# Effects of the Minute 319 Ecological Flows on Soil Salinity in the Colorado River Delta

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## Introduction

Riparian ecosystems are highly affected by flow management and river diversion. Lack of flood flows can:

- Minimize recruitment of native trees, such as cottonwoods (*Populus* spp.) and willows (*Salix* spp.).
- Desertify floodplains through channel incision and groundwater lowering.
- Salinize soils and groundwater, causing stress or mortality of salt-intolerant plants.

Limited research has been conducted on the effects of prescribed environmental flows on floodplain soil salinity, a limiting factor for native plants along the Lower Colorado River in the United States and Mexico.

Minute 319 to the US-Mexico water treaty dedicated environmental flows to the Colorado River in Mexico for the first time in history.

- 105,400 acre-feet (130 MCM) as "pulse flow" in spring 2014.
- 52,700 acre-feet (65 MCM) as "base flow" in 2014-2017.
- These flows provided the unique opportunity to determine if environmental flows reduce soil salinity.
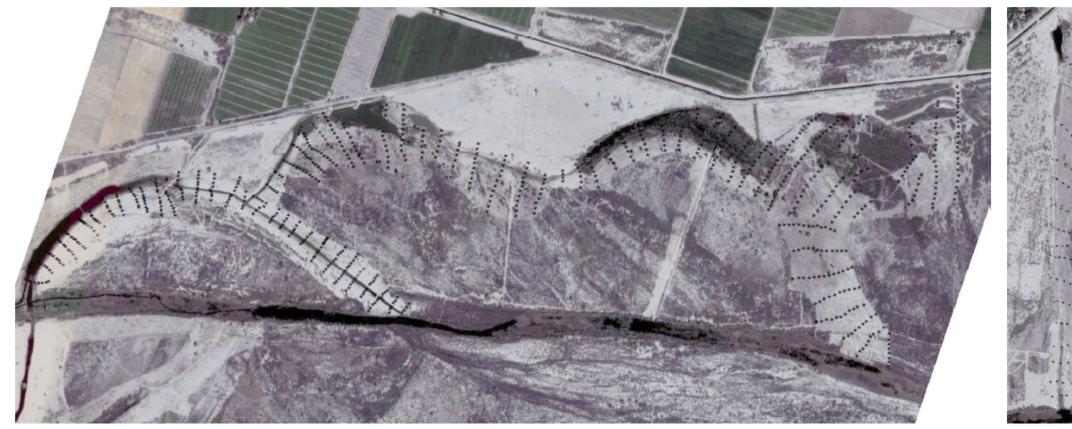
The large study area and short timeframe limited the development of a large-scale soil salinity monitoring program. Instead, we completed an electromagnetic induction (EM) survey for a 200 acre (80 ha) restoration site targeted for establishment of cottonwood and willow seedlings.

## Objectives

1. Determine if the EM sensor can provide reliable saturated paste extract (SPE) electrical conductivity (EC) estimates for near-surface soils in riparian floodplains.
2. Monitor SPE EC changes resulting from Minute 319 environmental flows.
3. Use results for active restoration planning and design.

## Methods

- Electromagnetic Induction (EM) transect survey using EM38-MK2 (Geonics Limited, Mississauga, Ontario, Canada) to obtain bulk conductivity across the anticipated inundated zone within the Laguna Cori land concession area.
- Calibration sample selection using ESAP software package (Agricultural Research Service, US Salinity Laboratory).
- Laboratory testing of soil samples for SPE EC, moisture content, texture.
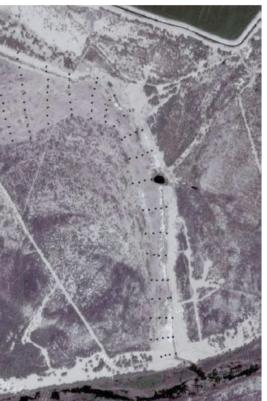


EM38 transects for Laguna Cori (Left) and the Herradura (right).

