Geomorphological and Stratigraphic Identification of Lunettes at the Great Sand Dunes National Park and Preserve, Colorado*

María E. Brunhart-Lupo[1]

Search and Discovery Article #50676 (2012)**
Posted August 6, 2012

*Adapted from oral presentation at AAPG Annual Convention and Exhibition, Long Beach, California, April 22-25, 2012

[1]Colorado School of Mines, Golden, CO (mbrunhar@mymail.mines.edu)

Abstract

The Great Sand Dunes National Park and Preserve (GRSA), located in the San Luis Valley of southern Colorado, contains Quaternary-aged deposits of dune sands, alluvial fans, stream channels, floodplain alluvium and lake sediments. The most well known deposits within the GRSA are the dune features, which include star, parabolic, barchan, transverse, and nebkha dunes that are present in the active dune field. In addition to the dune deposits, are lesser-known fluvial deposits associated with ephemeral streams. The fluvial deposits are part of a complex cycle of erosion and deposition between aeolian and fluvial processes.

An added complexity to this system are the playa and sabkha environments surrounding the Dry Lakes and San Luis Recreational areas, that lie to the west and south of the active dune fields. In the Dry Lakes area, well-formed lunettes have been identified that lie along the rim of playas. In the San Luis Recreational area, large dune-shaped features that have been mapped, but the origin of these features has not been identified. It has been suggested that these large features are parabolic dunes, a series of blowouts, or lunettes. Identification of these features is key to determining their role and importance in understanding the geomorphological evolution of the GRSA and surrounding areas.

This study presents the results of a geomorphological and stratigraphic study that were used to identify the lunette features within the San Luis Recreational area. The results show key findings in developing an understanding of the geomorphological evolution of lunettes in this area and the relationship with the GRSA.

Selected References

Couroux, E.G., 2001, an integrated study of landform development using near surface geophysics, remote sensing and geomorphology, at the Great Sand Dunes National Monument, southern Colorado: M.S. thesis University of Texas at El Paso, El Paso, Texas, 175 p.

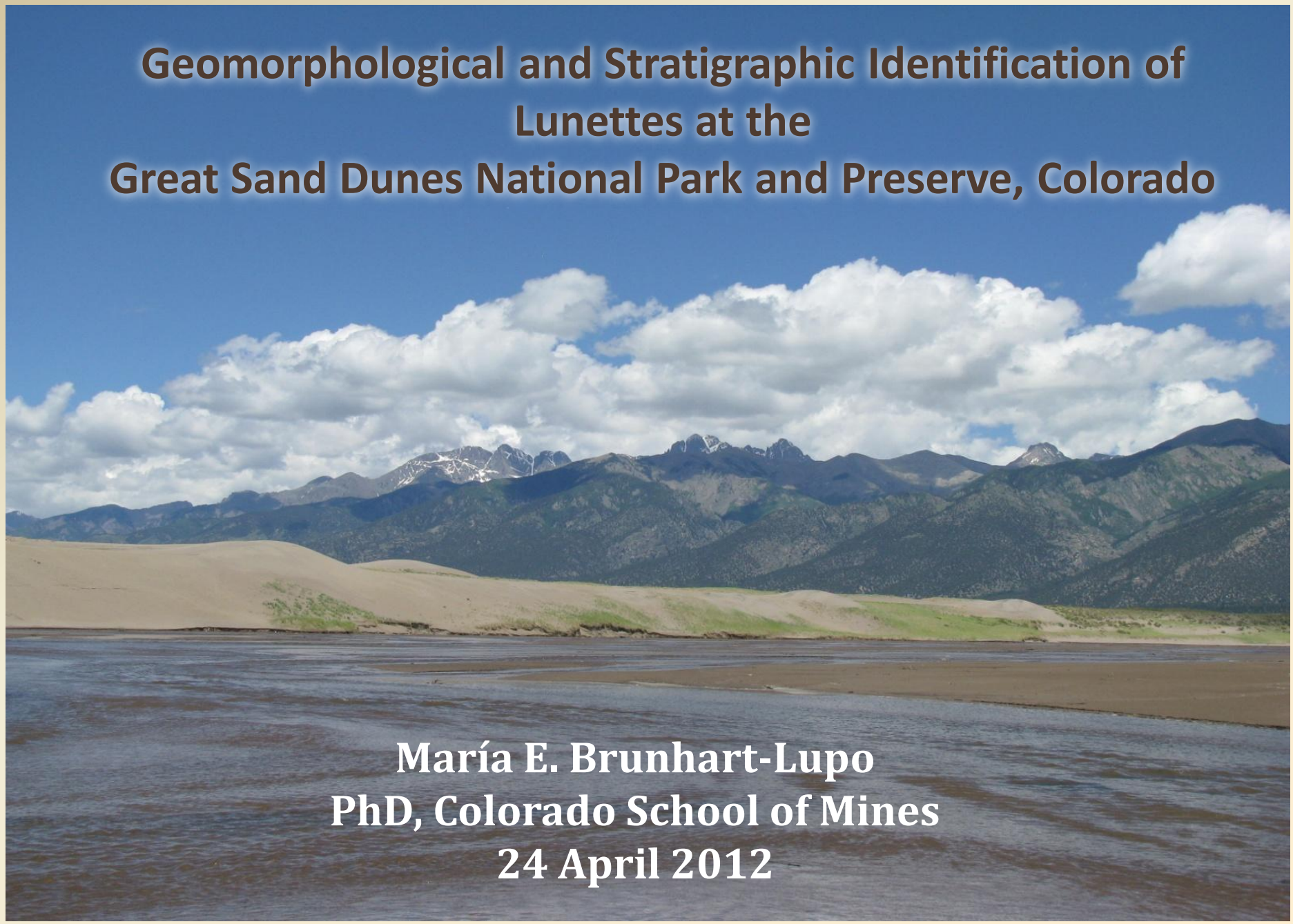
Madole, R.F., J.H. Aleinikoff, D.P. VanSistine, and E.Y. Yacob, 2008, On the origin and age of the Great Sand Dunes, Colorado: Geomorphology, v. 99, p. 99-119.

Madole, R.F., 2001, Quaternary geology and geomorphology of the Indian Spring district and adjoining areas: National Park Service, Great Sand Dunes National Monument and Preserve, Colorado, 37 p.

Website

Hesp, P., Patrick Hesp's field photos: Web accessed 25 July 2012. http://www.ga.lsu.edu/hesp/photos.html

Geomorphological and Stratigraphic Identification of Lunettes at the Great Sand Dunes National Park and Preserve, Colorado



María E. Brunhart-Lupo
PhD, Colorado School of Mines
24 April 2012

ACKNOWLEDGEMENTS

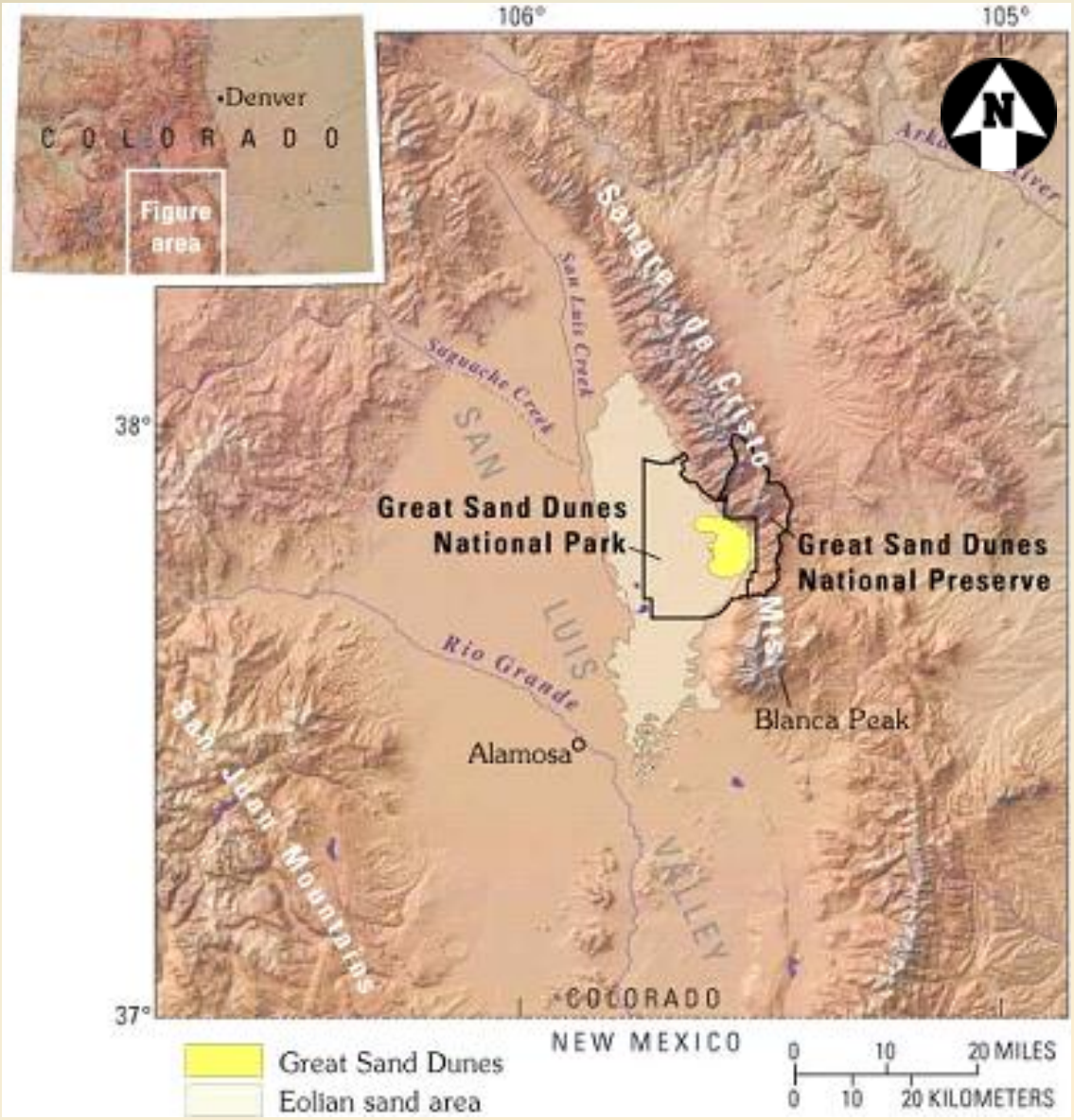
This project was possible through the generosity of the Great Sand Dunes National Park and Preserve; in particular, Mr. Andrew Valdez.

Thanks also go to Shannon Mahan, from the USGS, for all of her assistance and for OSL testing.

SCIENTIFIC AIMS AND OBJECTIVES

- Identify deposit at San Luis Lake and integrate it into a working model for the system
- Understand evolutionary history and formation of lunettes and playas
- Use GRSA lunette stratigraphy to understand the accretion method of lunettes in a system with a lack of available fines

