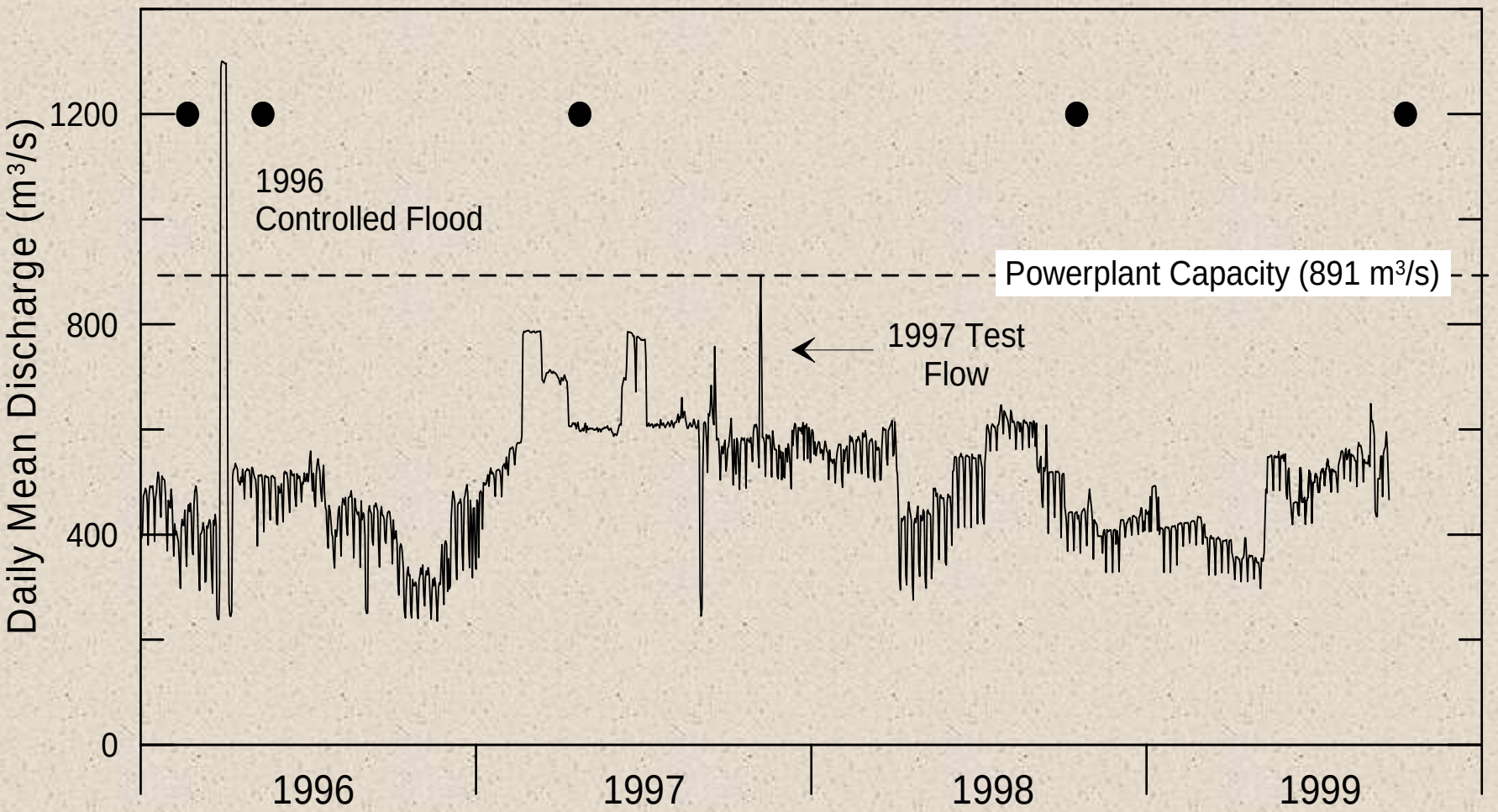
Monitoring Arroyos with Conventional Survey Techniques in Grand Canyon: 1996-2004

Joe Hazel, Matt Kaplinski, and Rod Parnell
Northern Arizona University

- One of the hypotheses listed in the GCD-EIS was that high flows could rebuild high elevation sand deposits and potentially preserve threatened cultural deposits *in situ*

