BUILDING A WORLD OF DIFFERENCE

ZERO LIQUID DISCHARGE DESALINATION USING ELECTRODIALYSIS

RICK BOND

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2013 MSSC Annual Salinity Summit

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Building a world of difference.

ZERO LIQUID DISCHARGE DESALINATION WITH ELECTRODIALYSIS

- **New research project funded by California Energy Commission (CEC).**
- **Dates: Start 11/2013 – End 2/2015.**
- **Objectives:**
  - Reduce the cost and energy to recover product water from concentrate streams.
  - Manage salts in concentrate streams.

THE NEED FOR INLAND DESALINATION IS BEING DRIVEN BY:

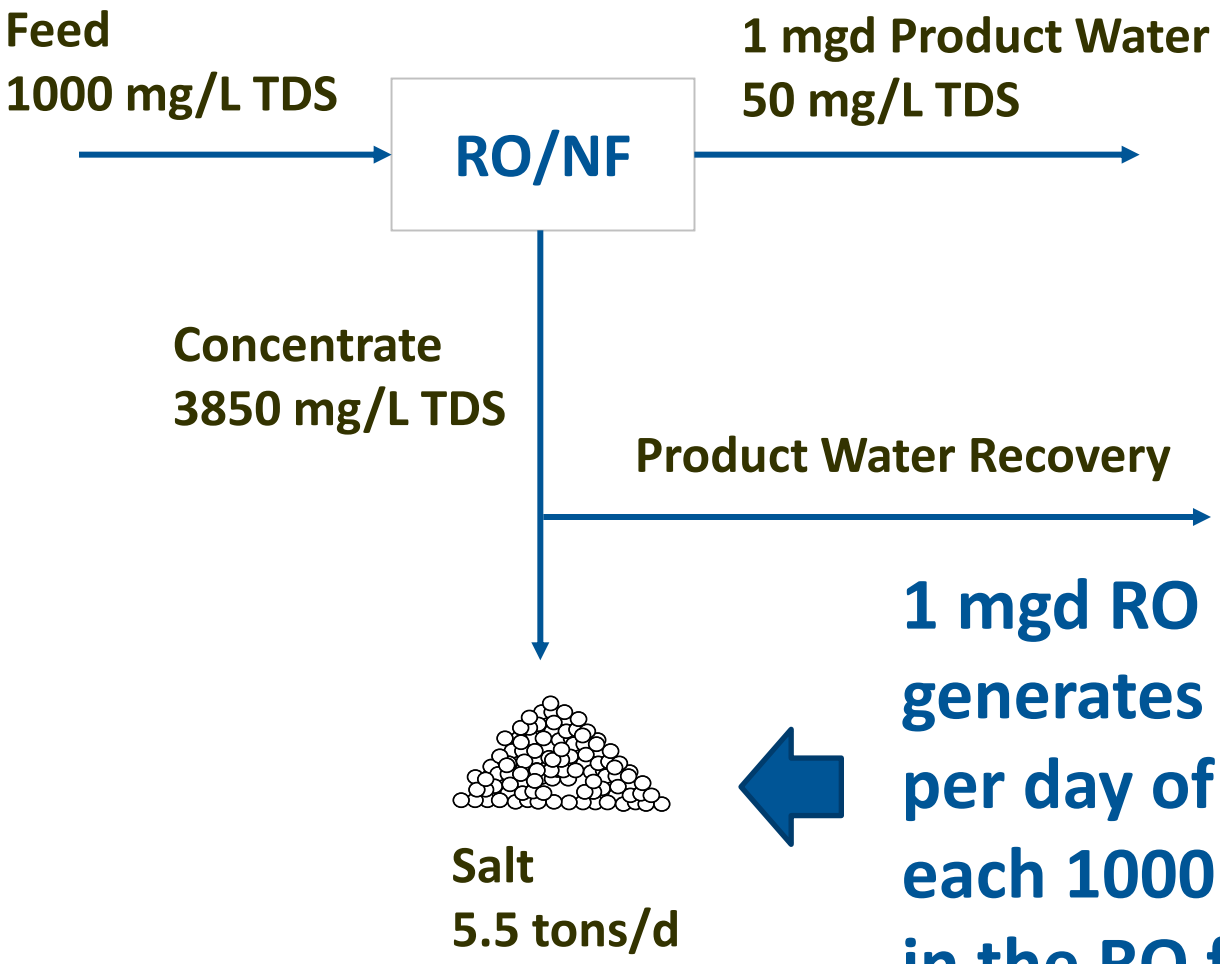
- Increasing water demand for potable and agricultural uses.
- Increasing salinity in fresh water supplies due to drought and water reuse.
- Increasing soil salinity threatening continued use of large agricultural areas (West San Joaquin Valley).
- Treatment of emerging contaminants.

Source: USGS

CONCENTRATE MANAGEMENT REMAINS AN OBSTACLE

- **Liquid component:**
  - Water can be recovered from concentrate through Zero Liquid Discharge (ZLD) desalination.
  - ZLD traditionally expensive and energy intensive, but recent research has shown both can be reduced.
- **Solids component:**
  - Vast amounts of salts remain after water is recovered.
  - Many of salts formed are currently used by a variety of industries.
  - Salt recovery may be an attractive alternative to landfill disposal.

SALT MANAGEMENT IS STILL AN ISSUE AFTER WATER RECOVERY



1 mgd RO plant generates over 5 tons per day of salt for each 1000 mg/L TDS in the RO feed!

SALT RECOVERY WITH ELECTRODIALYSIS

- ED has been used to recover acids, bases, and salts from concentrated solutions in the food and chemical industries for decades.
- Table salt has been manufactured in Japan using electrodialysis treatment of seawater since 1969.

