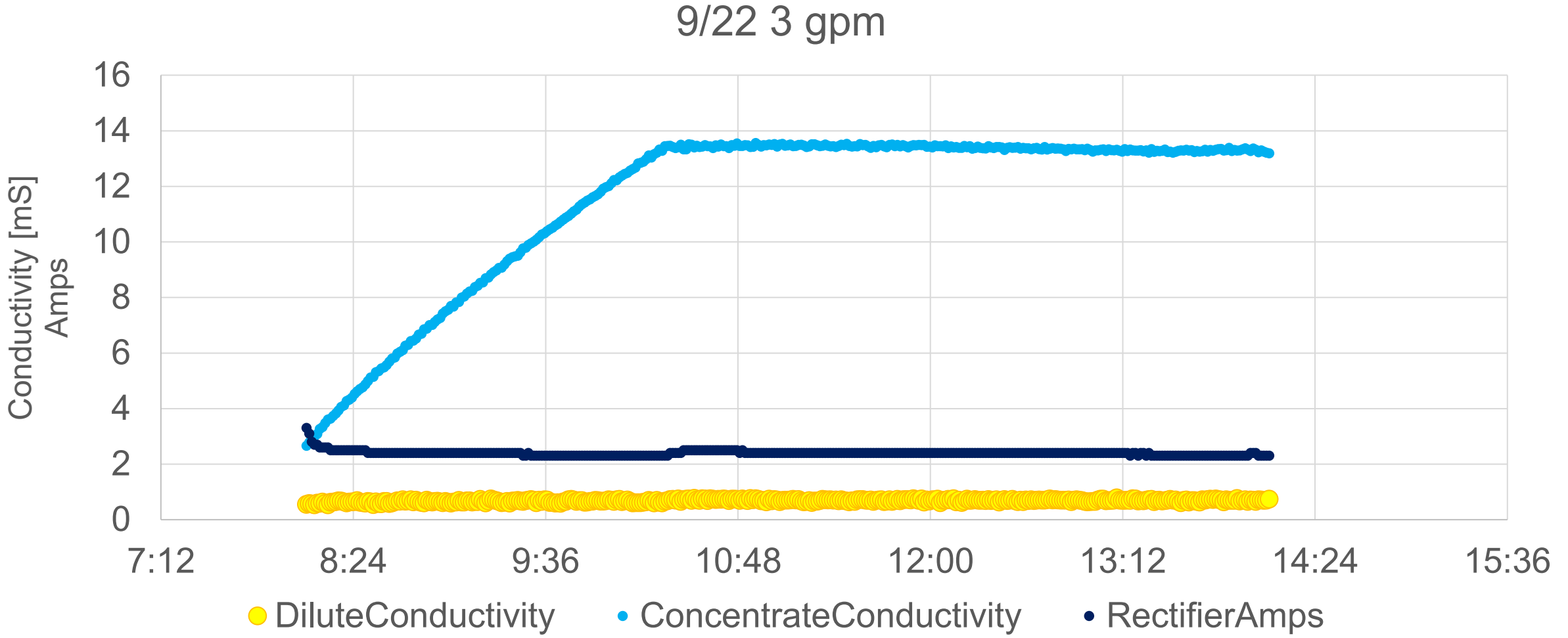

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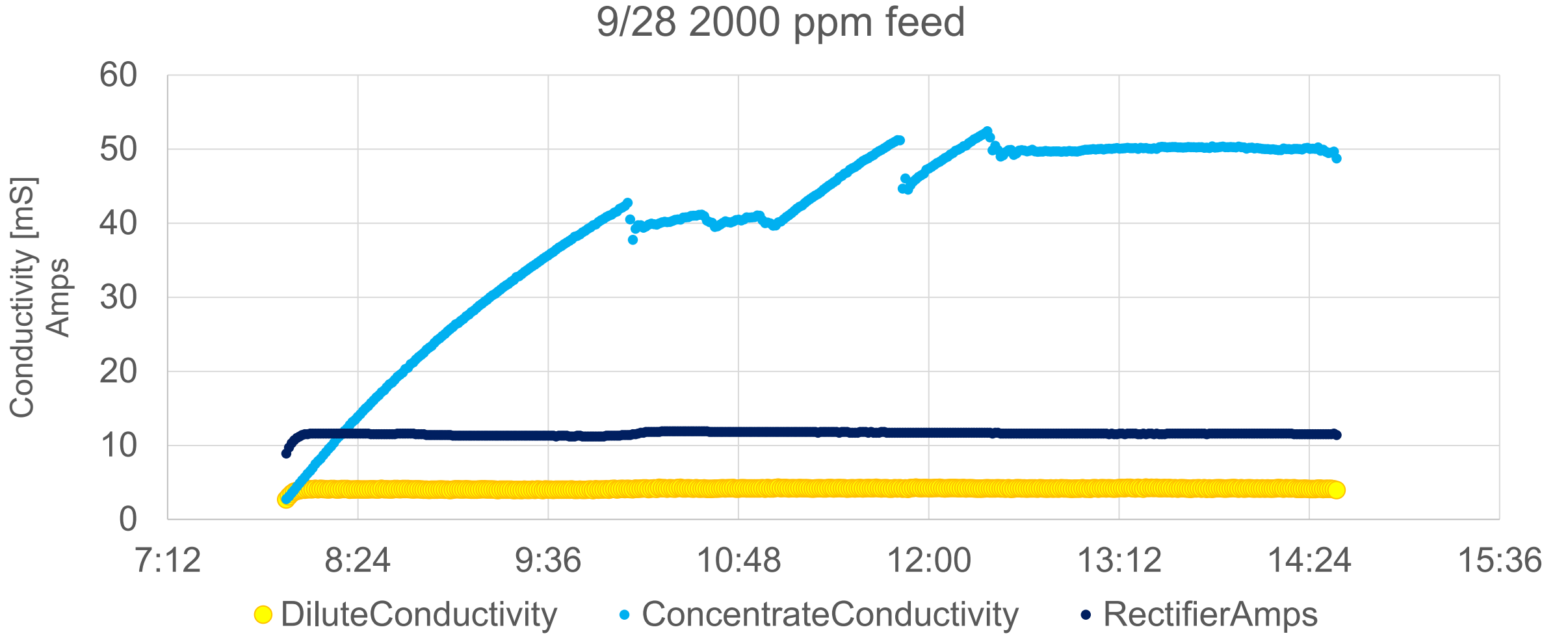