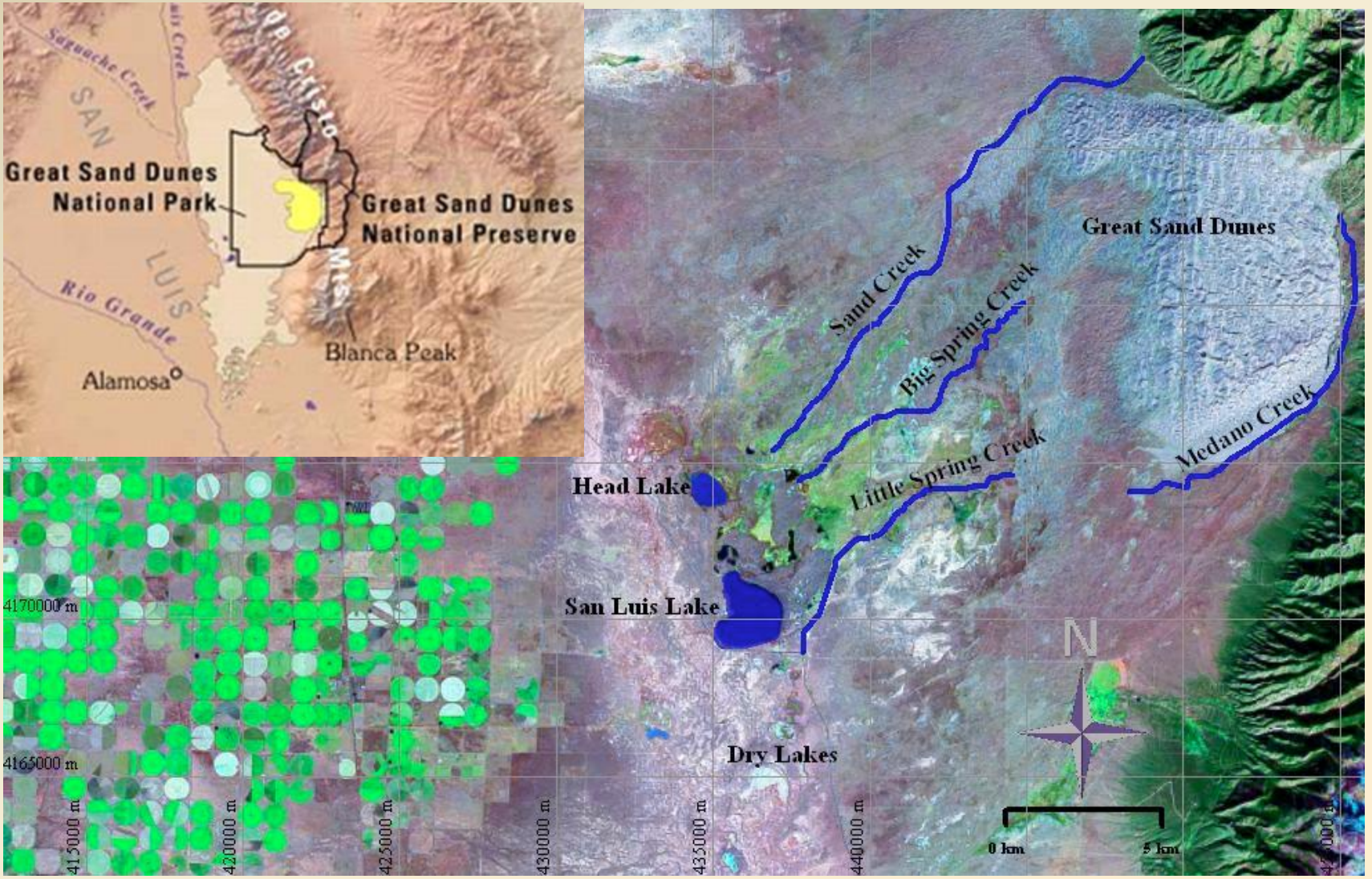
GEOLOGICAL SETTING

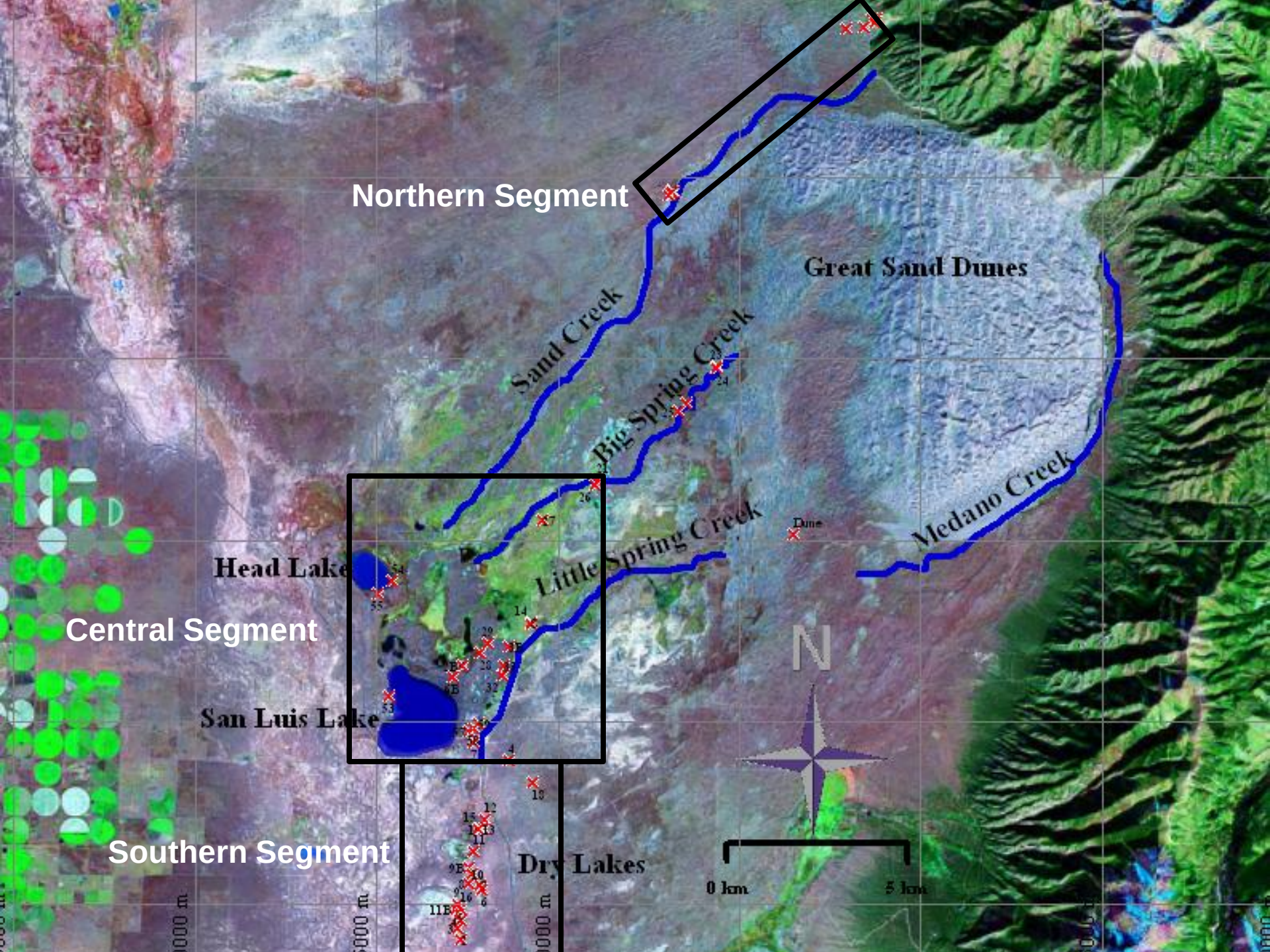


Prevailing Wind

Locational map of the GRSA site, modified after Matthews, 2003

FIELD LOCATION

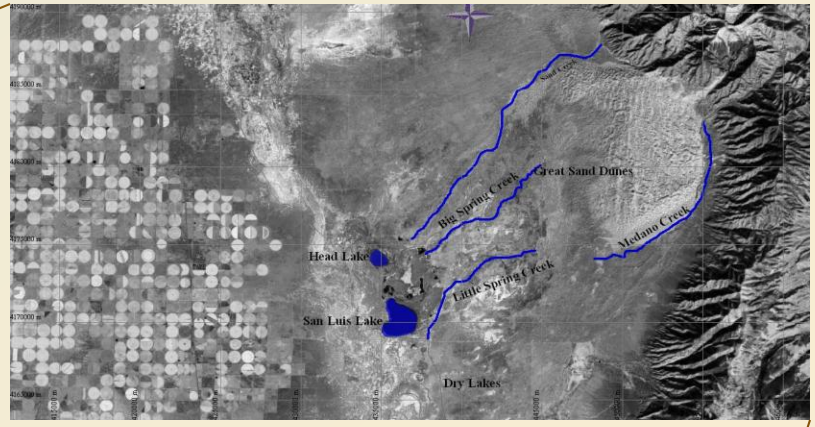


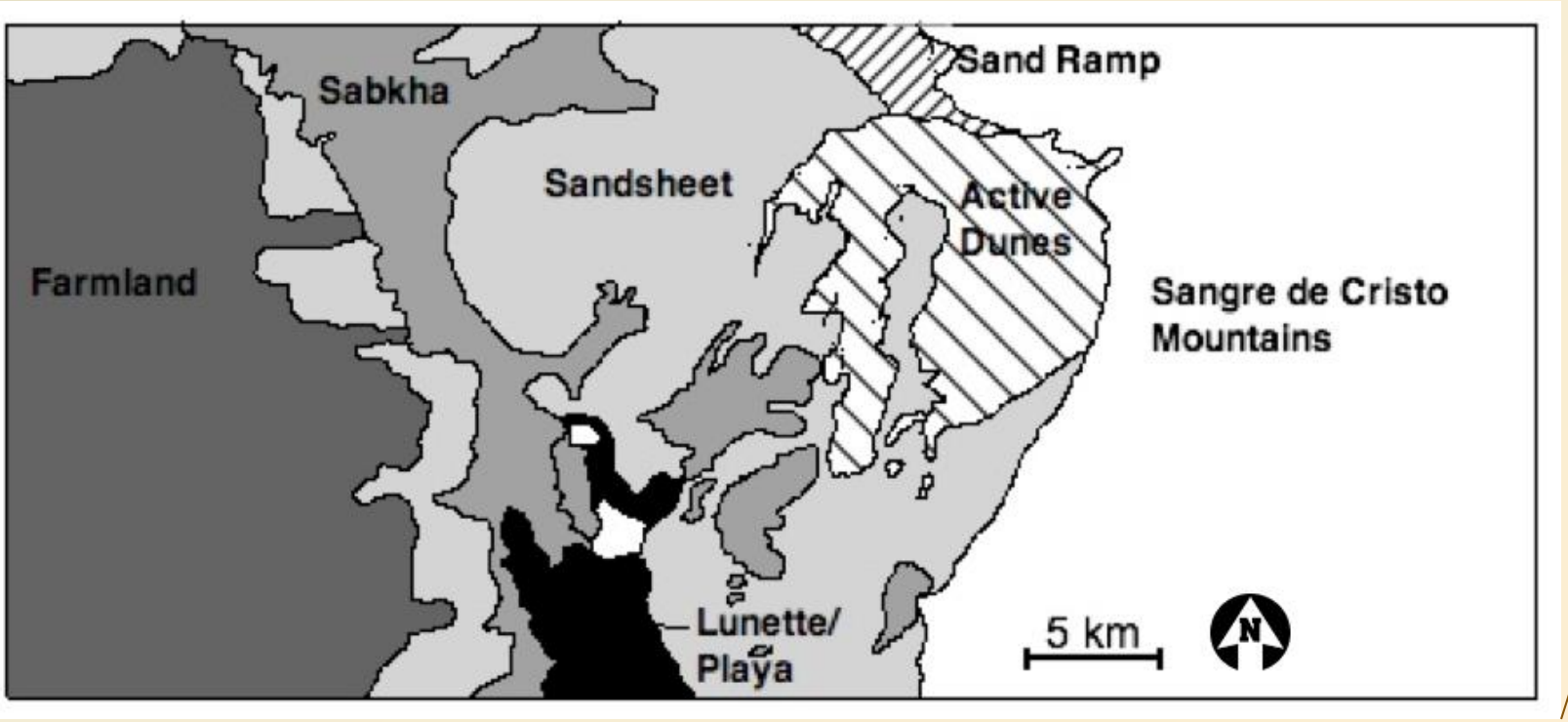

Northern Segment
Great Sand Dunes
Sand Creek
Big Spring Creek
Medano Creek
Little Spring Creek
Dune
Head Lake
Central Segment
San Luis Lake
Southern Segment
Dry Lakes
N
0 km
5 km

GEOMORPHOLOGICAL FEATURES

- Geomorphological features were mapped across the site to determine present landforms:
  - ***Active Dune Field*:** reversing dunes, star dunes, parabolic dunes, barchan dunes, transverse dunes and nebkha dunes
  - ***Sand Sheet:*** deflation surfaces, sand sheet containing fluvial deposits, and stabilized dunes
  - ***Sabkha***: sabkha surfaces
  - ***Lunette and Playa Systems:*** lunettes and playa deposits
  - ***Sand Ramps*:** sand ramp deposits and fluvial deposits
  - ***Farmland Zone*:** extensive anthropological modification located along the western margin of the field site
  - ***Sangre de Cristo Mountains***: border the GRSA to the east