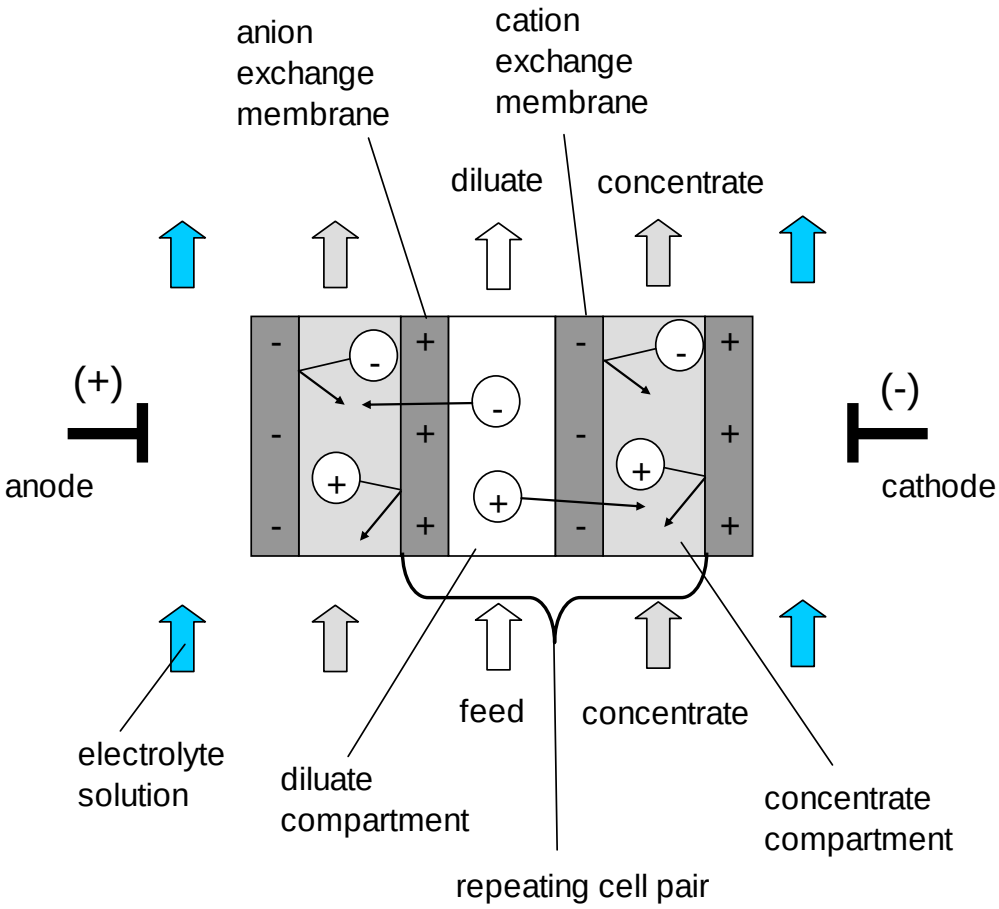
Source: The Tokyo Foundation

ELECTRODIALYSIS METATHESIS (EDM) IS A NEW ELECTRODIALYSIS TECHNOLOGY

- **Innovative arrangement of membranes used to separate concentrate into two streams of highly soluble salts. This provides two advantages:**
  - Significantly higher recovery
  - Facilitates separation of beneficial salts
- **Therefore potential to address water and salt recovery.**
- **Although this variation is new, electrodialysis has been used for decades.**

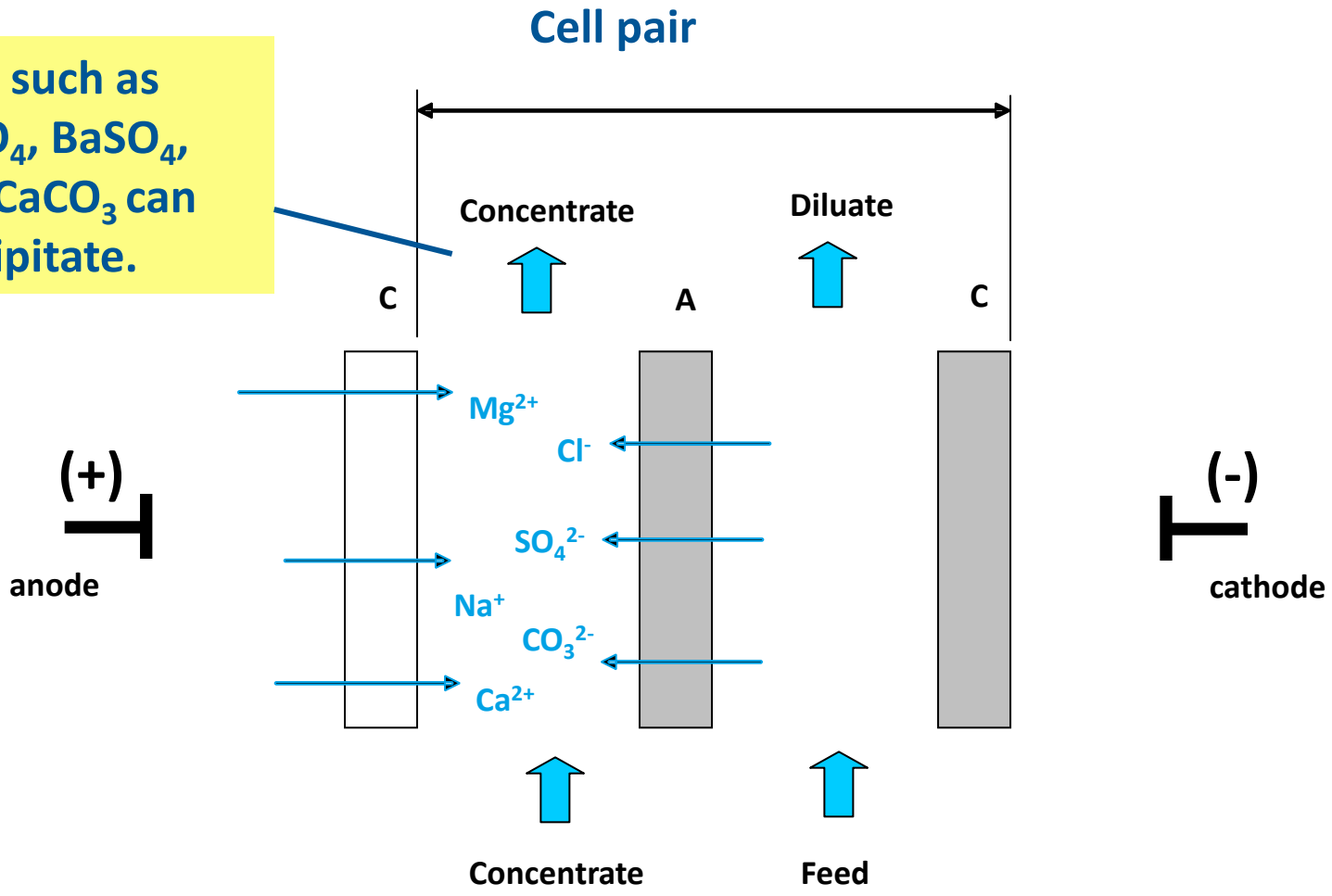
ELECTRODIALYSIS IS A MEMBRANE PROCESS DRIVEN BY ELECTRIC POTENTIAL

- Driving force is electric potential between anode and cathode.
- Cell pair comprises cation and anion exchange membranes, diluate cell, and concentrate cell.
- Ions are extracted from diluate compartment and held in concentrate compartment.
- A stack contains hundreds of cell pairs.

