

**Environmental Monitoring of the
Ciénega de Santa Clara, a Mexican Wetland:
Trans-boundary Water and the Yuma Desalting Plant**

**Monitoreo Ambiental de la
Ciénega de Santa Clara, un Humedal Mexicano:
Agua Transfronteriza y la Planta Desaladora de Yuma**

Karl W. Flessa, University of Arizona

José Campoy-Favela[†], Reserva de la Biósfera

Francisco Zamora-Arroyo, Sonoran Institute

Osvel Hinojosa-Huerta, Pronatura Noroeste

Jorge Ramírez-Hernández, UABC-Mexicali

Jaqueline García-Hernández, CIAD

Ed Glenn, Laura Lopez-Hoffman, University of Arizona

Steve Nelson, 6101 NE 102nd Avenue #5, Vancouver, WA

Binational Monitoring Program for the Ciénega de Santa Clara



Programa de Monitoreo Binacional de la Ciénega de Santa Clara

- *Location and water*
- *Rationale and support*
- *What we already knew*
- *Goals and methods*
- *Some results so far (still in progress)*
 - *inflows*
 - *water quality*
 - *vegetation dynamics*
 - *marshbirds*
- *Earthquake and fire*
- ***No conclusions....***

-
- *Localización y agua*
 - *Justificación y apoyo*
 - *Que sabemos ya?*
 - *Metas y metodos*
 - *Algunos resultados (en progreso)*
 - *flujos de entrada*
 - *calidad del agua*
 - *Dinámicas de la vegetación*
 - *Aves de marisma*
 - *Terremoto e incendio*
 - ***Sin conclusiones....***



UABC







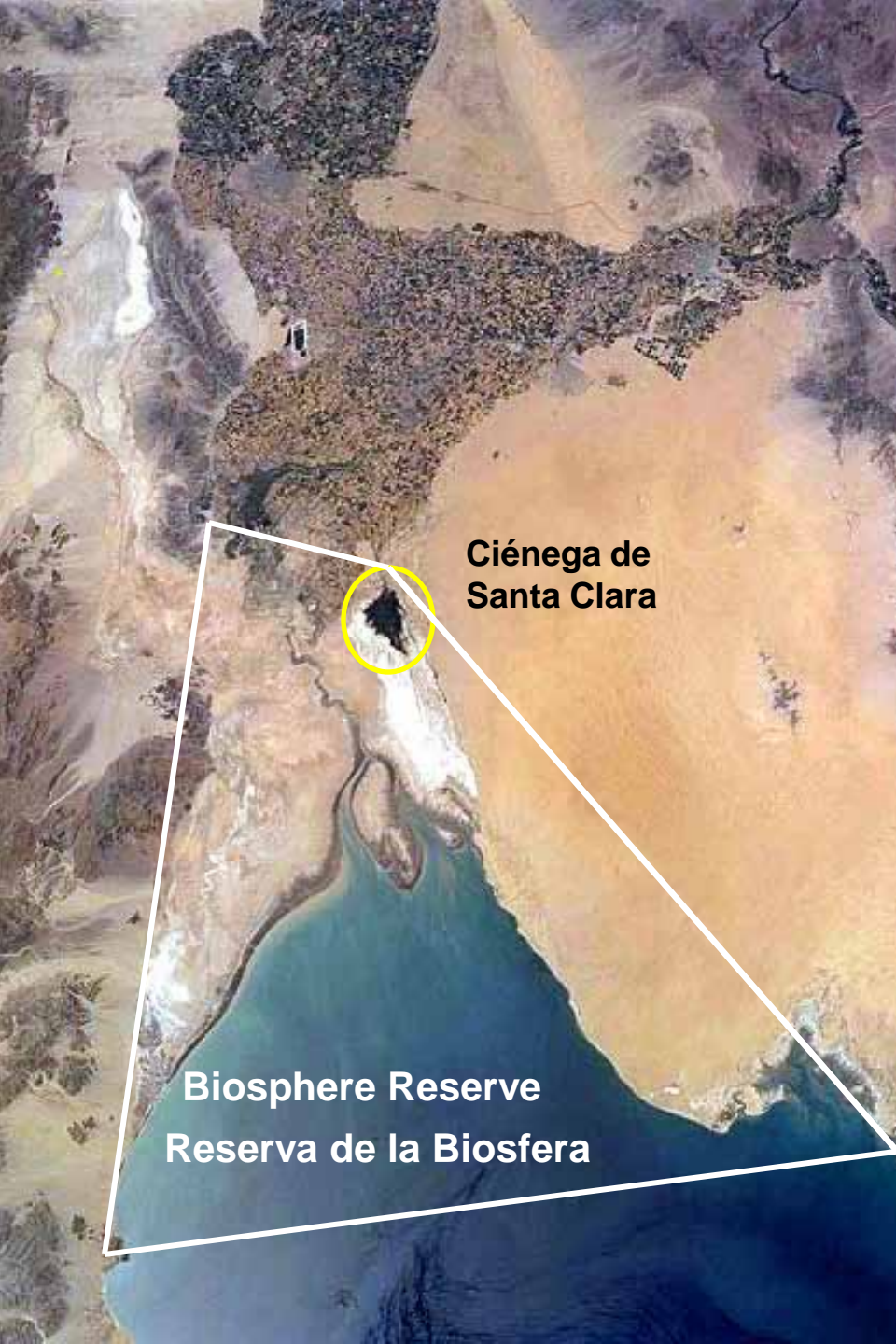
Reserva de la Biosfera Alto Golfo de California y Delta del Río Colorado



A formally-designated area to protect species and their critical habitats

- Migratory birds
- Shorebirds
- Resident birds
- Fish
- Marine mammals

“**Ramsar site**” for protection of wetlands of international importance



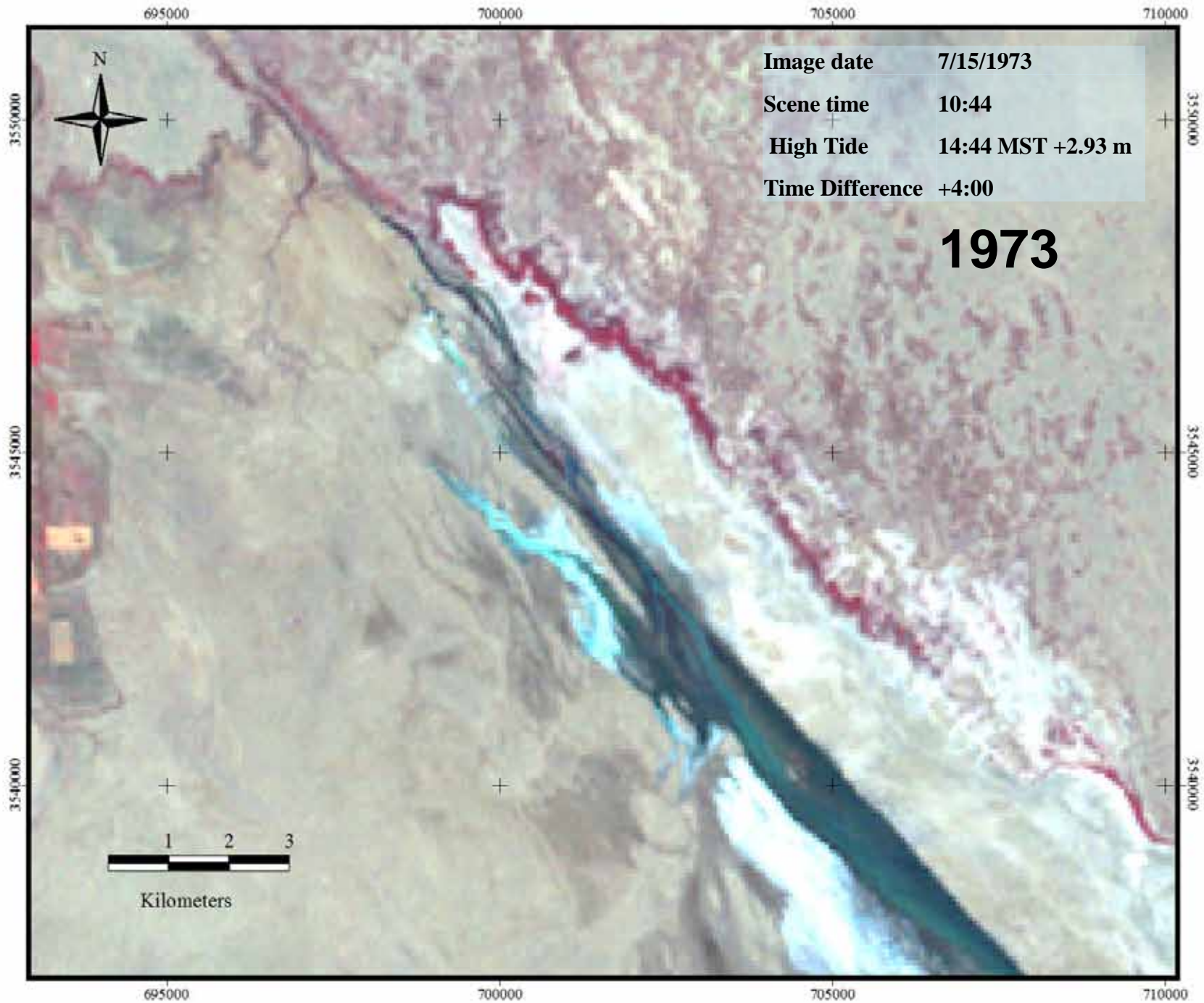
Ciénega de Santa Clara

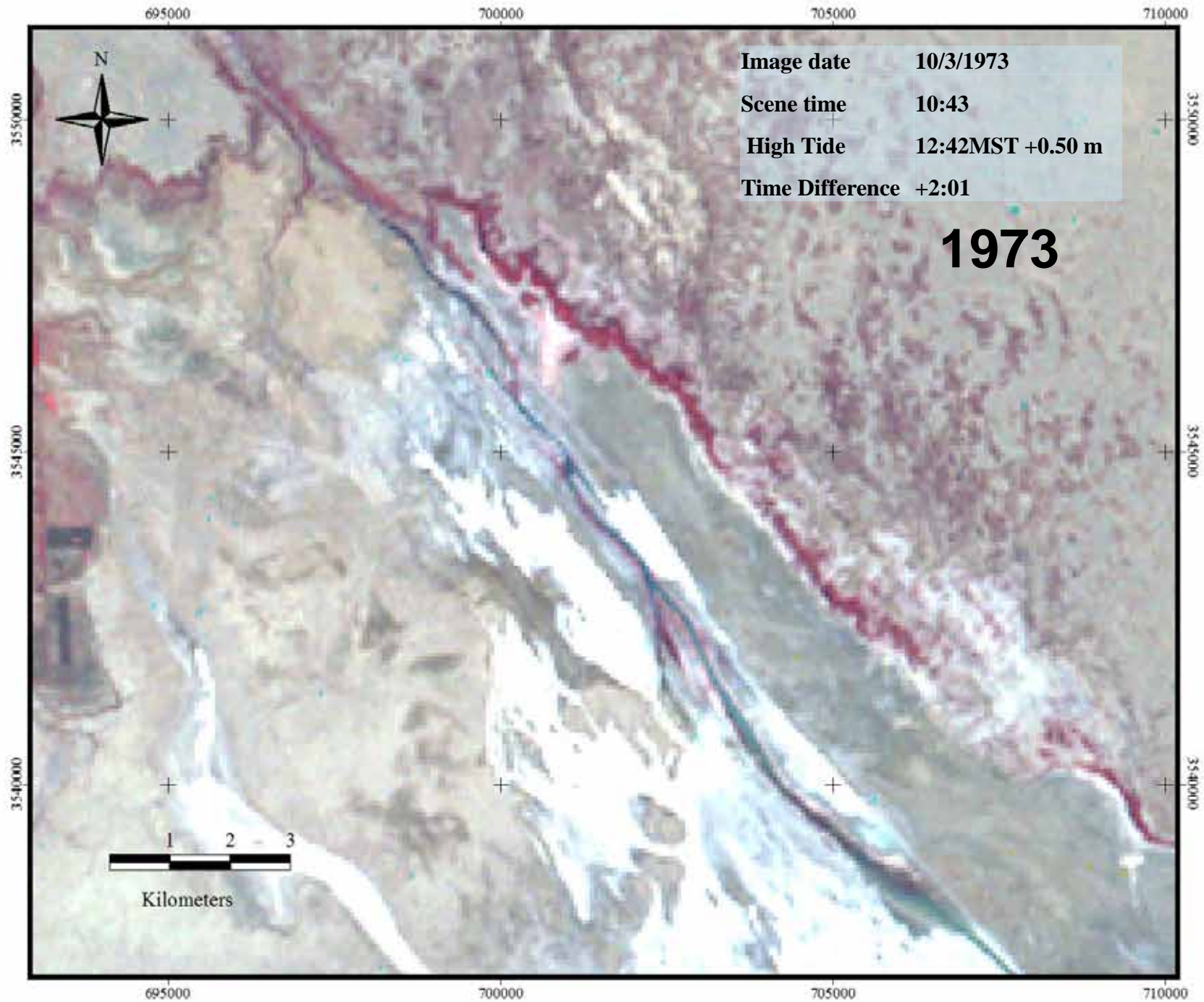
Biosphere Reserve
Reserva de la Biosfera

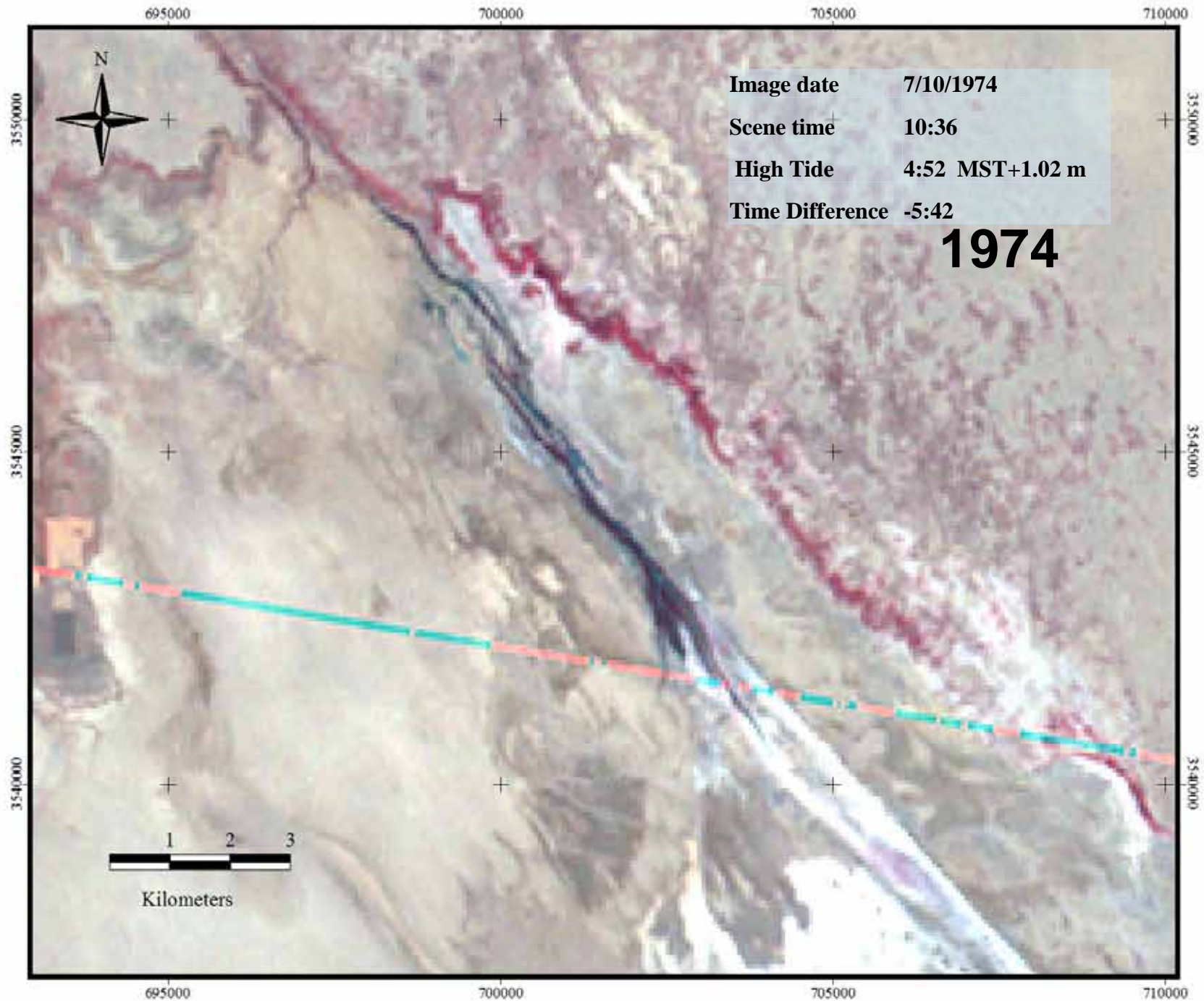
Área formalmente diseñada para proteger las especies y sus habitats críticos

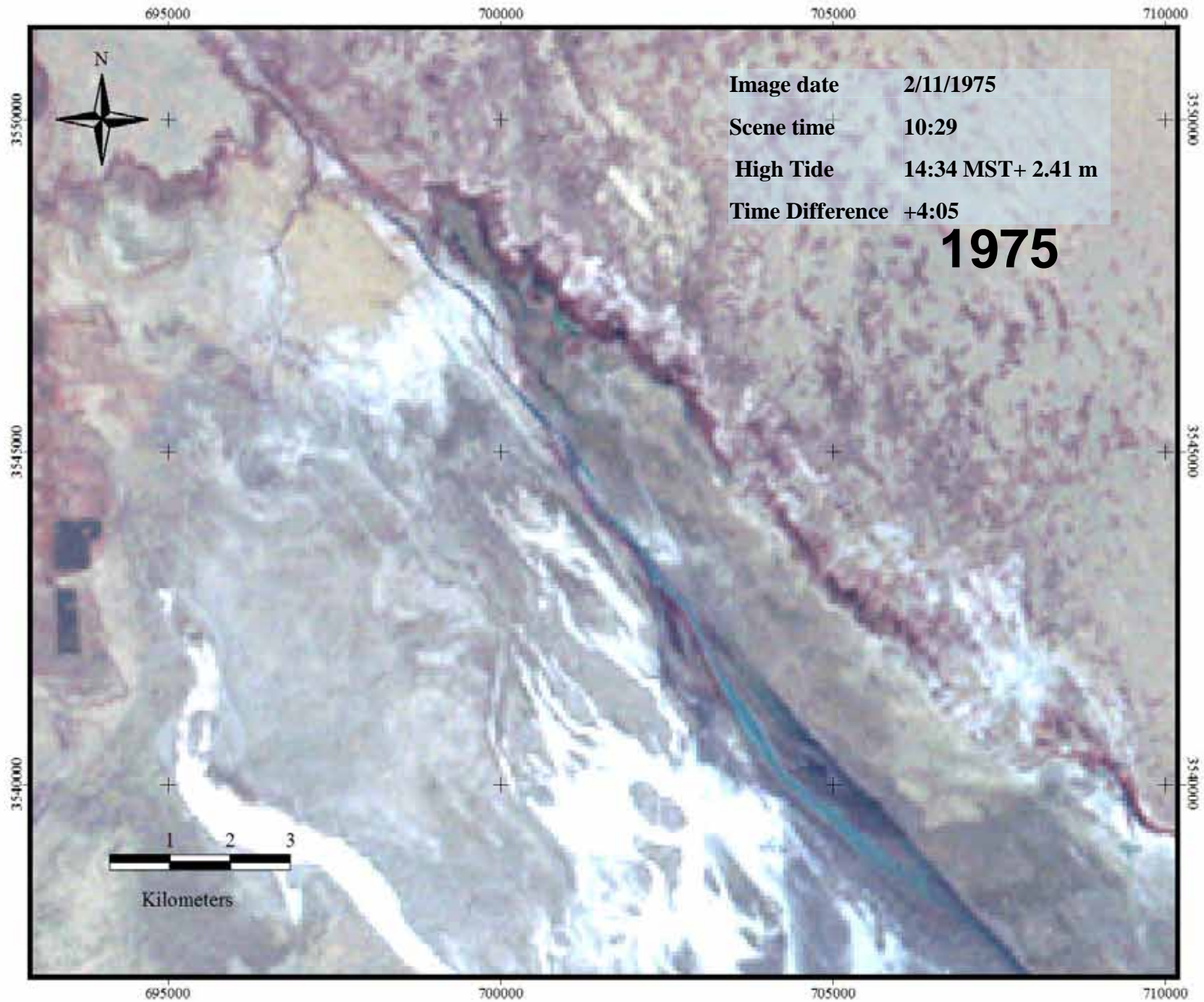
- Aves migratorias
- Ave playeras
- Aves residentes
- Peces
- Mamíferos marinos

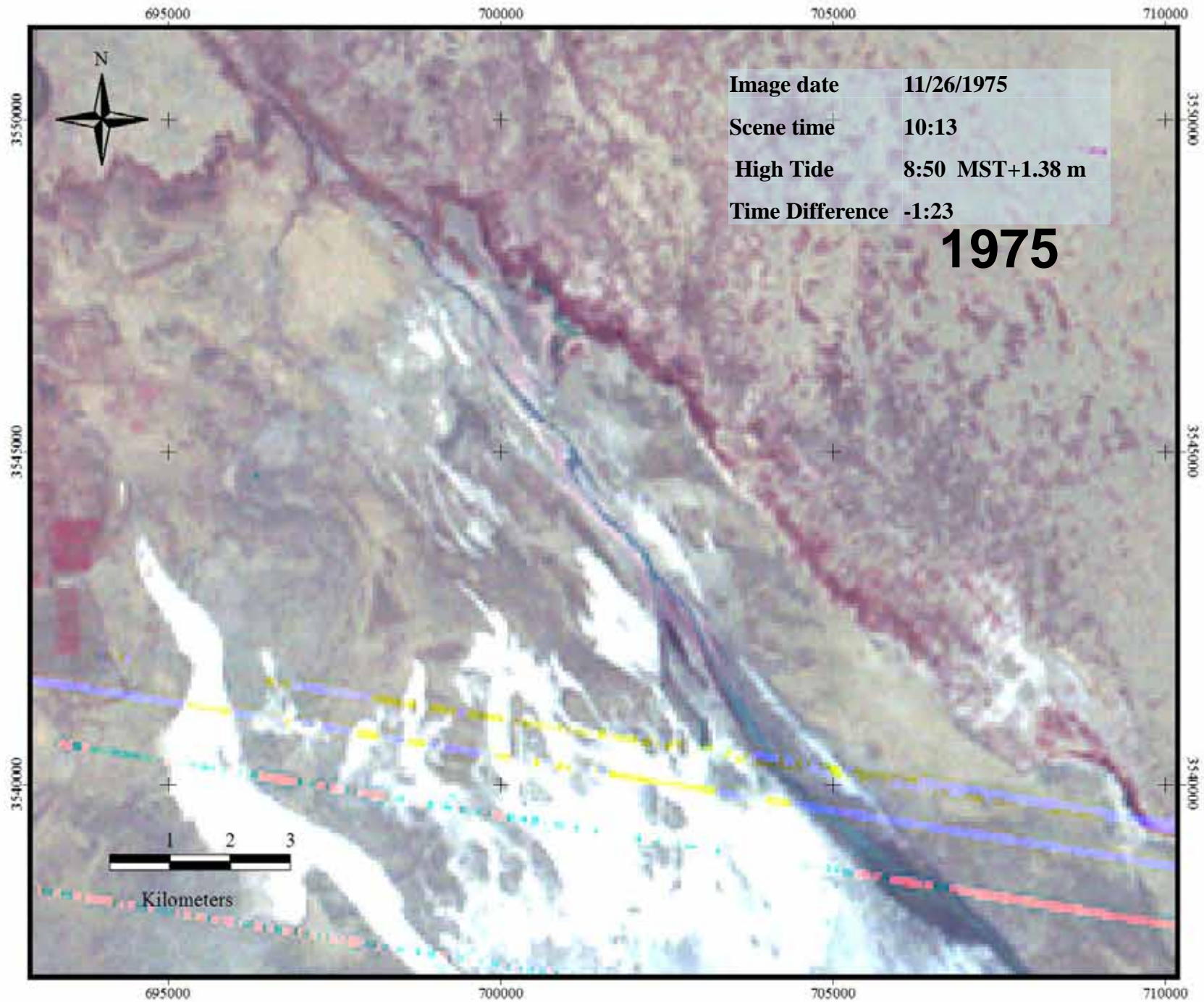
“**Sitio Ramsar**” para la protección de humedales de importancia internacional

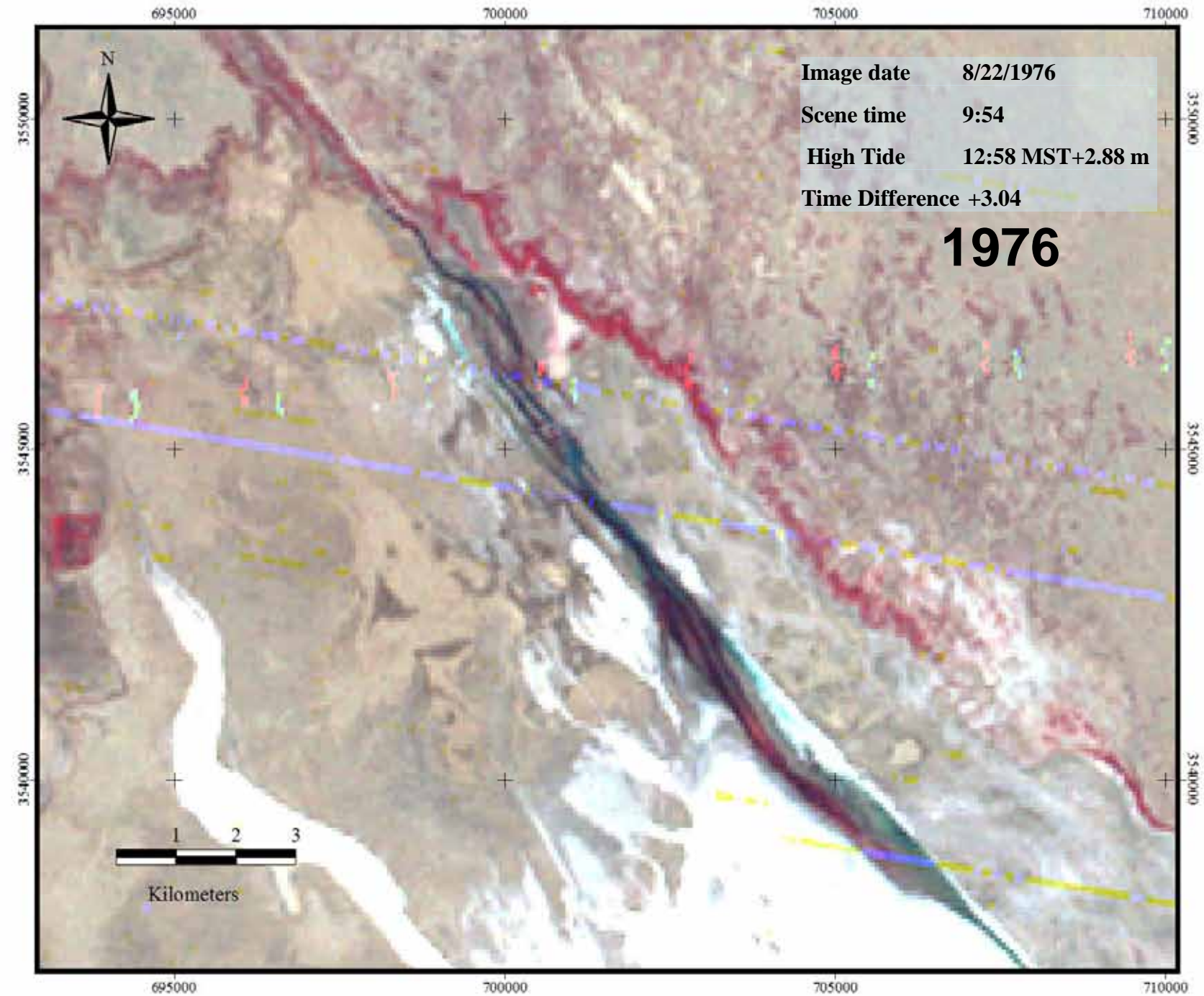


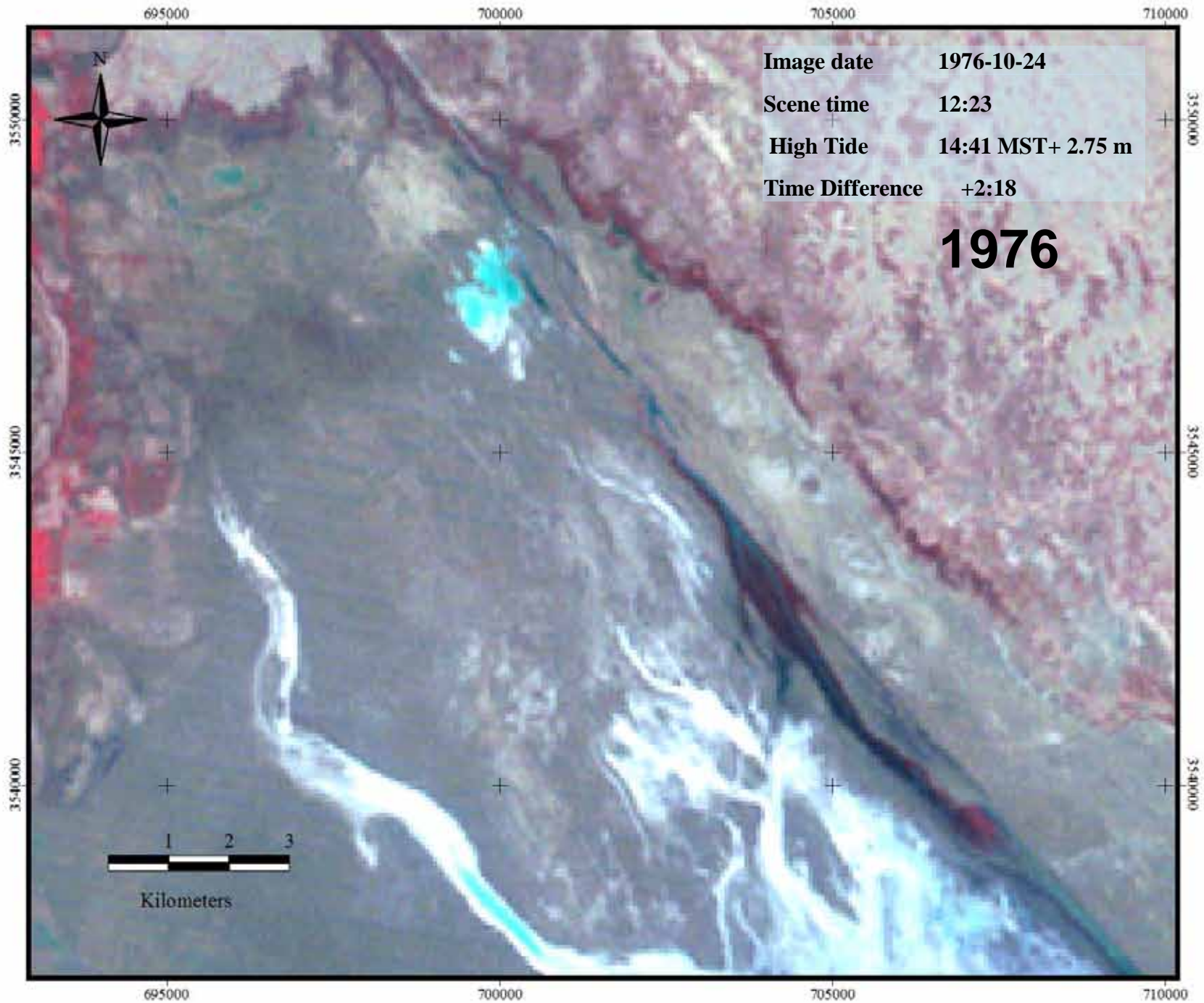


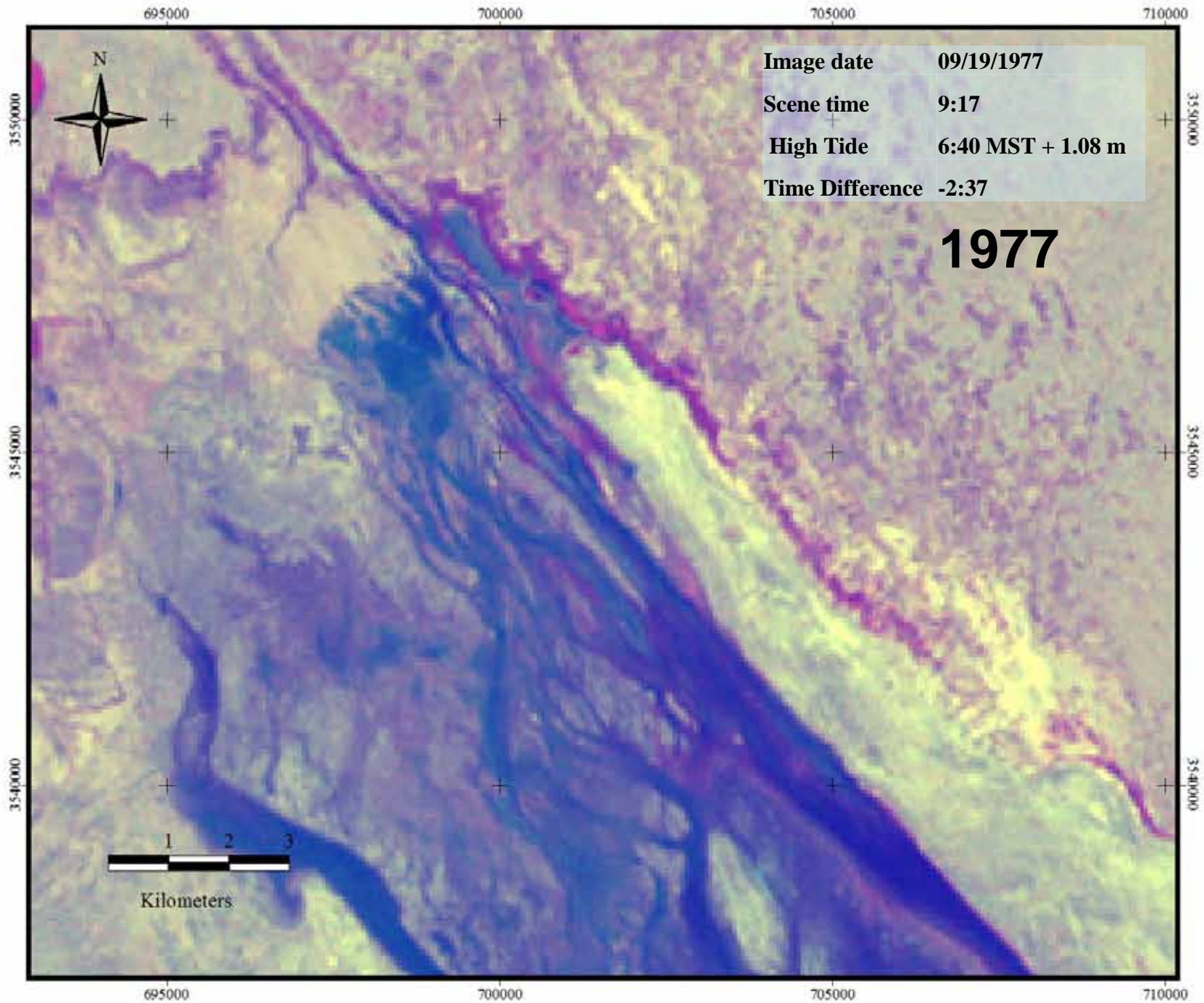












695000

700000

705000

710000



Image date	10/1/1977
Scene time	10:06
High Tide	15:28 MST +1.46 m
Time Difference	+5:22