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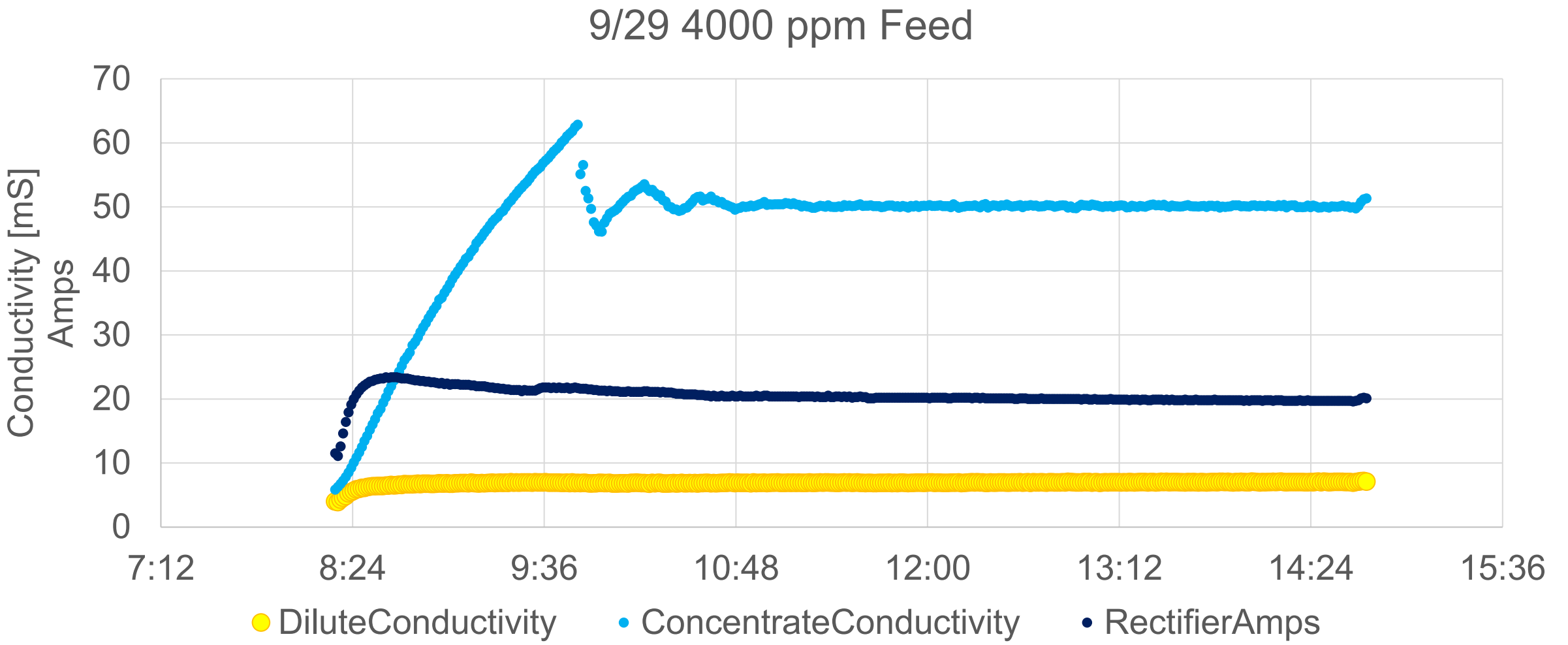