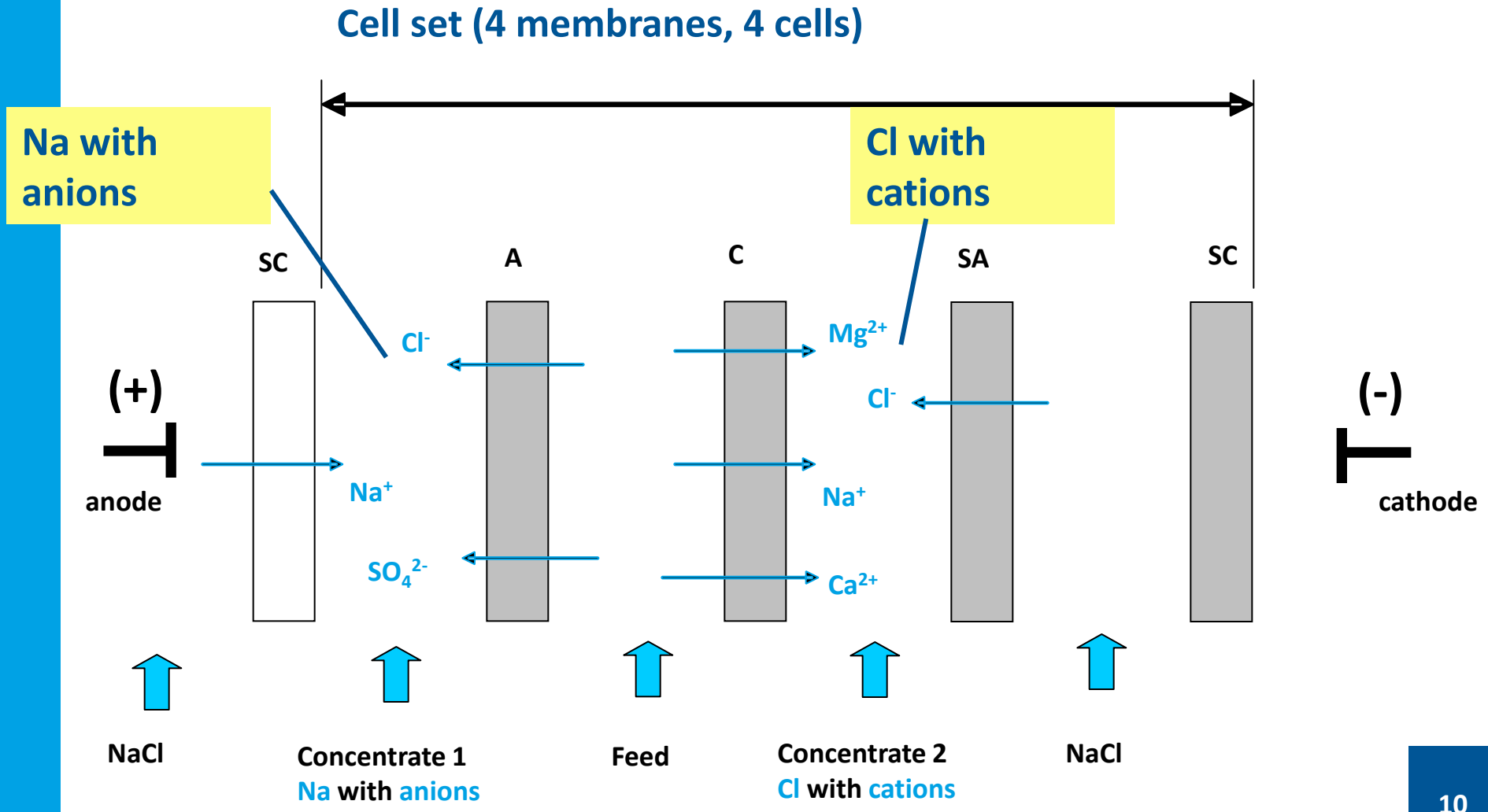


IN BASIC ELECTRODIALYSIS REMOVED IONS ARE IN ONE CONCENTRATE STREAM

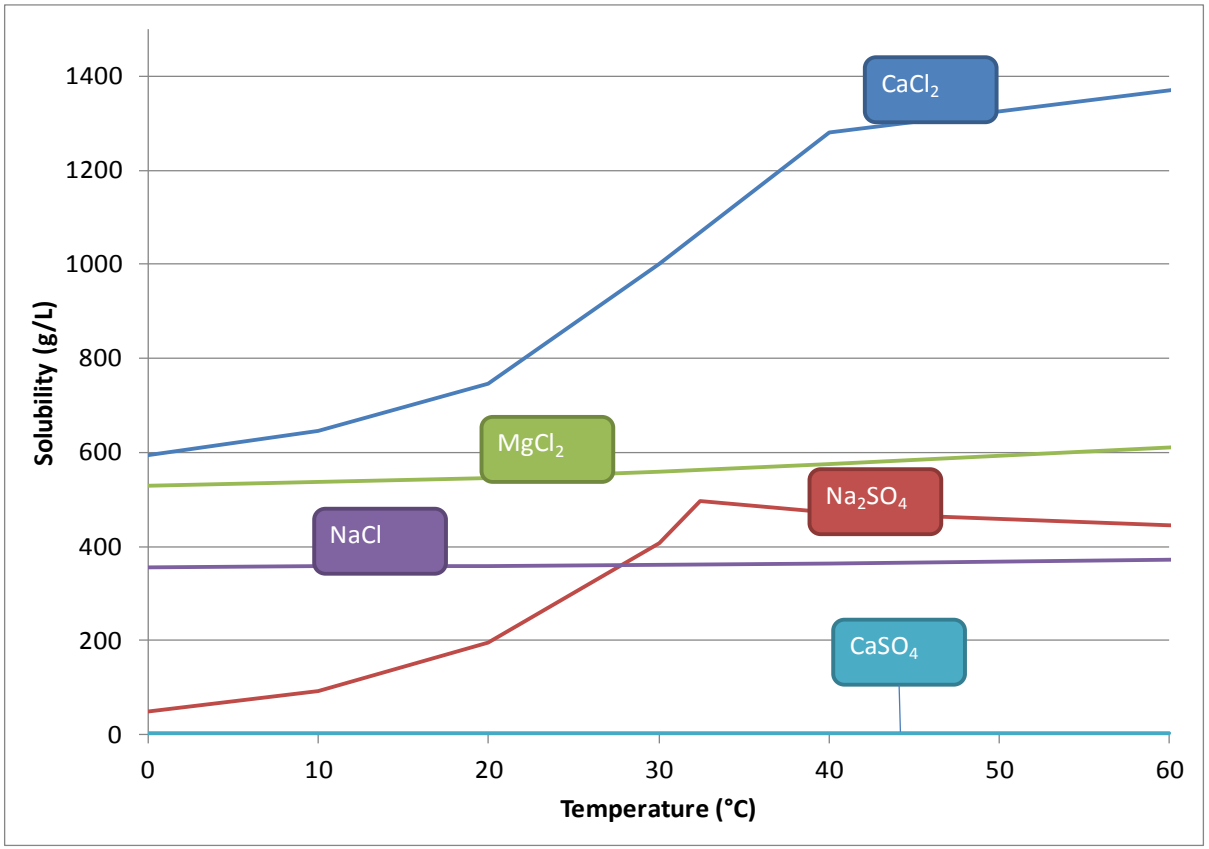
Salts such as $CaSO_4$, $BaSO_4$, and $CaCO_3$ can precipitate.