1977

3550000

3550000

3545000

3545000

3540000

3540000



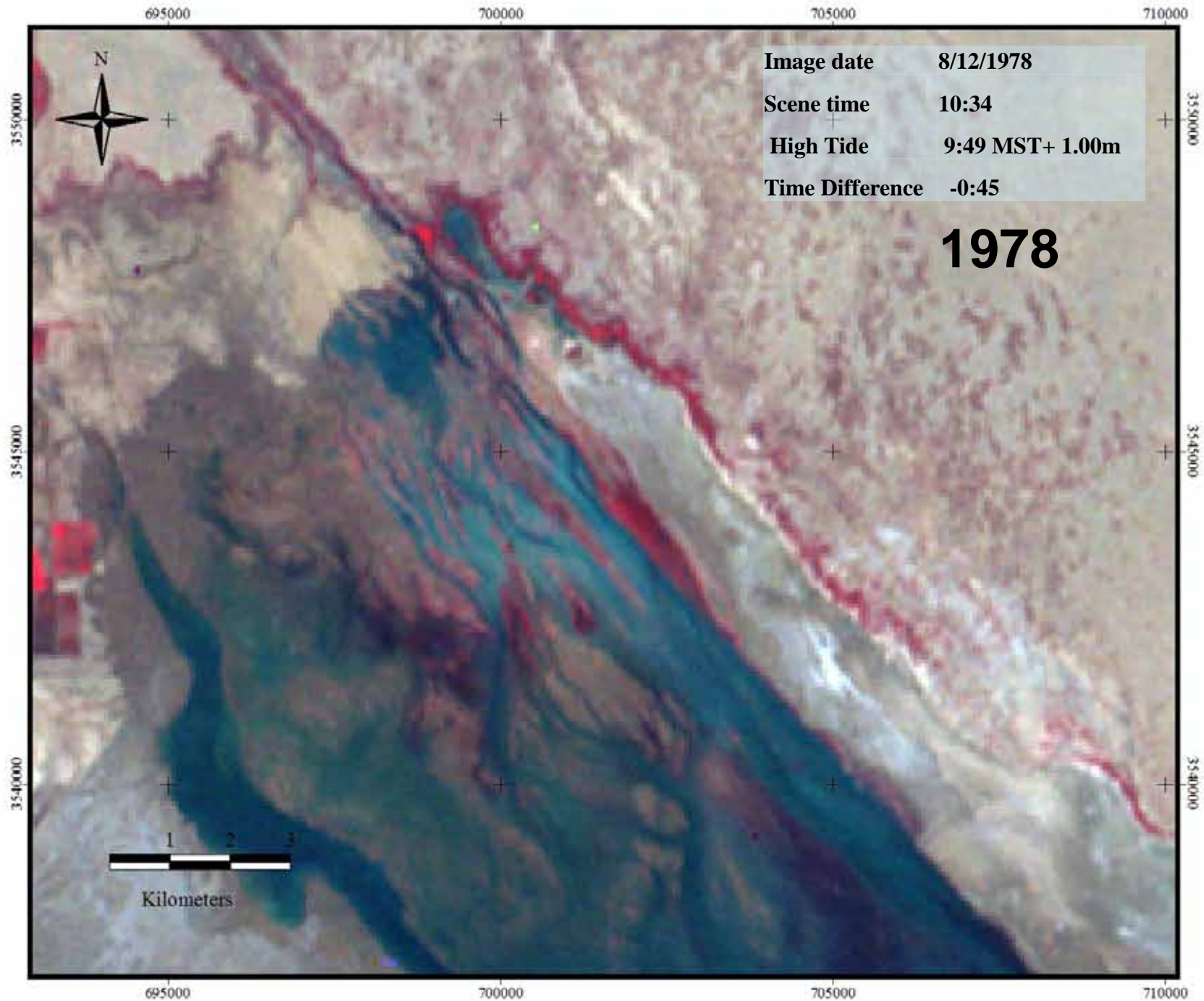
Kilometers

695000

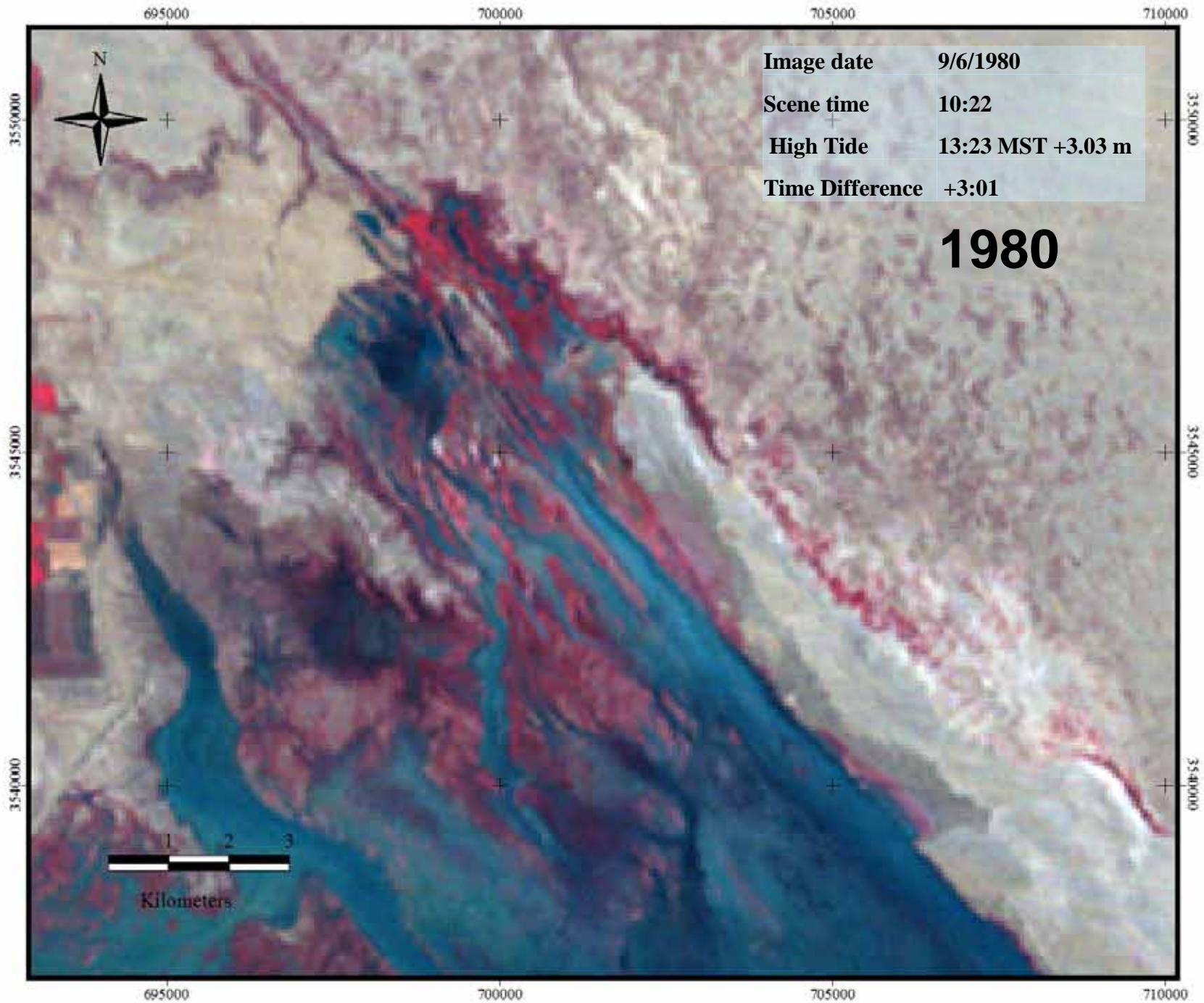
700000

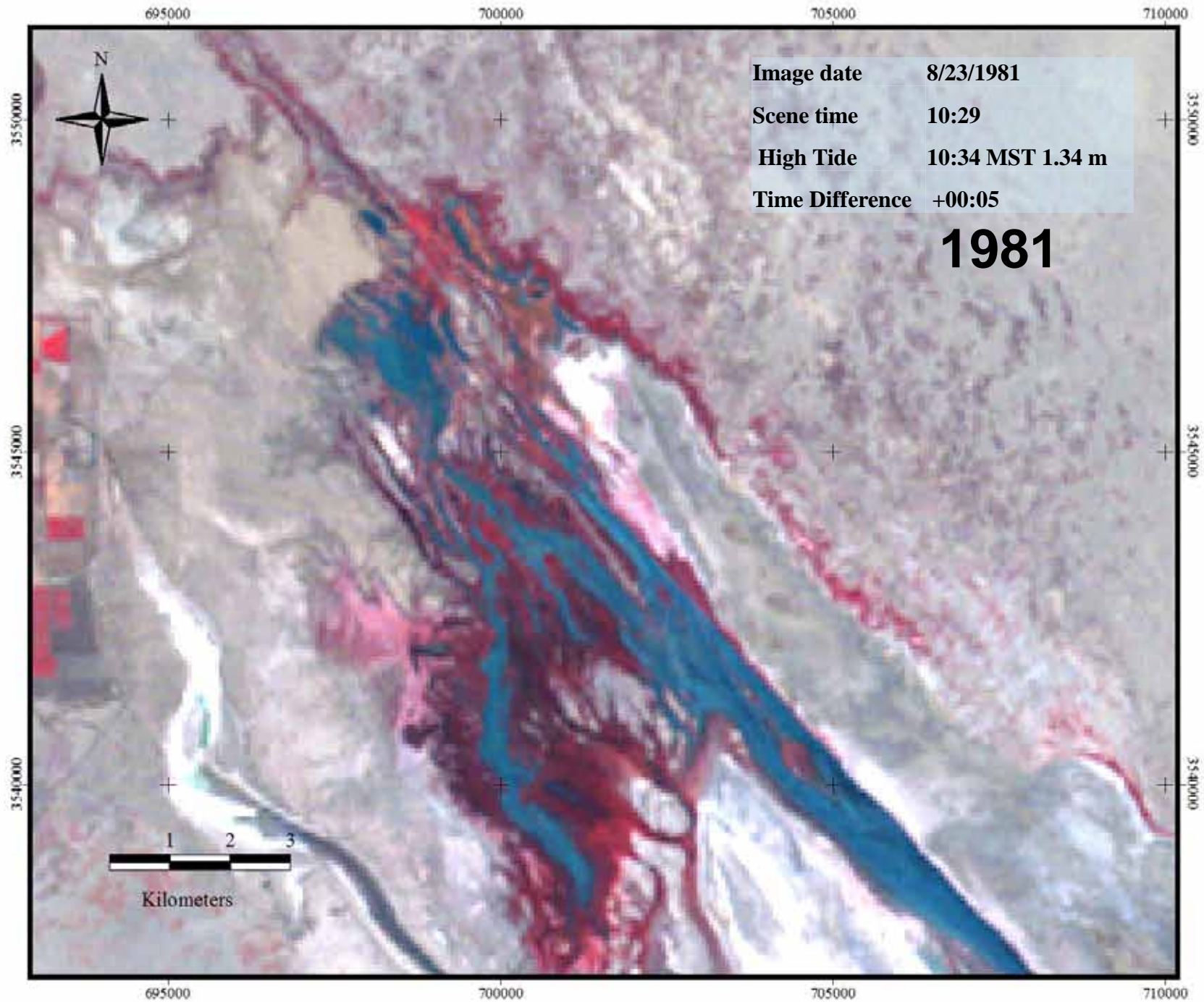
705000

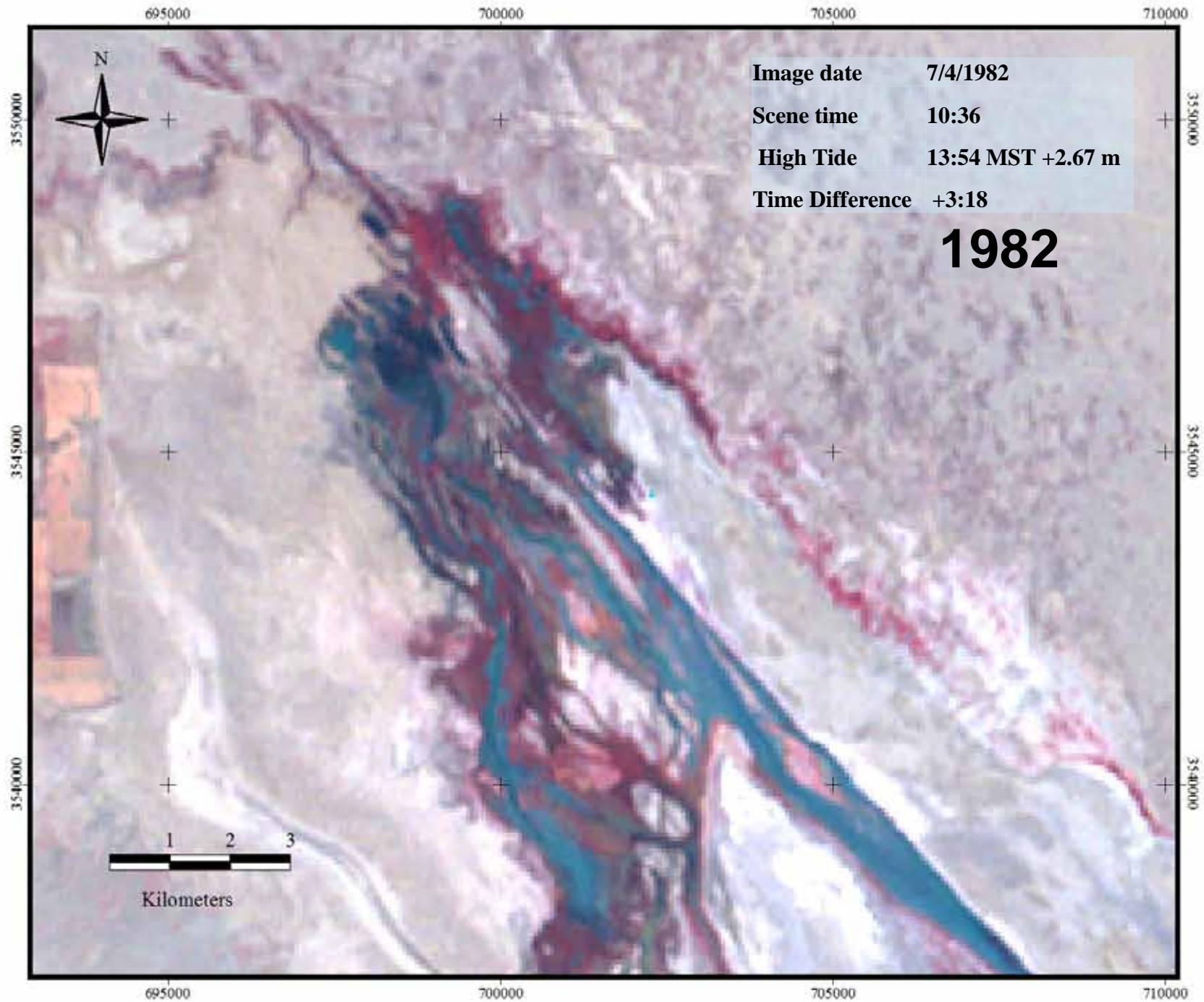
710000











695000

700000

705000

710000



Image date 5/30/1983
Scene time 10:40:00
High Tide 16:22MST+1.77 m
Time Difference +5.42

1983

3550000

3550000

3545000

3545000

3540000

3540000



Kilometers

695000

700000

705000

710000

695000

700000

705000

710000



Image date 1/6/1983
Scene time 10:39
High Tide 4:03MST+ 0.33m
Time Difference -6;36

1983

3550000

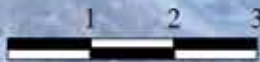
3550000

3545000

3545000

3540000

3540000



Kilometers

695000

700000

705000

710000

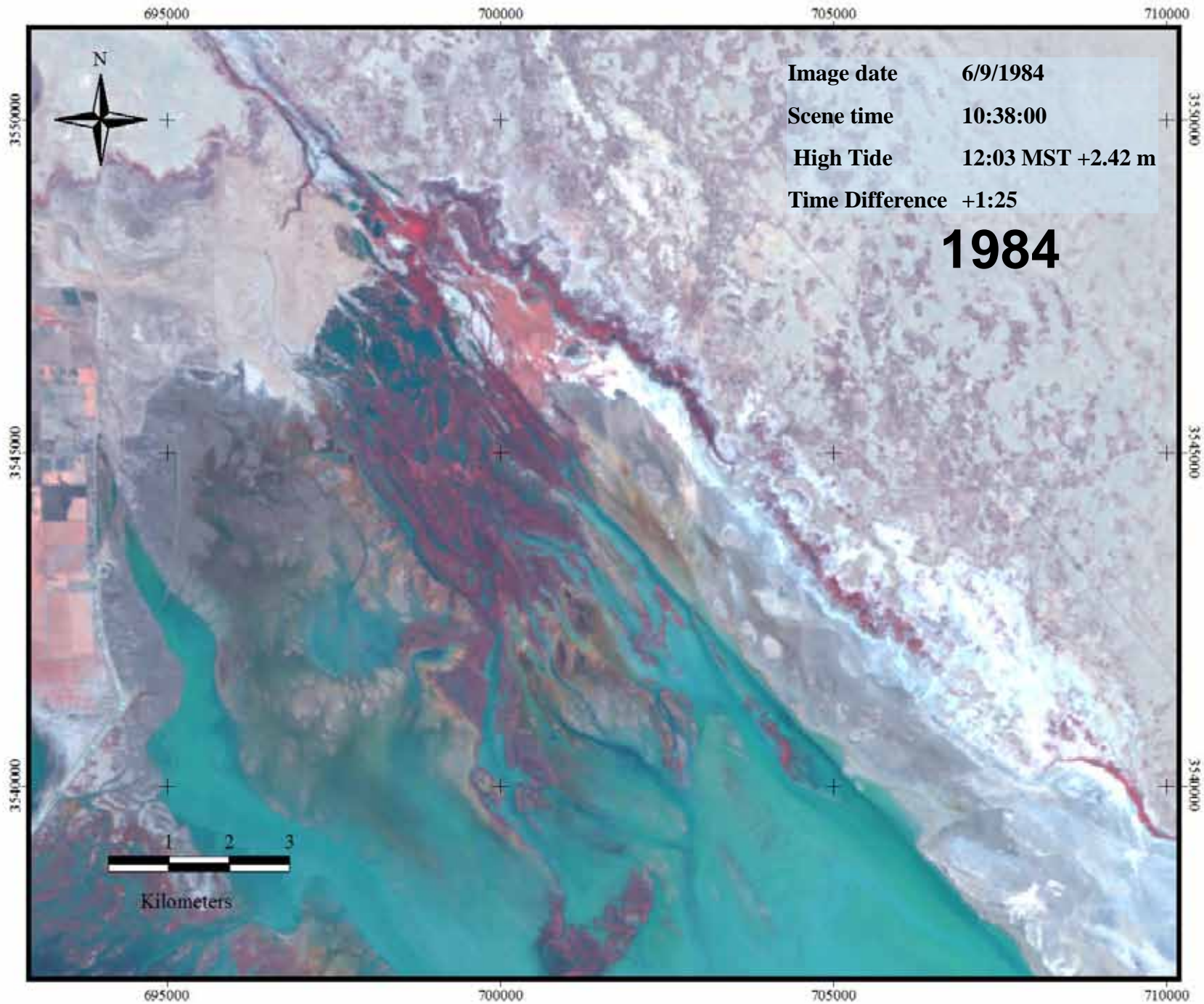
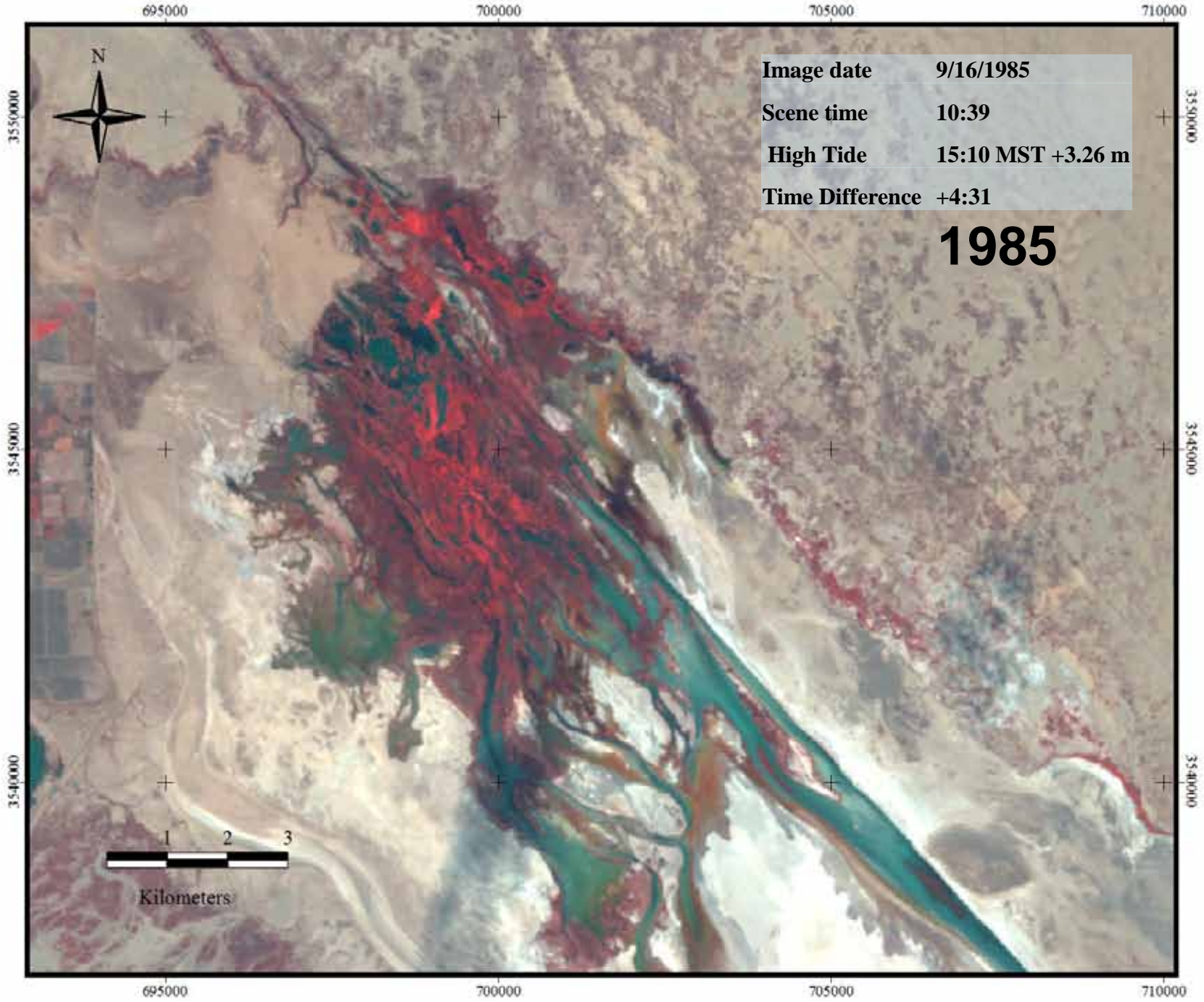


Image date 9/16/1985
Scene time 10:39
High Tide 15:10 MST +3.26 m
Time Difference +4:31

1985



Kilometers



695000

700000

705000

710000



Image date 10/2/1985
Scene time 17:39
High Tide 15:04 MST +1.89m
Time Difference -2:35