- Depth to groundwater estimated for each location using ground and interpolated groundwater elevation.
- Linear regression used to estimate SPE EC on 1-foot (30-cm) intervals to 4 feet (1.2 m) below ground surface.
- SPE EC interpolated across study area to estimate changes.
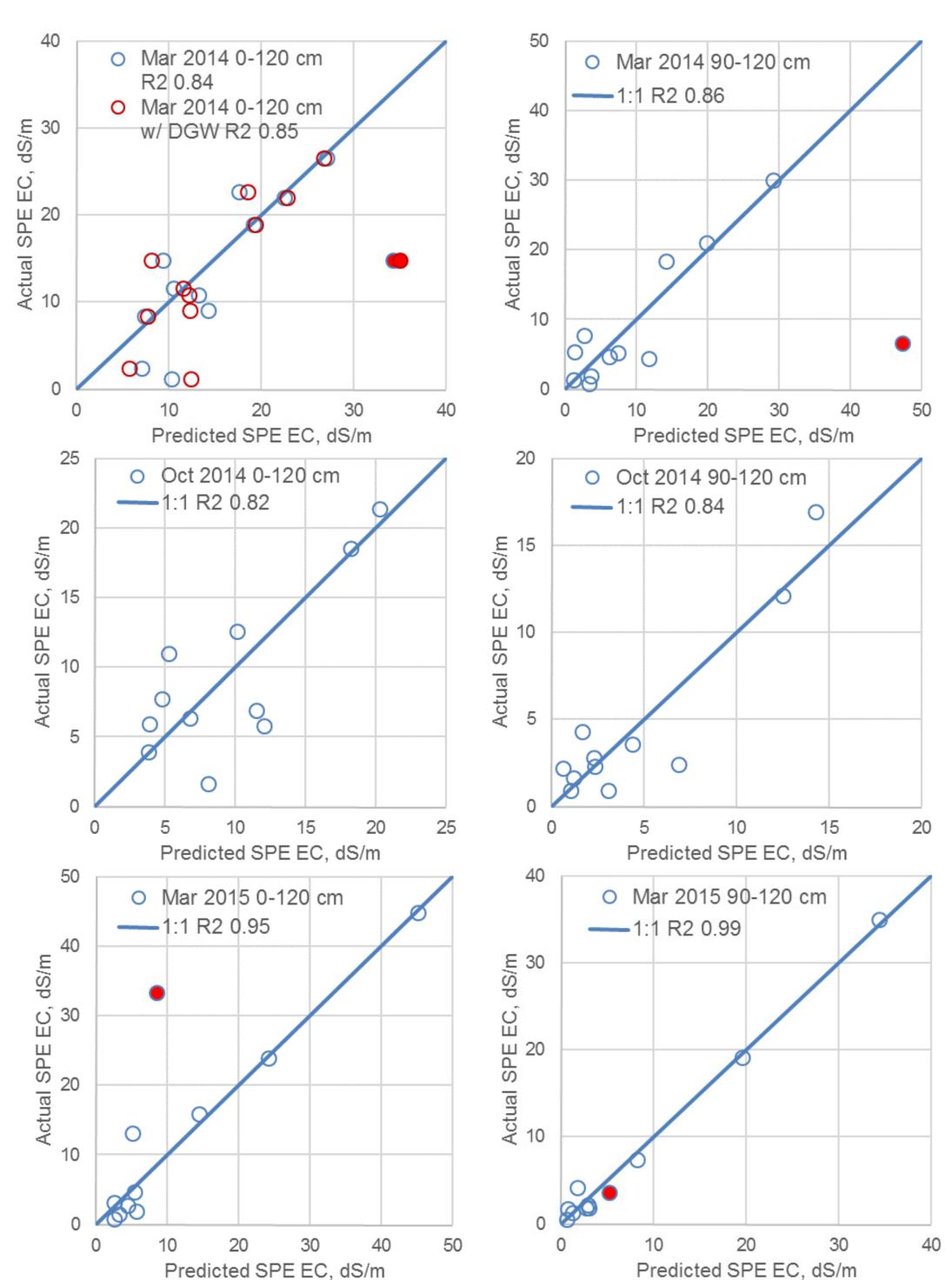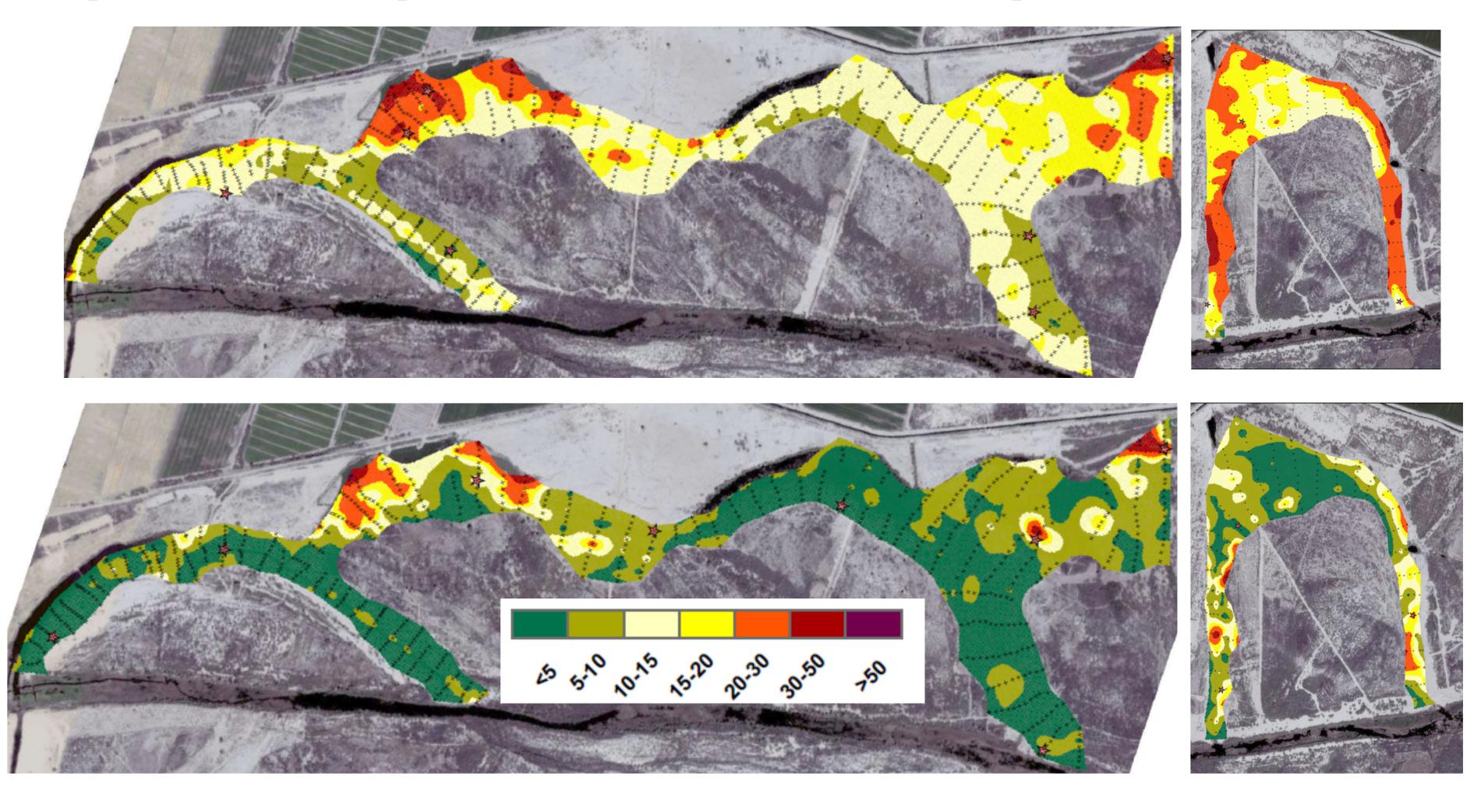
## Minute 319 Pulse Flow