EDM CONCENTRATE IS SEPARATED INTO TWO HIGHLY SOLUBLE STREAMS

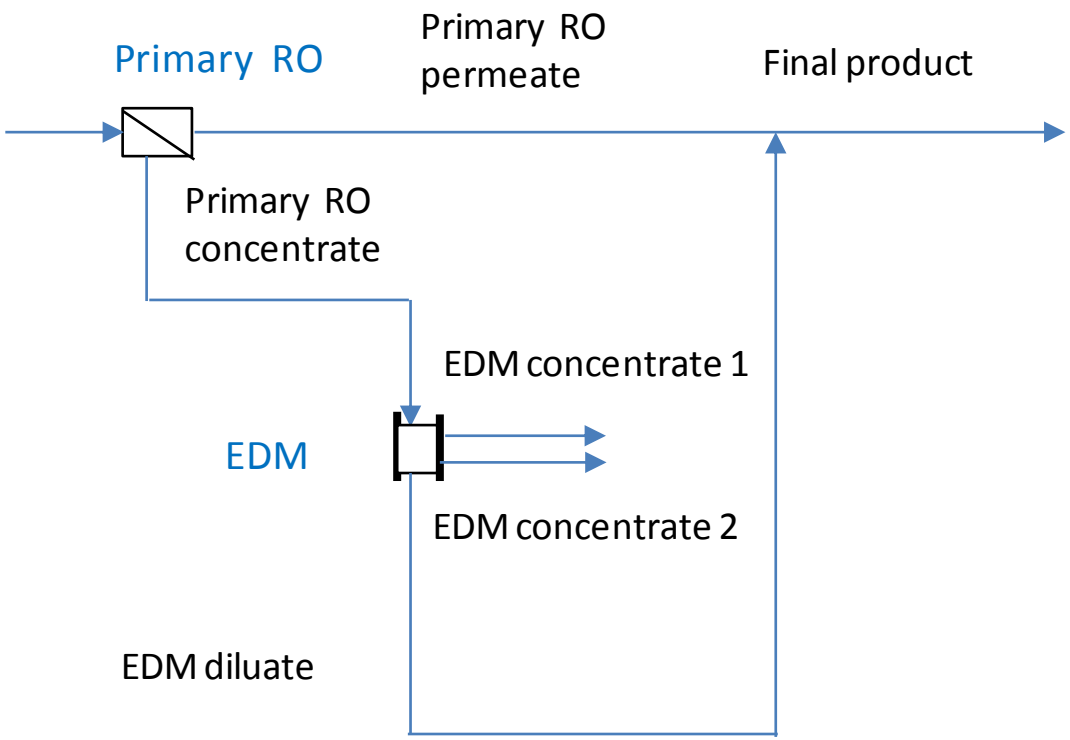


SOLUBILITY OF EDM SALTS COMPARED WITH CALCIUM SULFATE

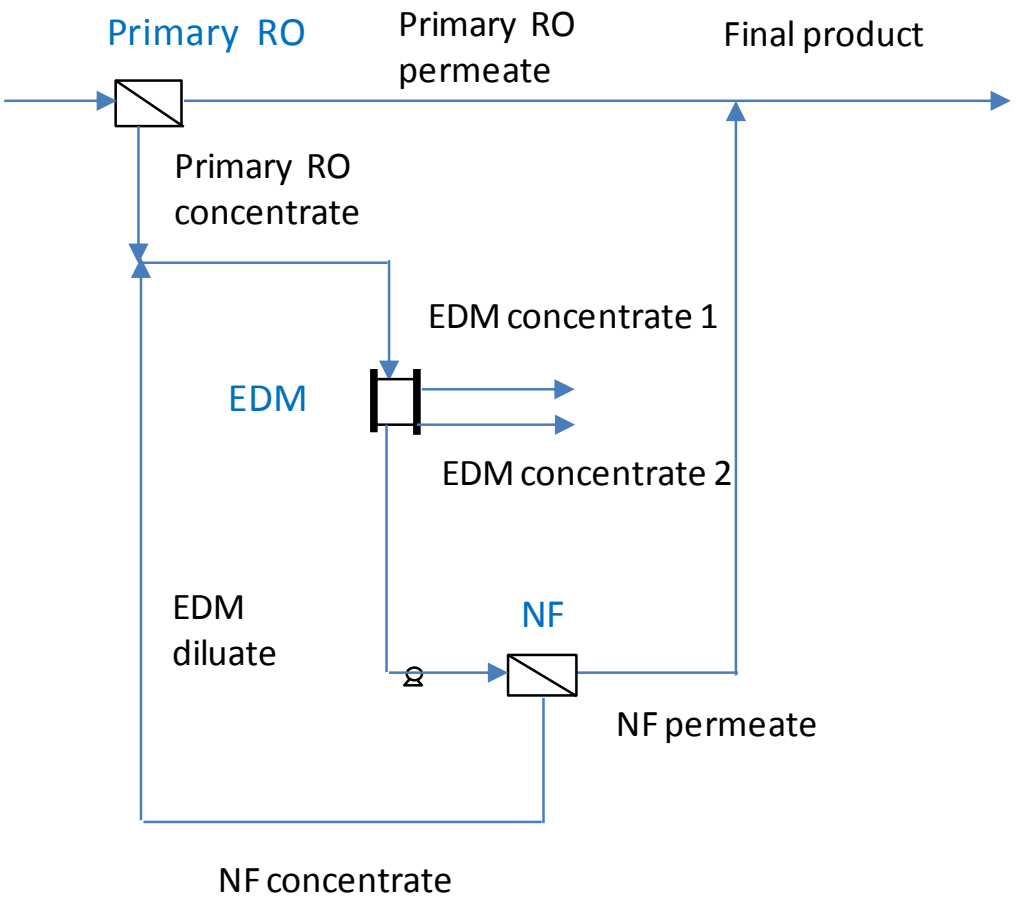


At 25 °C, Na_2SO_4 is over 100 times more soluble than $CaSO_4$.