1985

3550000

3550000

3545000

3545000

3540000

3540000



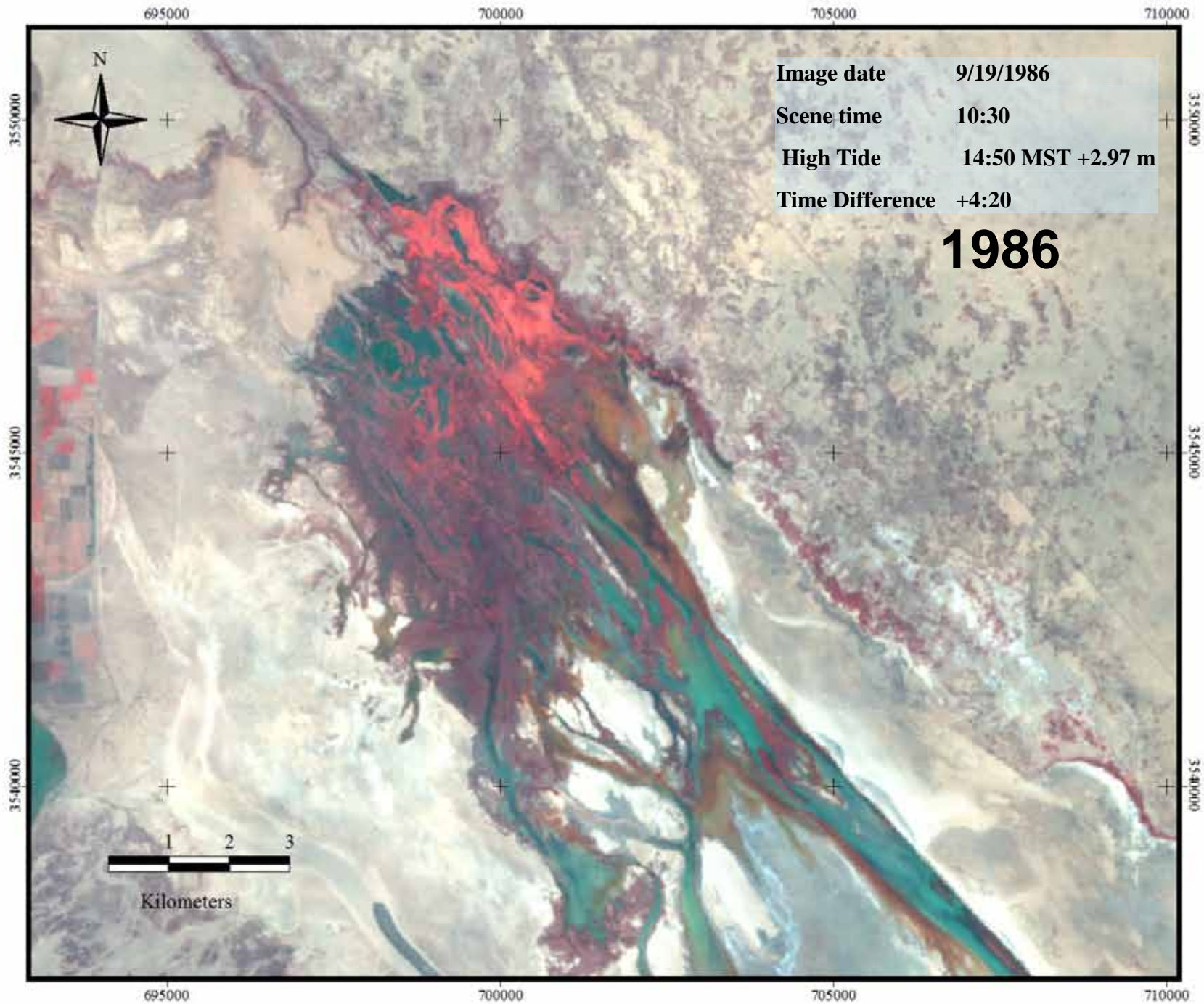
Kilometers

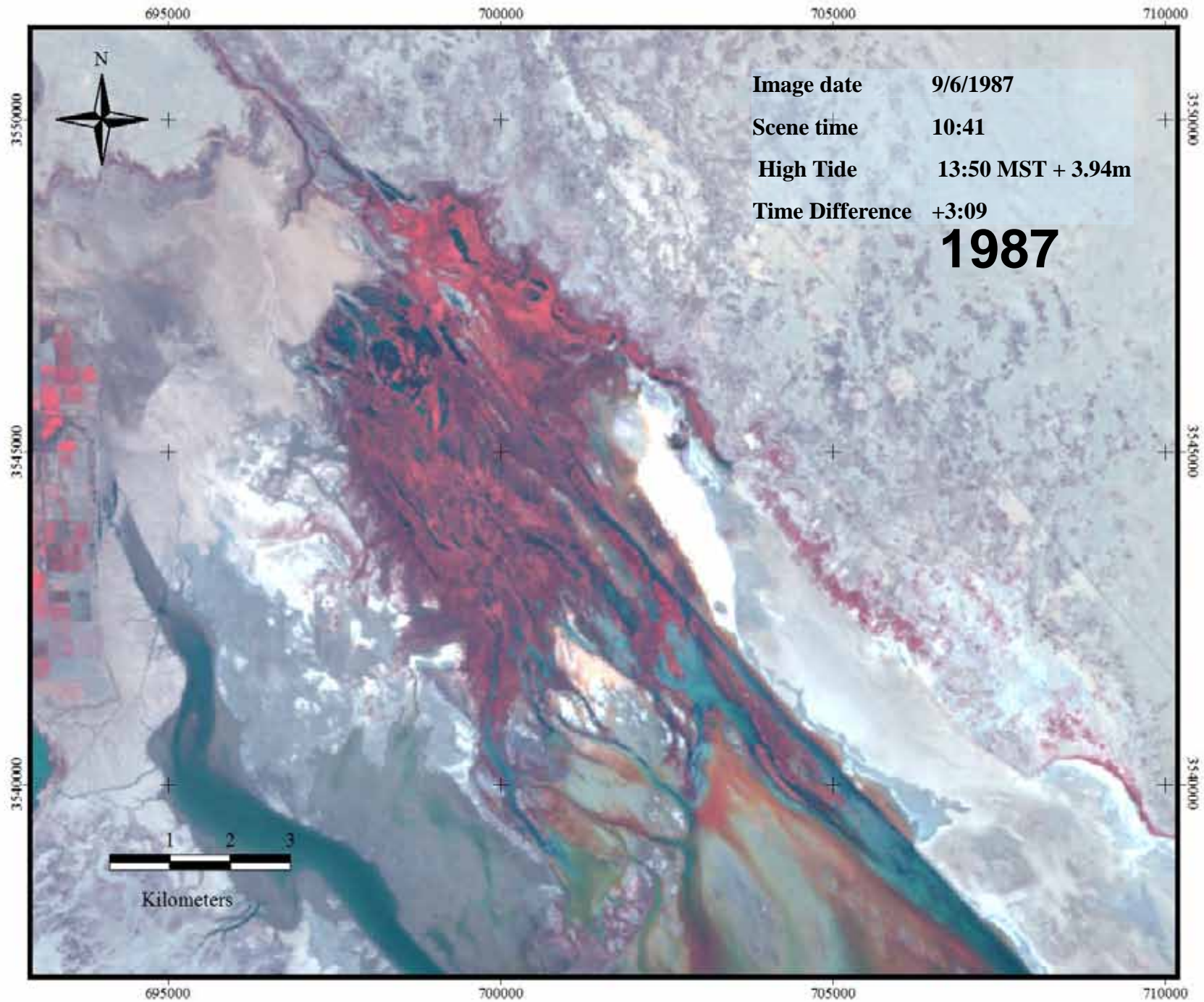
695000

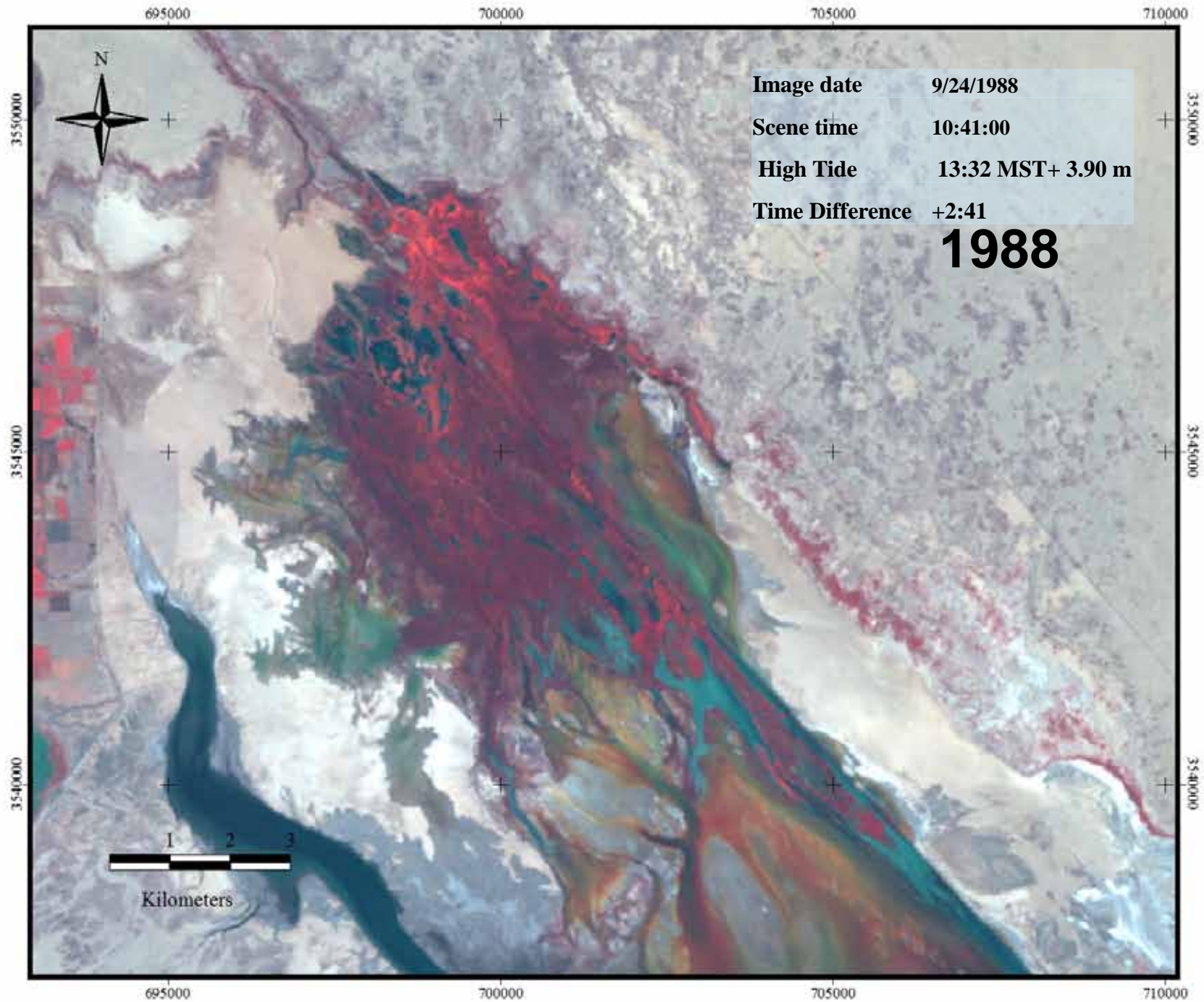
700000

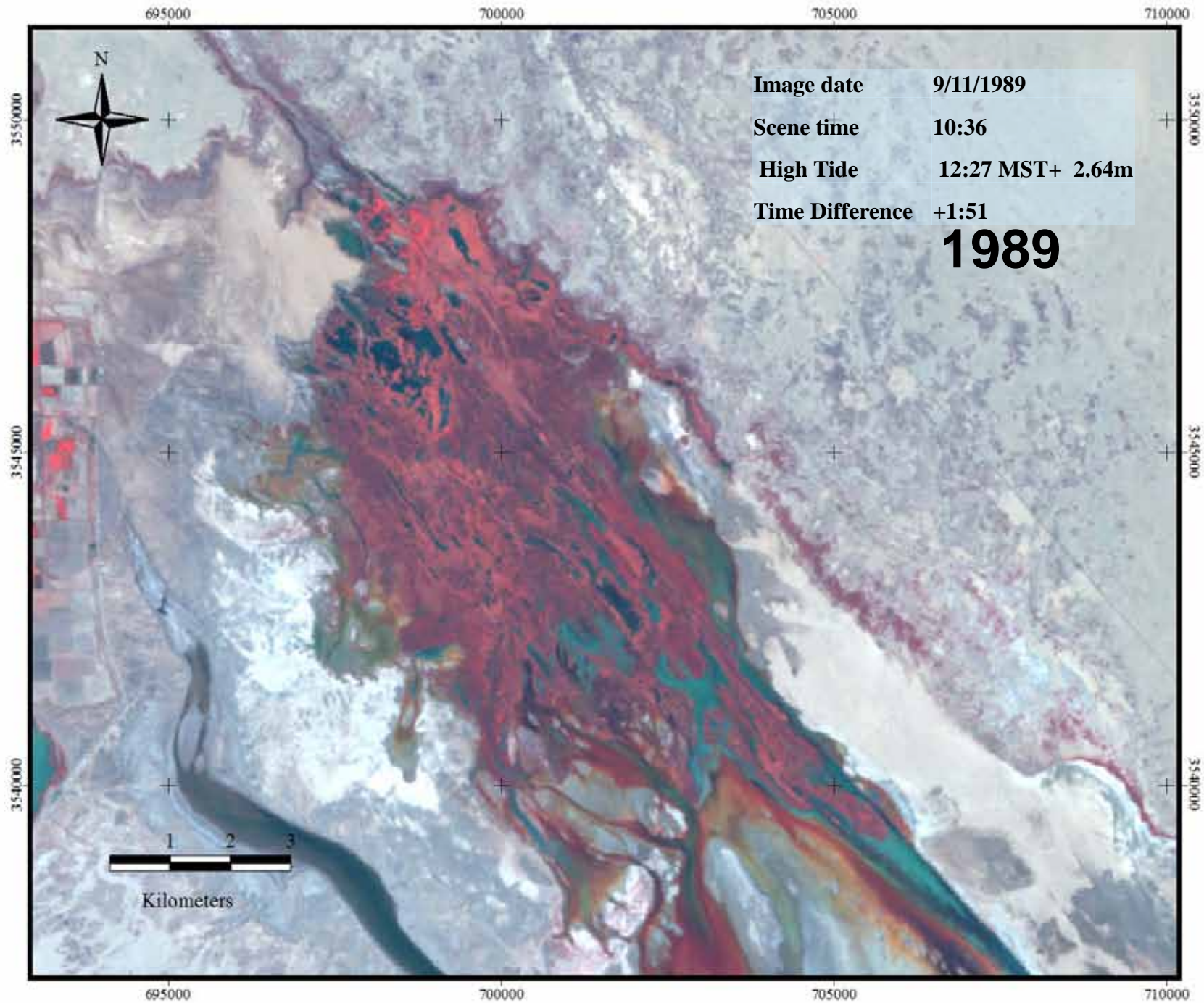
705000

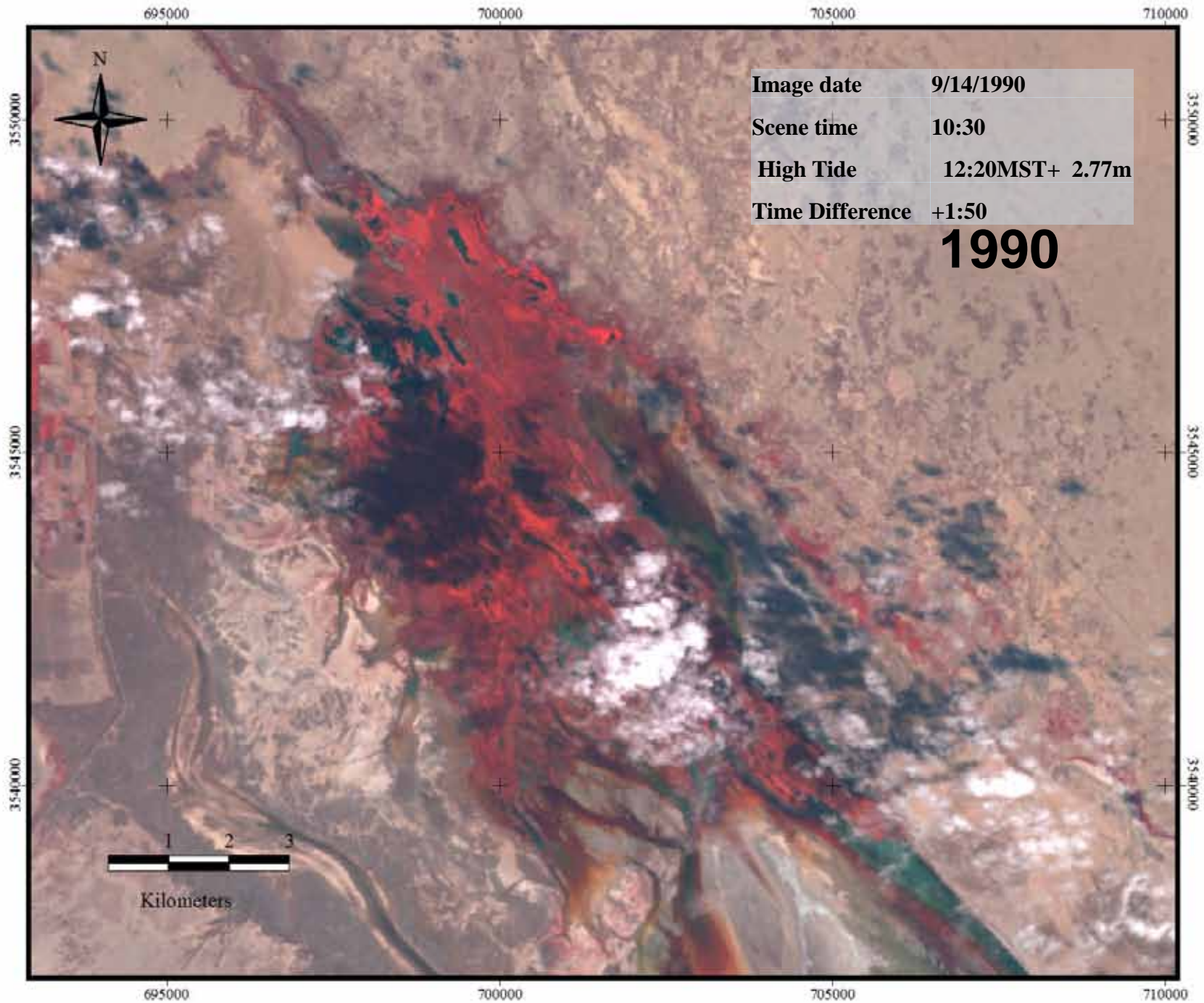
710000

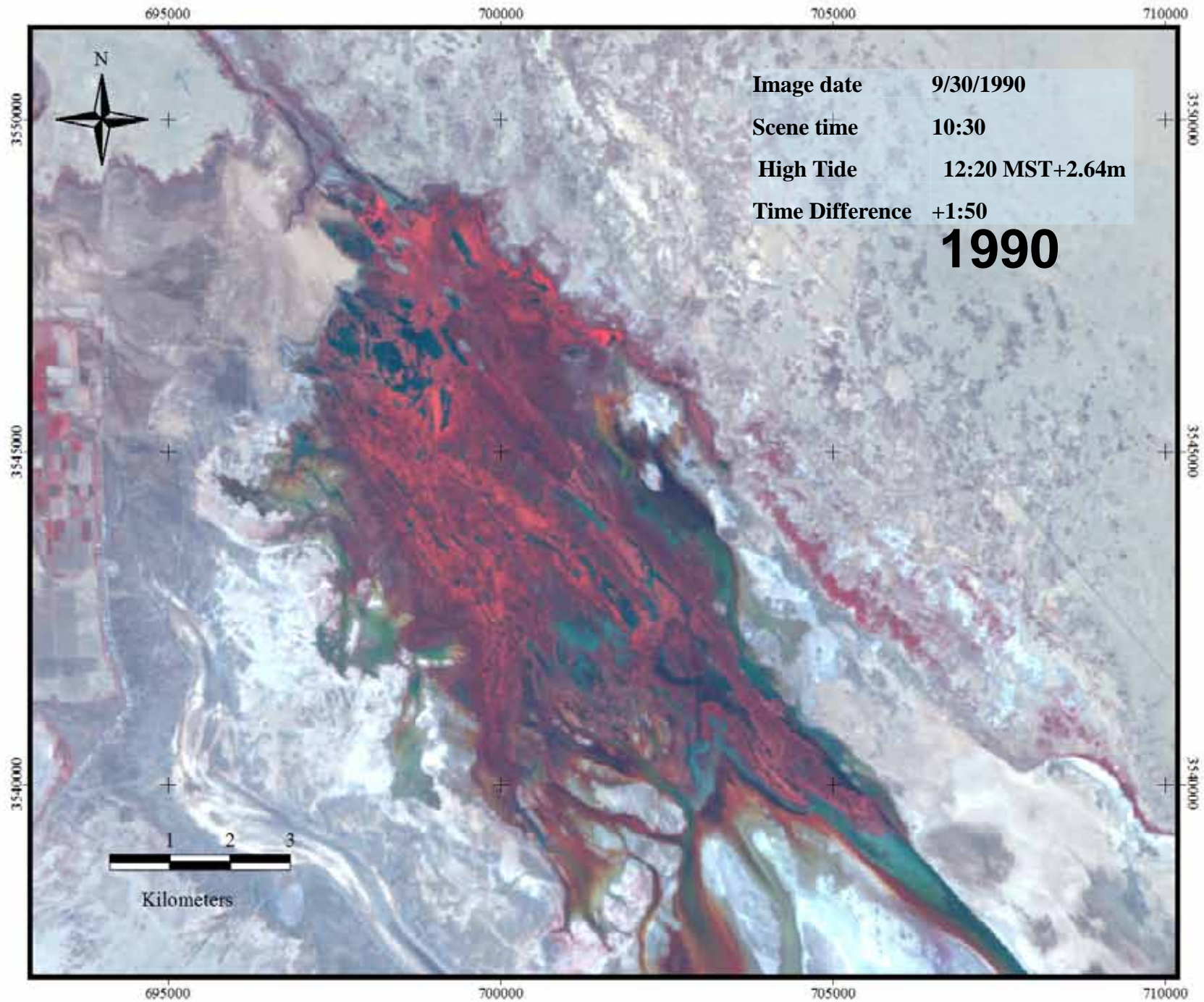


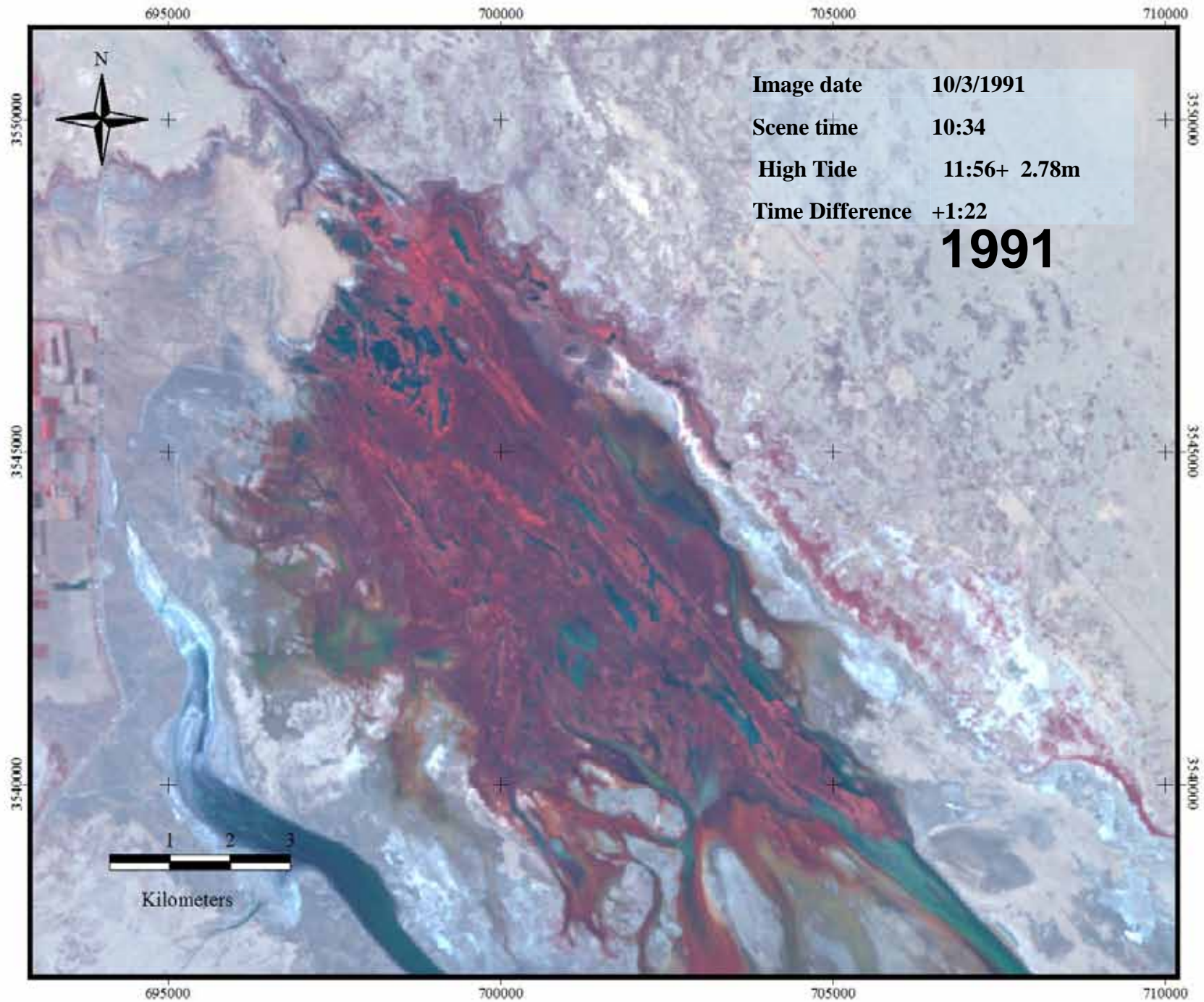


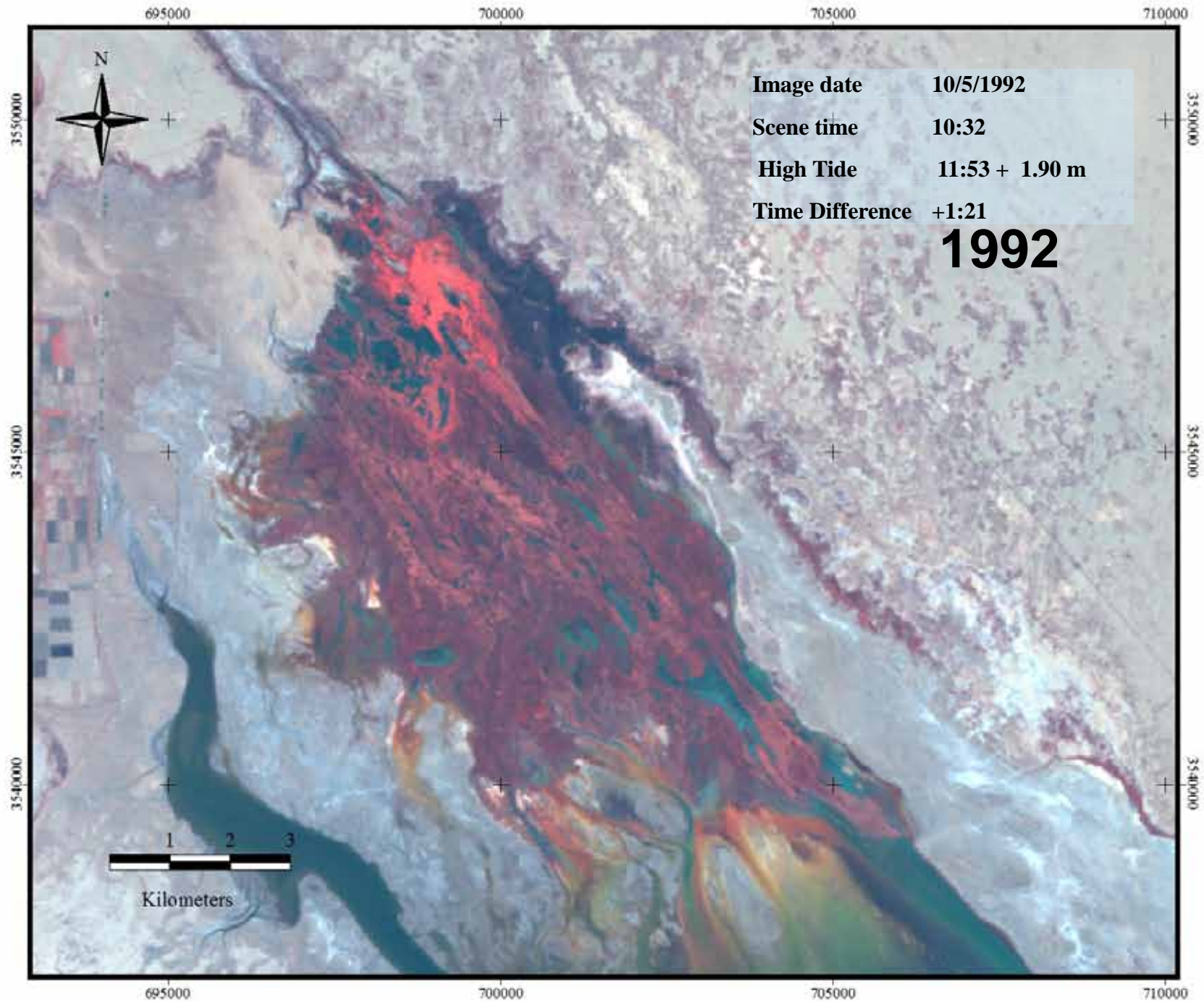


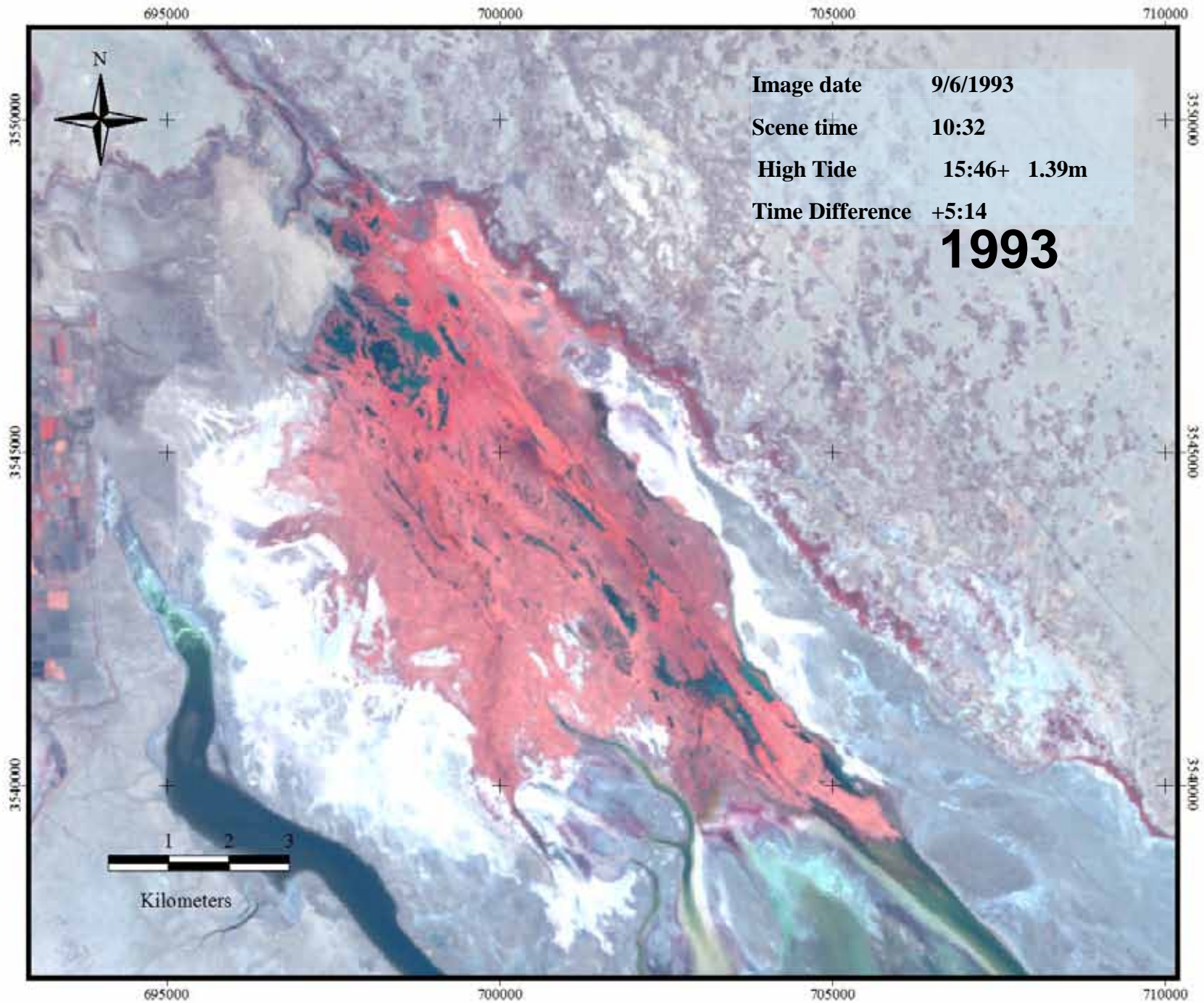


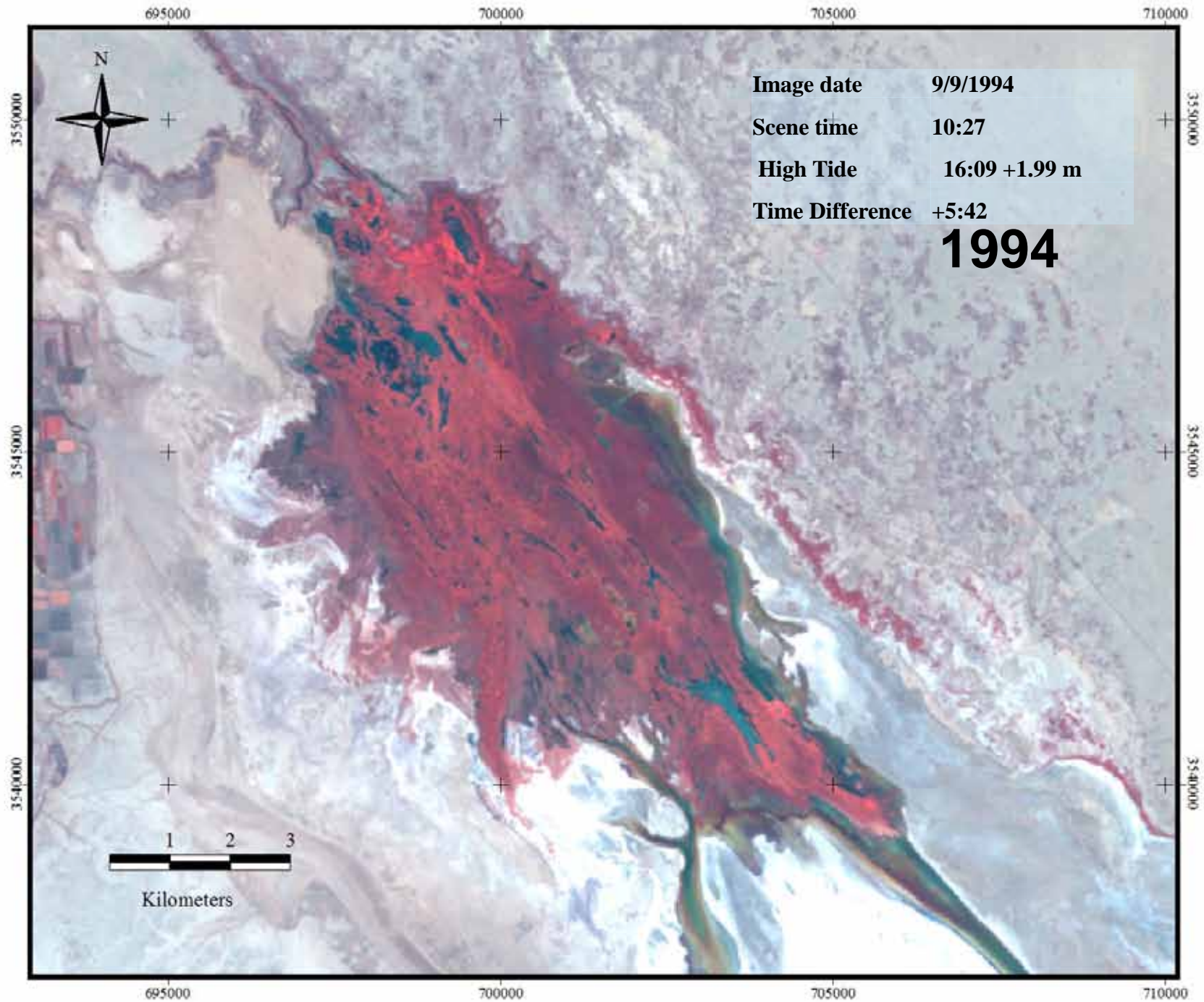


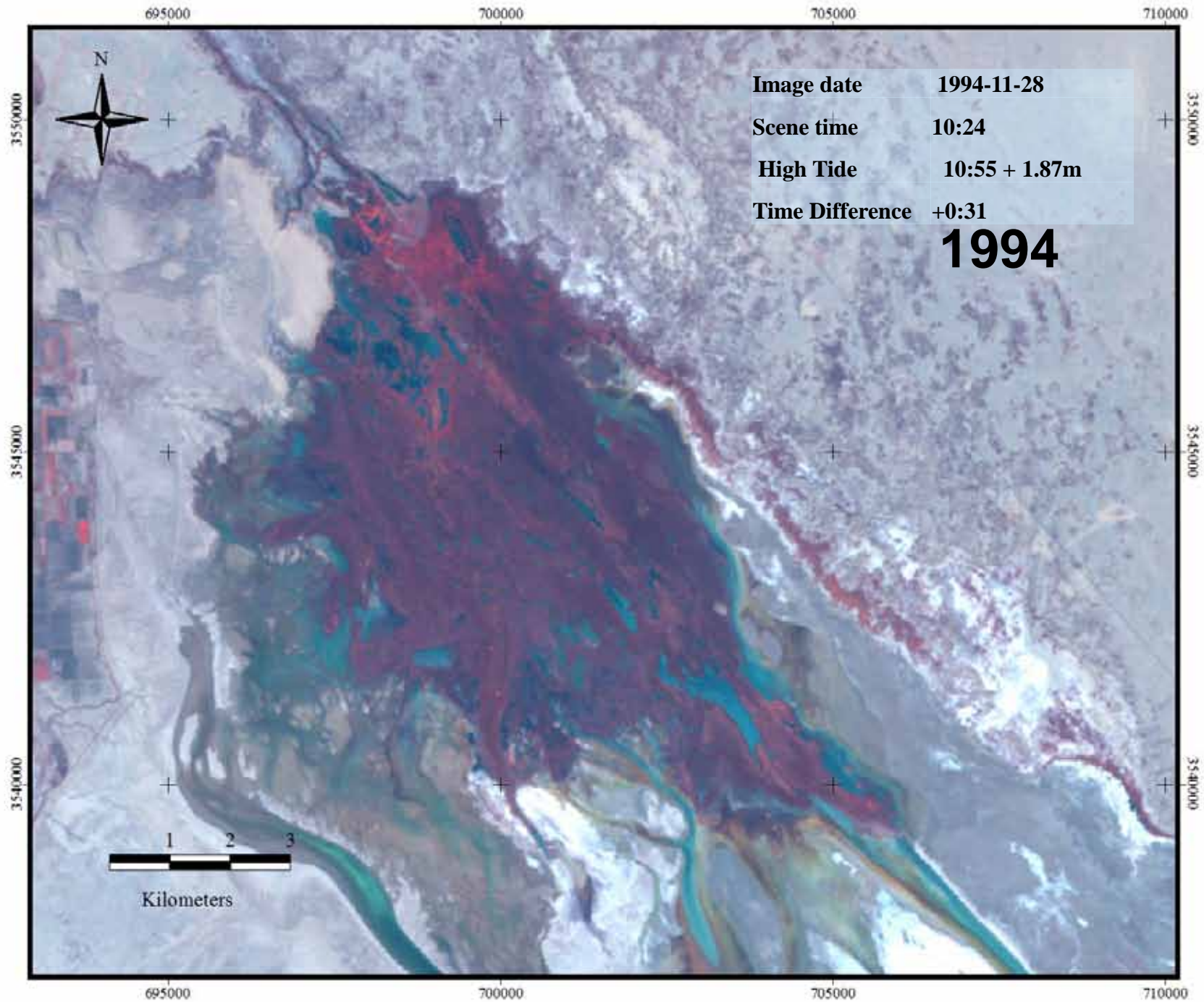












695000

700000

705000

710000



Image date	9/12/1995
Scene time	10:12
High Tide	15:38 + 2.00m
Time Difference	+5:26