GEOMORPHOLOGIC ZONE MAP

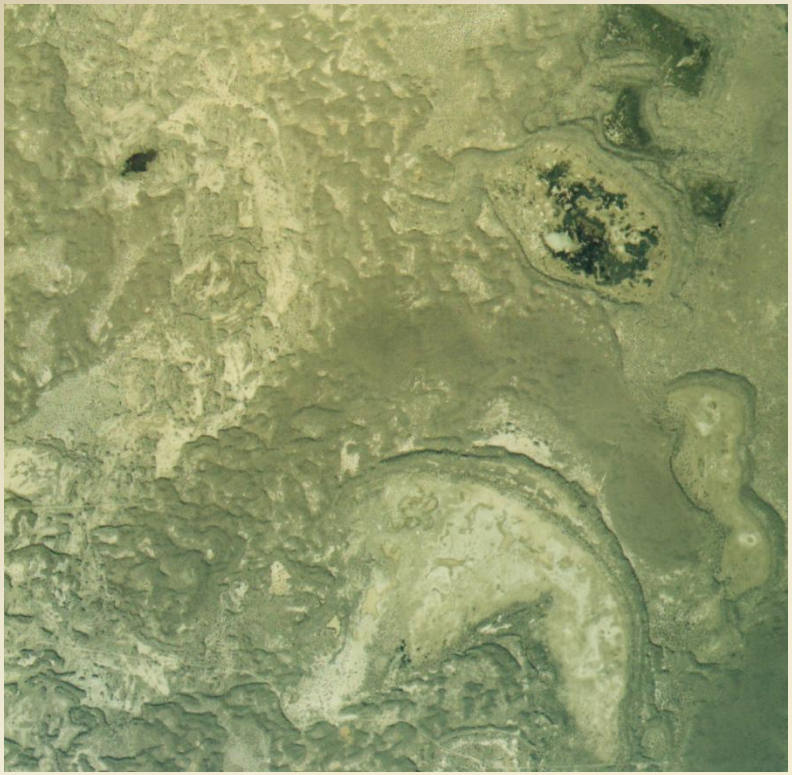




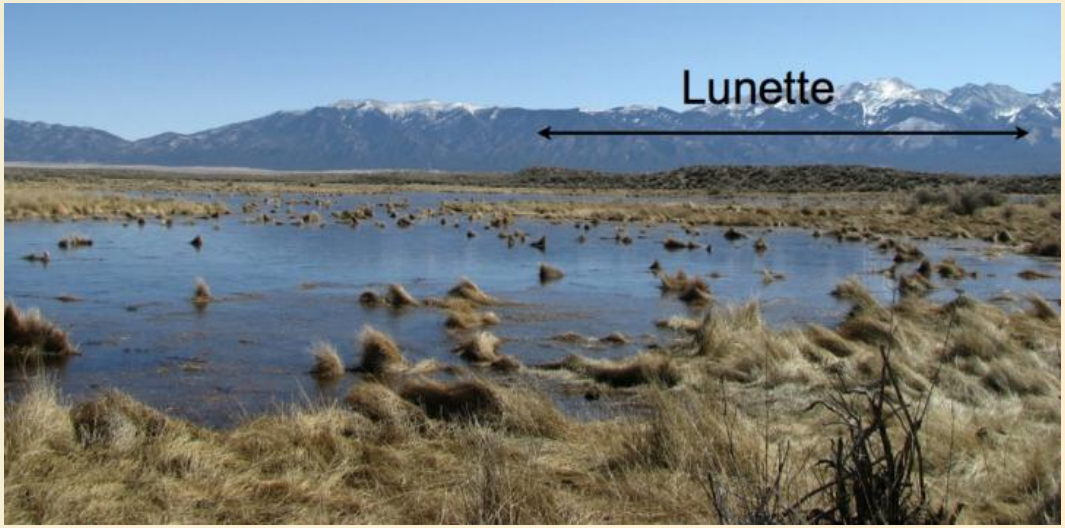
LUNETTES

- Definition of lunette - as accepted in current geological sciences:
  - a low, 'horse-shoe' shaped deposit
  - comprised of fines and sand sized particles – accretes with interbedding fines and sand layers
  - always adjacent to the lee side of a playa – playa controls shape and size of lunette and serves as source of fines
  - curves up to 2/3 around the lee perimeter of the playa
  - has a notable crest, with a steep lee face and gentle windward face
  - resembles a parabolic dune
  - contains a clay core