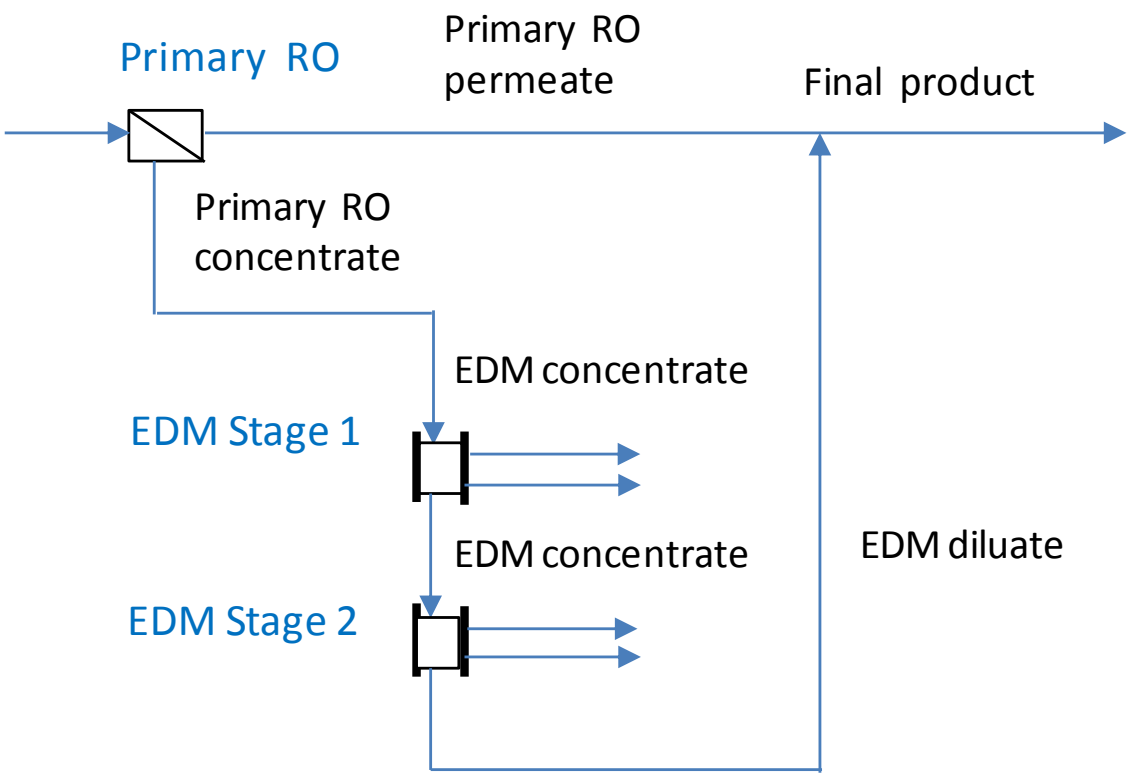
SINGLE STAGE EDM TREATMENT



SINGLE STAGE EDM FOLLOWED BY NF MEMBRANES

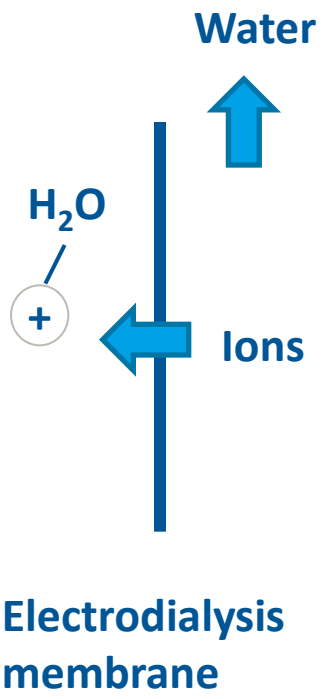


TWO STAGE EDM TREATMENT

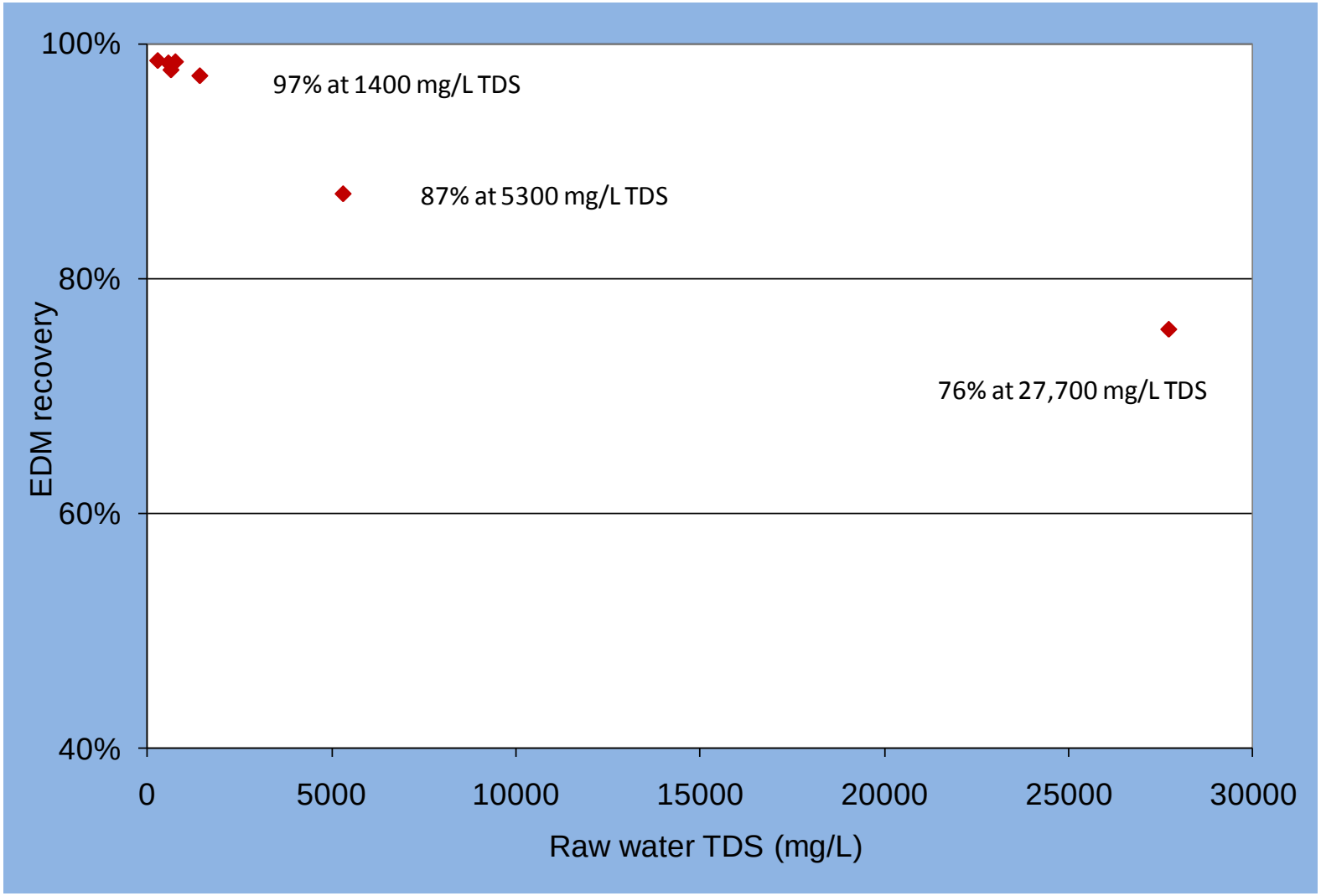


RECOVERY OF PRODUCT WATER WITH EDM

- Water molecules are transported through electrodialysis membranes with the ions removed from the feed stream.
- The amount of water transported is proportional to the number of ions transported. Therefore, recovery is proportional to the number of ions transported.
- Recovery of product water from RO concentrate with EDM ranges from 96 to 99 percent when RO feed is brackish water with TDS less than 1500 mg/L.