1995

3550000

3550000

3545000

3545000

3540000

3540000



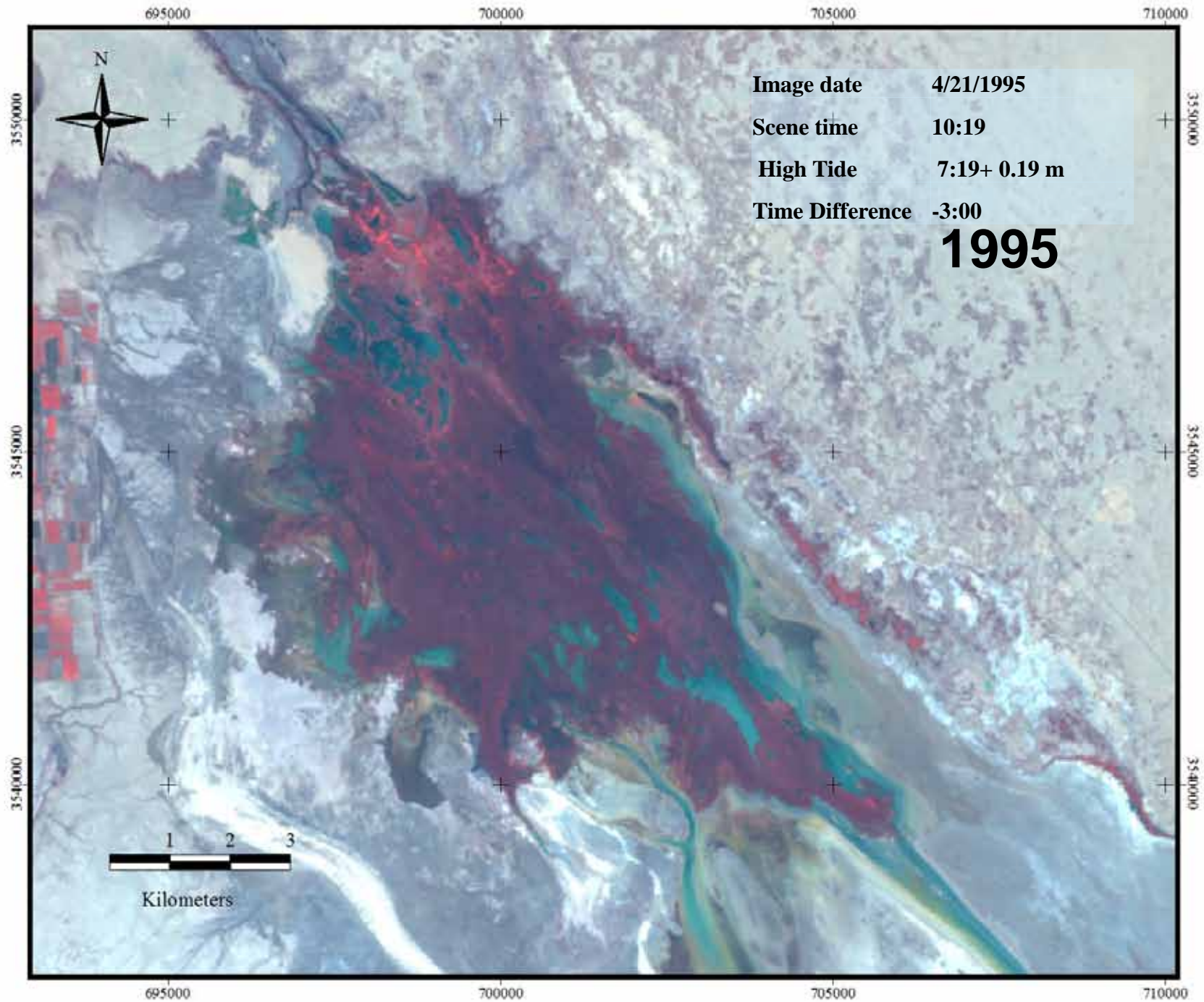
Kilometers

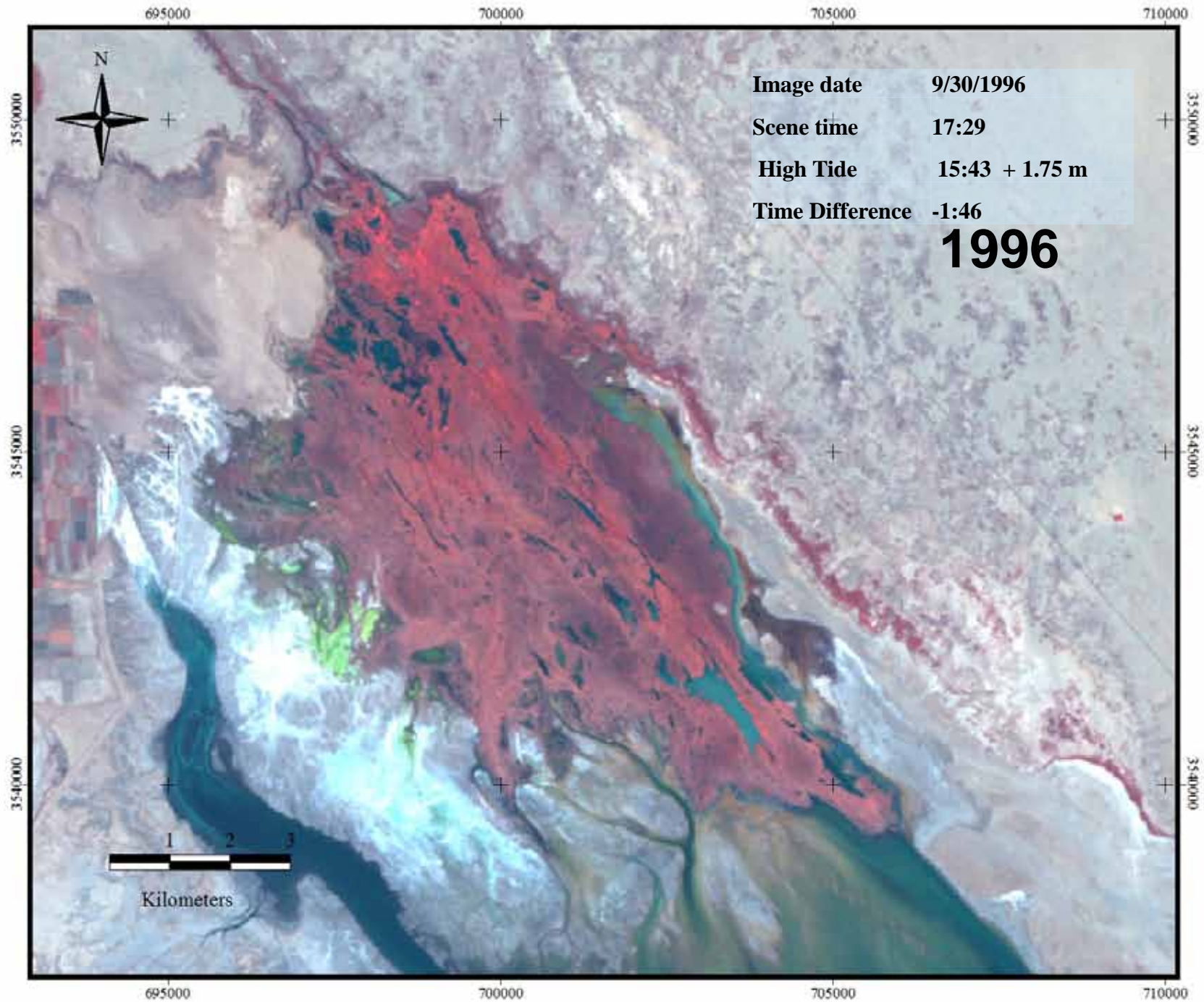
695000

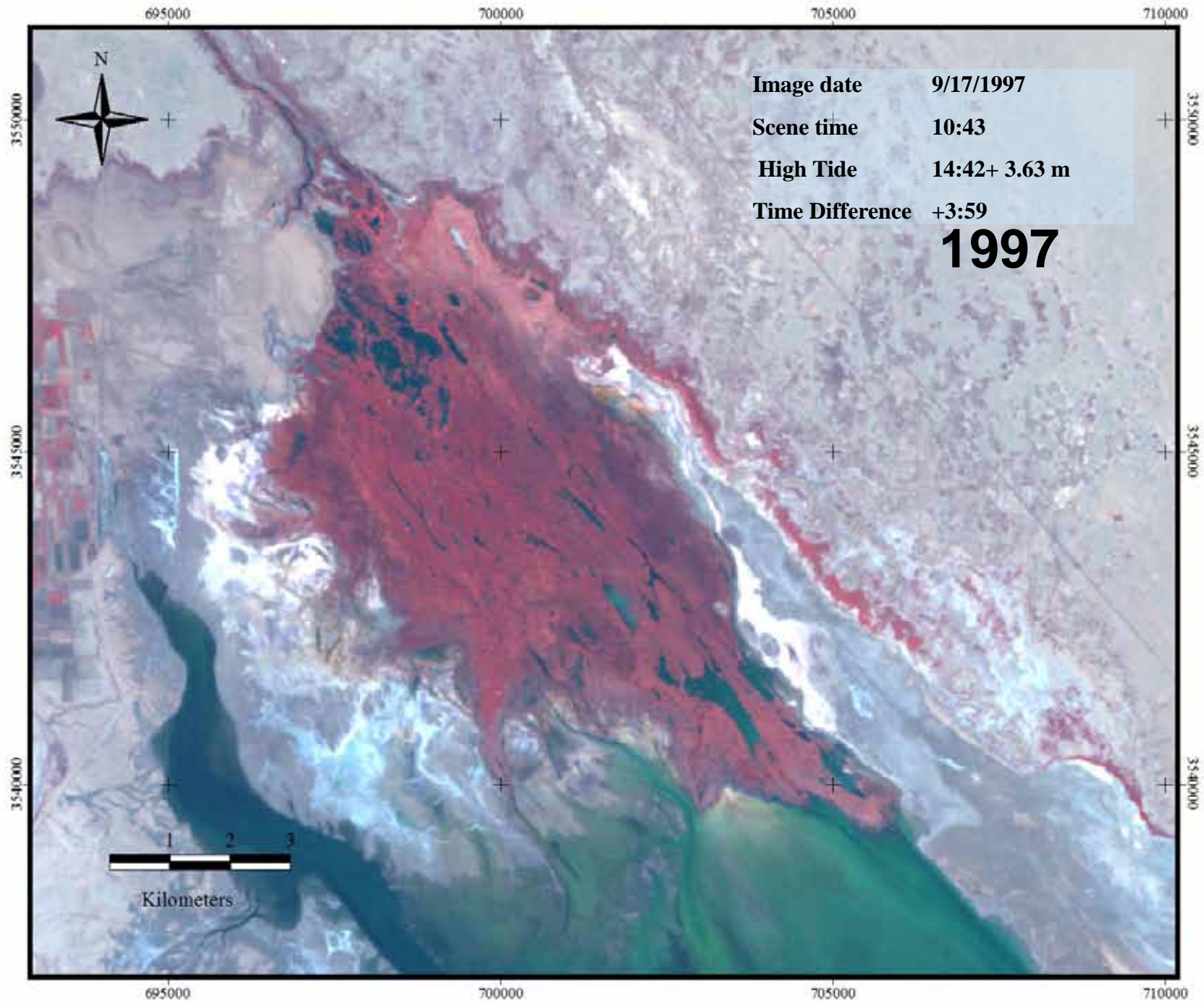
700000

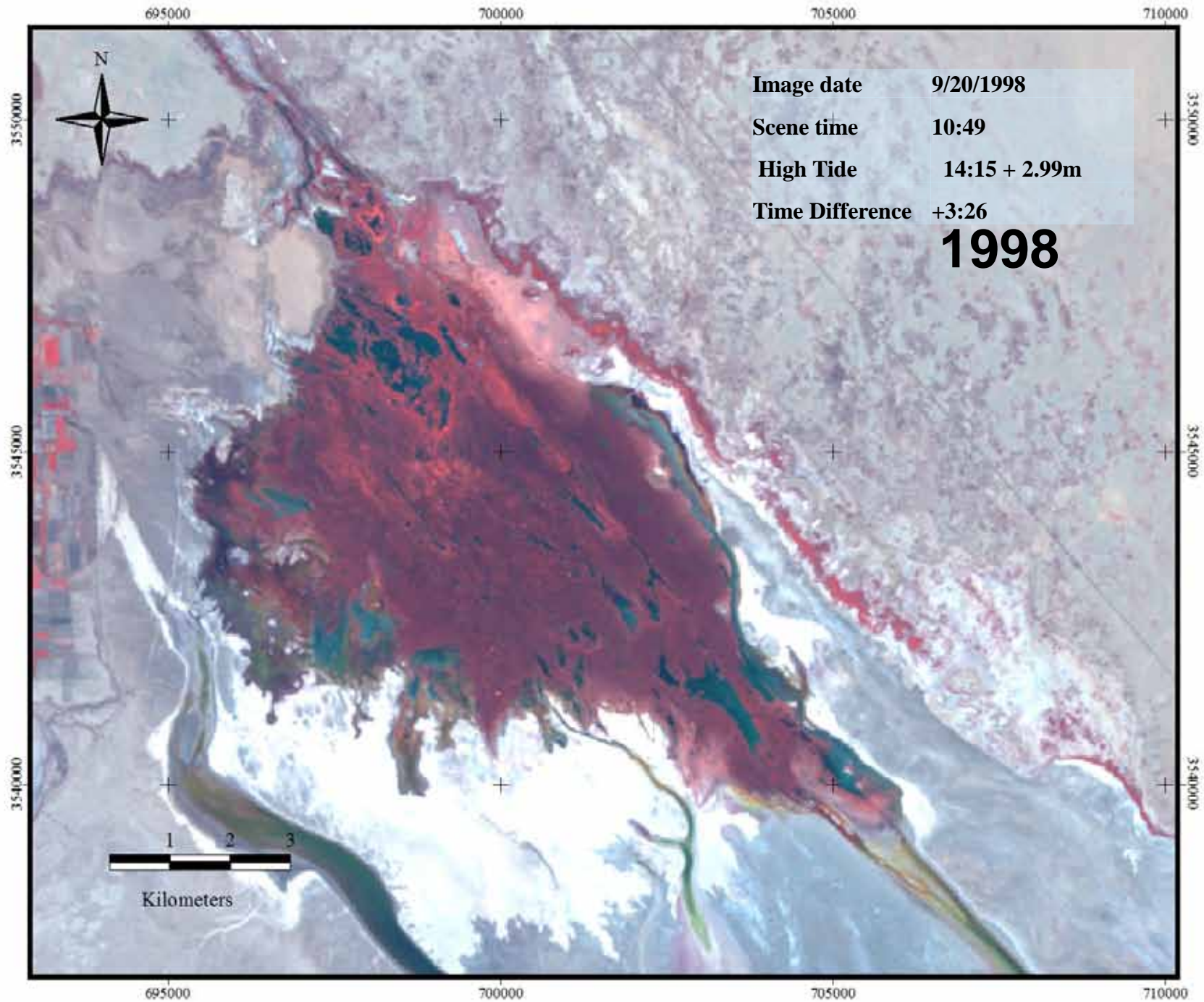
705000

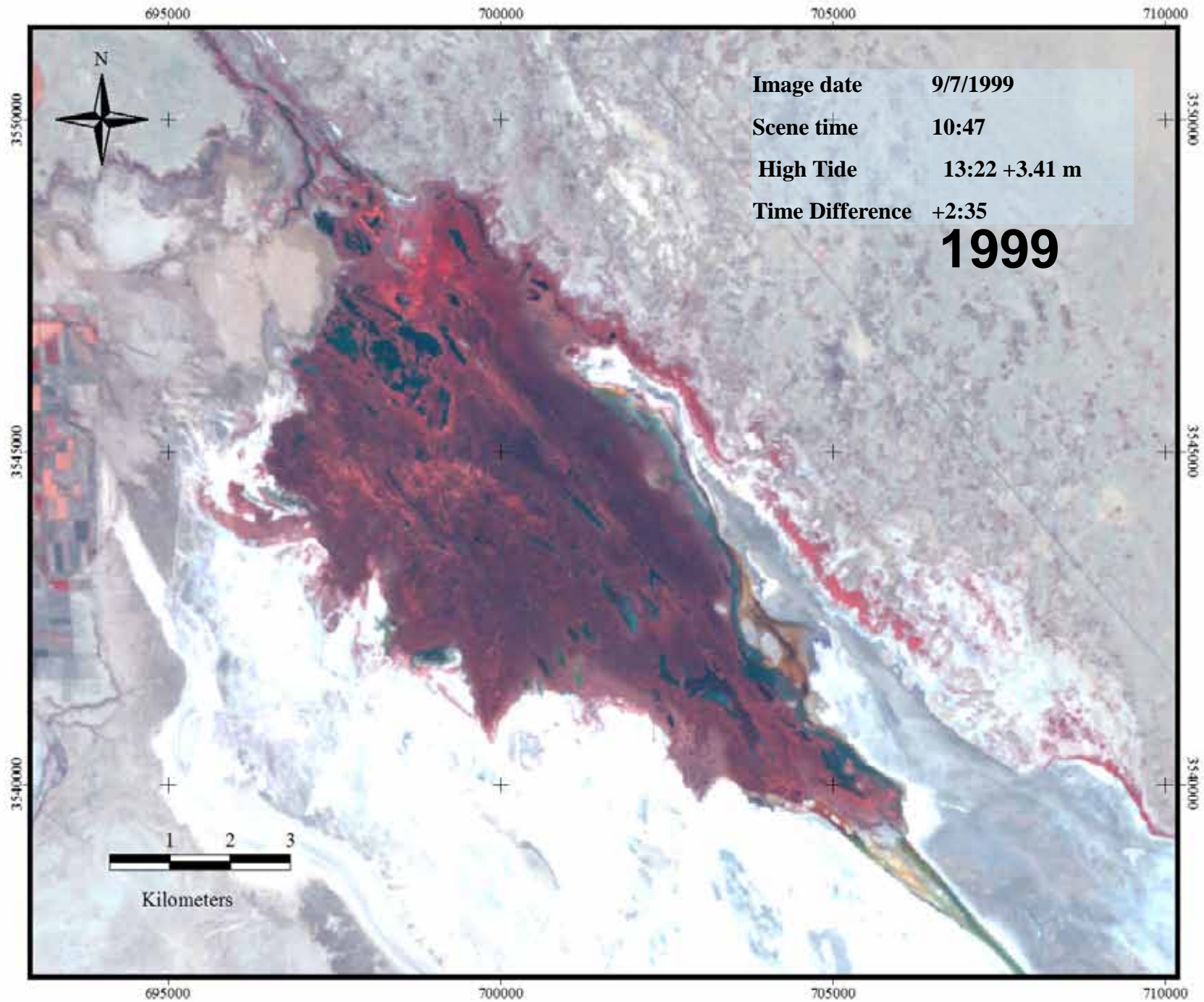
710000

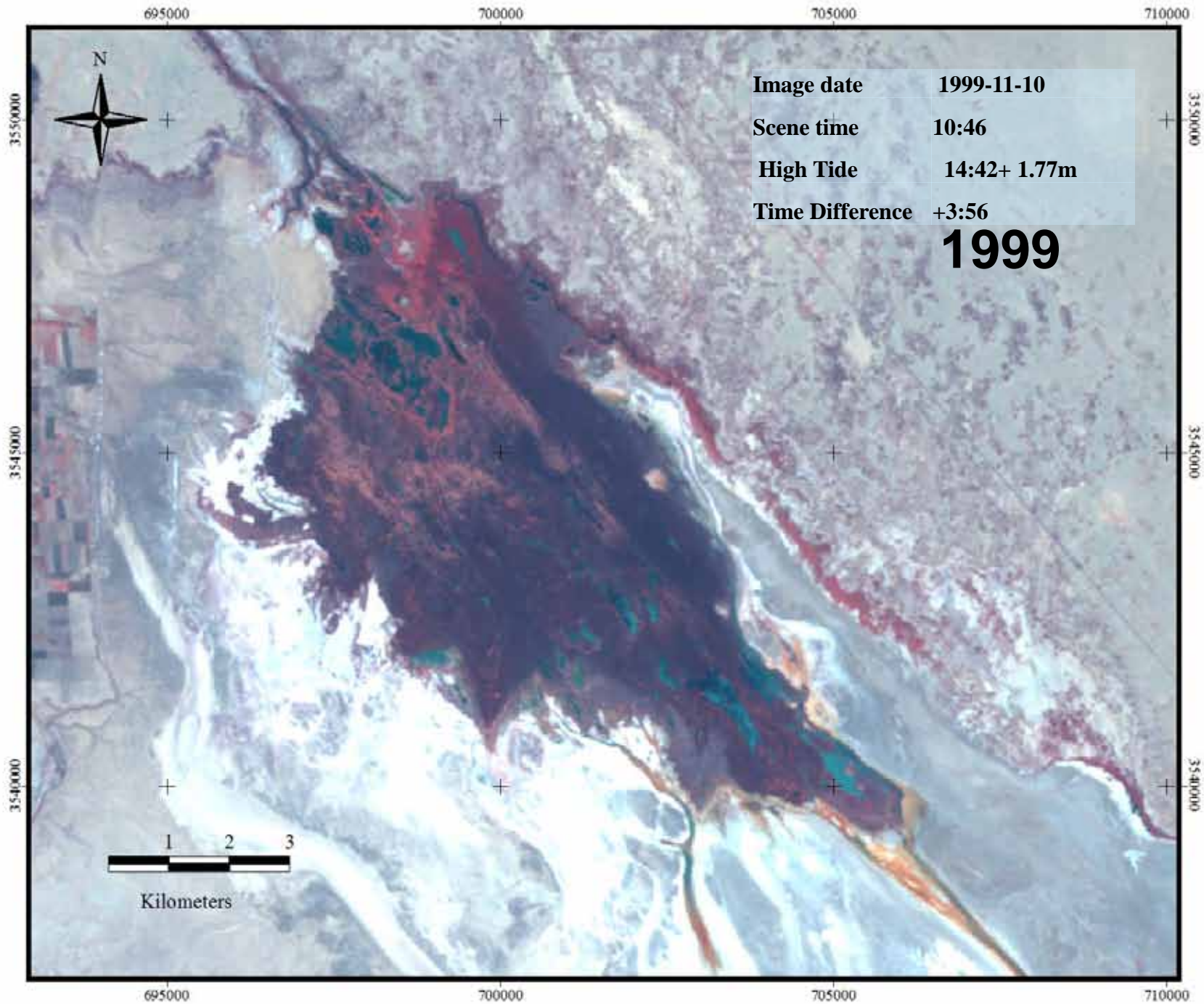


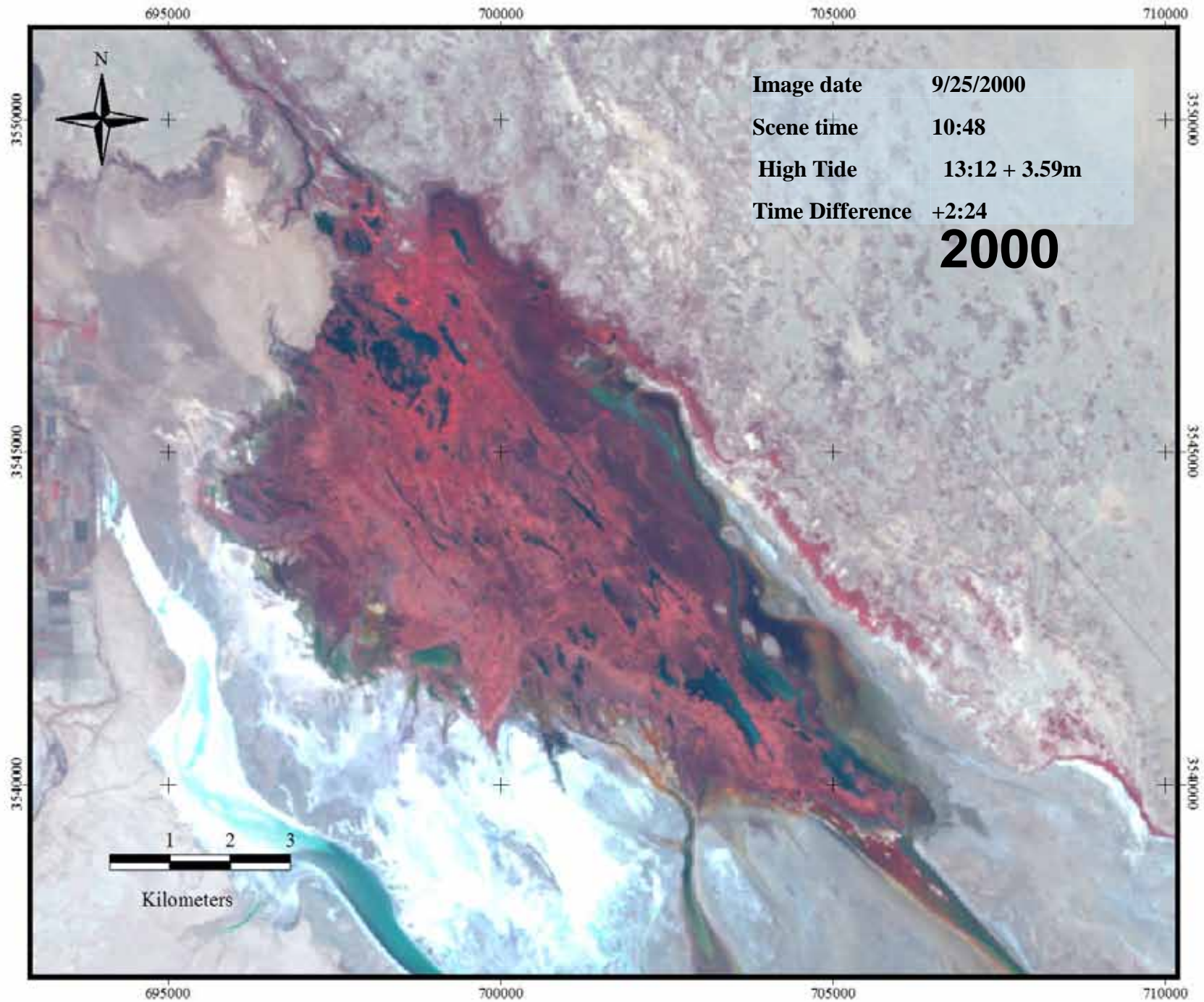


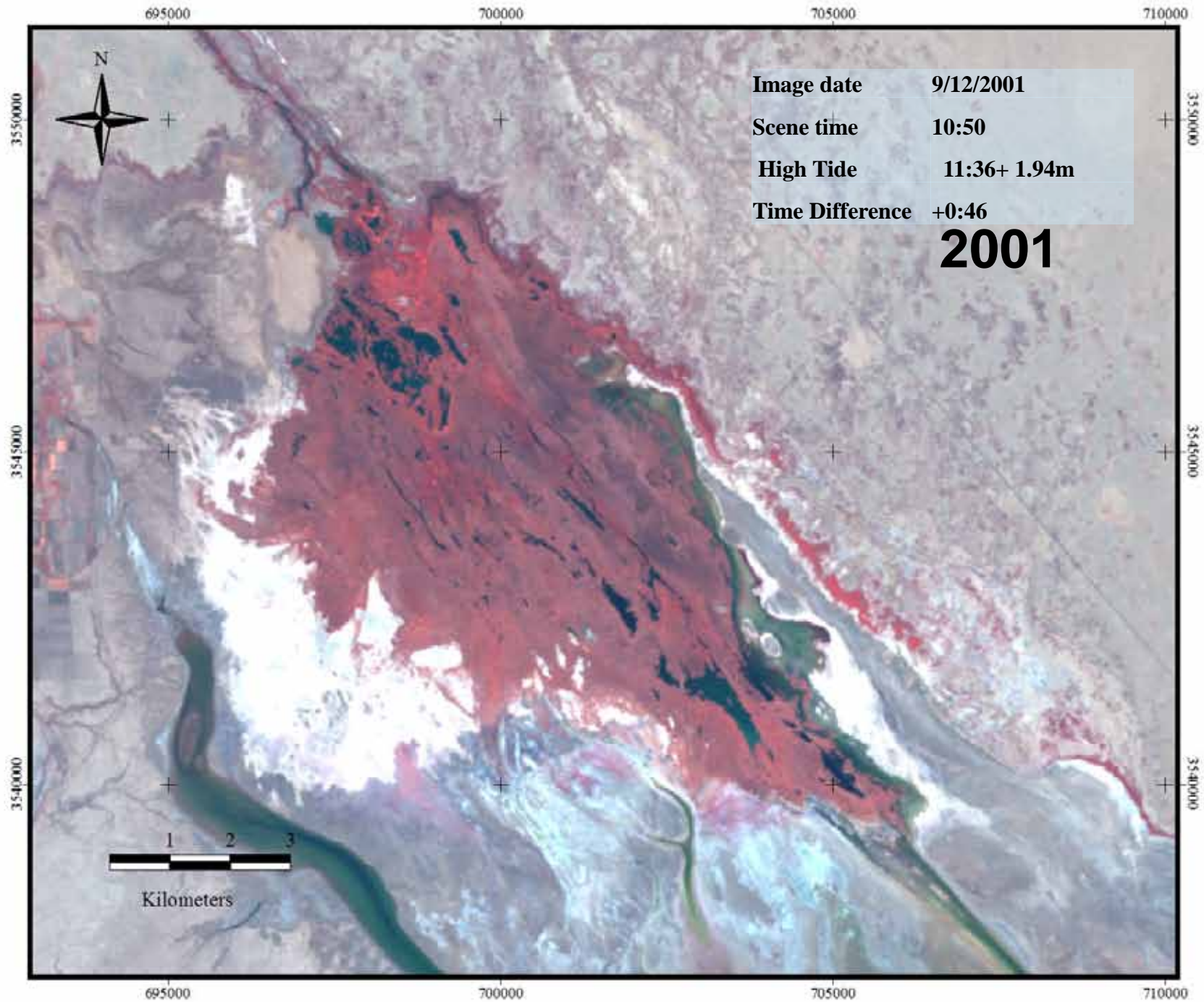


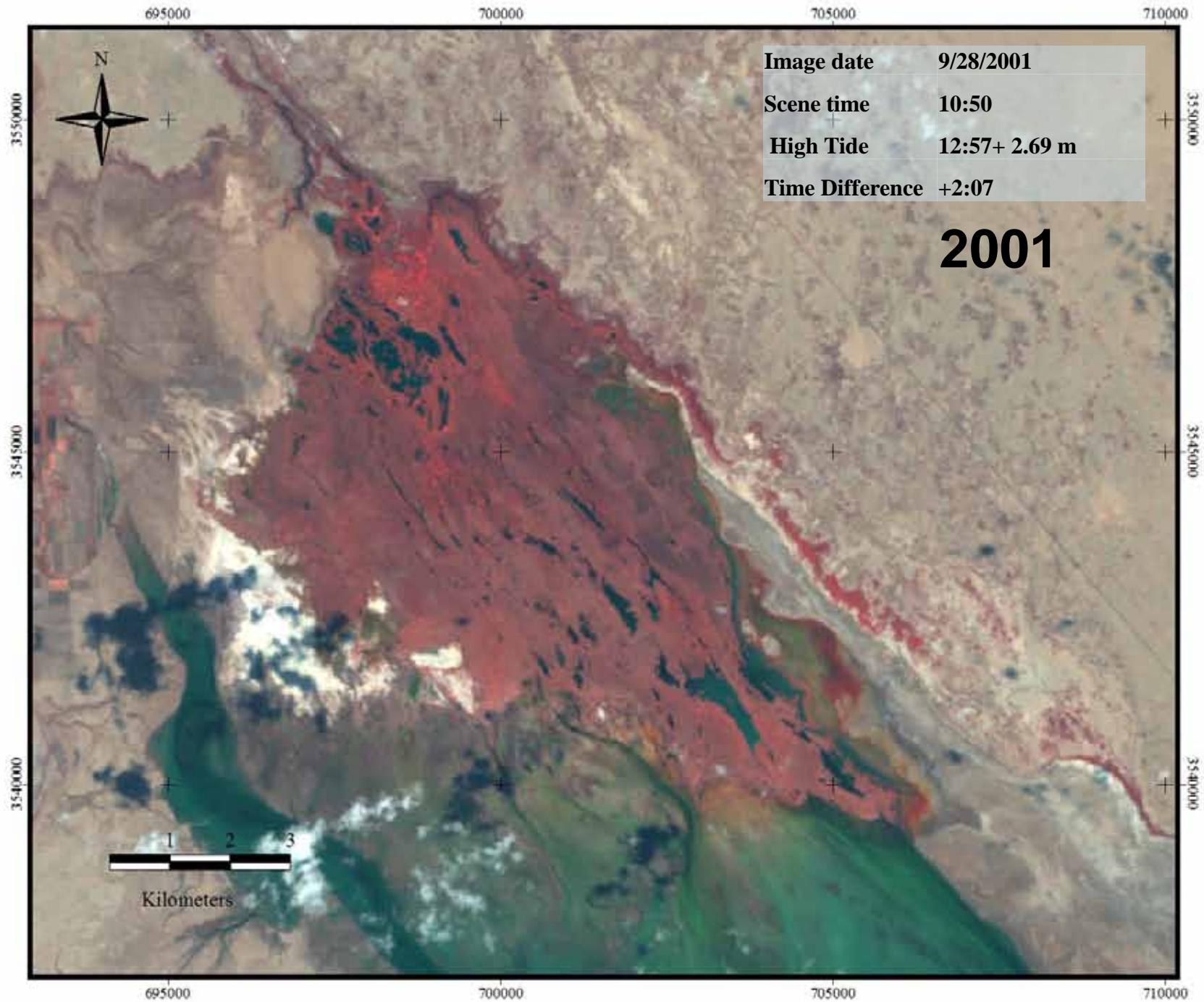












695000

700000

705000

710000



Image date	9/18/2002
Scene time	10:44
High Tide	13:23 + 3.05 m
Time Difference	+2:39

2002

3550000

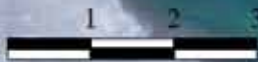