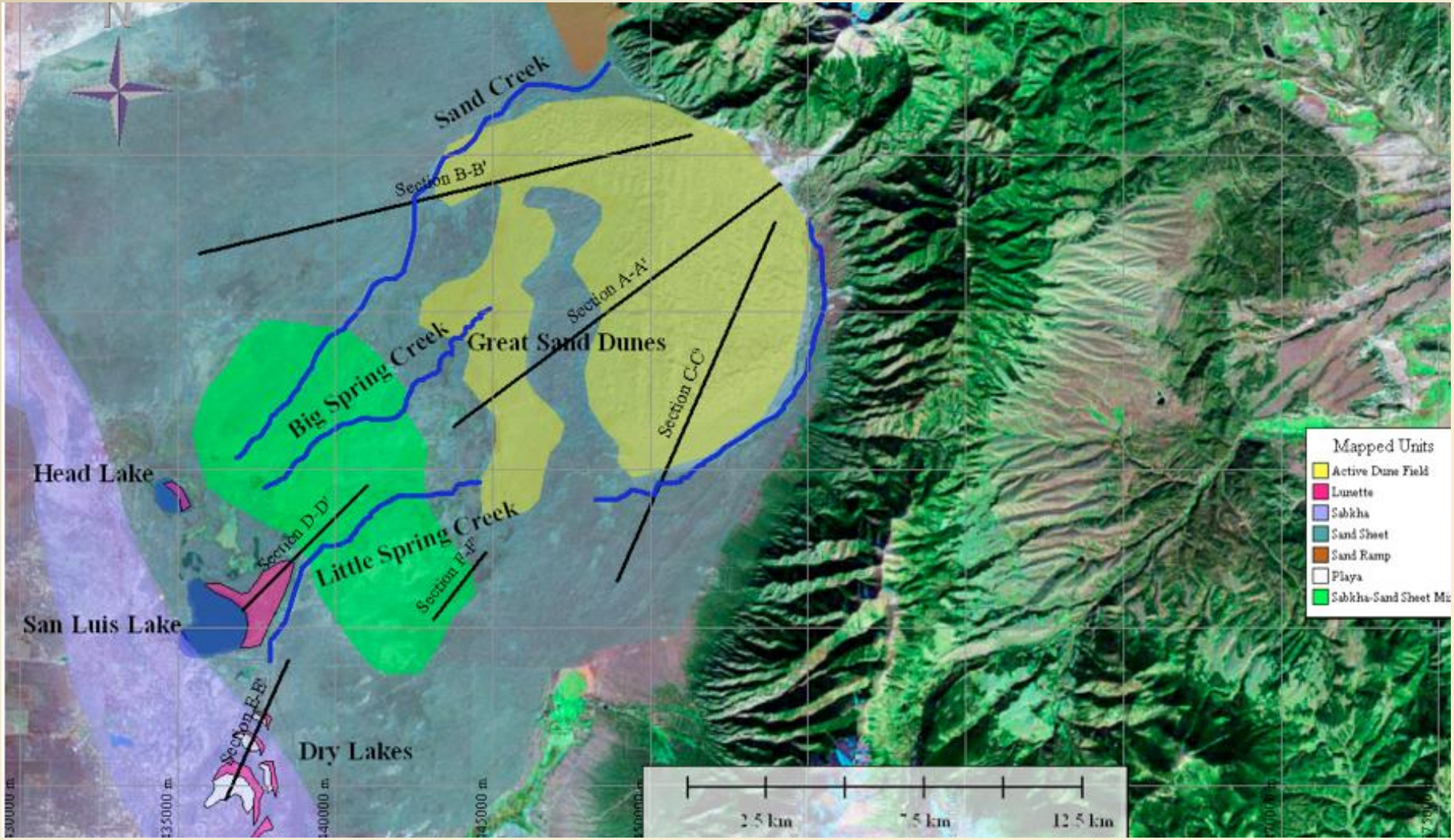
LUNETTES

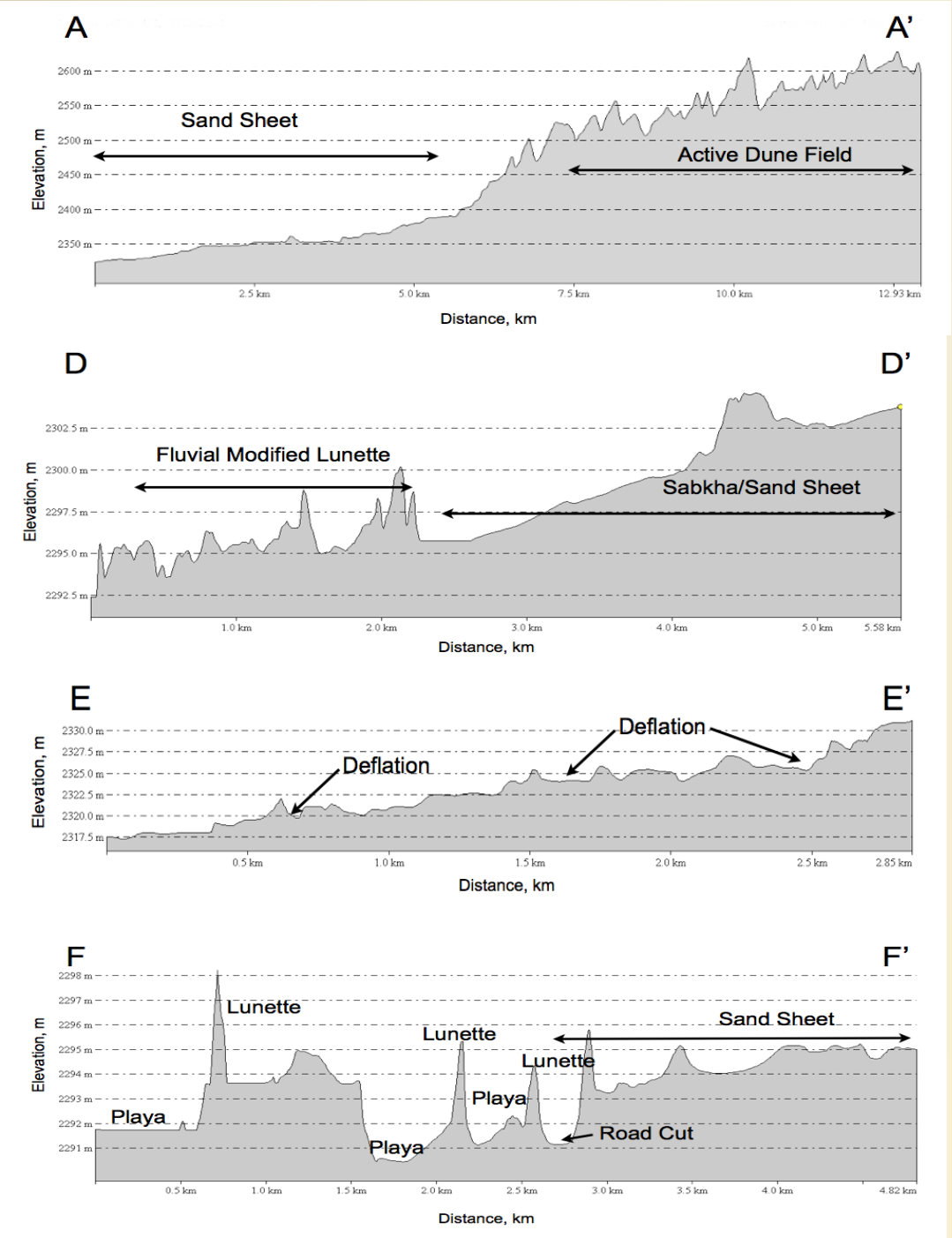


NPS aerial archive



COMPARISON CROSS SECTIONS

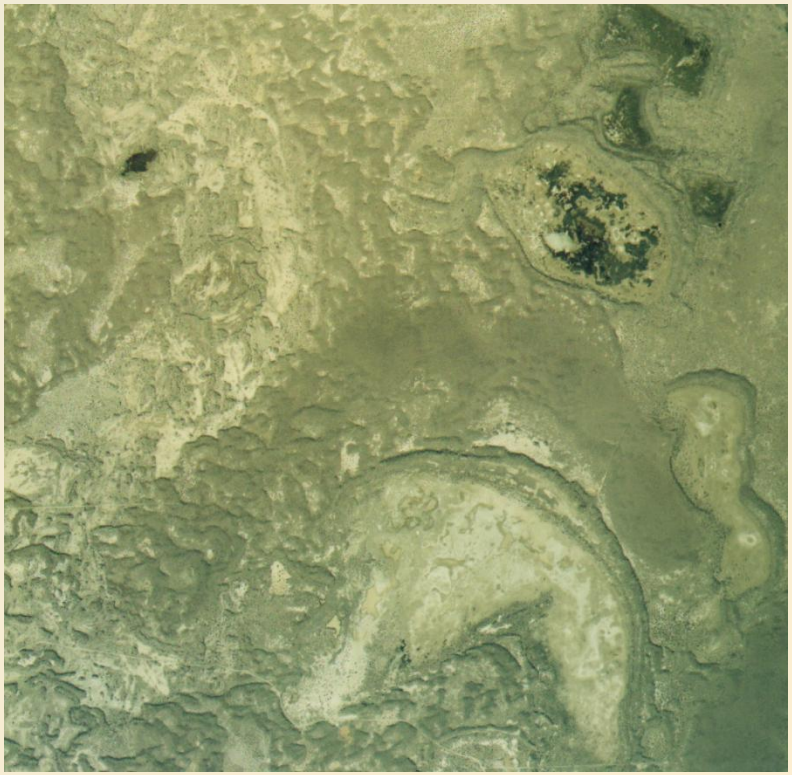




Note Vertical Exaggeration

BLOWOUT VS LUNETTE

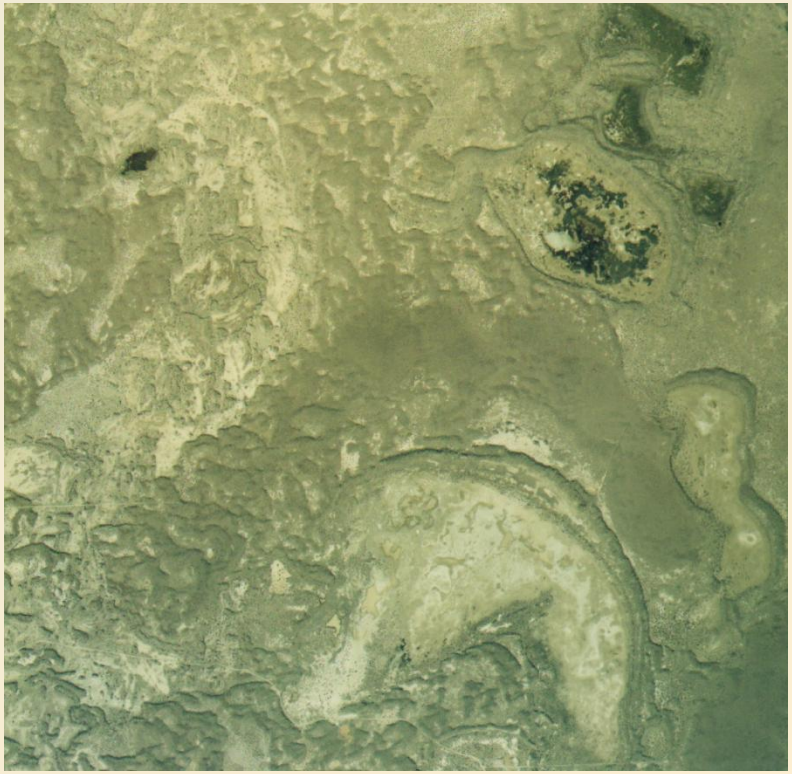
Hesp, 2000



NPS aerial archive

PARABOLIC DUNE VS LUNETTE

Hesp, Homer, 2000

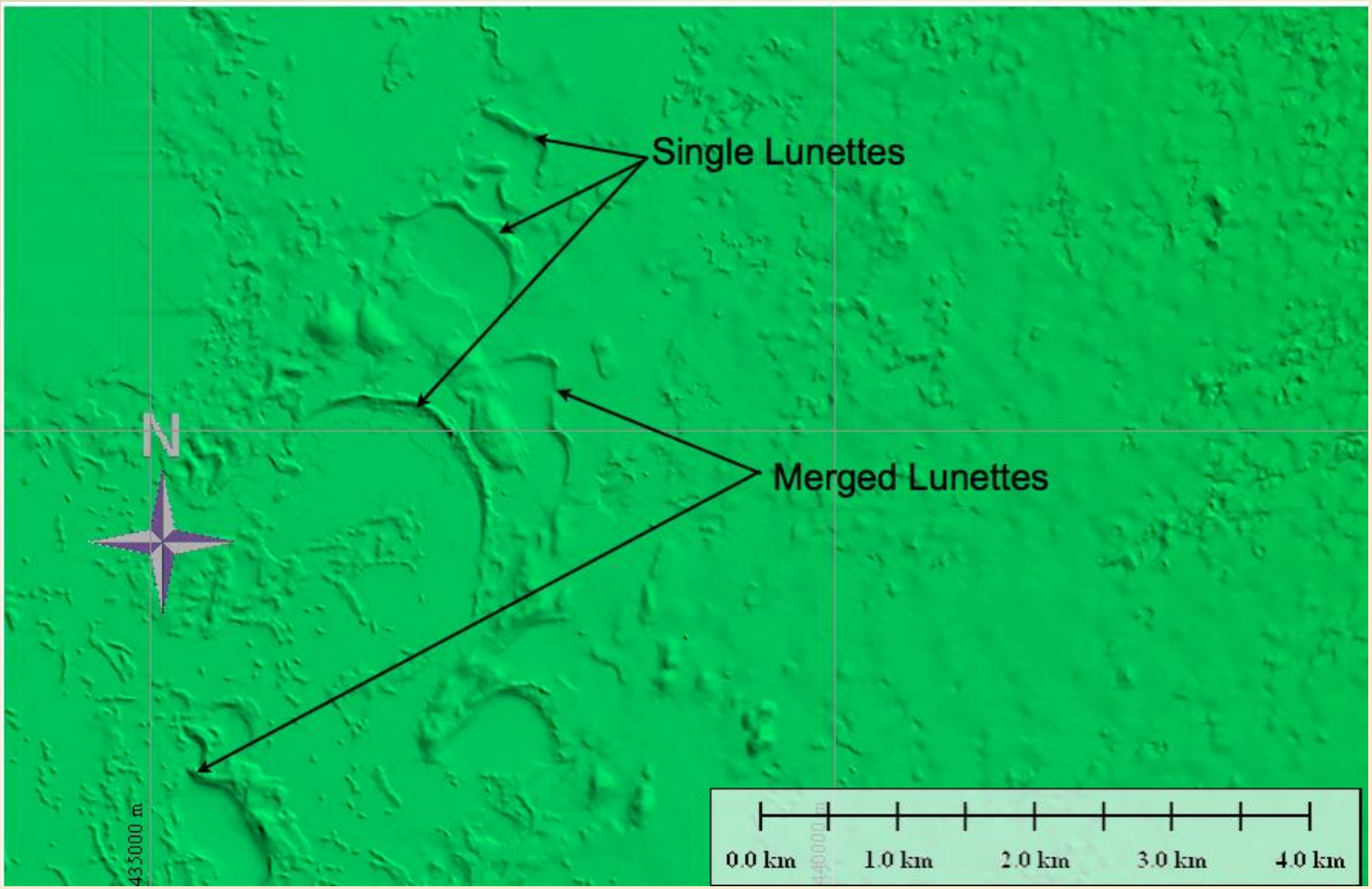


NPS aerial archive

GEOMORPHOLOGICAL IDENTIFICATION AND COMPARISON: SAN LUIS AND DRY LAKES SYSTEMS

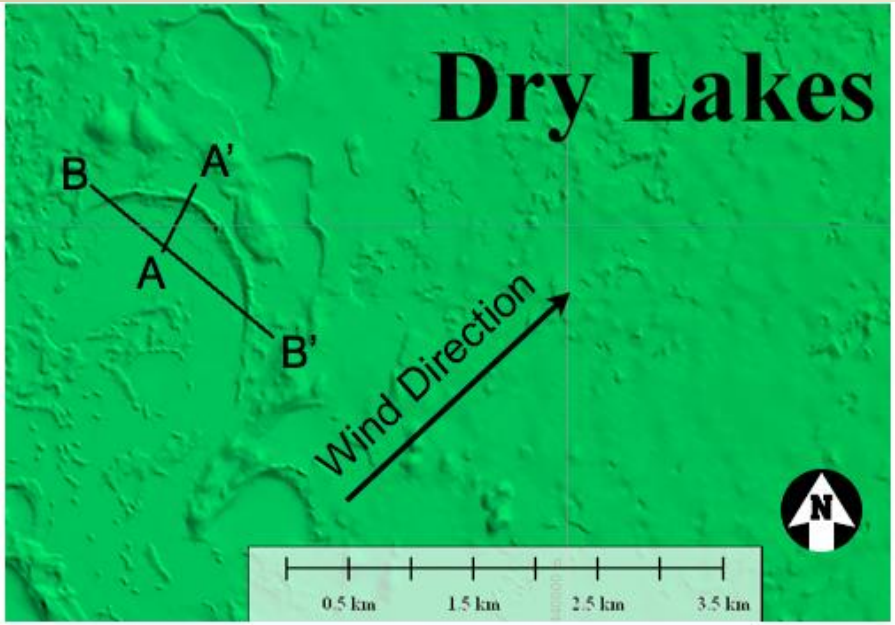
- Three lunette types mapped and described by segment
- Central Segment contains fluvially modified lunette at San Luis Lake
- Southern Segment contains single, discrete and merged lunette systems at the Dry Lakes
- Each lunette type displays a unique topographic profile

SINGLE AND MERGED LUNETTE MAP: DRY LAKES AREA DEM

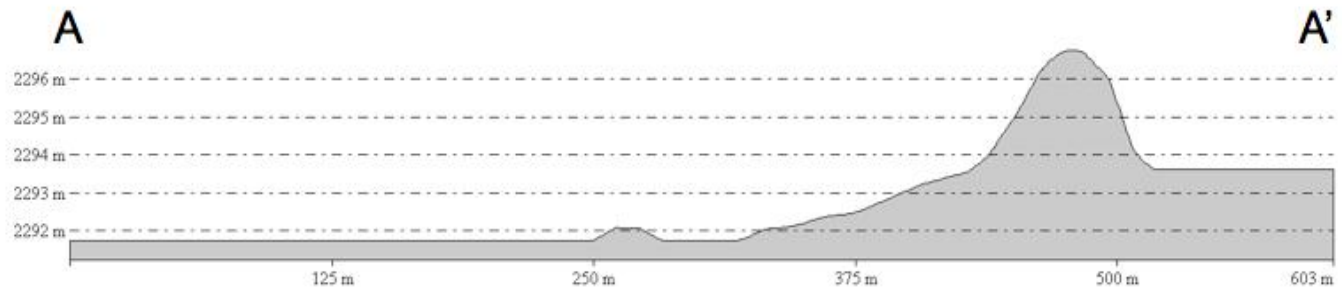


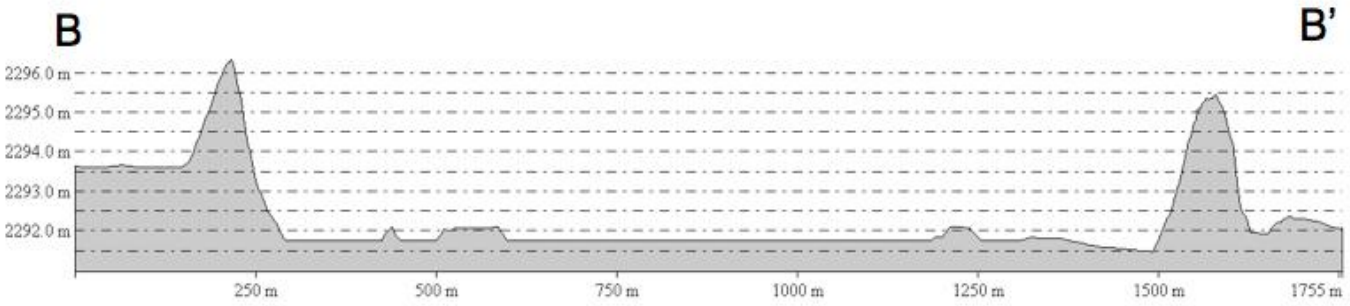
SINGLE DISCRETE LUNETTES

- Most common type of lunette, accounts for approximately 90% of all identified lunette deposits at GRSA
- Observed in Dry Lakes area
- Dimensions are generally narrow; width: 3 to 4 m, median height: 3 m
- Similar to lunettes recognized elsewhere: distinctive horseshoe shape, ~2/3 around lee side of associated playa
- Do not connect to any other morphologic features
- Closely linked to lee perimeter of the playa with no additional topography between lunette and playa