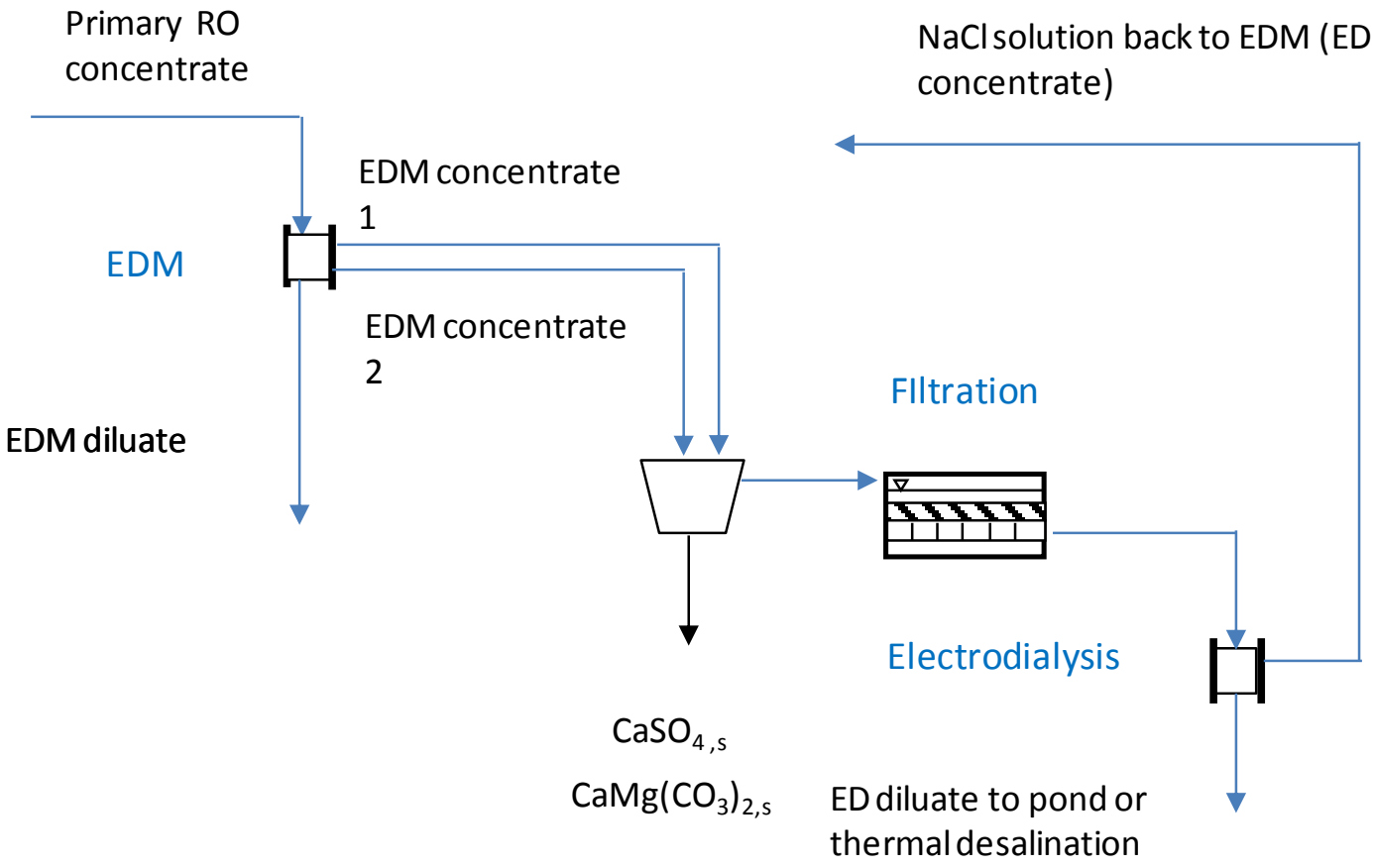
EDM RECOVERY DECREASES AS TDS INCREASES



EDM APPEARS ECONOMICAL SOLUTION FOR WATER RECOVERY, BUT…

- What about the salts that remain after 99 percent of the water is recovered?
- What about the NaCl required by EDM?
- An objective of this project is investigation of these questions.

TREATMENT OF EDM CONCENTRATE FOR BENEFICIAL USE



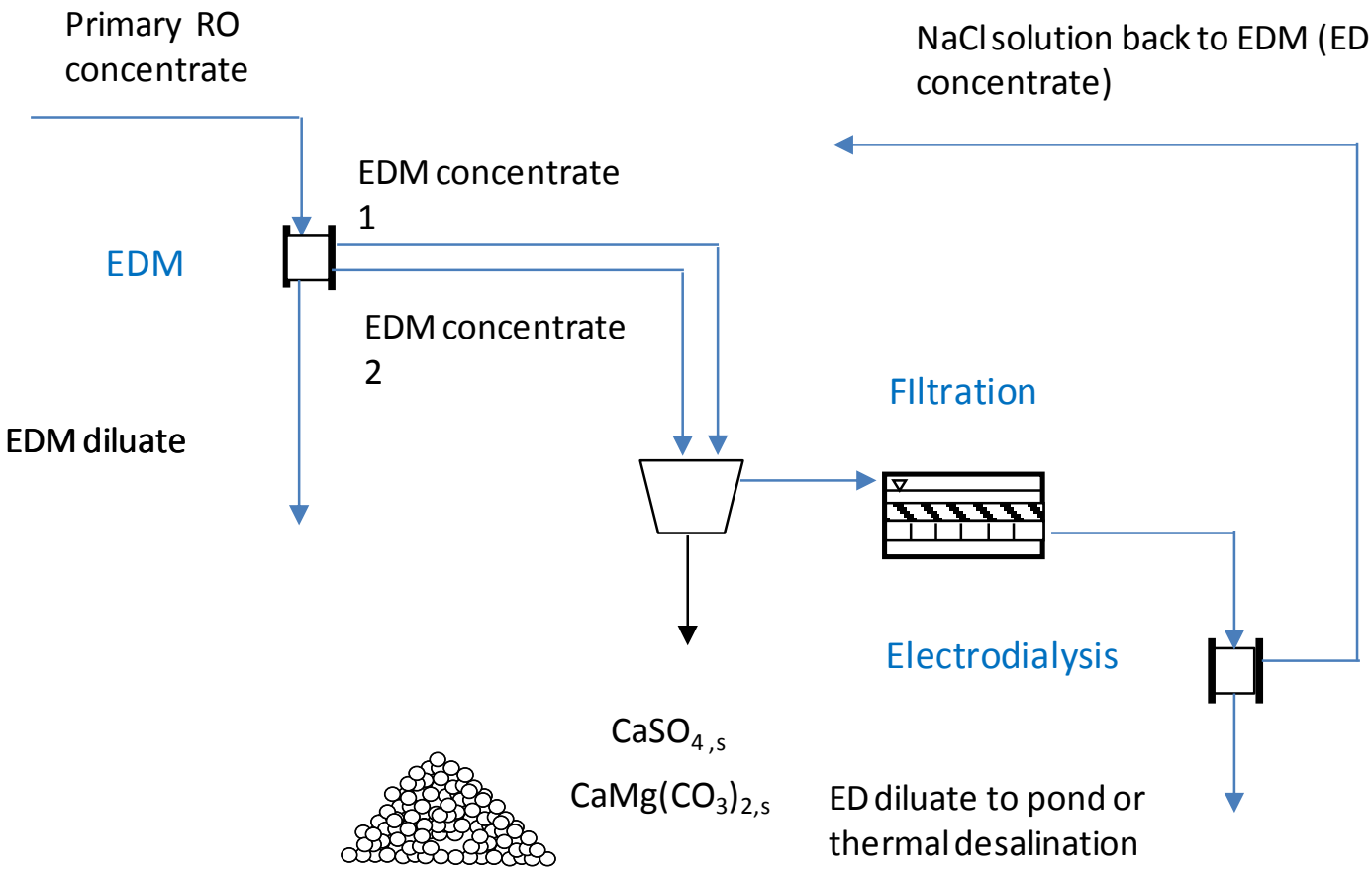
EDM'S TWO CONCENTRATE STREAMS FACILITATE SALT RECOVERY

Cl^- with cations.