3550000

3545000

3545000

3540000

3540000



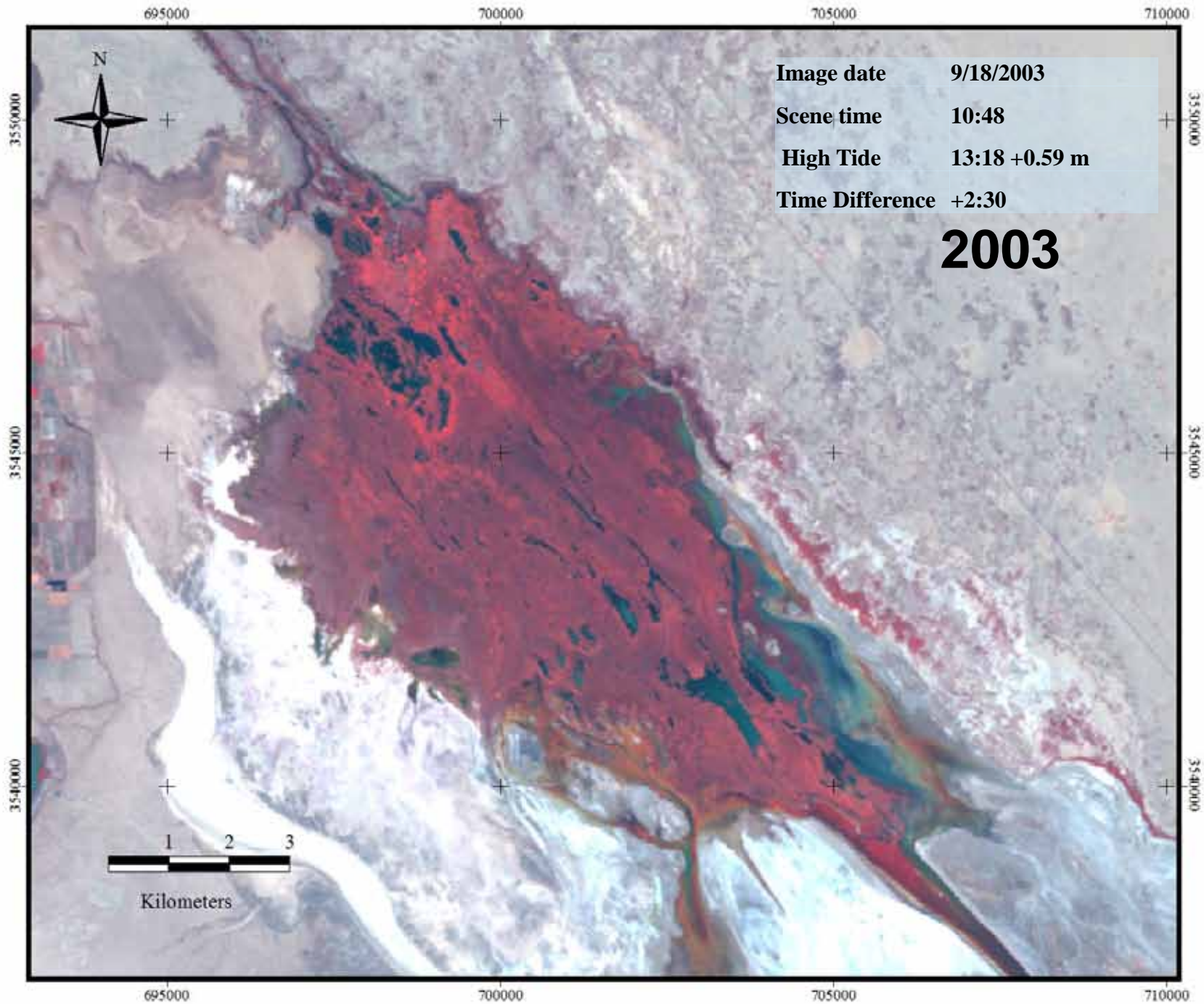
Kilometers

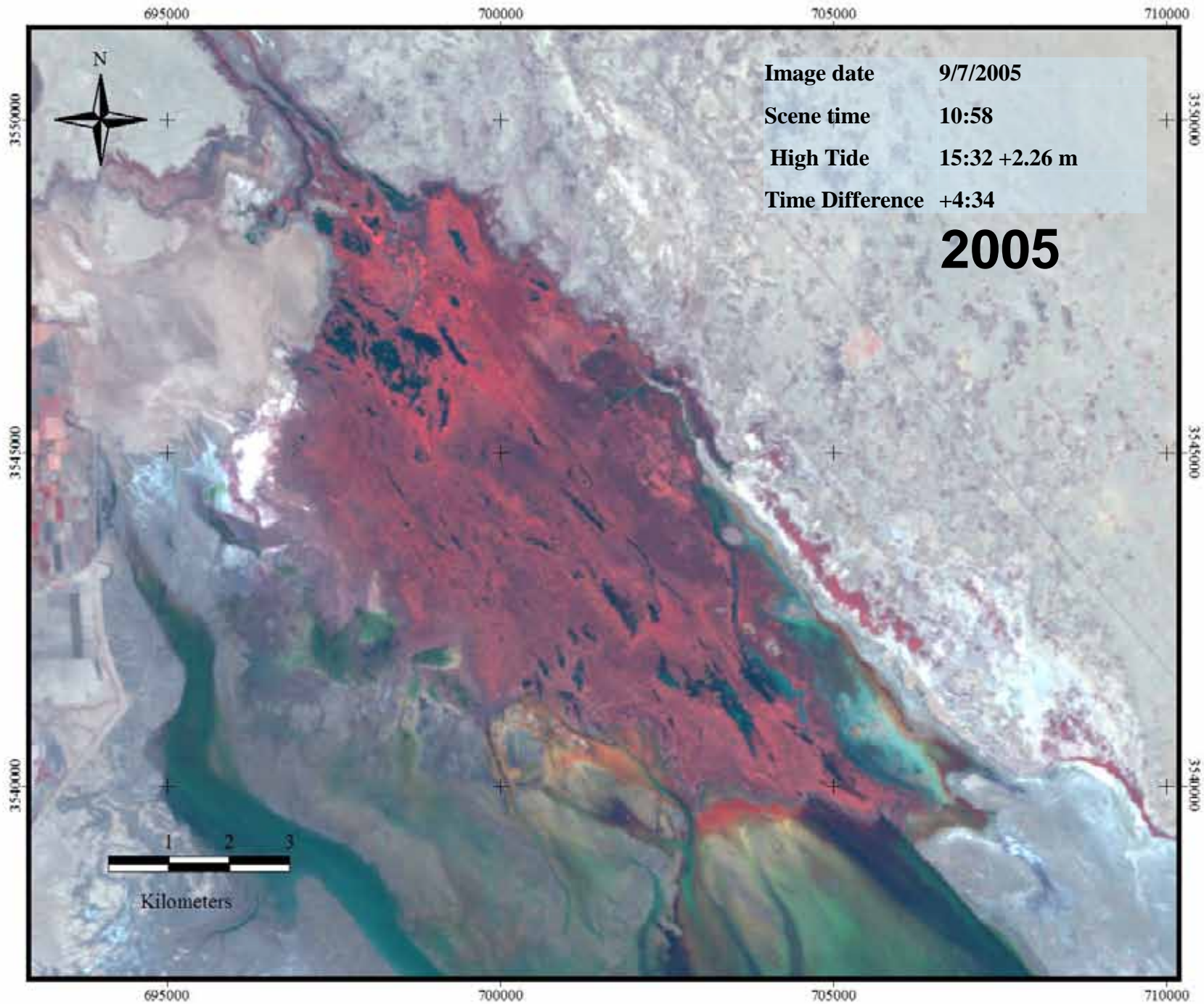
695000

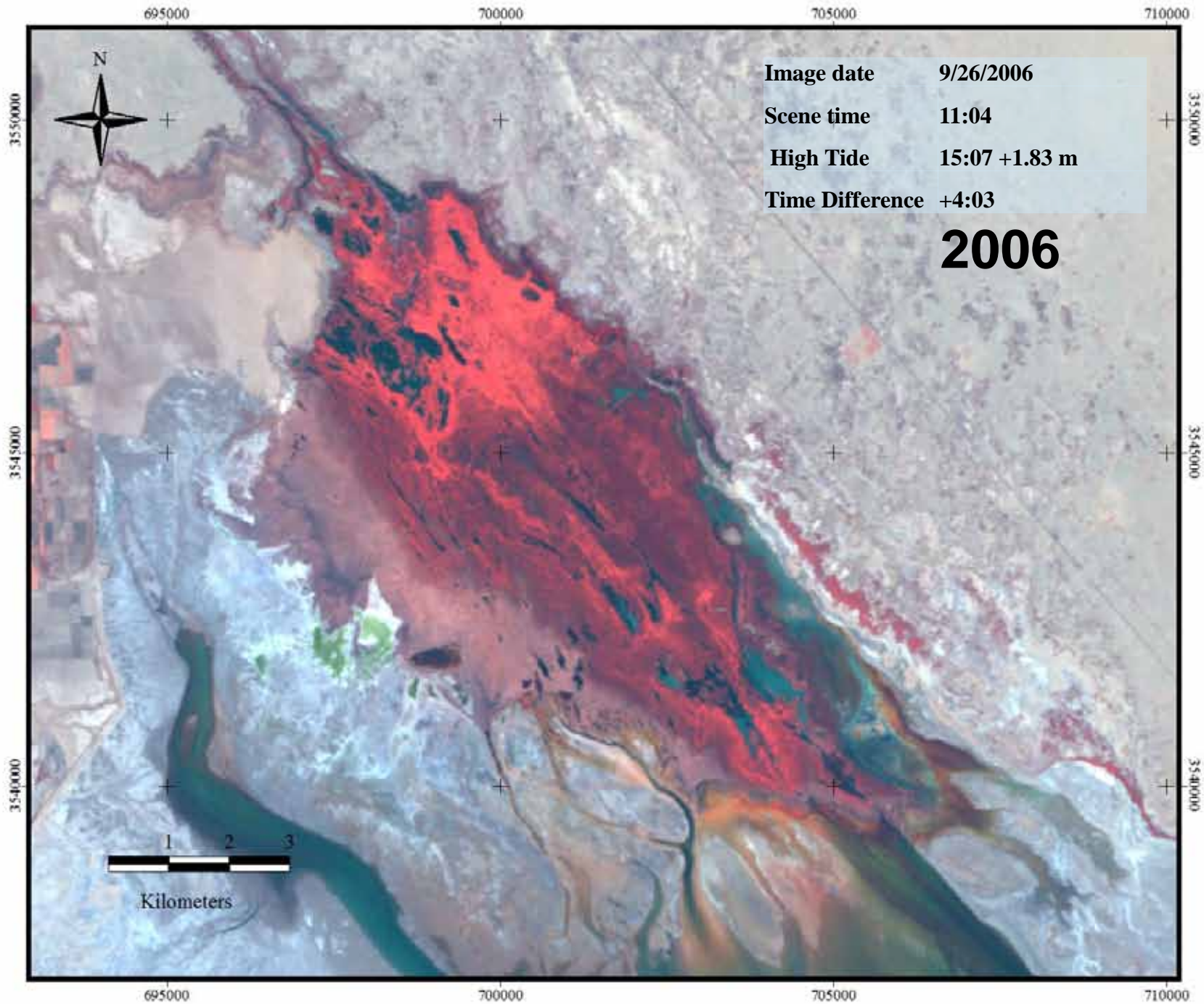
700000

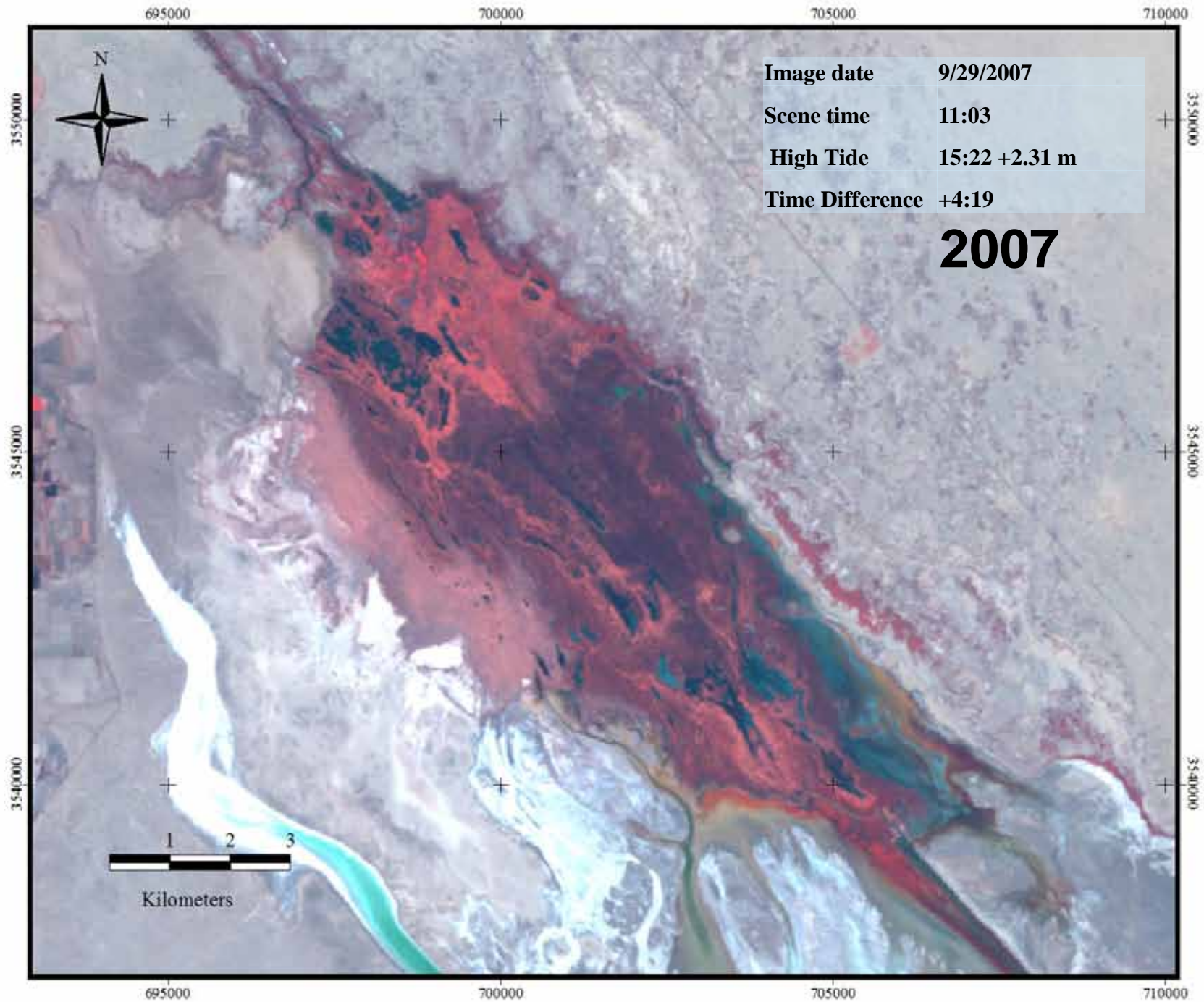
705000

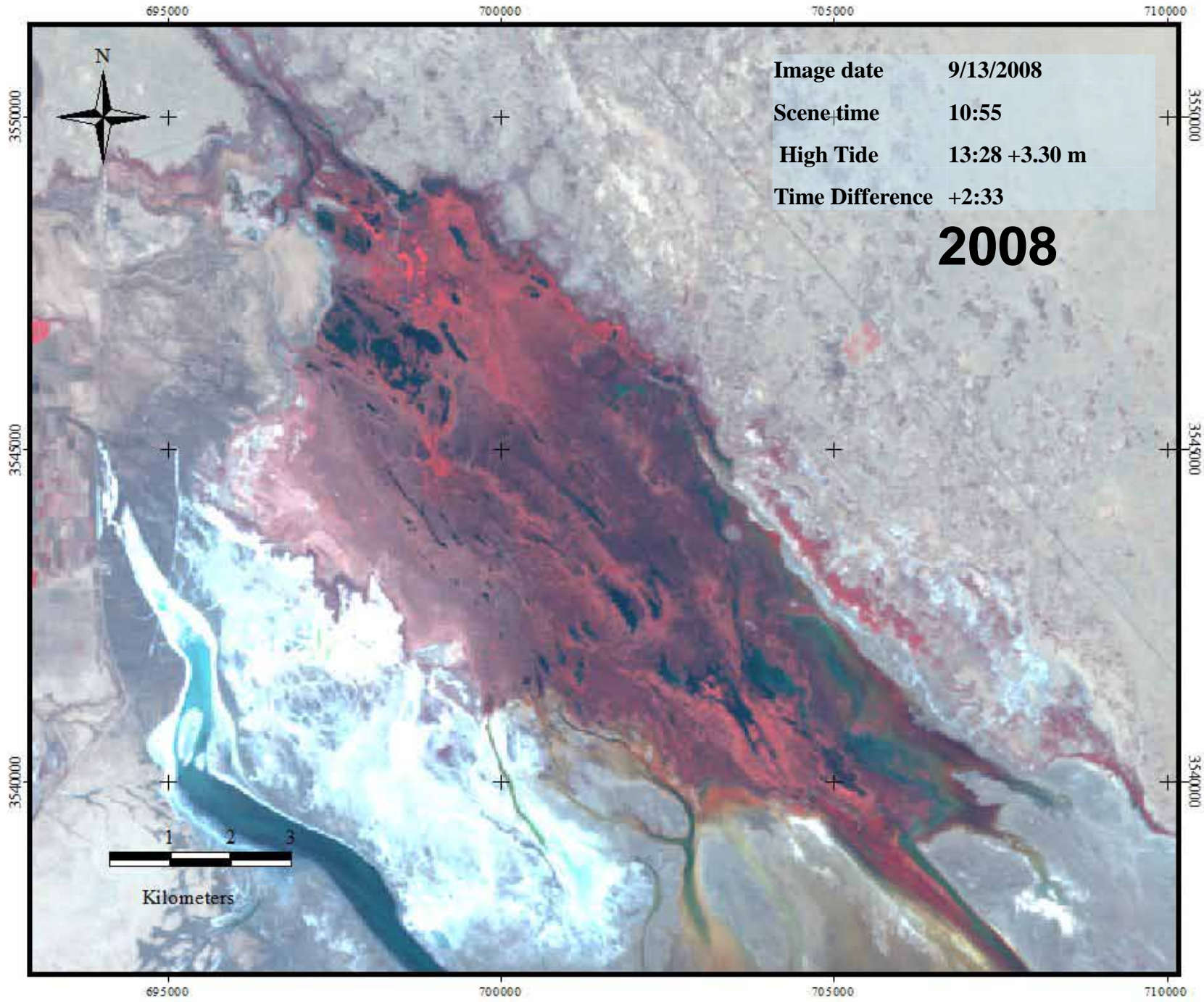
710000











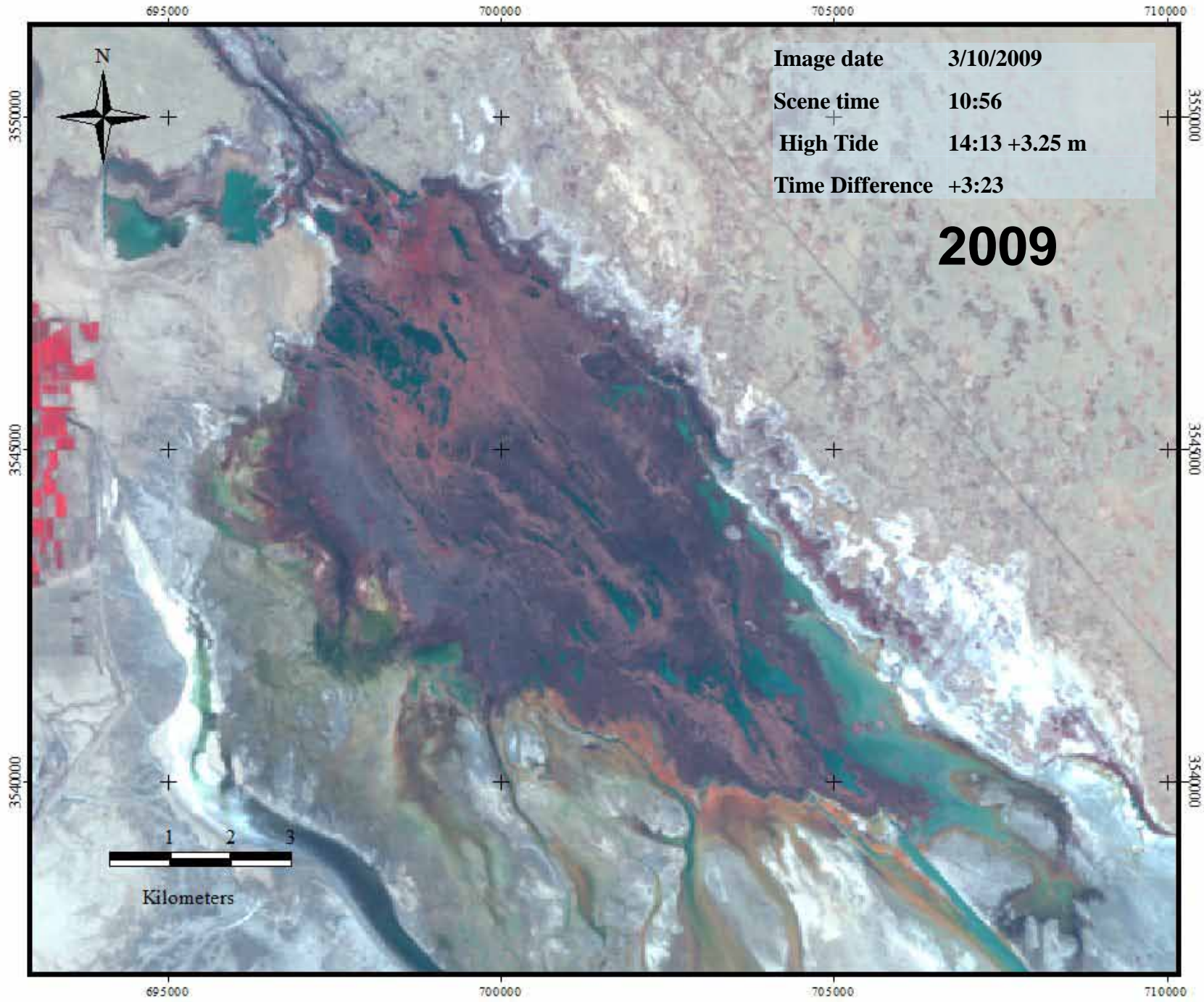


Image date 3/10/2009
Scene time 10:56
High Tide 14:13 +3.25 m
Time Difference +3:23

2009



Kilometers

Image date 9/17/2009

Scene time

High Tide

Time Difference

2009



0 1 2 3 Kilometers

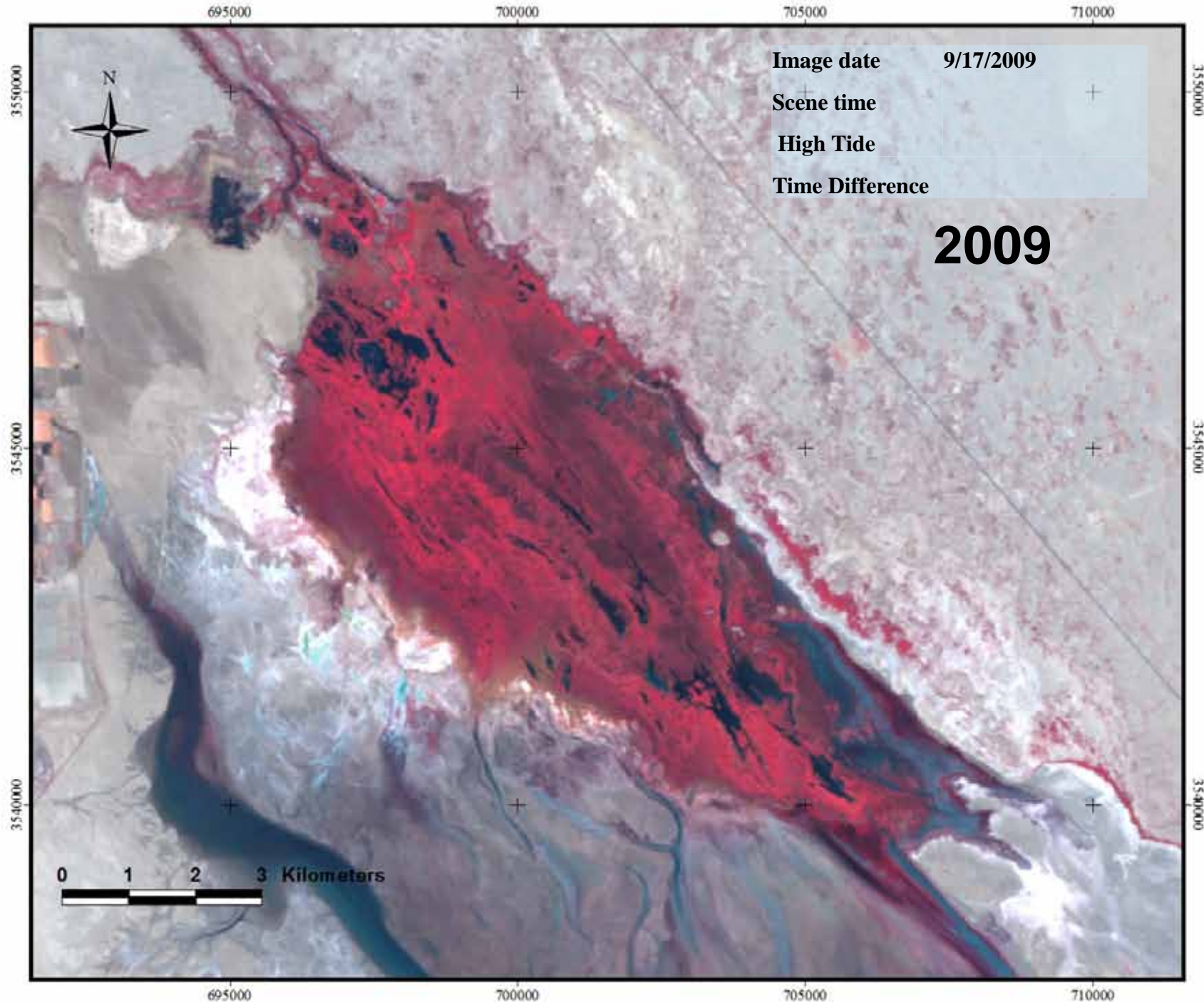
A horizontal scale bar with four segments, labeled 0, 1, 2, and 3 Kilometers.