Single Lunette



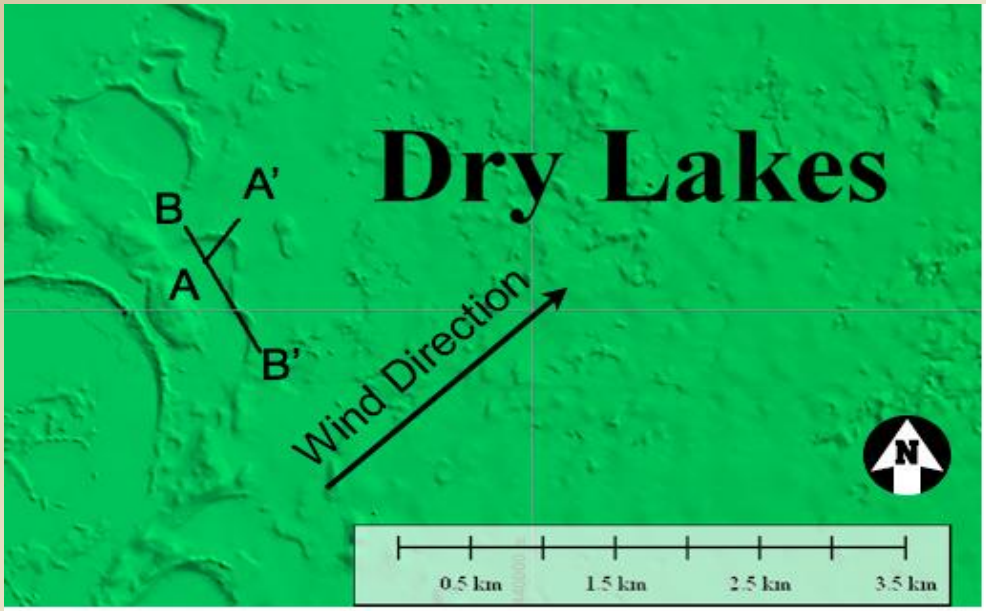


MERGED LUNETTES

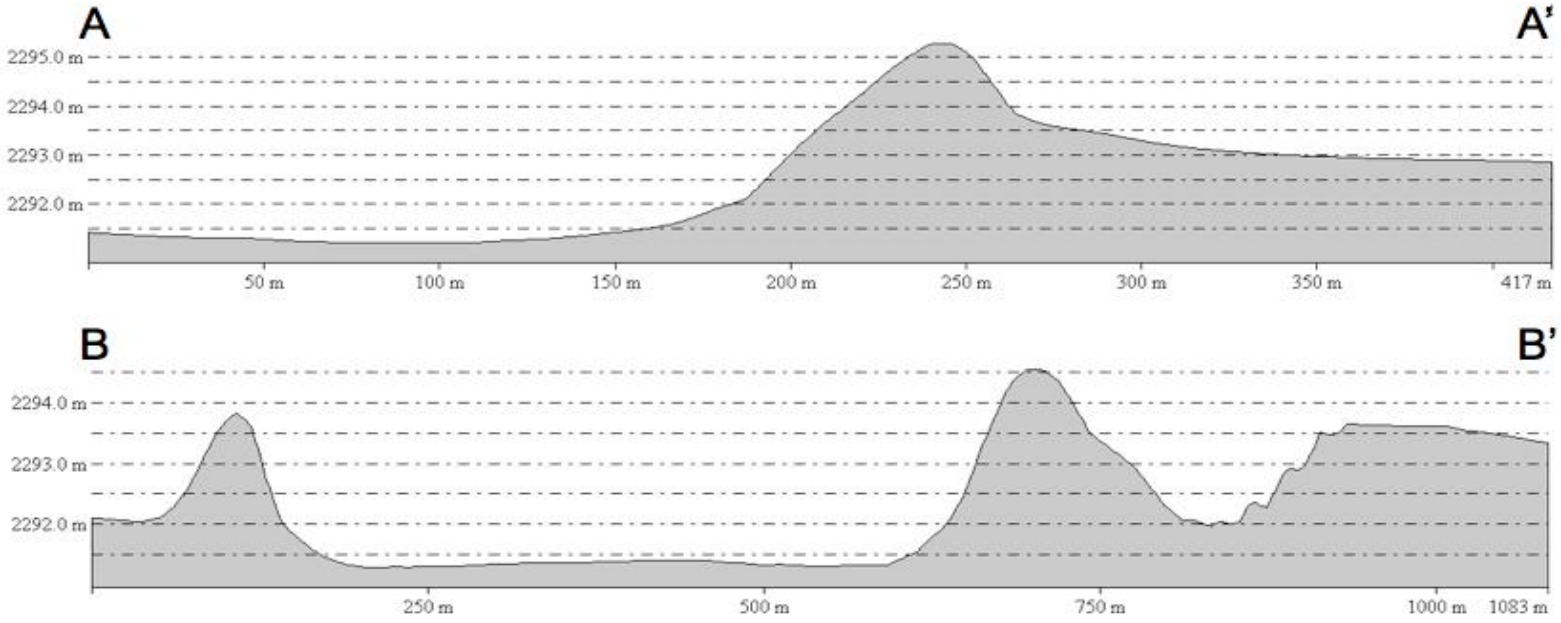
- Two positively identified; plausible third and fourth
- Form 7% of all identified lunettes in GRSA
- Merged lunettes consist of two single, discrete lunettes forming in close proximity and developing into single lunette front
- Merged lunettes occur predominantly in the vicinity of the Dry Lakes area

MERGED LUNETTES

- Dimensions and formation of original lunettes are identical to the profile of a single, discrete lunette; no topography between lunette and playa
- In merged lunette system, playa is furthest from lunette at edges
  - Up to 5 m between the lunette and the playa
  - Near center, playa is closer (3 m maximum distance)



Merged Lunette

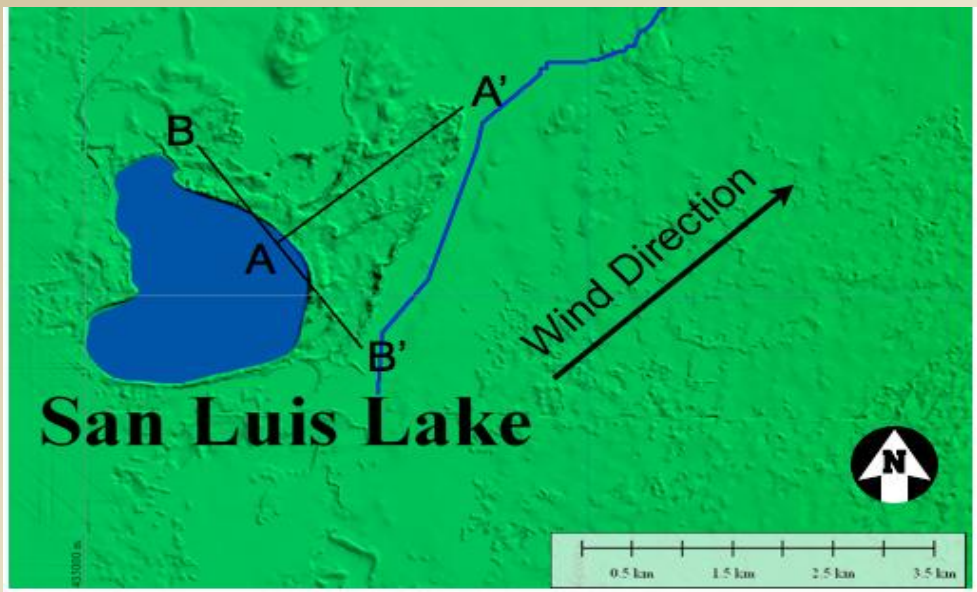


FLUVIALLY MODIFIED LUNETTE

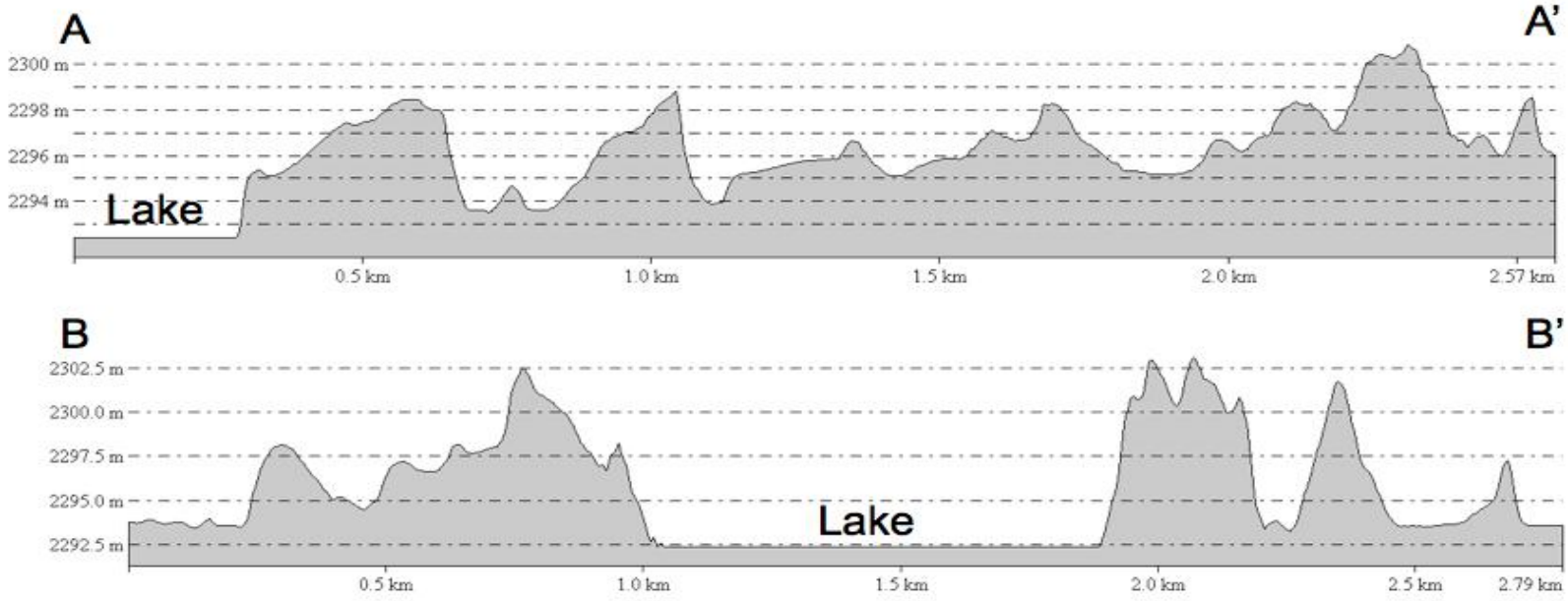
- Least populous (one lunette of this type, 3% of the population)
- Largest lunette in the field area
- This lunette deviates greatly from the common shape of lunettes documented elsewhere
- Fluvially modified system displays large amount of relief between the main lunette front and playa – three identified lunette ridges

FLUVIALLY MODIFIED LUNETTE

- Zone spans over a km in width/length
- Deposits have distinct internal architecture with complex mixture of different deposit types from different sub-environments
- Resembles that of single, discrete type, but does not have a singular, uniform, solid front
- Lunette front instead contains small valleys and ridges



Fluvial Modified Lunette



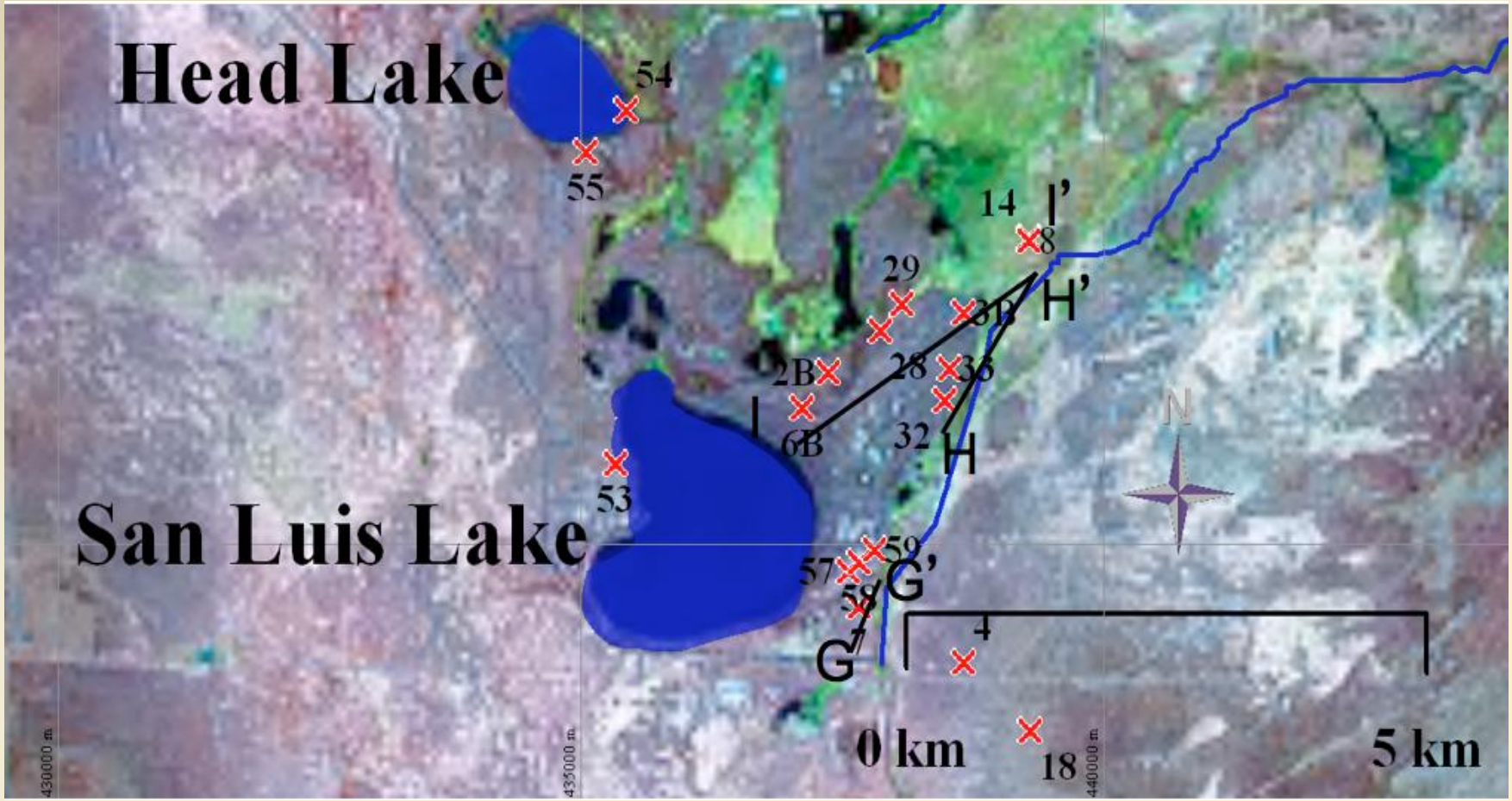
SEDIMENT TYPES

- Lunettes sampled to determine if type differences were geomorphic and/or stratigraphic
- Findings led to the identification and mapping of five distinct sediment types across lunettes
  - Discontinuous deposits (no connection of lunettes across the field)
  - Sediment types are common across the site