Laguna Cori Complex

Land preparation (top left) for pulse flows (right) and willow establishment (bottom left).
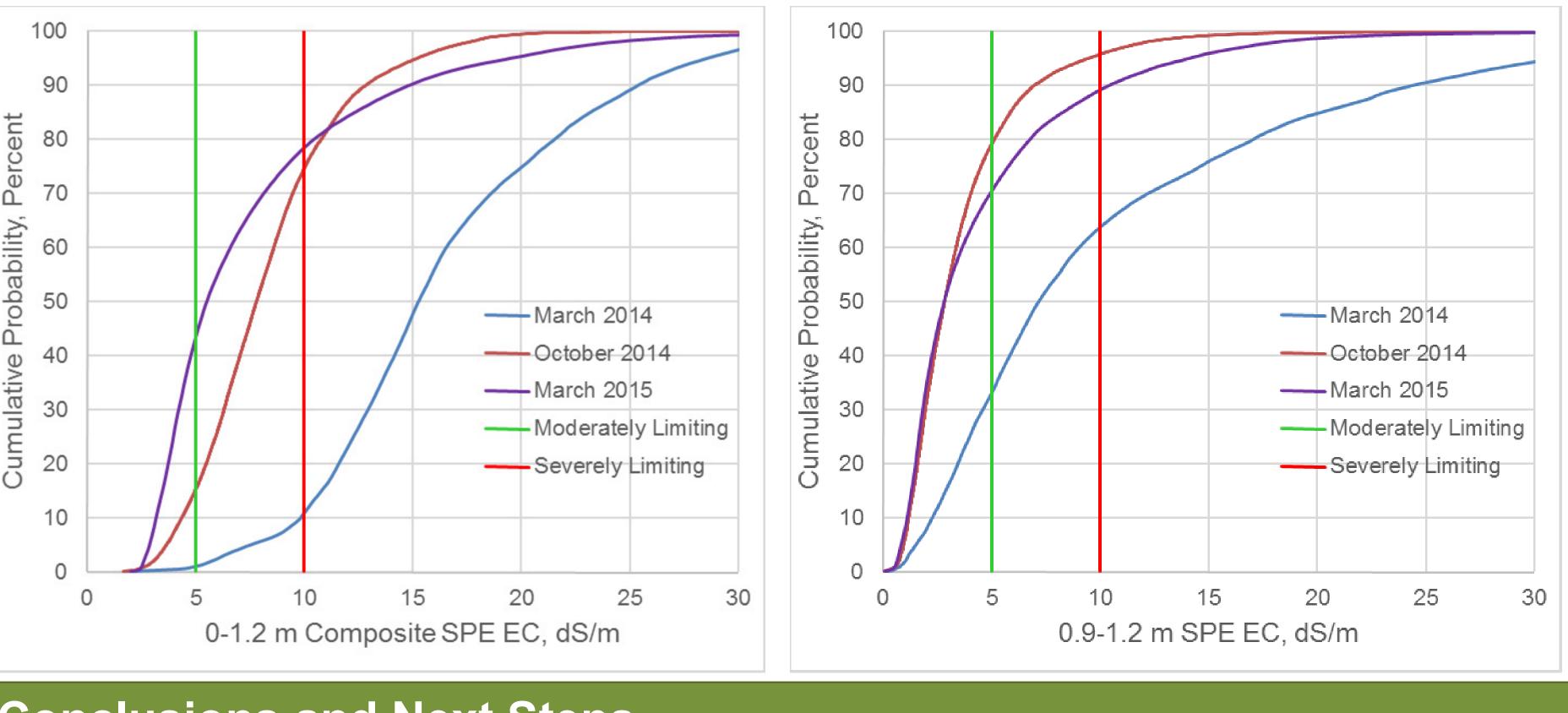
## Results

- Poor correlation for 0-30, 30-60 cm intervals, likely due to variation in soil moisture.
- High correlation for composite 0-120 cm and 90-120 cm SPE EC (below) with the exception of two outliers (red filled points).
- Limited predictive ability for low-salinity ranges; results most applicable to look at large changes.



## Results, continued

Interpolated 0-1.2 m composite SPE EC (dS/m) in March 2014 (top) and March 2015 (bottom).



Cumulative probability for 0-1.2 m composite (left) and 0.9-1.2 m composite (right) SPE EC.



## Conclusions and Next Steps

- The EM38 provided reliable predictions of SPE EC, especially for 0.9-1.2 m below ground surface. Due to correlation of salinity between depths at each location, the survey also provided reliable estimates for 0-1.2 m below ground surface.
- The sensor did not provide reliable estimates of surface soil salinity, likely due to variability in surface soil moisture.
- Calibration equations differed for each sampling event; this method requires new calibration samples for each survey.
- Based on EM38 results, the Minute 319 pulse and base flows reduced SPE EC at the study area by over 50% (composite and 0.9-1.2 m).
- Using a cottonwood-willow threshold of 5 dS/m at the 0.9-1.2 m interval, the portion of the study area suitable for revegetation increased by 37%.
- In some locations, SPE EC increased between October 2014 and March 2015, indicating the need for continued environmental flows to support initial EC reductions.
- Follow-up surveys will be conducted annually through the end of Minute 319.