Image date 01/01/2010
Scene time
High Tide
Time Difference

2010



0 1 2 3 Kilometers

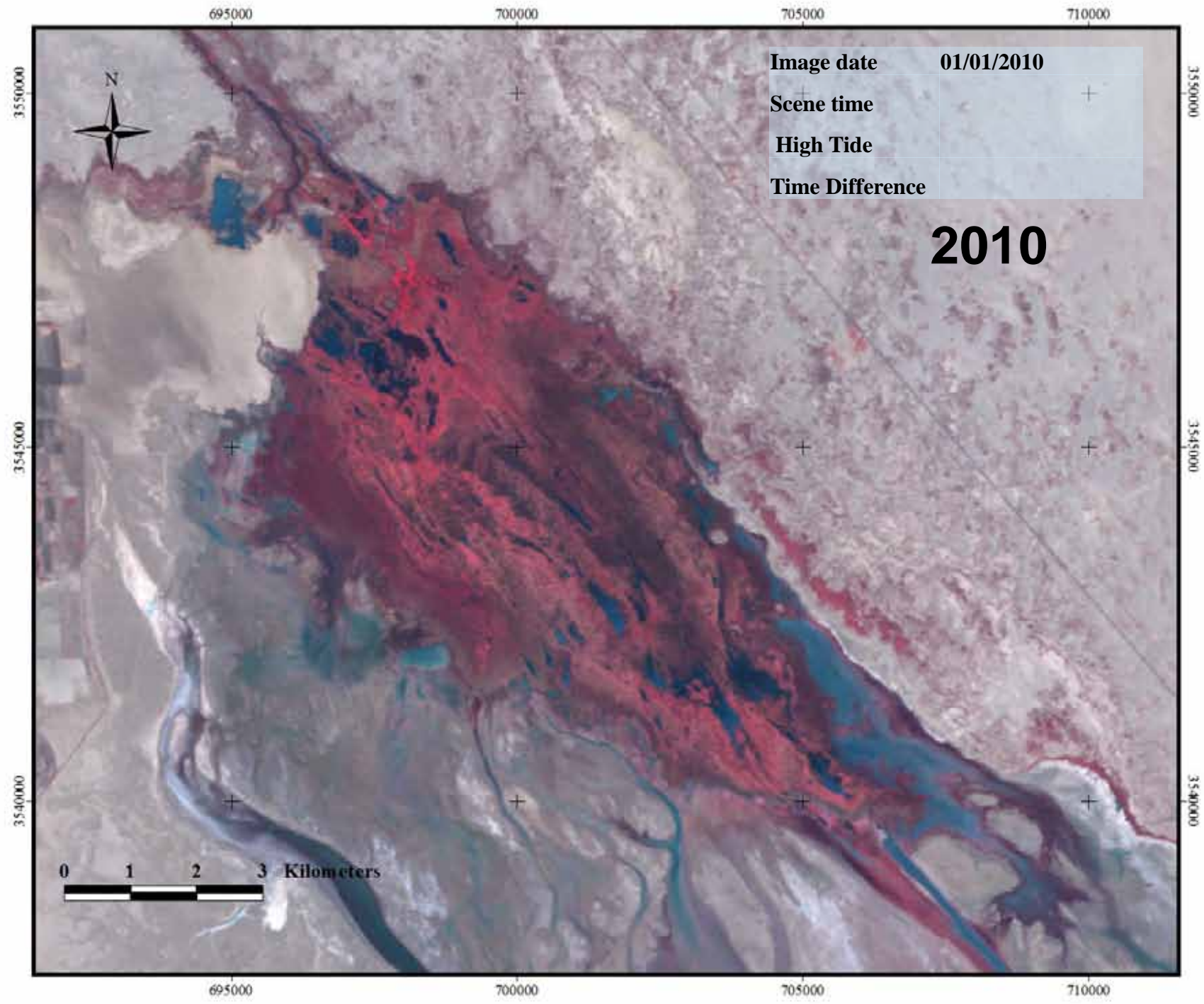
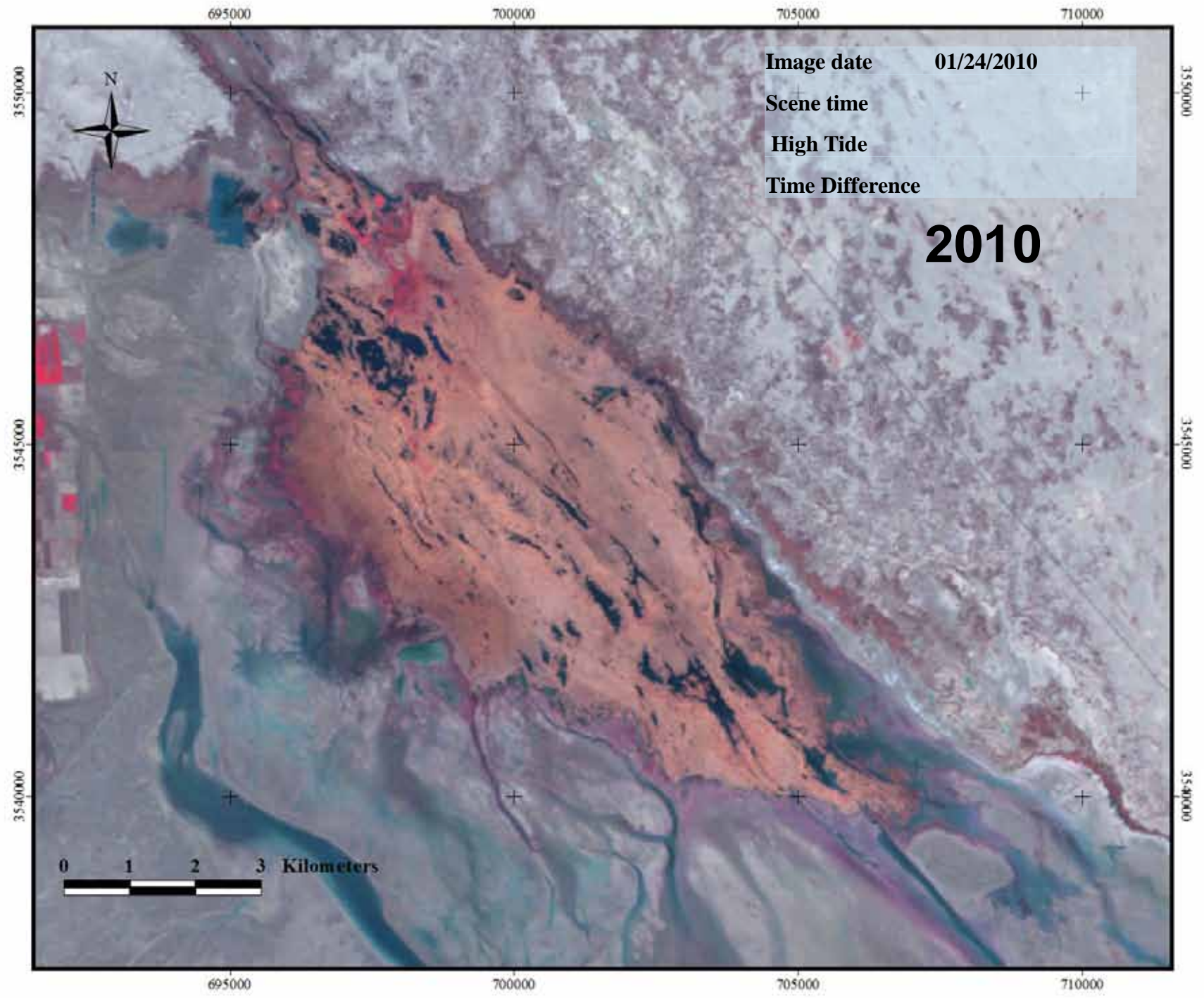


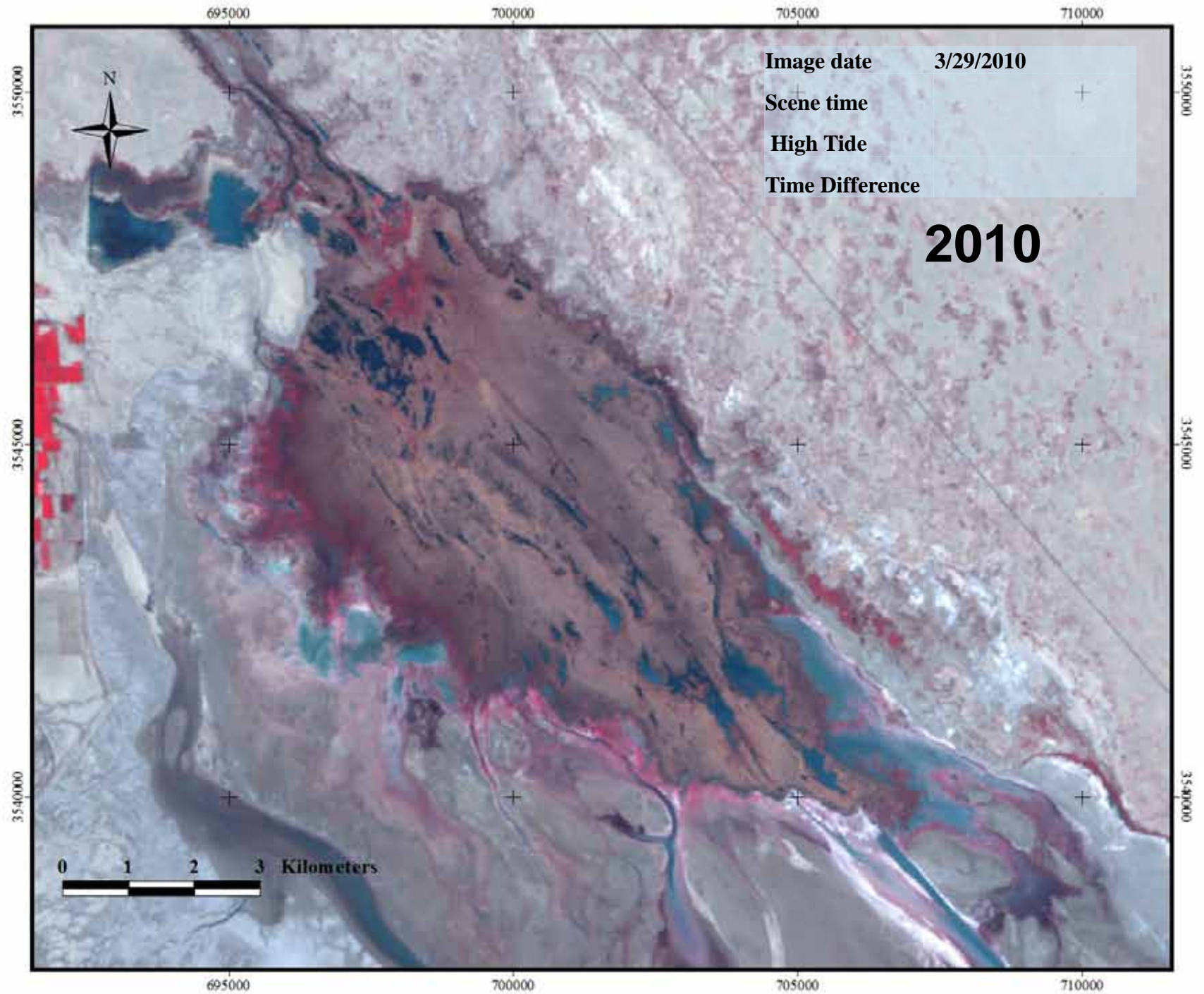
Image date 01/24/2010
Scene time
High Tide
Time Difference

2010



0 1 2 3 Kilometers





- ∅ Mixture of cattail marsh and shallow, open water
- ∅ Habitat for waterfowl, shorebirds, migratory birds, fish
- ∅ Habitat for species at risk
 - **Yuma Clapper Rail**
 - **Least Bittern**
 - **Black Rail**
 - **Virginia Rail**
 - **Desert Pupfish**

- ∅ Mezcla de cattail marismas , someras y aguas abiertas
- ∅ Hábitat para aves acuáticas, playeras, migratorias y peces
- ∅ Hábitat para especies amenazadas y en peligro
 - **Palmoteador de Yuma**
 - **Avetoro Mínimo**
 - **Cachorrito del desierto**



Ciénega de Santa Clara

bienvenido



Especie que puedes encontrar en esta Área Protegida



Reserva de la Biosfera
Alto Golfo de California y Delta del Río Colorado

Ayúdanos a mantener limpia el agua que alimenta tus humedales

**Por un México limpio,
¡llévate tu Basura!**



PESCA COMERCIAL CON MALLA
MENOR A 6" CON PERMISO



PESCA DE
CONSUMO DOMÉSTICO



INSPECCIÓN
Y VIGILANCIA



COLECTA CON
PERMISO



PROHIBIDO
TIRAR BASURA



PROHIBIDO
HACER FOCATAS

Canal Wellton-Mohawk

Principal fuente de agua que alimenta la Ciénega de Santa Clara. El canal nace en el Distrito de Riego Wellton-Mohawk ubicado al este de Yuma, Arizona y viaja más de 80 Km. hasta desembocar en la Ciénega de Santa Clara.

Esta agua no es parte de la asignación del Río Colorado de México, por lo tanto, Estados Unidos potencialmente podría desviarla hacia la desaladora de Yuma para limpiarla y darle un uso humano y agrícola; esto afectaría negativamente la vida silvestre de la Ciénega de Santa Clara.



GOALS/METAS

∅ Provide a common dataset for analysis and interpretation

∅ Characterize normal variability

- Seasonal
- Irrigation practices
- Earthquake effects
- Fire effects

QUESTIONS

- Does 30% operation of the YDP cause variation beyond the normal range?
- If so, is the additional variation harmful?

NO ANSWERS YET

∅ Proveer una dataset común para análisis e interpretación

∅ Caracterizar variabilidad normal

- Estacionaria
- Prácticas de Irrigación
- Efectos del Terremotos
- Efectos de Incendios

PREGUNTAS

- ¿El 30% de operación de la YDP causa variaciones más allá del nivel normal?
- ¿Si es así, es esta variación adicional dañina?

NO HAY RESPUESTA AÚN



What do we already know?

1. The Ciénega de Santa Clara is an ecologically important wetland.
 - Habitat for endangered species, listed in both US and Mexico
 - Migratory birds
 - Resident shorebirds
 - Ecotourism

Biosphere Reserve



Que sabemos ya?

1. La Ciénega de Santa Clara es un humedal ecológicamente importante.
 - Es hábitat para especies en peligro, listadas por los E.U. y México
 - Aves migratorias
 - Ecoturismo

Reserva de la Biosfera

What do we already know? ¿Que sabemos ya?

2. Growth of cattail (*Typha domingensis*) decreases as salinity increases.



2. Crecimiento de cattail (*Typha domingensis*) disminuye conforme la salinidad se incrementa

What do we already know?

3. Yuma Clapper Rail

(*Rallus longirostris yumanesis*), an endangered species in both the US and Mexico, likes cattail marsh for nesting. Largest population (75%) is in Ciénega de Santa Clara.

3. Palmoteador de Yuma

(*Rallus longirostris yumanesis*), una especie en peligro tanto en E.U y México, le gusta el cattail marsh para la anidación. La población más grande (75%) se localiza en la Ciénega de Santa Clara.

- Hinojosa-Huerta et al., 2001, Journal of Arid Environments 49: 171-182.
- Conway et al., 2010. Ecological Applications 20: 2024-2035.



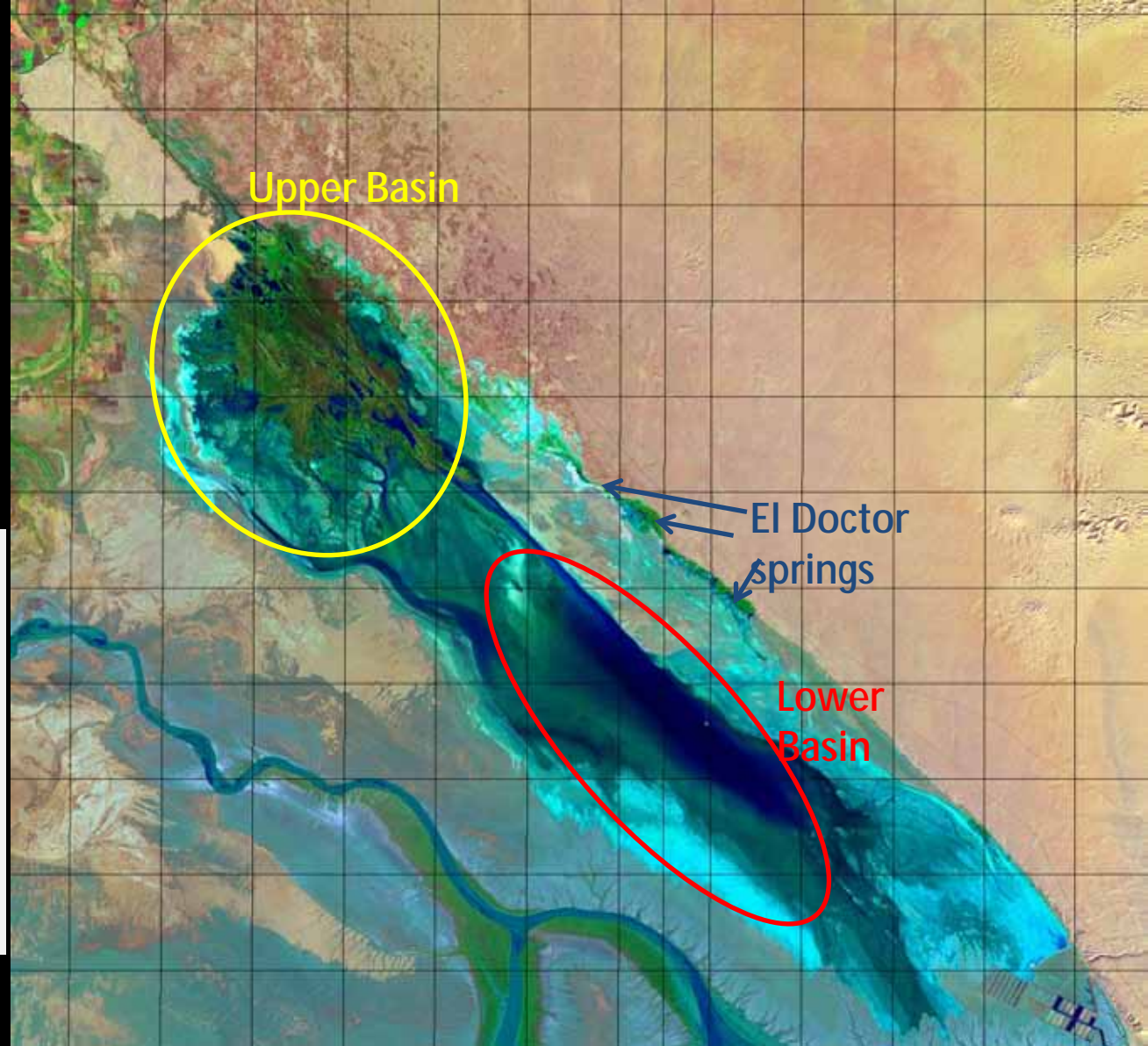
Image: F. Zamora, Sonoran Institute, 2011

What do we already know?

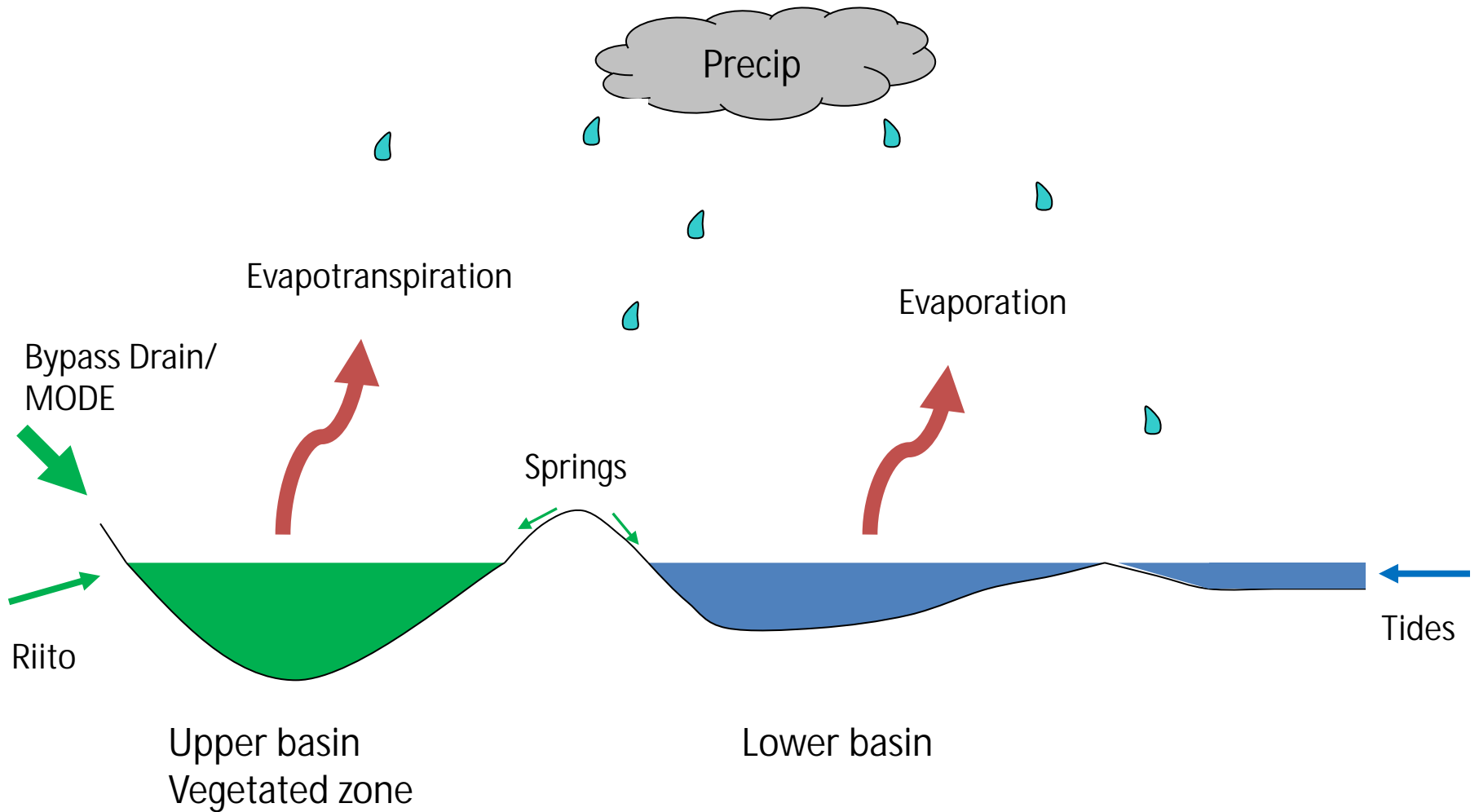
- Upper, vegetated basin (Ciénega de Santa Clara) salinity <6 ppt;
- Lower, unvegetated basin (Santa Clara Slough) > 6 ppt

¿ Que sabemos ya?

- Cuenca superior con vegetación (Ciénega de Santa Clara) salinidad <6 ppt;
- Cuenca baja sin vegetación (Santa Clara Slough) > 6 ppt



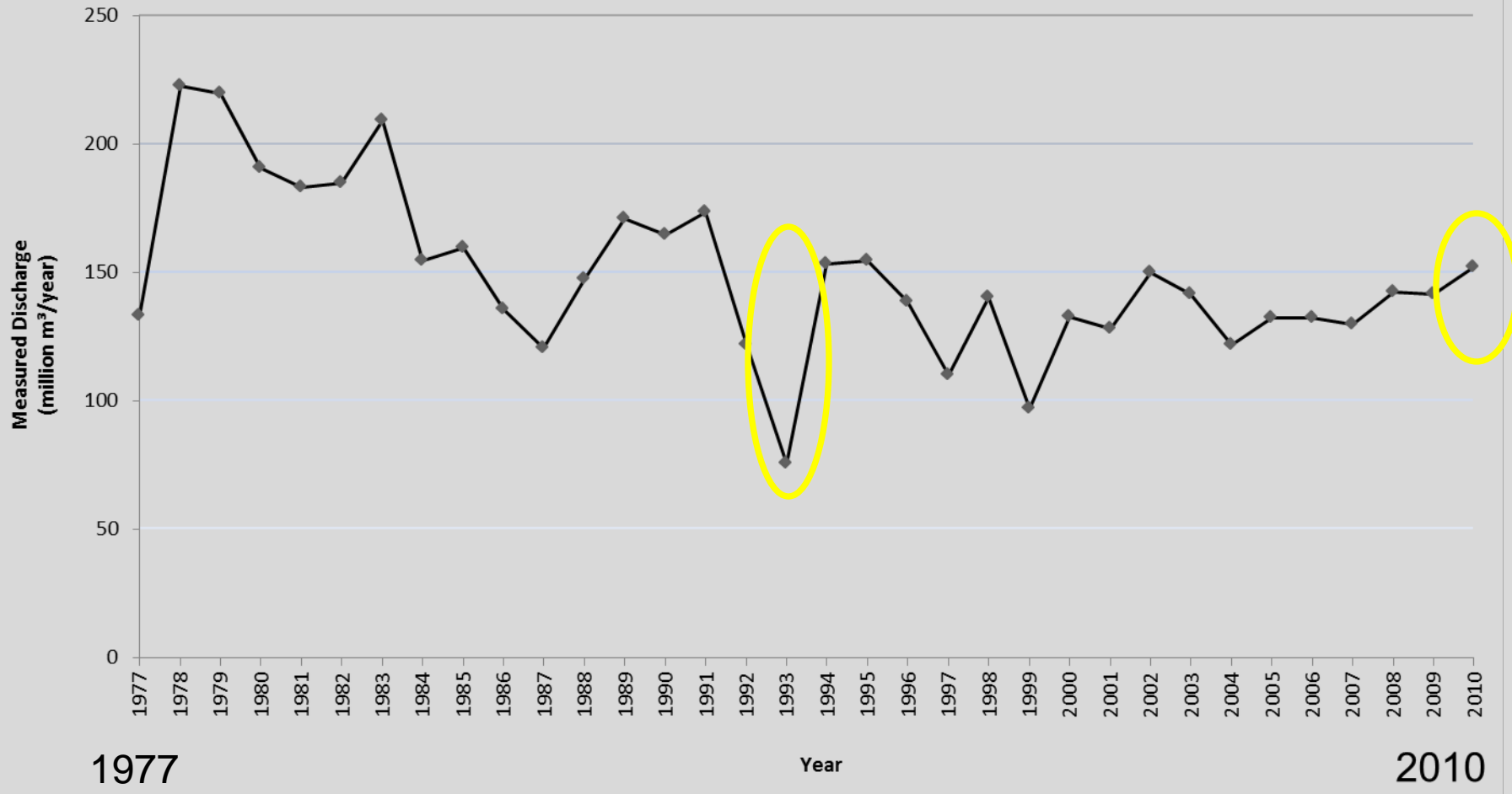
Ciénega de Santa Clara Schematic Water Budget



What do we already know? ¿ Que sabemos ya?

- 5. Flow into the Ciénega varies through time (1977-2010)
- 5. Los flujos a la Ciénega varían a través del tiempo (1977-2010)

Wellton-Mohawk Bypass Drain at Southern International Boundary



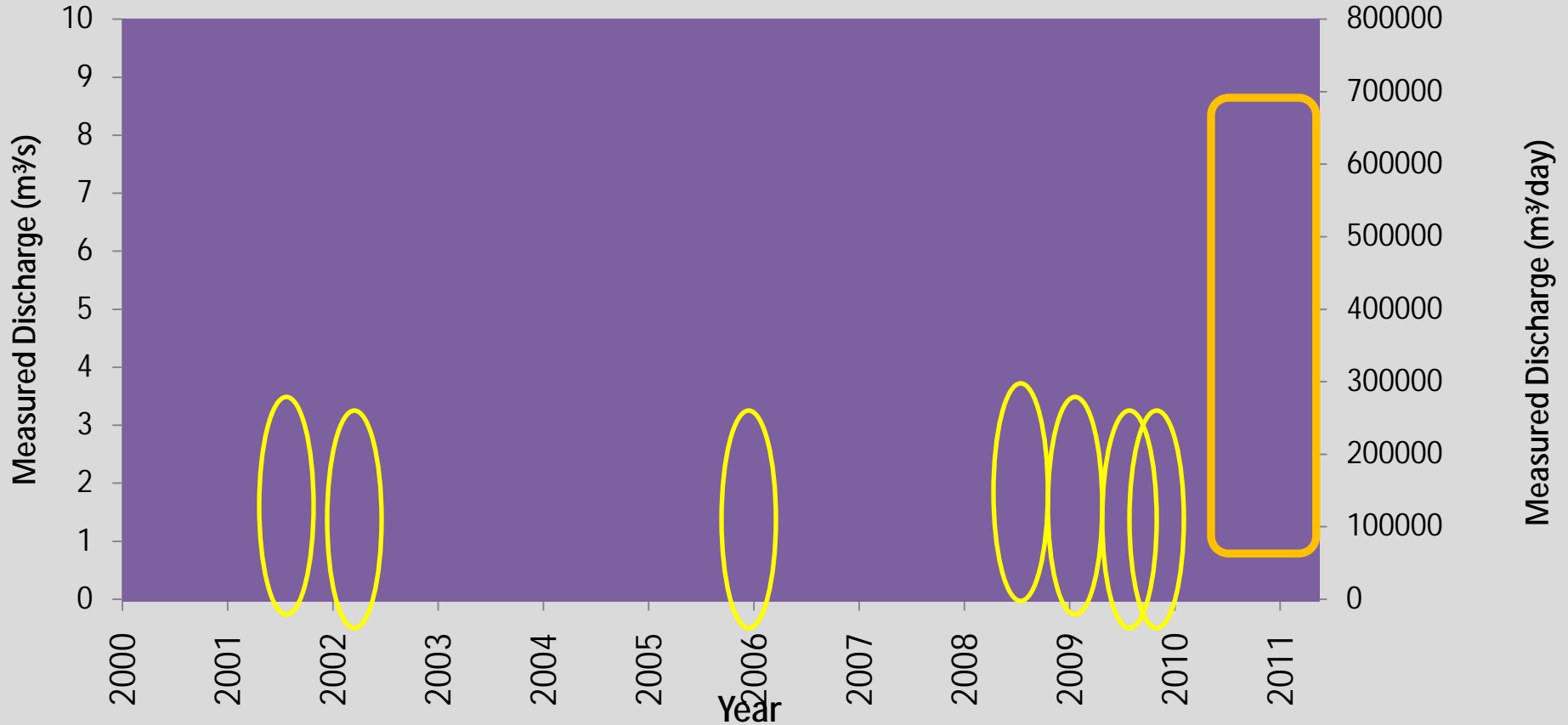
Los datos de flujos en SIB para el 2010 son prelimiaries

2010 SIB flow data are preliminary

What do we already know? ¿ Que sabemos ya?