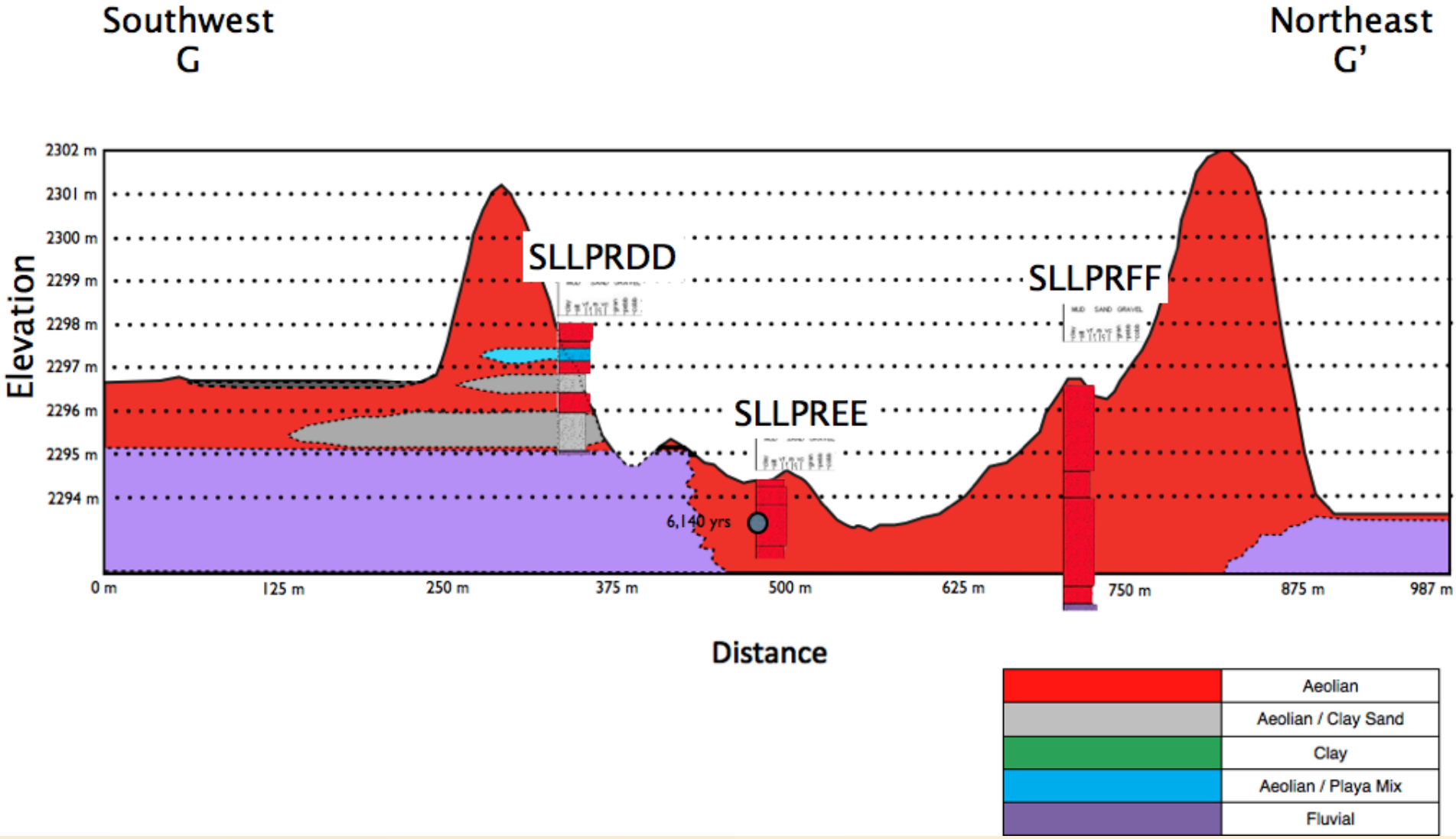
SEDIMENT TYPES

- Type 1 – **Fluvial Sand**
- Type 2 – **Clay – Arid Stage Playa Depocenter or Wet Cycle Playa Depocenter**
- Type 3 – **Aeolian Sand: Lunette Body, partial Sand Sheet**
- Type 4 – **Aeolian Sand and Playa Fines: Lunette/Playa Boundary Zone**
- Type 5 - **Aeolian Sand and Clay Mix: Playa Deposit**

SAN LUIS LAKE CROSS-SECTION AND SAMPLE MAP

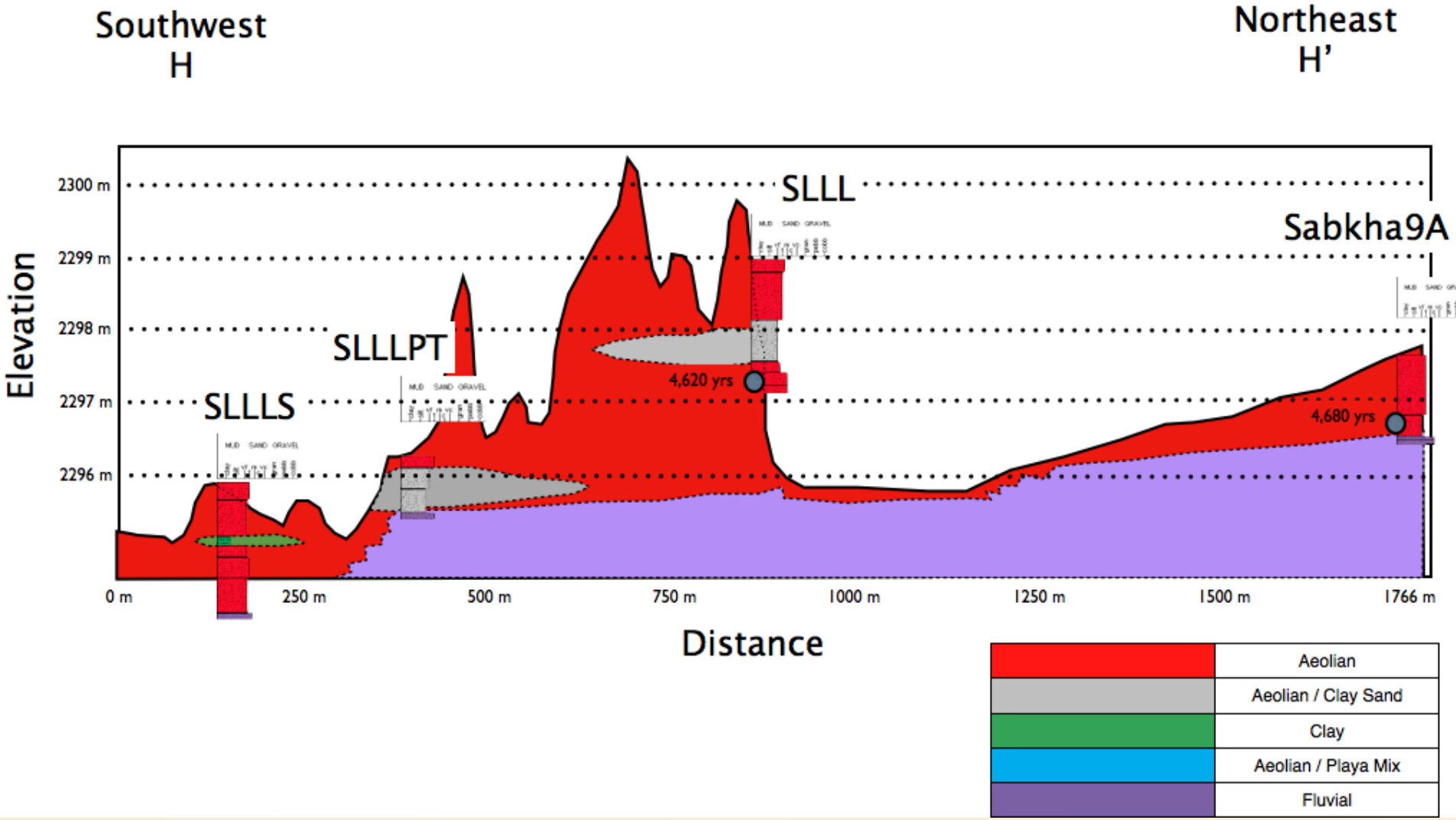


SECTION G-G’



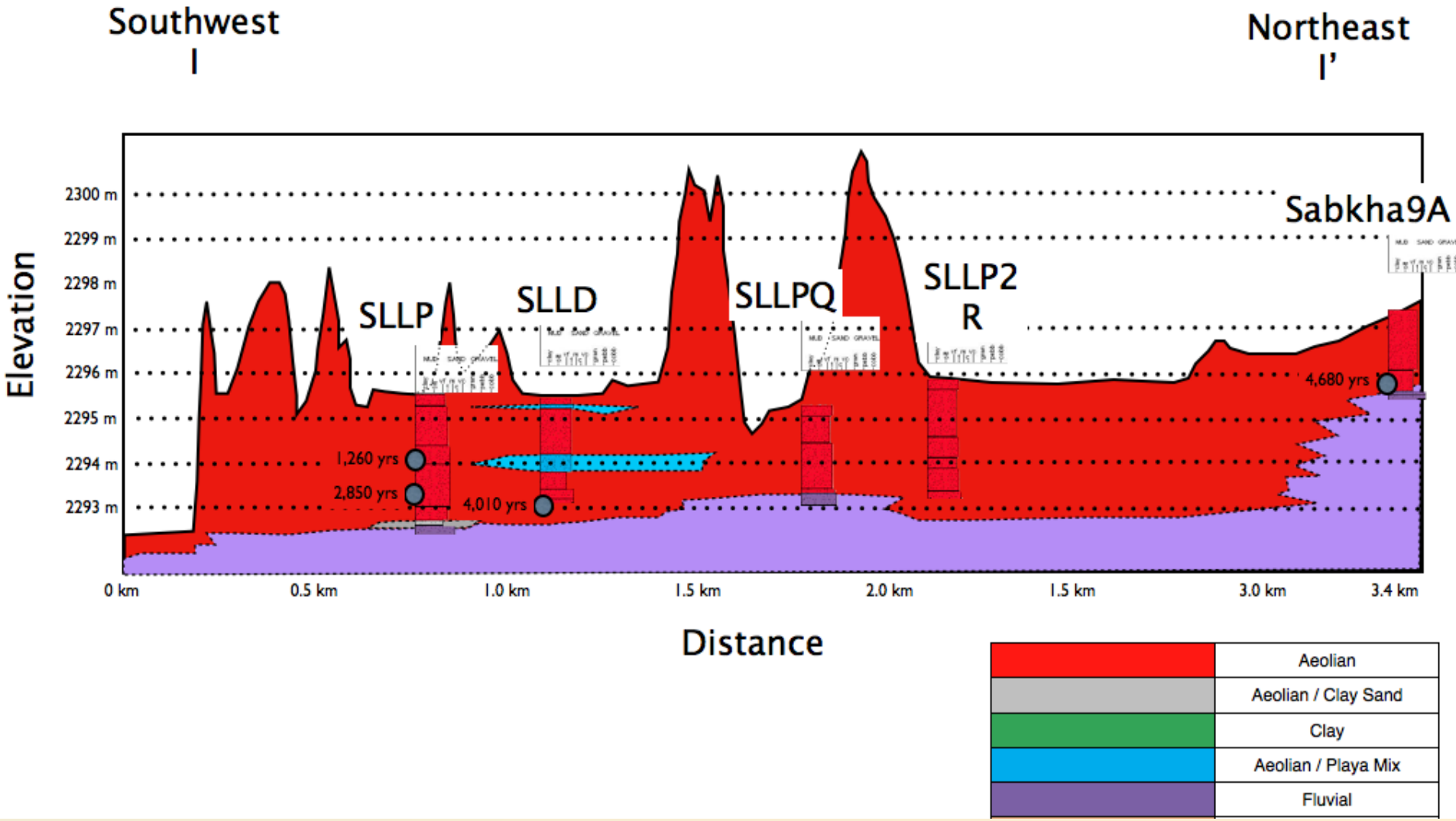
Vertical Exaggeration = 32x

SECTION H-H’