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Plans for Future Testing, Development, and Commercialization

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Current Tasks

- Operate at 8000 ppm EDR feedwater concentration
- Simulate a second stage of EDR by preprocessing collected concentrate
- Analyze Pilot Data
  - Evaluate the lowest wastewater TDS that may be economically treated

Next Steps

- Prepare the Final TEA
  - Full scale (150 gpm) wastewater flow
  - Optimize EDR Stack Configuration
  - Include Permanent Pretreatment
    - Pilot to inform extent of pretreatment
- Prepare a Site-Specific Design for NPPD Gerald Gentleman
  - Example of actual site installation
  - Reuse of existing plant infrastructure

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Project Summary

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- Pilot is in Operation
  - 2000 ppm EDR Feedwater results
    - Concentrated to 20,000 ppm
    - Estimated specific power will be determined when analytical results are available
  - 4000 ppm EDR Feedwater results
    - Concentrated to 21,000 ppm
    - Estimated specific power will be determined when analytical results are available
- Next step in pilot testing is 8000 ppm
  - Collect sufficient volume for maximum concentration testing
- Maximum concentration testing TBD

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Thank You

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Water Electrodialysis Reversal Pilot Team

Sargent & Lundy

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Water Electrodialysis Reversal Pilot Schedule

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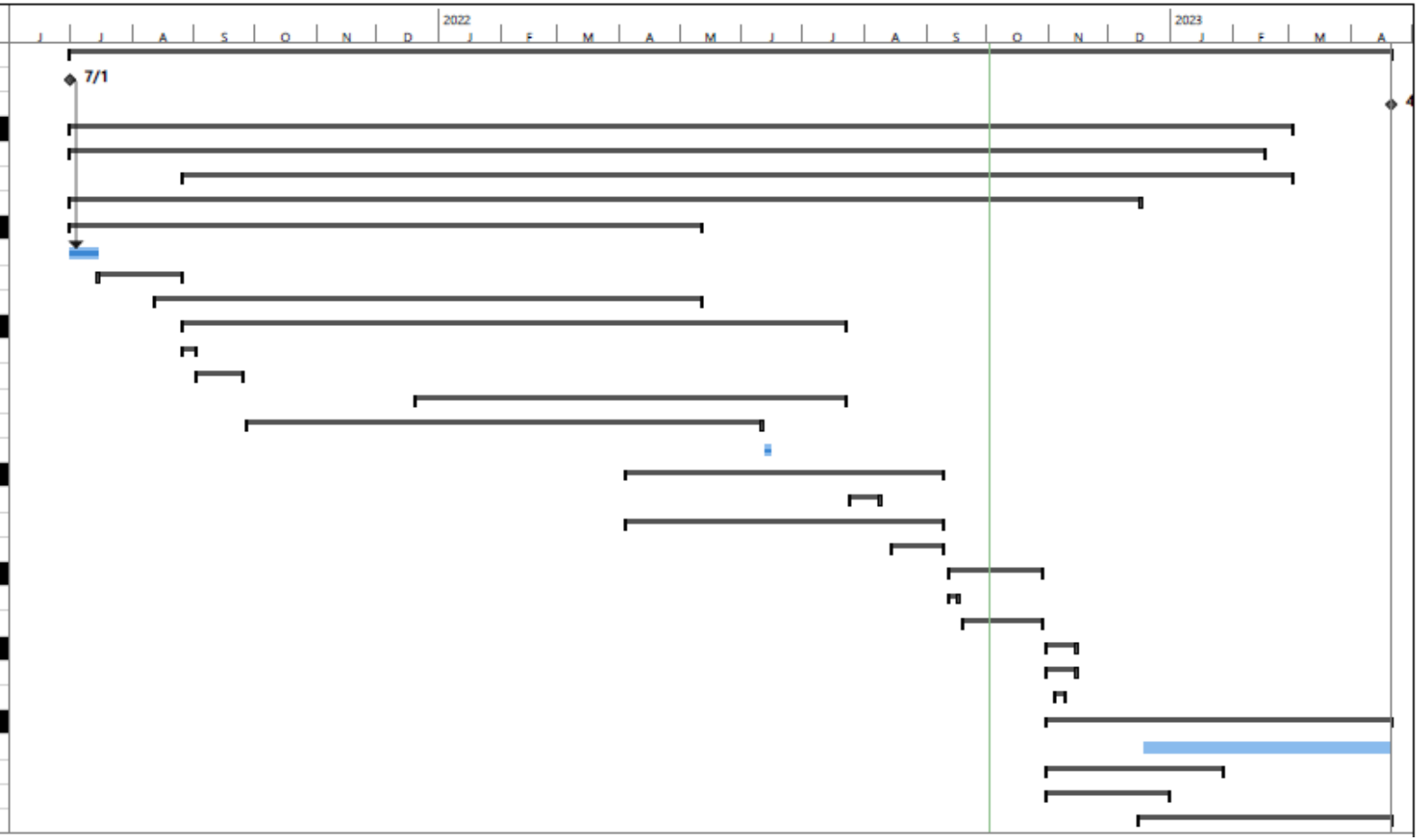
ID	% Complete	Task Name	Duration	Start	Finish
1	66%	**GGS Grey Water Reclamation Project**	**471 days**	**7/1/2021**	**4/20/2023**
2	100%	Start Date	0 days	7/1/2021	7/1/2021
3	0%	End Date	0 days	4/20/2023	4/20/2023
4	**61%**	**Task 1 - Project Management and Planning**	**436 days**	**7/1/2021**	**3/2/2023**