5. Flow into the Ciénega varies through time (2000-2010)
5. Los flujos a la Ciénega varían a través del tiempo (2000-2010)

Wellton-Mohawk Bypass Drain at Southern International Boundary



Los datos de flujos en SIB para el 2010 son preliminares

2010 SIB flow data are preliminary

More what we already know:

- Winter 2009-2010 canal **dredging**
- From Nov. 2010 to August 2011: 30,000 acre-feet of **replacement water** to be delivered to the Bypass Drain/Riito and Ciénega (Minute 316)
- April 4, 2010: Magnitude 7.2 **earthquake** on the delta
- May 3, 2010 to March 26, 2011: **Pilot run**, Yuma Desalting Plant, ~30,000 acre-feet
 - Reduced flow to the Bypass Drain and Ciénega
 - Brine delivered to the Bypass Drain and Ciénega
- March 23-25, 2011: Widespread **fire** in Ciénega de Santa Clara

What you should know:

- A lot happened to the Ciénega de Santa Clara in the past 24 months.
- A monitoring program, not an experiment.
- Monitoring is not yet complete.

Mas sobre lo que ya sabemos:

- De nov. 2010 a agosto 2011; 30,000 pies- acre de agua de reemplazamiento es liberada por el Bypass Drain/Riito y Ciénega (Minuta 316)
- Abril 4, 2010: Terremoto con magnitud de 7.2 en el delta
- Mayo 3, 2010 a marzo 26, 2011: **Operación Piloto** de la Planta Desaladora de Yuma, ~30,000 acre-pie
 - Reducción del flujo al Bypass Drain y Ciénega
 - Salmuera entregada al dren "Bypass" y Ciénega
- Marzo 23-25, 2011: **Incendio** extensivo en la Ciénega de Santa Clara

Que debe usted saber:

- Muchas cosas sucedieron en la Ciénega de Santa Clara en los últimos 24 meses.
- Un programa de monitoreo, no un experimento.
- El monitoreo no esta completo aún.



Ciénega monitoring: work to date

Instruments in the field, on-the-ground monitoring, satellite images

- Inflows
- Water quality
- Vegetation extent and quality
- Marshbird surveys

Monitoreo de la Ciénega: trabajo efectuado

Instrumentos en el campo, en tierra-monitoreos e imágenes de satélite

- Flujos
- Calidad de agua
- Extensión y calidad de la vegetación
- Monitoreo de aves de marisma



Inflow to the Ciénega de Santa Clara, Jan 2010 – Mar 2011

Flujos en la Ciénega de Santa Clara, enero 2010 – marzo 2011







- Bypass Drain a major source
- Different estimates of flow match
- Riito Drain a minor source
- Flow prior to YDP run unusually high
- Some flow during YDP run unusually high

- Principal fuente de agua, dren “Bypass”
- Diferentes estimaciones de flujos de contraparte
- Dren “Riito” fuente menor
- Flujos antes de la operación de YDP inusualmente alto
- Algunos flujos durante la operación YDP inusualmente alto

2010 SIB flow data are preliminary

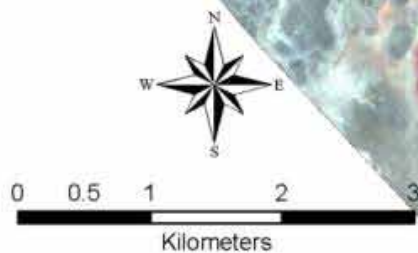
Ciénega de Santa Clara Water Quality - Sampling Sites

Equipment installed and parameters measured

-  HOBO - Water level and temperature
-  None - measured with portable multiparameter sonde
-  YSI 600LS - Temp, EC, Water level
-  YSI XLM - Temp, EC, Water level, DO, pH/ORP

Sampling points 14 and 15
are pending

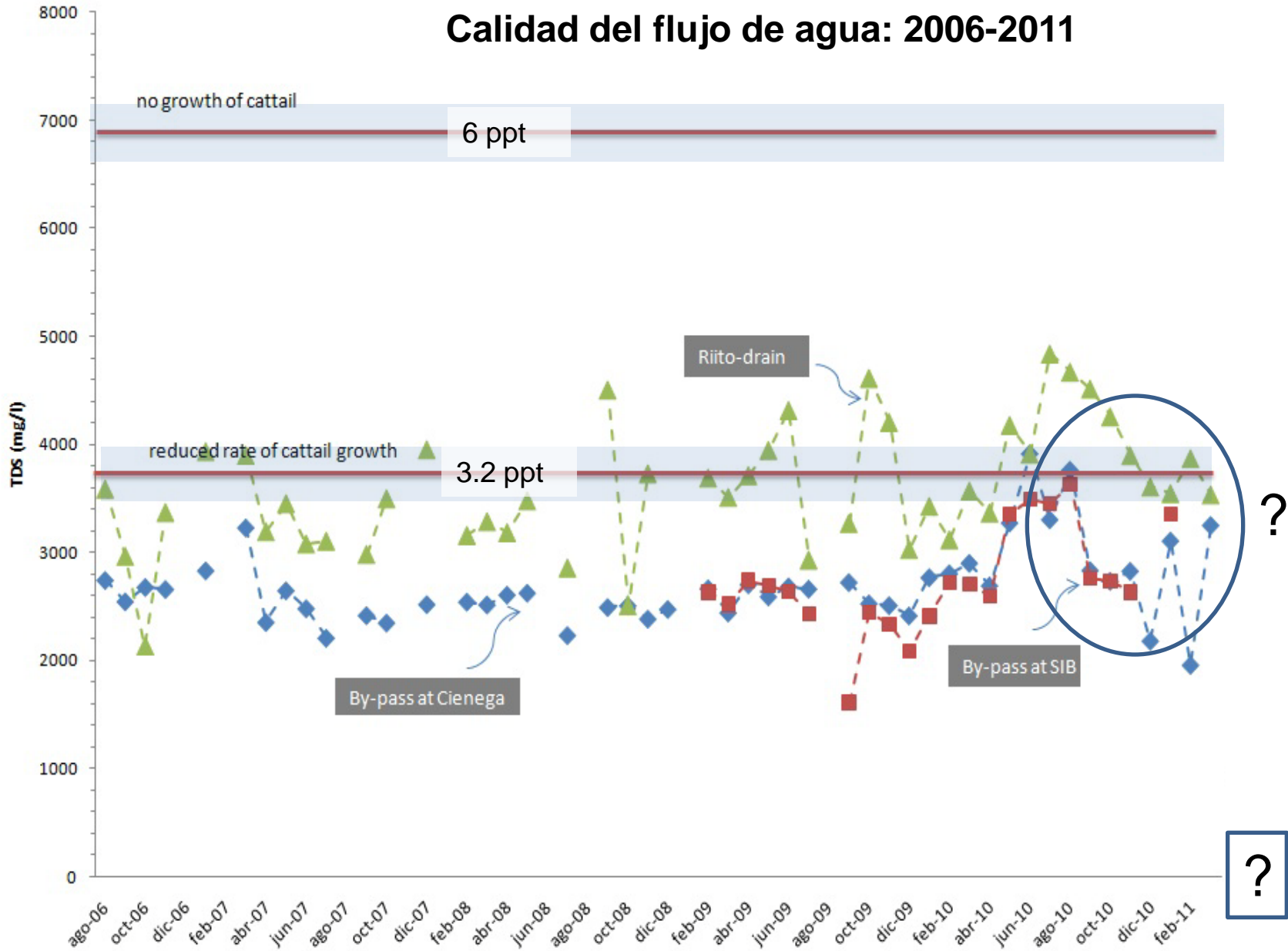
Sampling site #9 - Riito Drain
is not shown.



Map created April 20, 2010

Inflow water quality: 2006-2011

Calidad del flujo de agua: 2006-2011



Ciénega de Santa Clara Water Quality - Sampling Sites

Sites 1, 2 & 3, water
depths approx 0.8m

Sampling points 14 and 15
are pending

Sampling site #9 - Riito Drain
is not shown

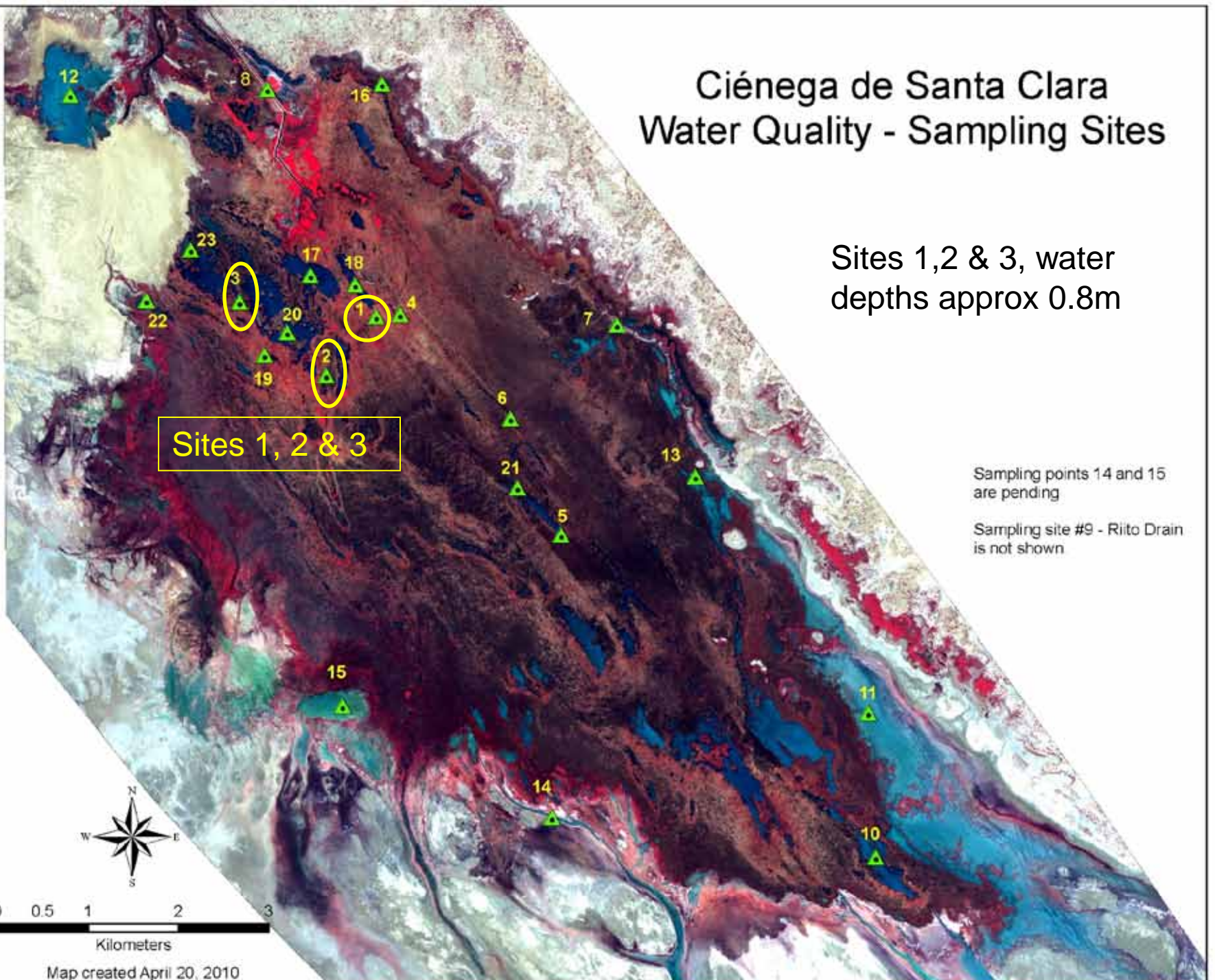
Sites 1, 2 & 3



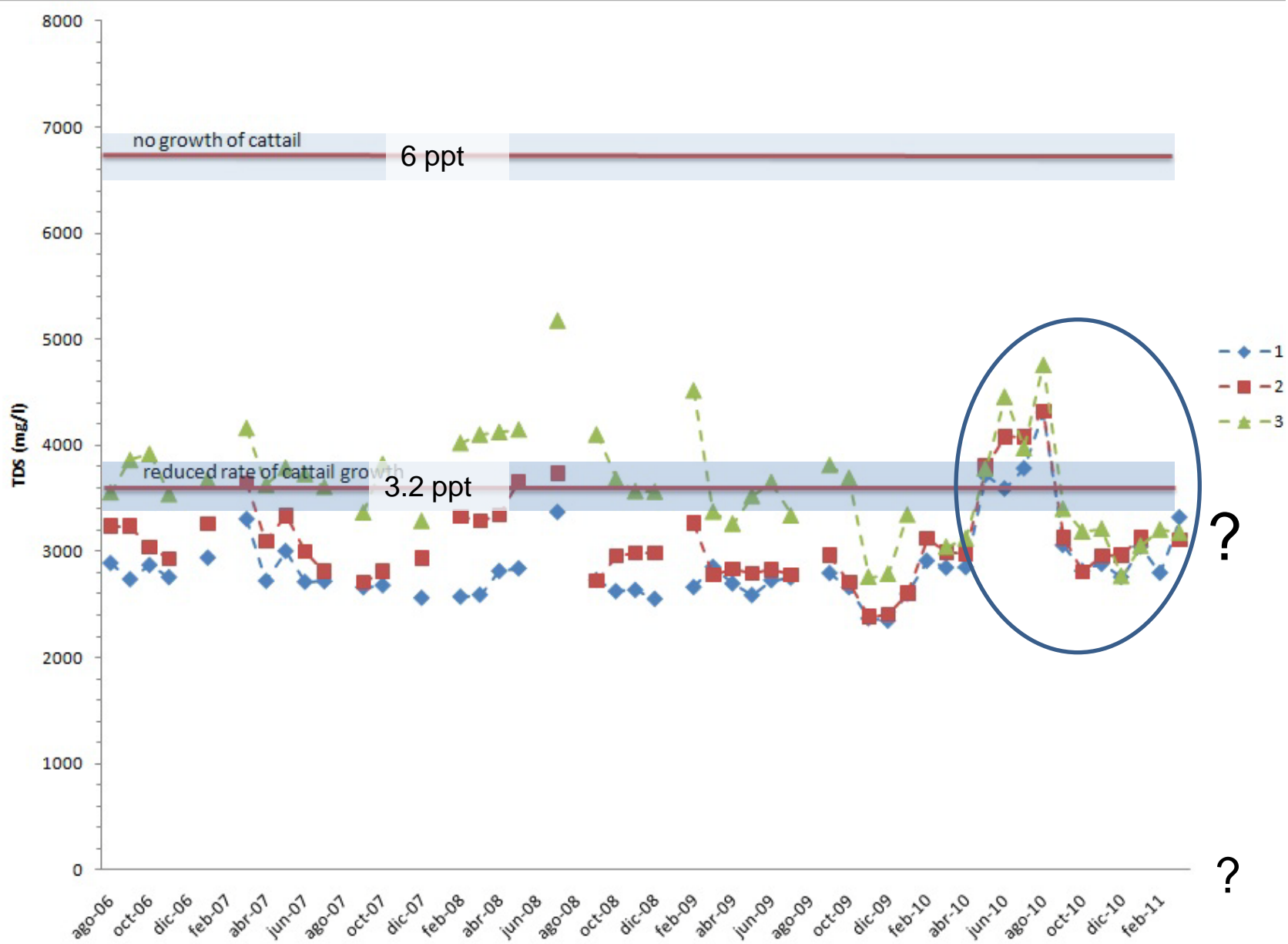
0 0.5 1 2 3

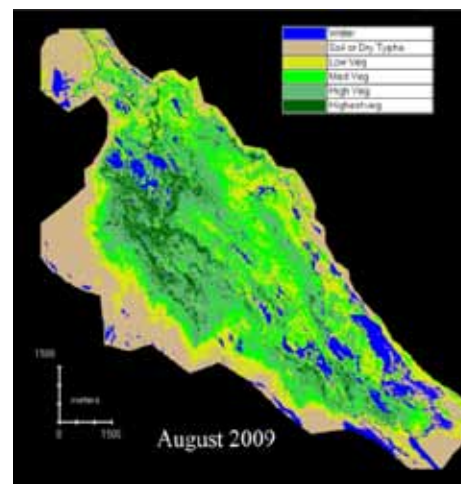
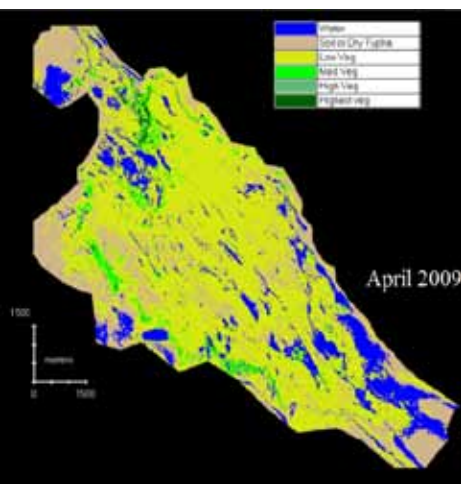
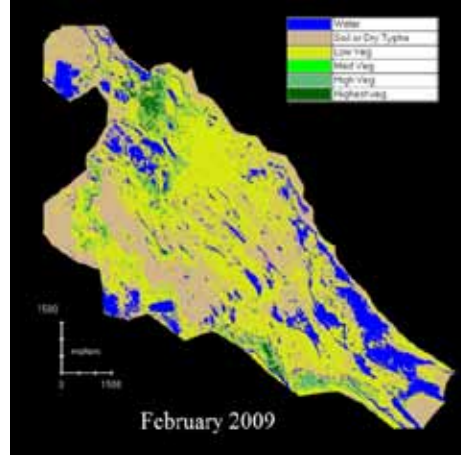
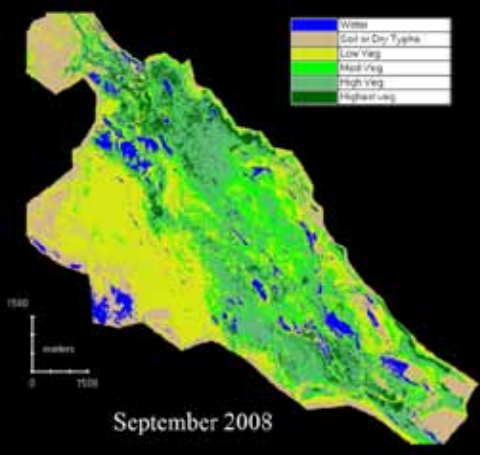
Kilometers

Map created April 20, 2010

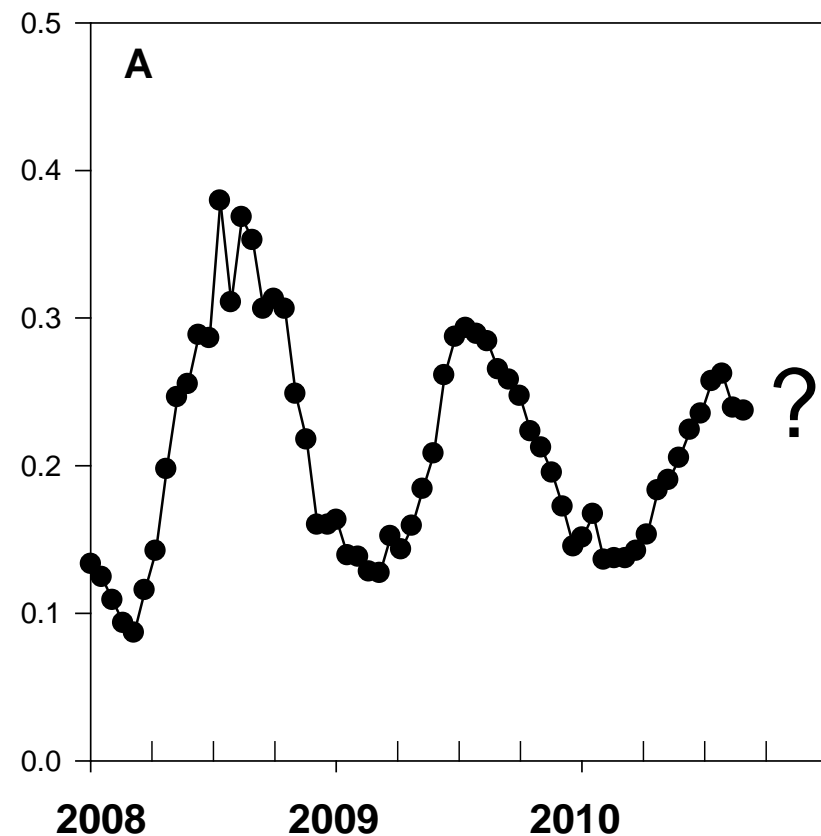


Interior sites, 2006-2011 Sitios interiores, 2006-2011





Scaled EVI



Enhanced Vegetation Index – a measure of photosynthetic activity

Enhanced Vegetation Index – una medida de la actividad fotosintética

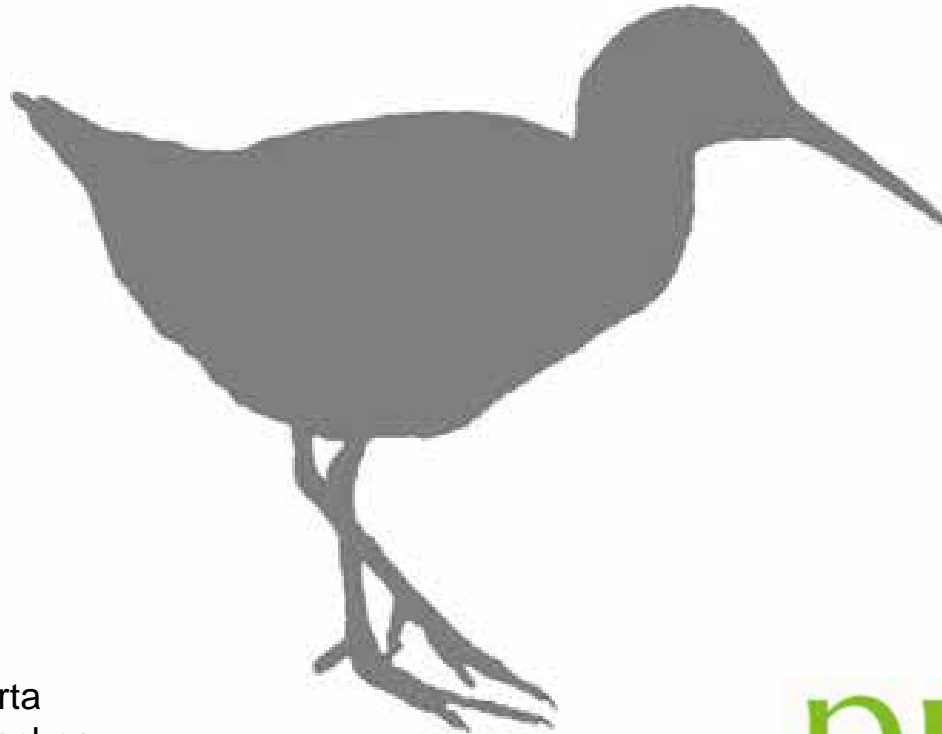


WVU image, July 7, 2010



Vegetation “brown-up”, July 8, 2010

Status of Marshbirds
Binational Monitoring Program in the Ciénega de Santa Clara
January, 2011



Osvel Hinojosa-Huerta
Ricardo Guzmán Olachea
Juan Butrón Méndez
José Juan Butrón Rodríguez
Alejandra Calvo Fonseca

Pronatura Noroeste
San Luis Río Colorado, Sonora, México





Protocol

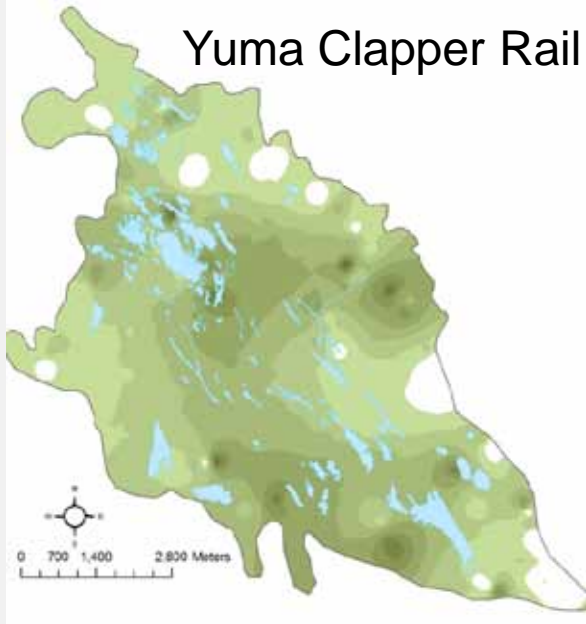
- Standardized Protocol for Monitoring Marshbirds in North America
- Two times per year: March and May
- Based on statistical power analysis to detect trends $>3\%$ per year
- 12 years of data: 1999-2010
- 1999-2002: CLRA and BLRA only

-
- Protocolo estandarizado para el monitoreo de aves de marismas en Norte América
 - Dos veces al año: marzo y mayo
 - Basado en análisis estadístico para detectar tendencias $>3\%$ por año.
 - 12 años de datos: 1999-2010
 - 1999-2002: solo CLRA y BLRA



2010

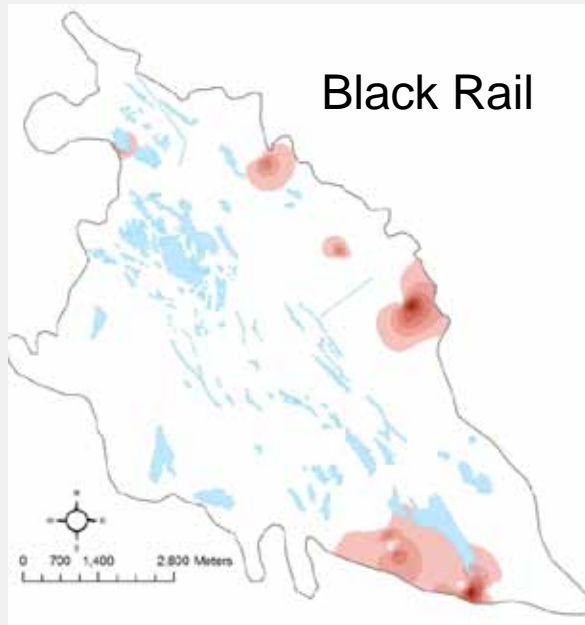
Yuma Clapper Rail



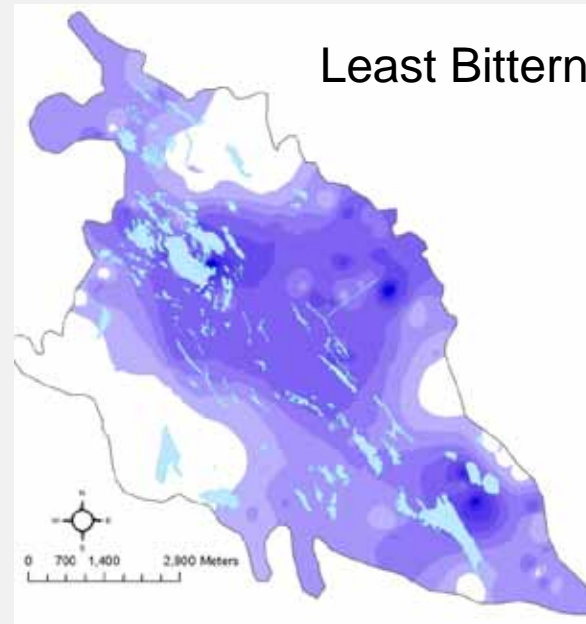
Virginia Rail



Black Rail

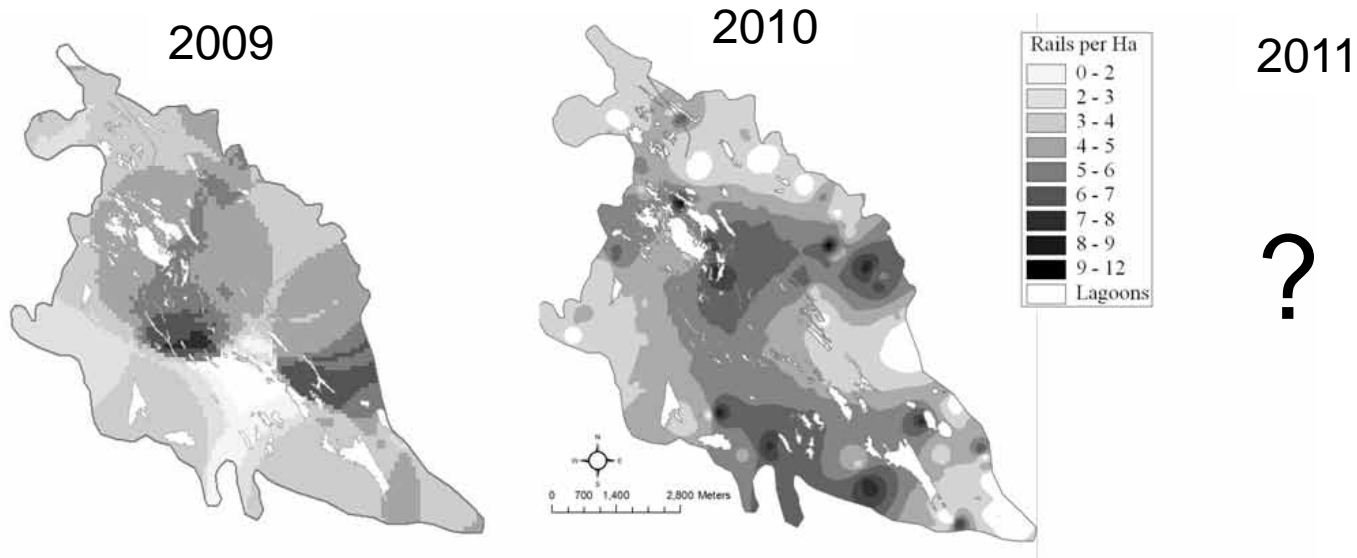
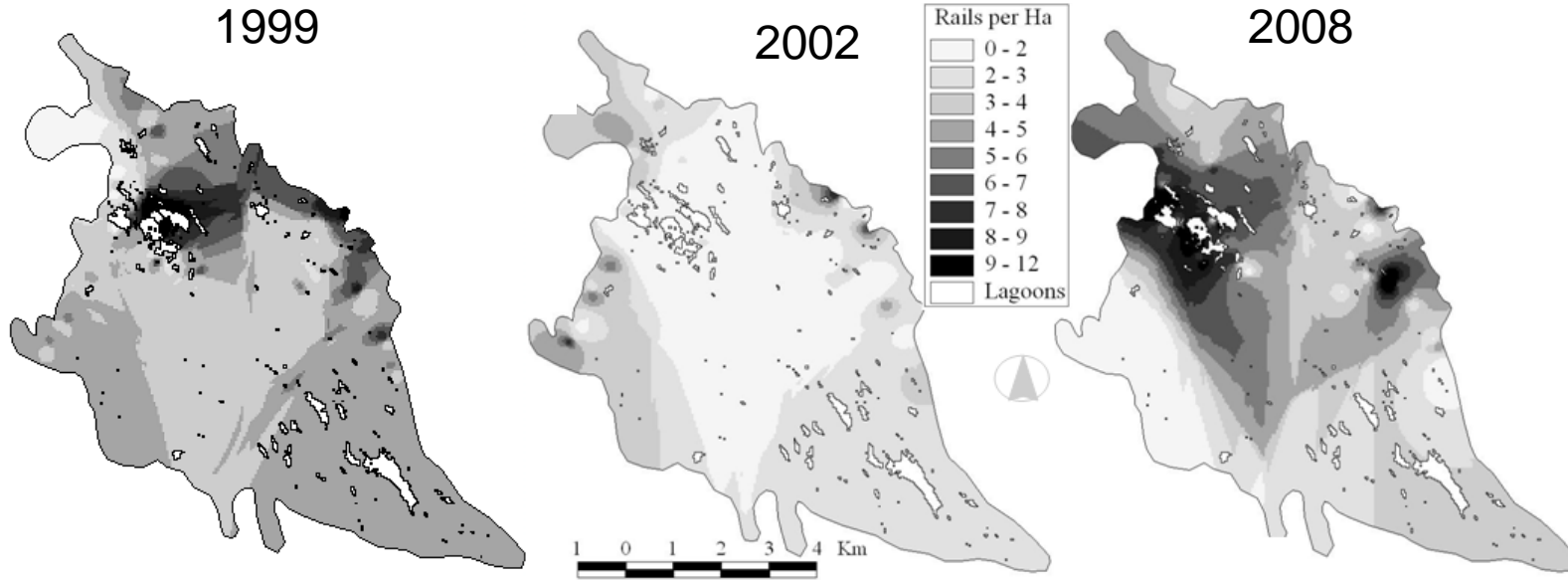