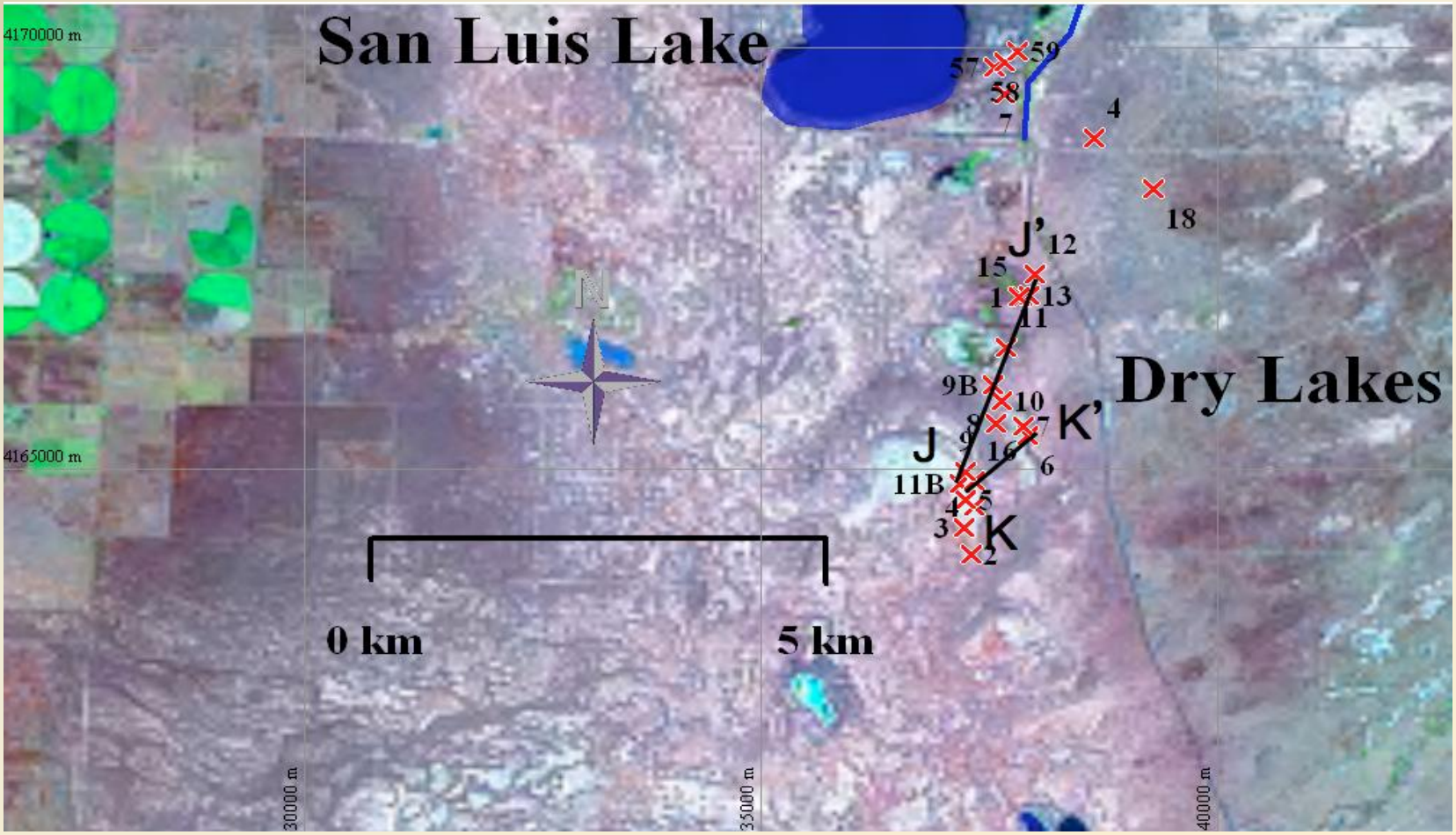
Vertical Exaggeration = 90x

SECTION I-I’

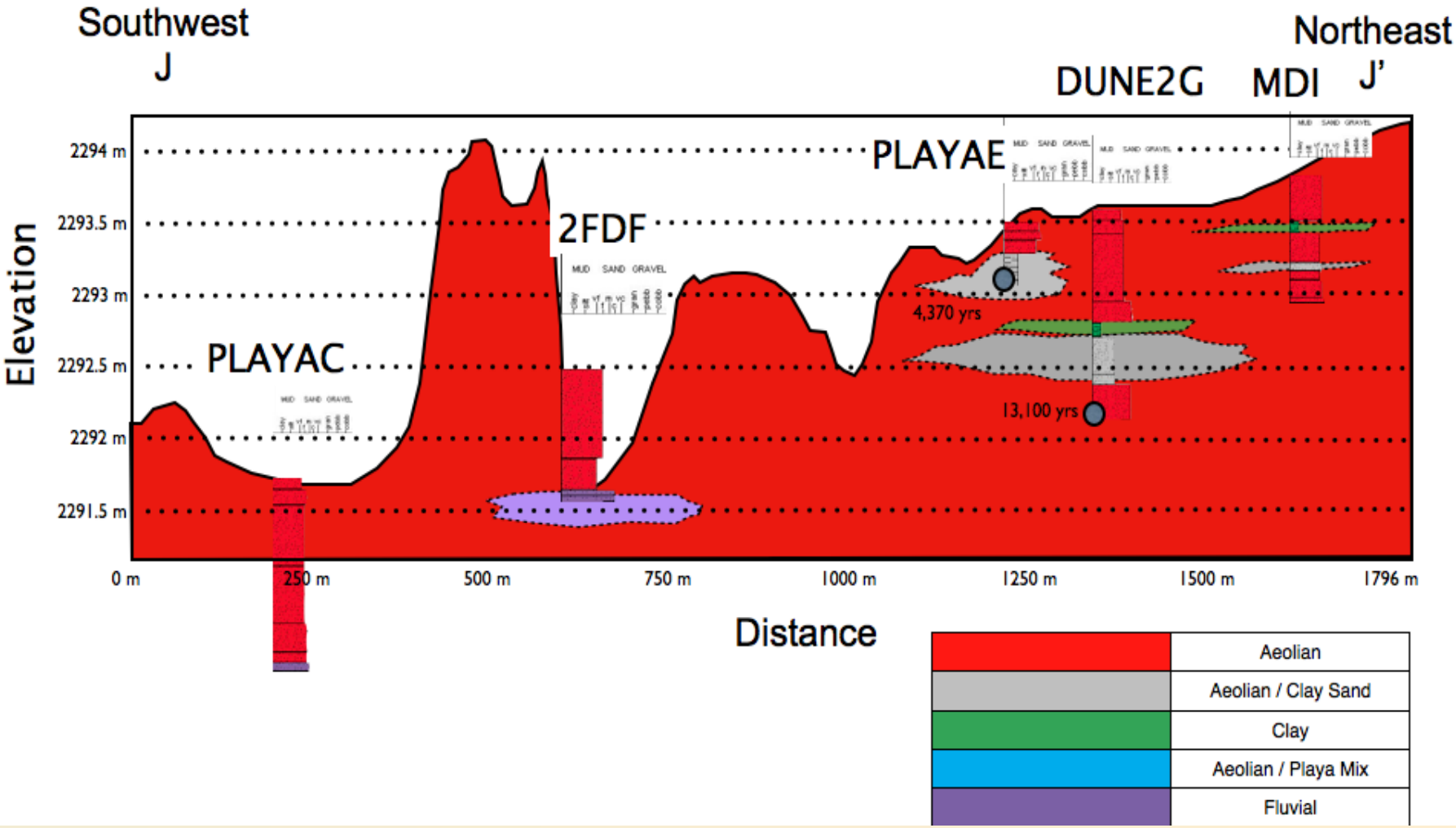


Vertical Exaggeration = 115x

DRY LAKES CROSS-SECTION AND SAMPLE MAP

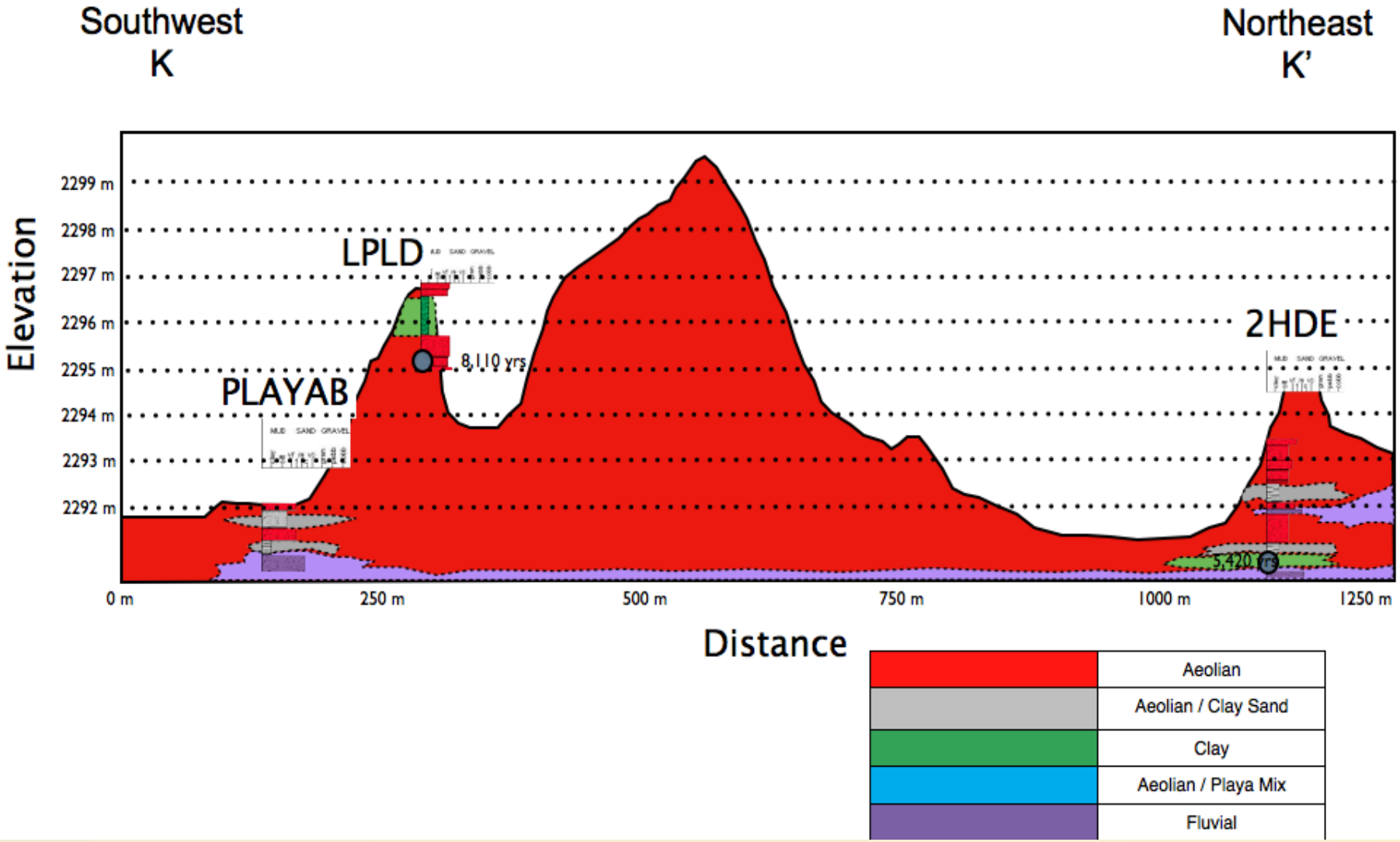


SECTION J-J’



Vertical Exaggeration = 200x

SECTION K-K’



Vertical Exaggeration = 40x

KEY FINDINGS

- Aeolian feature located at San Luis Lake is fluvially modified lunette; reflects the complex and active depositional environment influenced by Sand Creek and Big Spring Creek
- In contrast, the Dry Lakes lunettes are single and merged lunettes, associated with distinct and relatively stable playas
- There are three types of lunettes present within the GRSA:
  - Single lunettes
  - Merged lunettes
  - Fluvially modified lunette

CONCLUSIONS OF STUDY

- Geomorphology:
  - San Luis Lake deposit is consistent with the geomorphological expression of a lunette although shape does not fit the idealized lunette profile
  - Three types of lunettes within the system, all are geomorphologically distinct
  - Development and implementation of lunette classification scheme not previously suggested or used in lunette systems