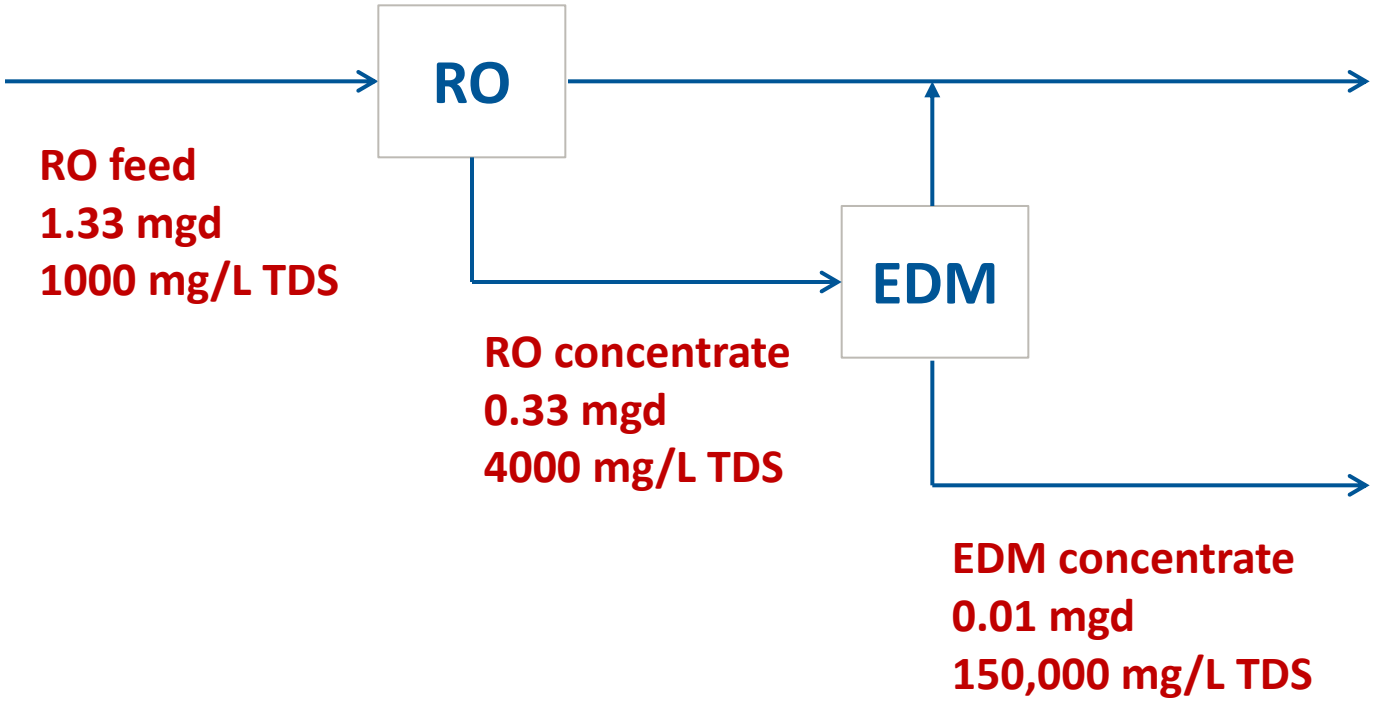
	EDM feed	EDM concentrate 1	EDM concentrate 2
Ca (mg/L)	290	50	14,900
Mg (mg/L)	70	5	2220
Na (mg/L)	380	38,600	14,000
Cl (mg/L)	850	30,800	53,700
SO_4 (mg/L)	420	42,400	Below detection
HCO_3 (mg/L)	30	350	Below detection

Na^+ with anions.