Least Bittern

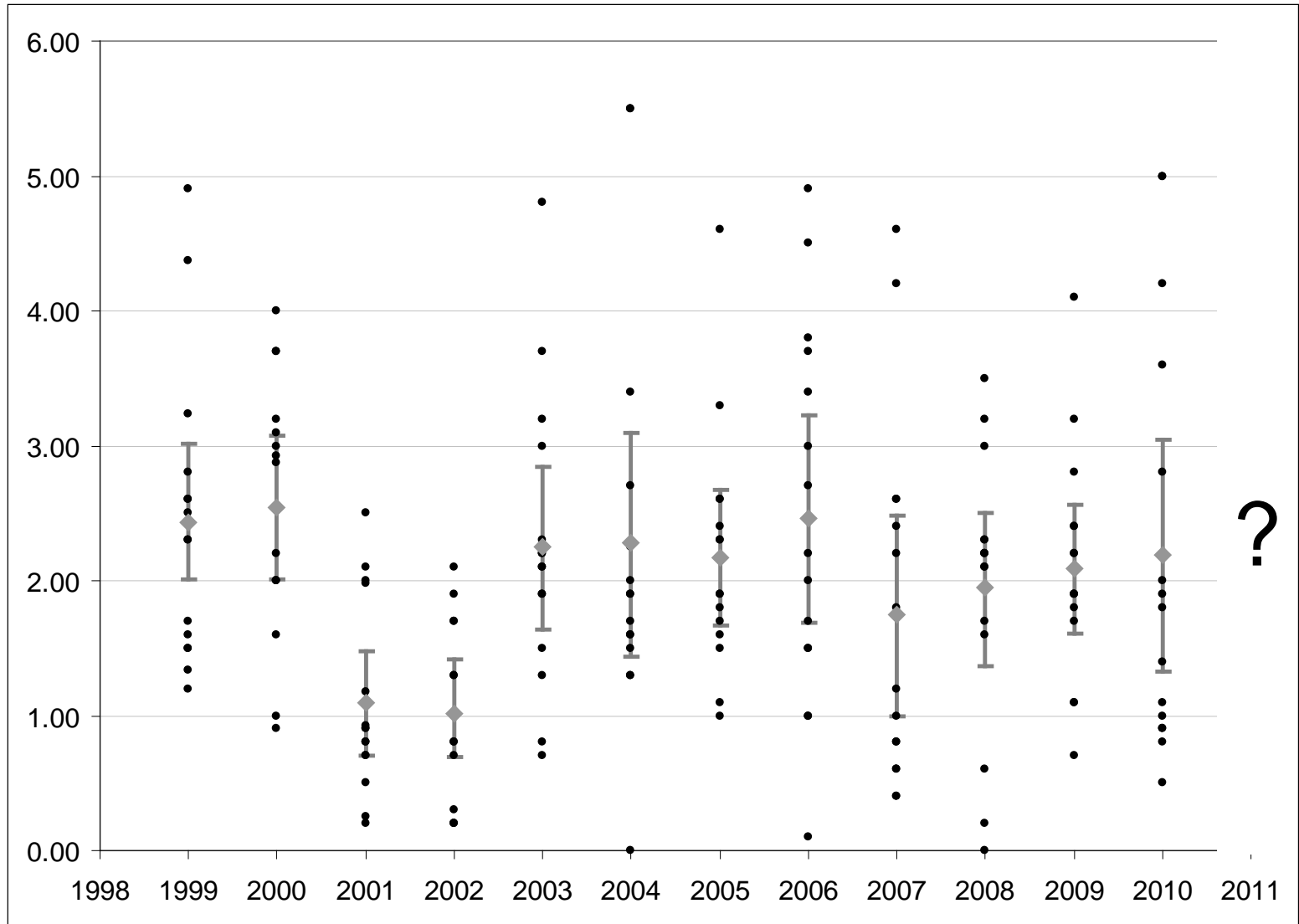


Densities of Yuma Clapper Rail, Ciénega Santa Clara 1999-2010

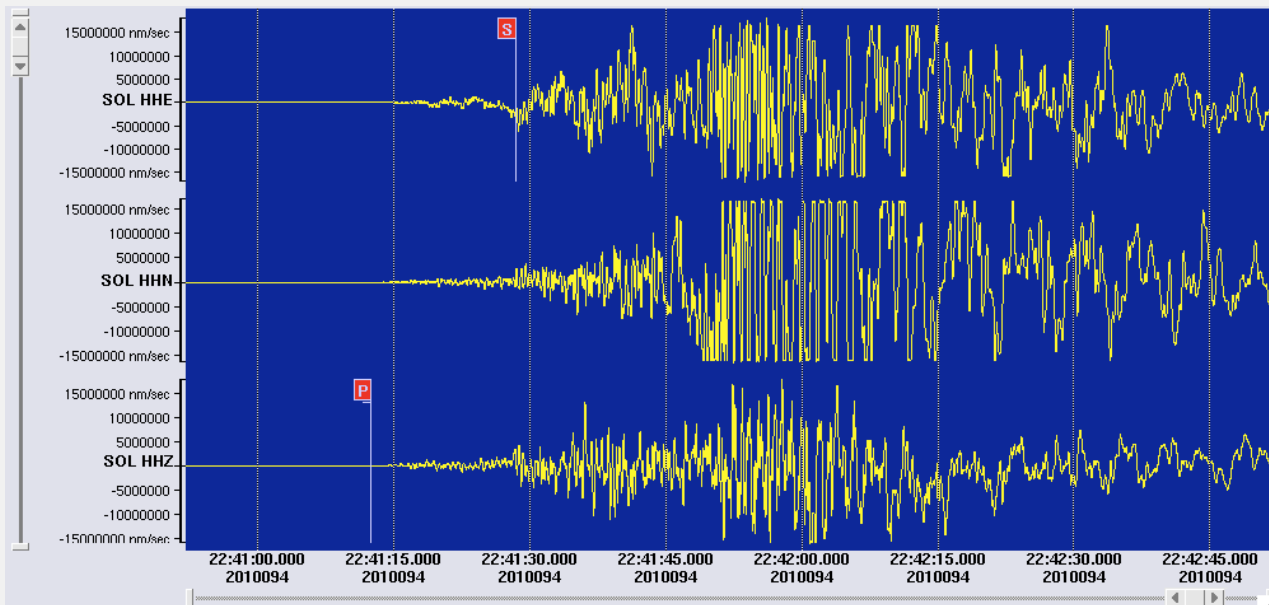
Densidades del Palmoteador de Yuma, Ciénega Santa Clara 1999-2010



Detections of Yuma Clapper Rails in the Ciénega de Santa Clara, 1999-2010
Presencia del Palmotaedor de Yuma en la Ciénega de Santa Clara, 1999-2010



7.2 M El Mayor–Cucapah Earthquake, 3:40 PM, April 4, 2010





epicenter

32 14.84 -115 17.59

32-14.428 -115 16.901

Indiviso -32° 10' 17.0" -115° 10' 39.0"

32 01.709 -115 00.172

32-00.414 -114 58.578

Ciénega de Santa Clara

14.7 km

Image © 2010 GeoEye
Image © 2010 DigitalGlobe
© 2010 Cnes/Spot Image
© 2010 INEGI

©2009 Google

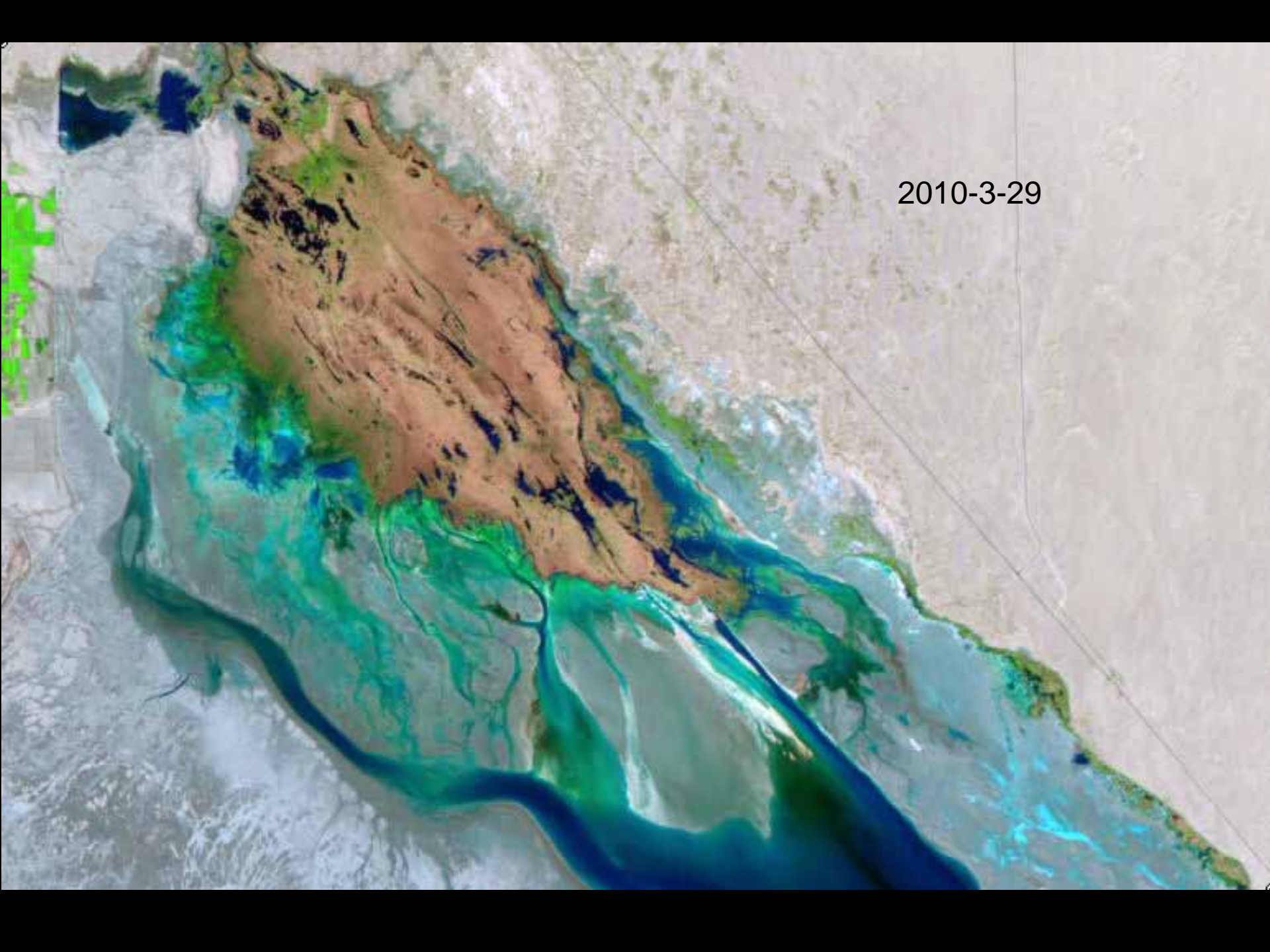
Imagery Dates: Sep 18, 2004 - Jan 18, 2008

32-06'43.39" N 115-06'03.61" W elev 0 m

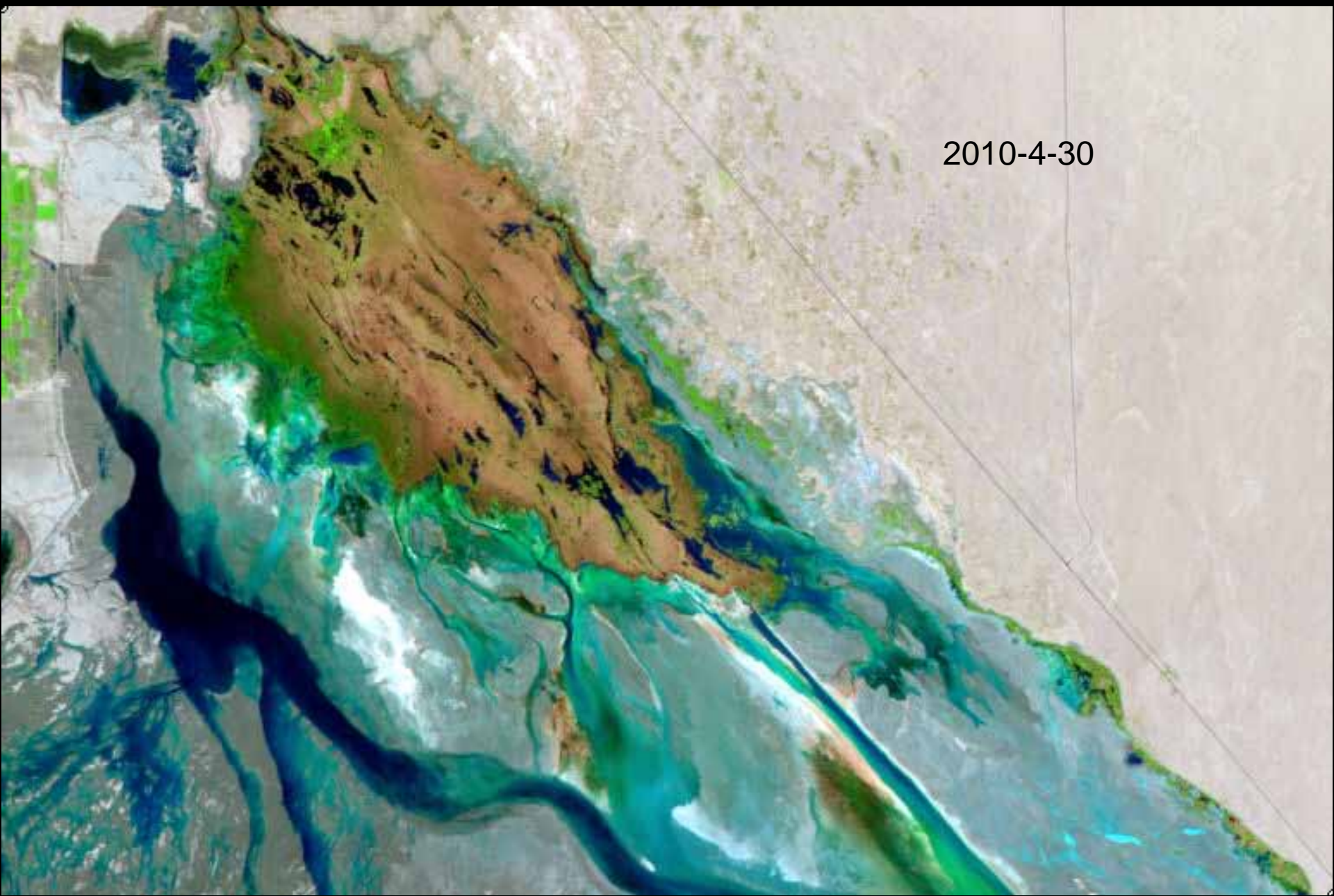
Eye alt 50.80 km



Photos by Sandra Dibble, San Diego Union-Tribune



2010-3-29



2010-4-30



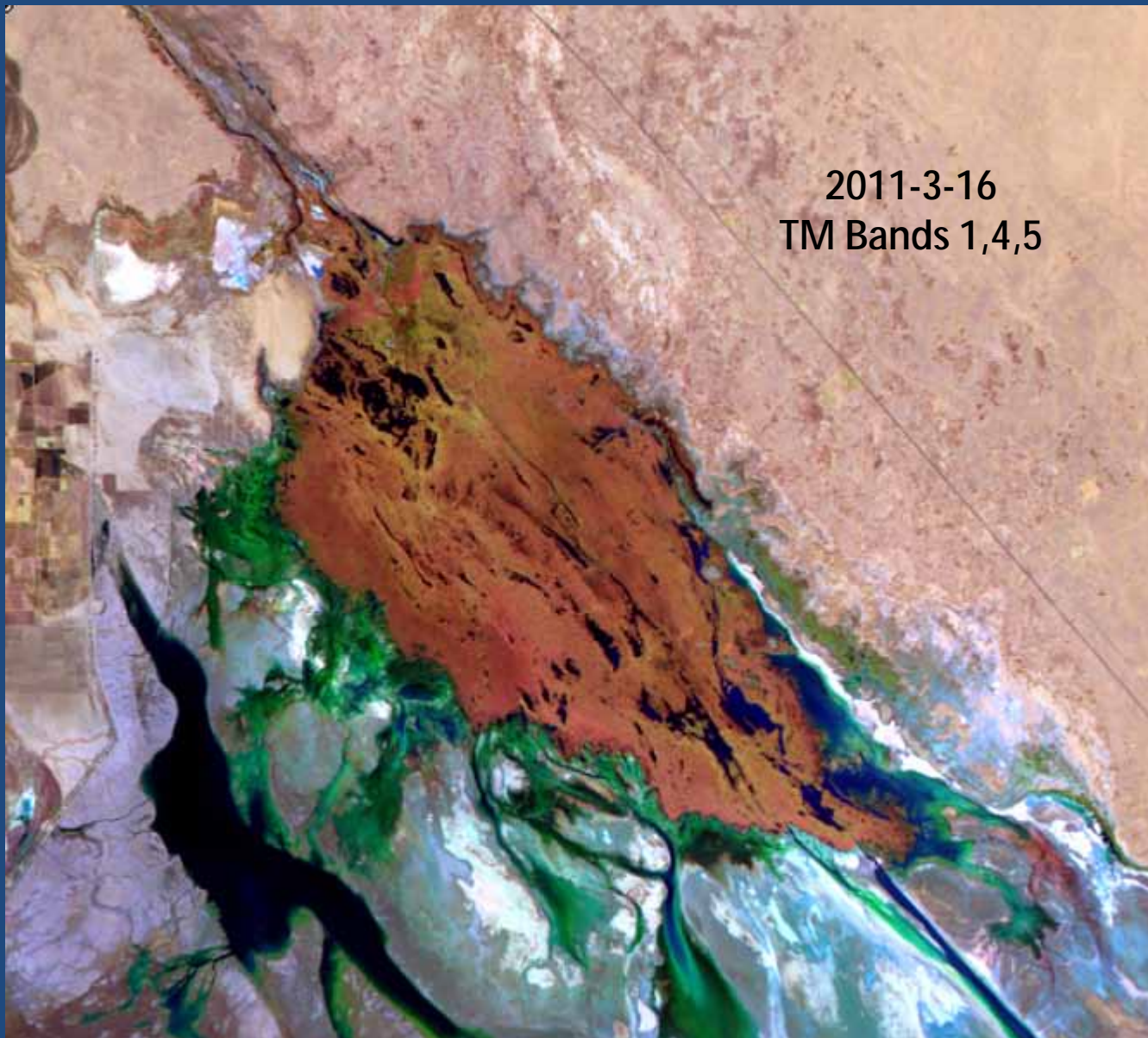
- Localized flooding from liquefaction, subsidence, tilting and breaks in levees.
- Localized tidal flooding from subsidence.
- Damage to irrigation system.
- Evacuation of Ejido Luis Encinas Johnson.
- Limited access to west side of Ciénega de Santa Clara.
- The Ciénega de Santa Clara did not drain.**

- Localización de inundación por licuefacción, subsidencia, desnivel y ruptura de diques.
- Localización de inundación por mareas por subsidencia.
- Daños al sistema de irrigación.
- Evacuación del Ejido Luis Encinas Johnson.
- Acceso limitado a la zona oeste de la Ciénega de Santa Clara
- La Ciénega de Santa Clara no drenó.**

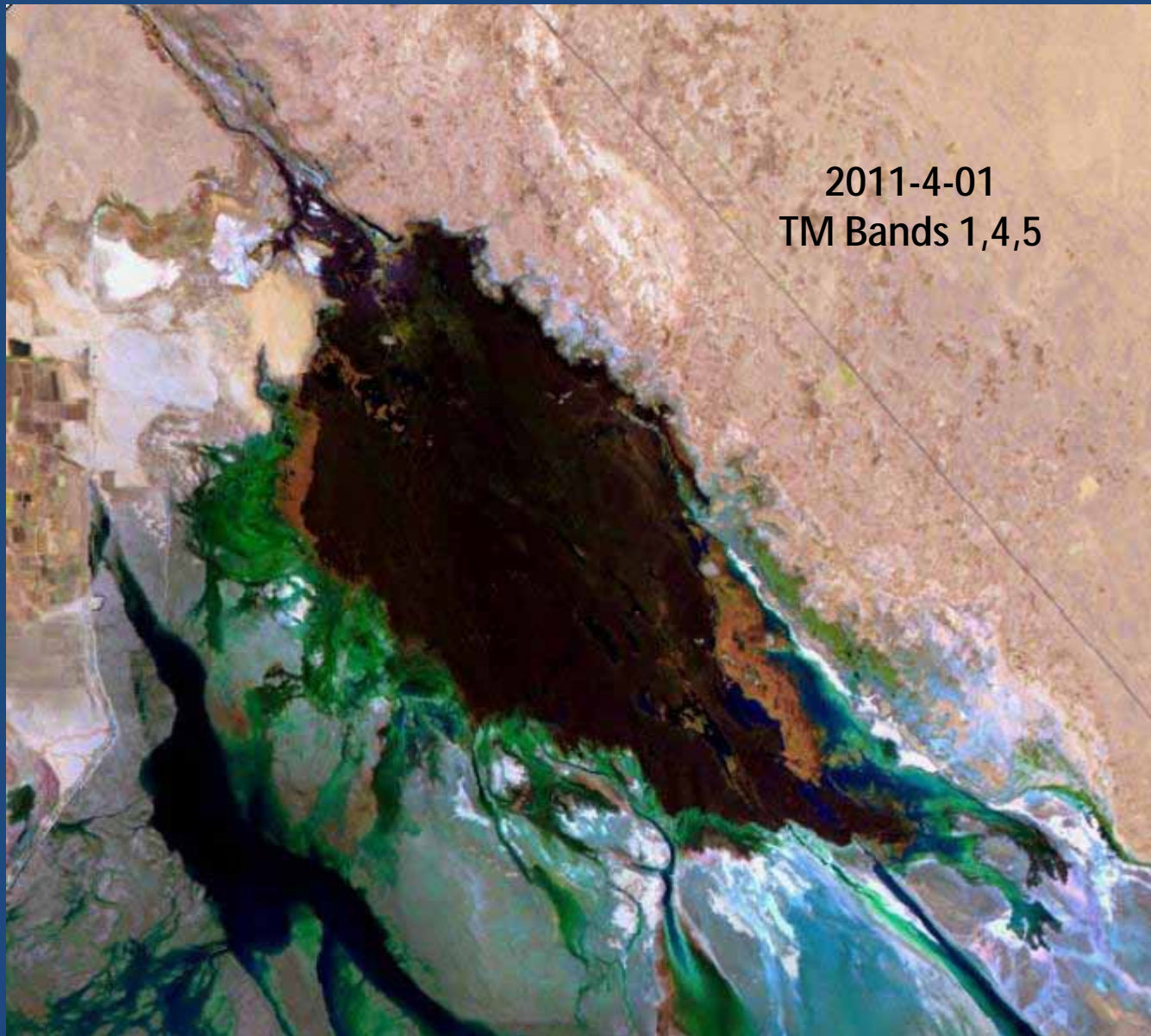


March 24, 2011. Images by Salvador Chavez, Pronatura

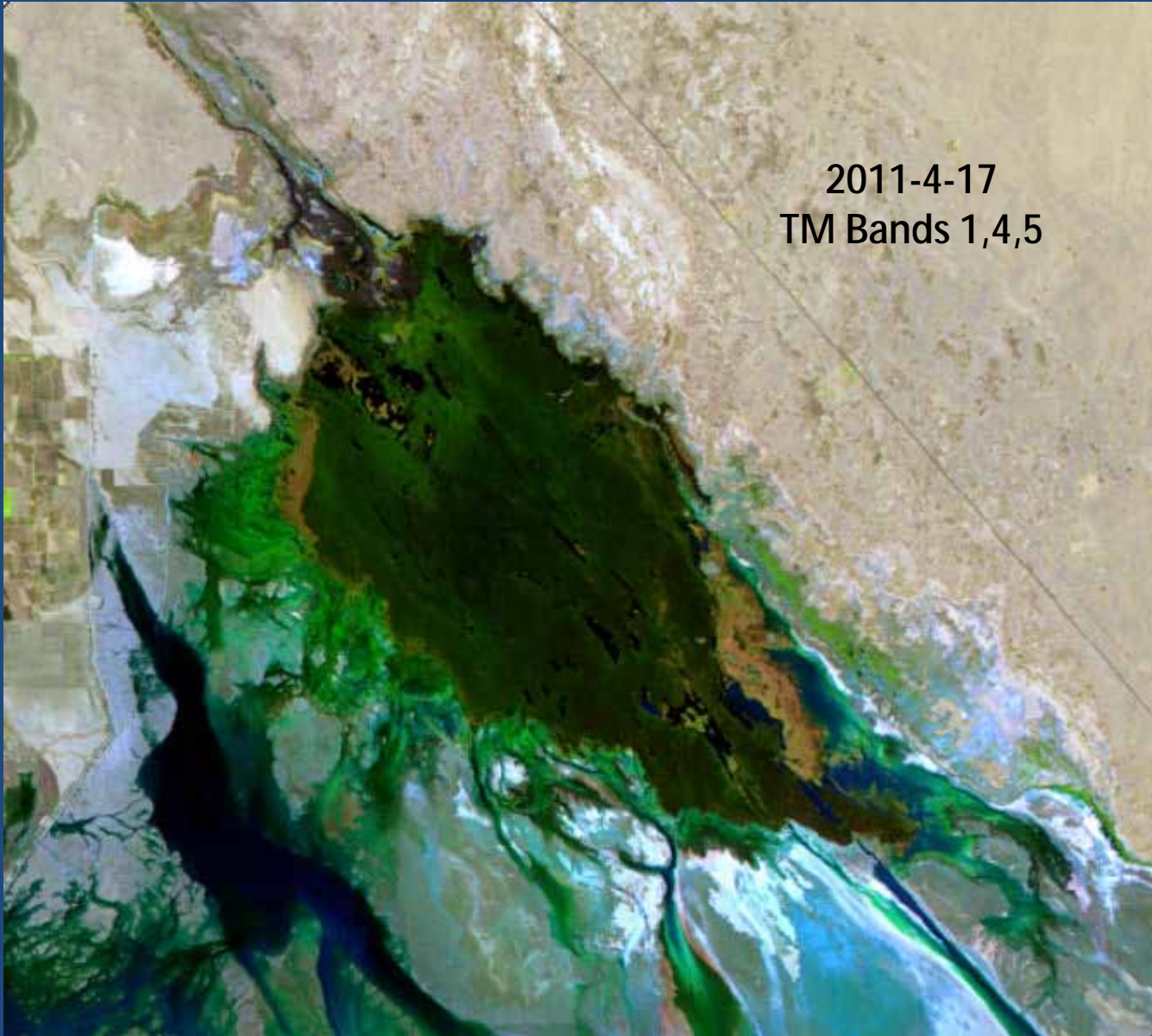




2011-3-16
TM Bands 1,4,5



2011-4-01
TM Bands 1,4,5



2011-4-17
TM Bands 1,4,5



Quick recovery of vegetation, damage to monitoring gear, fish mortality
Recuperación rápida de la vegetación, daños al equipo de monitoreo, mortandad de peces





Image by F. Zamora,
Sonoran Institute

April 13, 2011, three weeks after fire
Abril 13, 2011, tres semanas después del incendio



Image: F. Zamora, Sonoran Institute

More what we already know:

- Winter, 2009-2010 Canal dredging
- Nov. 2010 to August 2011: 30,000 acre-feet of **replacement water** to be delivered to the Bypass Drain/Riito and Ciénega (Minute 316)
- April 4, 2010: Magnitude 7.2 **earthquake** on the delta
- May 3, 2010 to March 26, 2011: **Pilot run**, Yuma Desalting Plant, ~30,000 acre-feet
 - Reduced flow to the Bypass Drain and Ciénega
 - Brine delivered to the Bypass Drain and Ciénega
- March 23-25, 2011: Widespread **fire** in Ciénega de Santa Clara

What you should know:

- A lot happened to the Ciénega de Santa Clara in the past 24 months.
- A monitoring program, not an experiment.

- Resilient ecosystem in the face of short-term perturbations.
- Longer-term responses not yet known.
- Monitoring is not yet complete.
- **Need for continued monitoring**

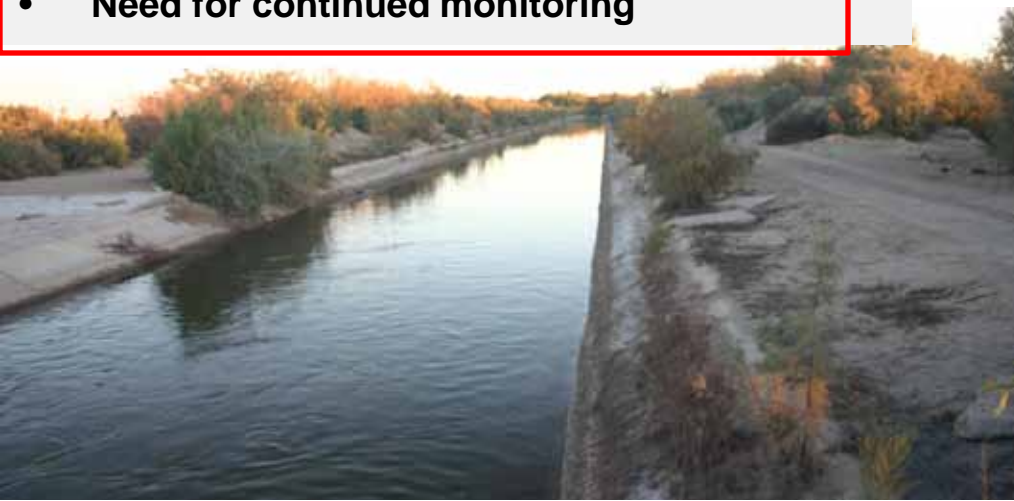
Mas sobre lo que ya sabemos:

- De nov. 2010 a agosto 2011; 30,000 pies- acre de agua de reemplazamiento es liberada por el Bypass Drain/ Riito y Ciénega (Minute 316)
- Abril 4, 2010: Terremoto con magnitud de 7.2 en el delta
- Mayo 3, 2010 a marzo 26, 2011: **Operación Piloto** de la Planta Desaladora de Yuma, ~30,000 acre-pie
 - Reducción del flujo al Bypass Drain y Ciénega
 - Brine delivered to the Bypass Drain y Ciénega
- Marzo 23-25, 2011: Incendio extensivo en la Ciénega de Santa Clara

Que debe usted saber:

- Muchas cosas sucedieron en la Ciénega de Santa Clara en los últimos 24 meses.
- Un programa de monitoreo, no un experimento.

- Ecosistema resiliente a perturbaciones de corto plazo.
- Respuestas a largo plazo aun no se conocen.
- El monitoreo no esta completo aún.



Ciénega de Santa Clara monitoring: Shared environments and international cooperation

- International agreements (IBWC, treaty minutes)
- International cooperation among water agencies and environmental NGOs
- International support (US water agencies, Mexican agencies)
- International implementation and collaboration (US and Mexican universities, NGOs)

Monitoreo de la Ciénega de Santa Clara: Ambientes compartidos y cooperación internacional

- Acuerdos internacionales (IBWC, minutas de tratados)
- Cooperación internacional entre agencias de agua y ONG's ambientalistas
- Apoyo internacional (agencias de agua de los E.U y de México)
- Implementación y colaboración internacional (universidades de EU y México, ONGs)

Next steps:

- **Continued monitoring**
- **Active management**