5	62%	1.1 - Revision and Maintenance of the PMP	426 days	7/1/2021	2/16/2023
8	58%	1.2 - Technology Maturation Plan	396 days	8/26/2021	3/2/2023
17	42%	1.3 - Reporting, Briefings and Technical Presentations	382 days	7/1/2021	12/16/2022
31	**100%**	**Task 2 - Project Design Basis**	**225 days**	**7/1/2021**	**5/11/2022**
32	100%	Kickoff Meeting Preparation	10 days	7/1/2021	7/14/2021
33	100%	2.1 - Develop Project Design Basis Document	30 days	7/15/2021	8/25/2021
42	100%	2.2 - Preliminary TEA and Test Plan	195 days	8/12/2021	5/11/2022
48	**100%**	**Task 3 - EDR Pilot System Conceptual Plan**	**237 days**	**8/26/2021**	**7/22/2022**
49	100%	3.1 - As-Built System Design Package	5 days	8/26/2021	9/1/2021
55	100%	3.2 - EDR Pilot Evaluation	17 days	9/2/2021	9/24/2021
59	100%	3.3 - EDR Pilot Pre-Test	155 days	12/20/2021	7/22/2022
65	100%	3.4 - Test Plan and BOP Design	185 days	9/27/2021	6/10/2022
80	100%	M4: Prepare & Submit Conceptual Study Results to DOE	2 days	6/13/2022	6/14/2022
81	**100%**	**Task 4 - System Installation**	**115 days**	**4/4/2022**	**9/9/2022**
82	100%	4.1 - EDR System Updates	11 days	7/25/2022	8/8/2022
85	100%	4.2 - Site Specific Modifications	115 days	4/4/2022	9/9/2022
103	100%	4.3 - EDR Pilot System Installation	20 days	8/15/2022	9/9/2022
108	**41%**	**Task 5 - Operations**	**35 days**	**9/12/2022**	**10/28/2022**
109	100%	5.1 - Commission System	5 days	9/12/2022	9/16/2022
117	31%	5.2 - Pilot Operation	30 days	9/19/2022	10/28/2022
145	**0%**	**Task 6 - Decomissioning the Pilot**	**11 days**	**10/31/2022**	**11/14/2022**
146	0%	6.1 - Decommissioning	11 days	10/31/2022	11/14/2022
152	0%	6.2 - Site Cleanup	3 days	11/4/2022	11/8/2022
155	**0%**	**Task 7 Reporting**	**124 days**	**10/31/2022**	**4/20/2023**
156	0%	NPPD Reporting Support	89 days	12/19/2022	4/20/2023
157	0%	7.1 - M7: Techno-Economic Analysis	64 days	10/31/2022	1/26/2023
161	0%	7.2 - M8: Technology Gap Assessment	45 days	10/31/2022	12/30/2022
165	0%	7.3 - M9: Commercialization Plan	90 days	12/16/2022	4/20/2023



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