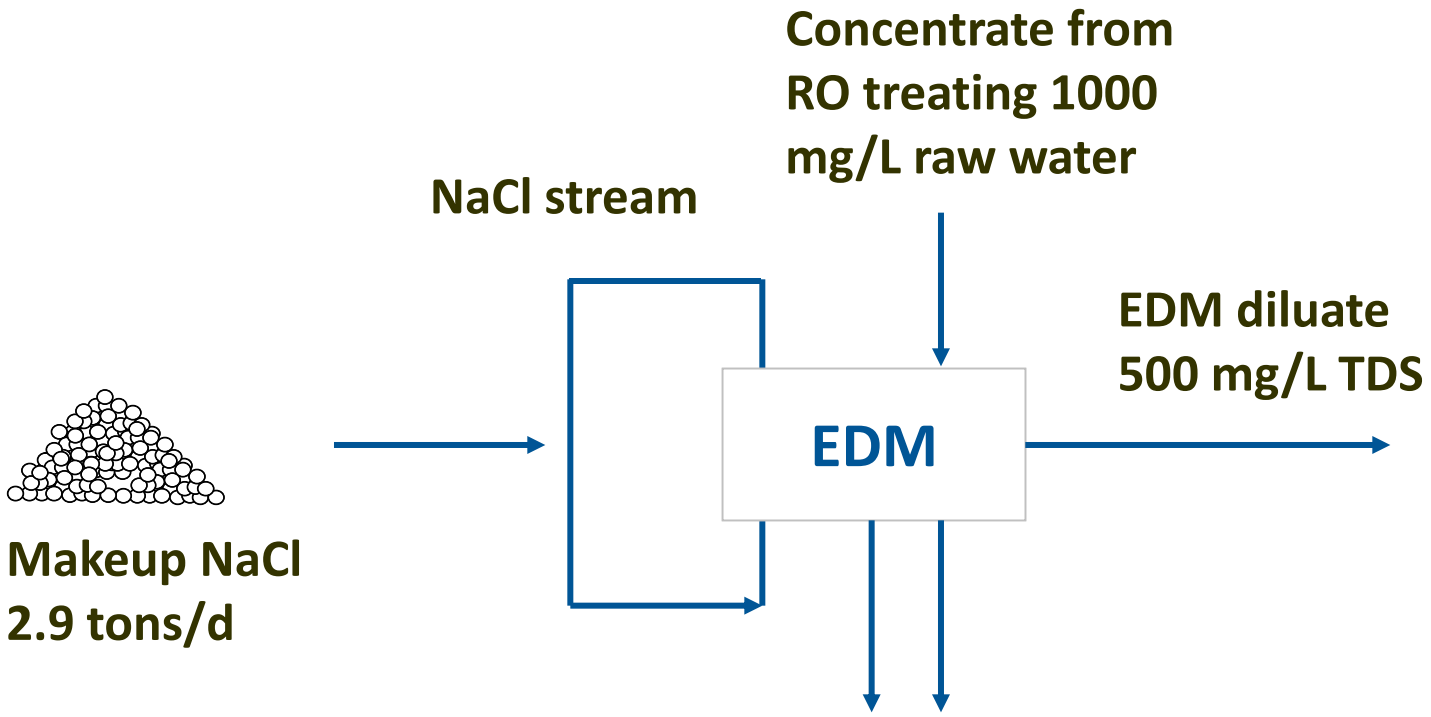
TREATMENT OF EDM CONCENTRATE FOR BENEFICIAL USE



SALT RECOVERY AIDED BY STARTING WITH HIGHLY CONCENTRATION SOLUTION

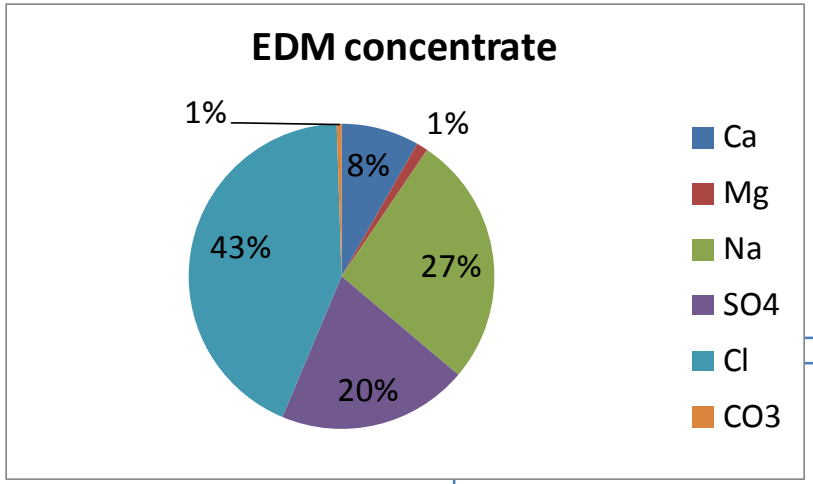


NACL REQUIRED BY EDM

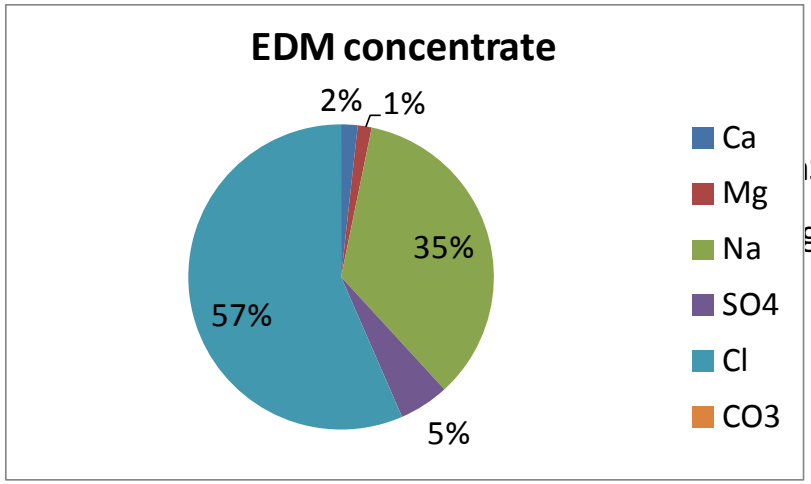


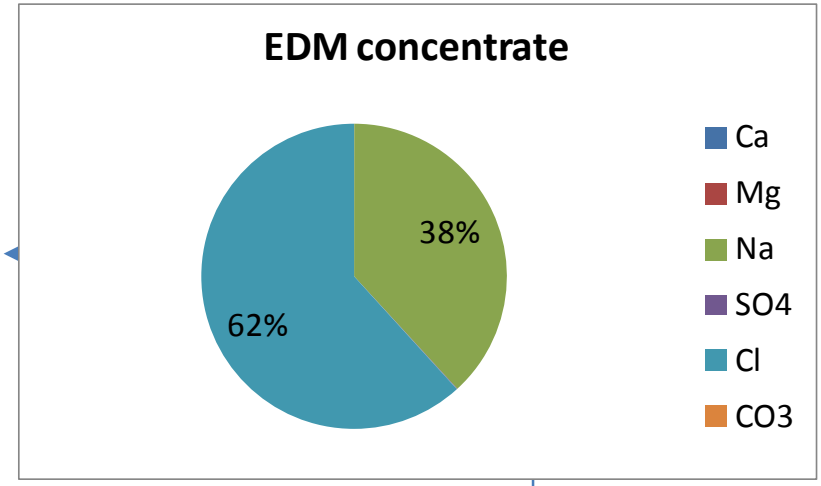
EDM treating concentrate from 1 mgd RO plant consumes almost 3 tons of NaCl per day!

RECOVERY OF NACL AND RECYCLE TO EDM

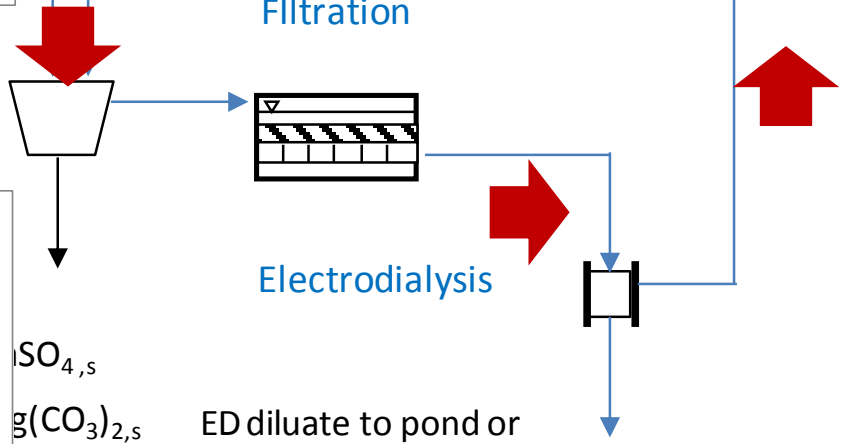


EDM diluate





FIltration



Electrodialysis

$SO_{4,s}$

$g(CO_3)_{2,s}$

ED diluate to pond or thermal desalination

SUMMARY

- EDM separates concentrate into two streams of highly soluble salts.
- Previous work has shown it is possible to recover up to 98 percent of the water from RO concentrate with EDM.
- EDM concentrate streams are highly concentrated facilitating the recovery of salts.

ACKNOWLEDGEMENTS

- This project is sponsored by the California Energy Commission.
- The City of Beverly Hills is hosting the demonstration, and the research team is being assisted by Kevin Watson of the City of Beverly Hills.
- The research team includes Dr. Tom Davis of UTEP, and Vasu Veerapaneni and Jay DeCarolis of Black & Veatch.

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