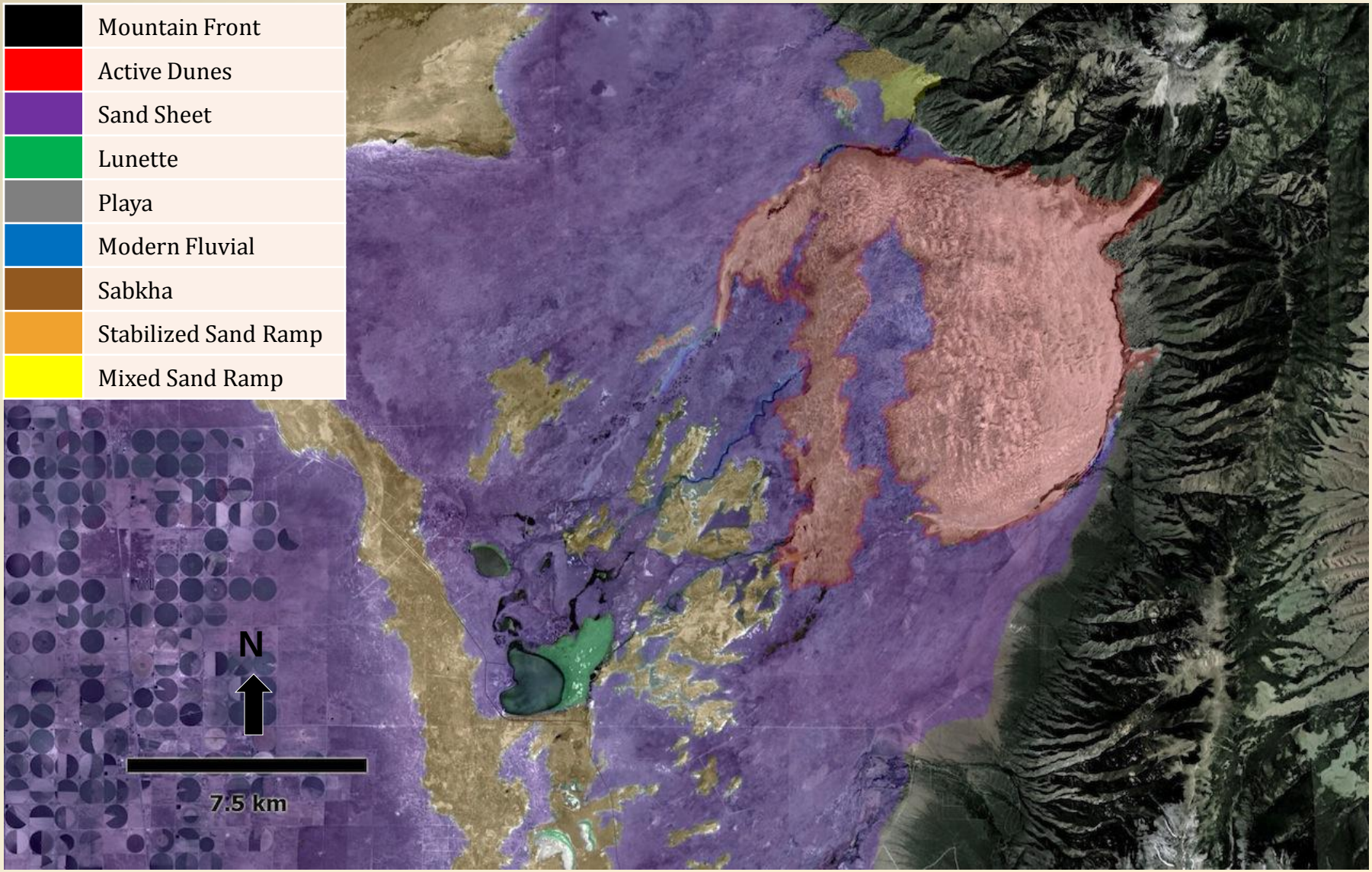
CONCLUSIONS OF STUDY

- Lunette and Playa Systems:
  - Lunettes have different geomorphological expressions
  - Consistent stratigraphic and sedimentologic characteristics across all types
  - Classification by modification, not depositional processes - differentiation is geomorphological
  - Lunettes are stable features unlike surrounding dynamic aeolian system
  - Current surfaces of lunettes not accreting, instead are sediment bypass surfaces

THANK YOU

Thank you for attending this presentation and for your questions.

OVERALL SURFICIAL MAP



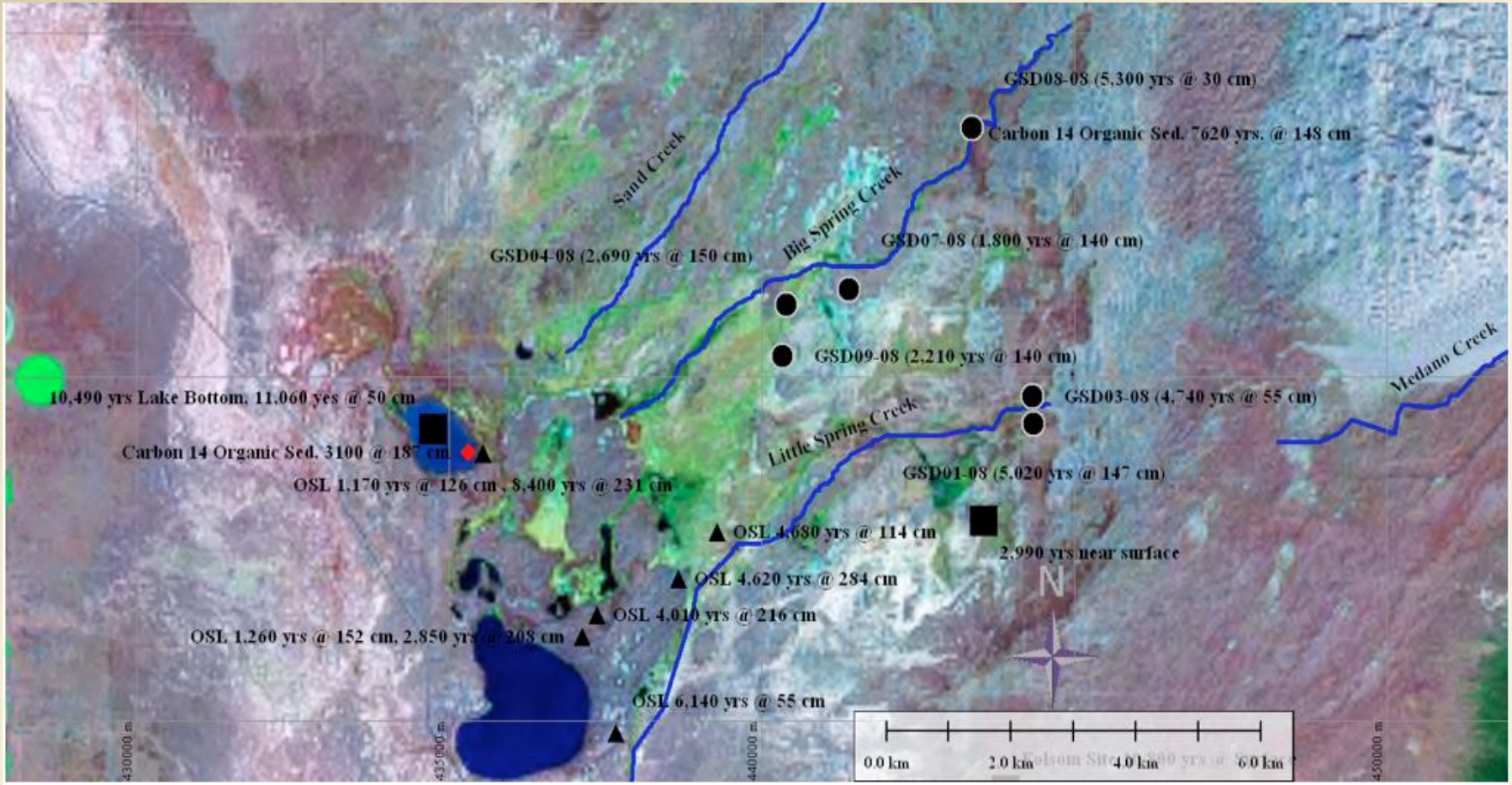
Sediment Type Interpretation								
Type	**Predominant Grain Size**	**Sorting**	**Rounding**	**Mineralogy**	**Organics**	**Clay Content**	**Deposit Occurrence**	**Interpreted Environment**
1	710-2000 µm	Well to moderate	Subrounded to subangular	Quartz, plagioclase, orthoclase, pyroxenes, amphiboles, magnetite, volcanic fragments	None present	None to minor	Layer or discrete lenses	Fluvial Sand
2	Clay (small, varying amounts of silt/ very fine sand present)	Well to moderate	N/A	Montmorillonite, illite, quartz, plagioclase, orthoclase pyroxenes, amphiboles, magnetite, volcanic fragments	Yes, varying: none to minor presence	Almost entirely clay	Discrete, commonly thin, discontinuous layers	Clay – Arid Stage Playa Depocenter or Wet Cycle Playa Depocenter
3	177-350 µm	Well to moderate	Subrounded to subangular	Quartz, plagioclase, orthoclase, pyroxenes, amphiboles, magnetite, volcanic fragments and clay	Yes, varying: none to minor presence	Minor	Discontinuous layers of varying internal structure	Aeolian Sand: Lunette Body, partial Sand Sheet
4	177-350 µm	Well to moderate	Subrounded to subangular	Quartz, plagioclase, orthoclase, pyroxenes, amphiboles, magnetite, volcanic fragments, and clay	Yes, always present	Minor to moderate	Discontinuous lenses and layers of varying internal structure	Aeolian Sand and Playa Fines: Lunette/Playa Boundary Zone
5	177-350 µm, second fraction within 74 to 105 µm	Moderate	Subrounded to subangular	Quartz, plagioclase, orthoclase, pyroxenes, amphiboles, magnetite, volcanic fragments and clay	Yes, varying: none to minor presence	Moderate	Discontinuous lenses of varying internal structure	Aeolian Sand and Clay Mix: Playa Deposit

AGE DATE RESULTS – CENTRAL SEGMENT

OSL Dates – Central Segment							
Sample ID	**K%**	**U (ppm)**	**Th (ppm)**	**n**	**Depth (cm)**	**Deposit Type**	**Age (ka)**
HL6BB	3.71±0.09	3.78±0.17	14.4±0.29	22(25)	231	Aeolian Sand	8.40±0.68
SLLPR22EE	3.96±0.15	4.18±0.24	14.6±0.29	19(20)	55	Aeolian Sand	6.14±0.48
Sabkha 9A	3.51±0.12	3.74±0.13	12.7±0.32	25(30)	114	Aeolian/Fluvial Sand	4.68±0.34
SLLL7	3.96±0.14	3.41±0.20	12.3±0.22	19(20)	284	Aeolian Sand	4.62±0.51
SLLD5	3.75±0.07	4.03±0.20	13.2±0.6	20(30)	216	Aeolian Sand	4.01±0.30
SLLP6	3.62±0.12	3.76±0.10	11.1±0.25	16(20)	208	Aeolian Sand	2.85±0.30
SLLP3	3.62±0.12	3.76±0.10	11.1±0.25	26(28)	152	Aeolian Sand	1.26±0.10
HL4BB	3.71±0.09	3.78±0.17	14.4±0.29	20(35)	126	Aeolian Sand	1.17±0.09

Carbon 14 Dates – Central Segment				
Sample ID	**Material Tested**	**Depth (cm)**	**Deposit Type**	**Age** (conventional radiocarbon age)
CBN4	organic sediment	148	Aeolian Sand	7,620±50 years BP
HL5BB	organic sediment	187	Aeolian Sand	3,100±40 years BP

AGE DATE LOCATION MAP- CENTRAL SEGMENT



This Study

Couroux, 2001

Madole, 2008

AGE DATE RESULTS – SOUTHERN SEGMENT

OSL Dates – Southern Segment							
Sample ID	**K%**	**U (ppm)**	**Th (ppm)**	**n**	**Depth (cm)**	**Deposit Type**	**Age (ka)**
2DH#12E	3.96±0.13	4.18±0.15	14.0±0.37	17(25)	305	Fluvial Sand	**5.42±0.34**
PLAYA6E	3.42±0.14	3.97±0.17	13.1±0.20	18(25)	100	Aeolian Sand/Clay	**4.37±0.32**
LPL#5A	3.80±0.08	4.54±0.23	11.8±0.63	26(28)	153	Aeolian Sand/Clay	**4.27±0.36**

Carbon 14 Dates – Southern Segment				
Sample ID	**Material Tested**	**Depth (cm)**	**Deposit Type**	**Age** (conventional radiocarbon age)
DUNE2G6	wood fragment	322	Aeolian Sand/Clay	**13,100±60 years BP**
DUNEPLAYA3D	Shells	129	Aeolian/Playa Mix	**8,280±50 years BP**
LPL10GG	Shells	264	Aeolian/Playa Mix	**8,110±50 years BP**
PLAYA4C	organic sediment	307	Aeolian Sand	**4,840±40 years BP**

AGE DATE LOCATION MAP – SOUTHERN SEGMENT