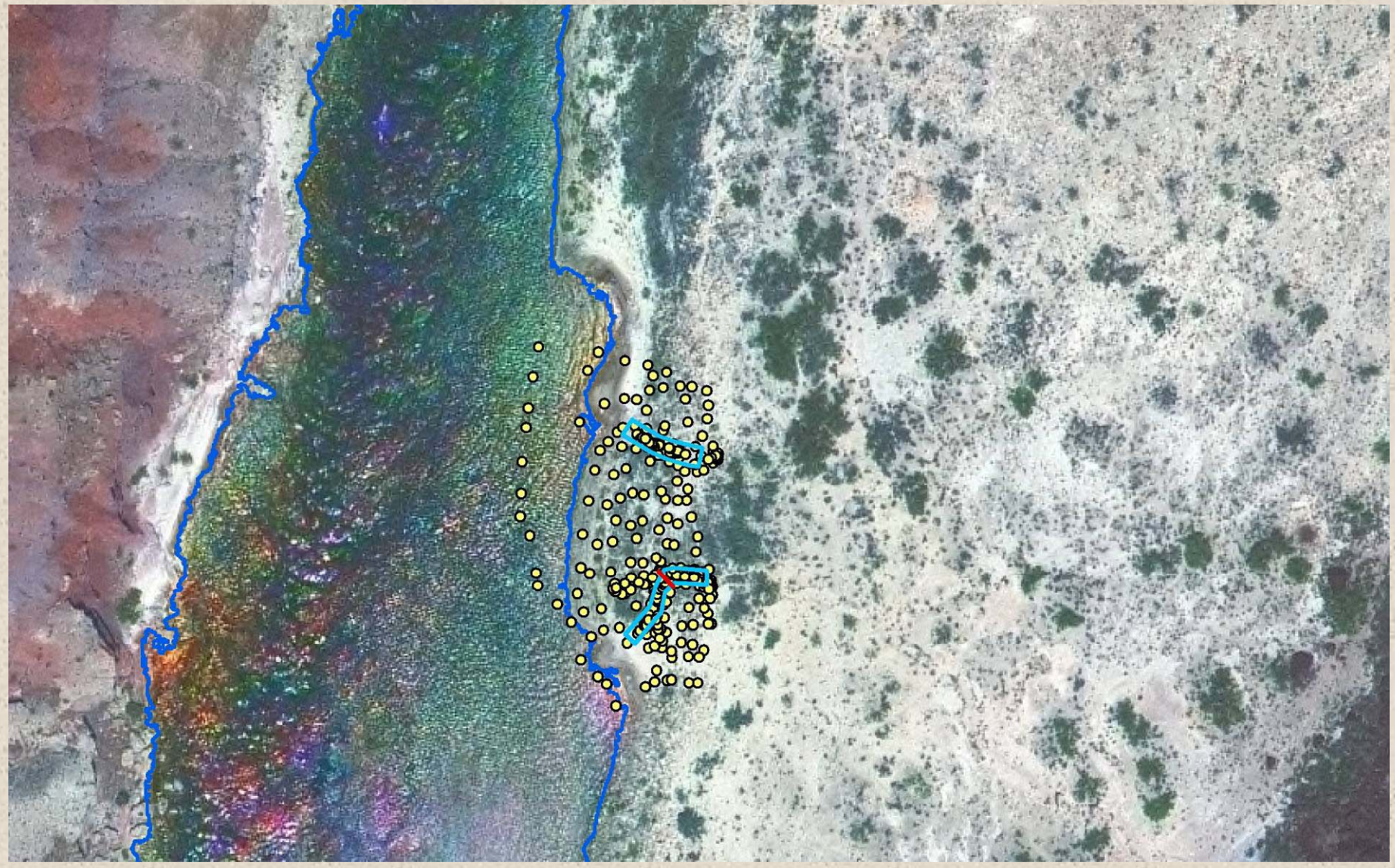
- It was theorized that deposition in arroyo mouths would lessen or slow arroyo cutting and thus reduce impacts to cultural resources.


Daily Mean Discharge (m3/s)
1200
800
400
0
1996
Controlled Flood
Powerplant Capacity (891 m3/s)
1997 Test
Flow
1996
1997
1998
1999

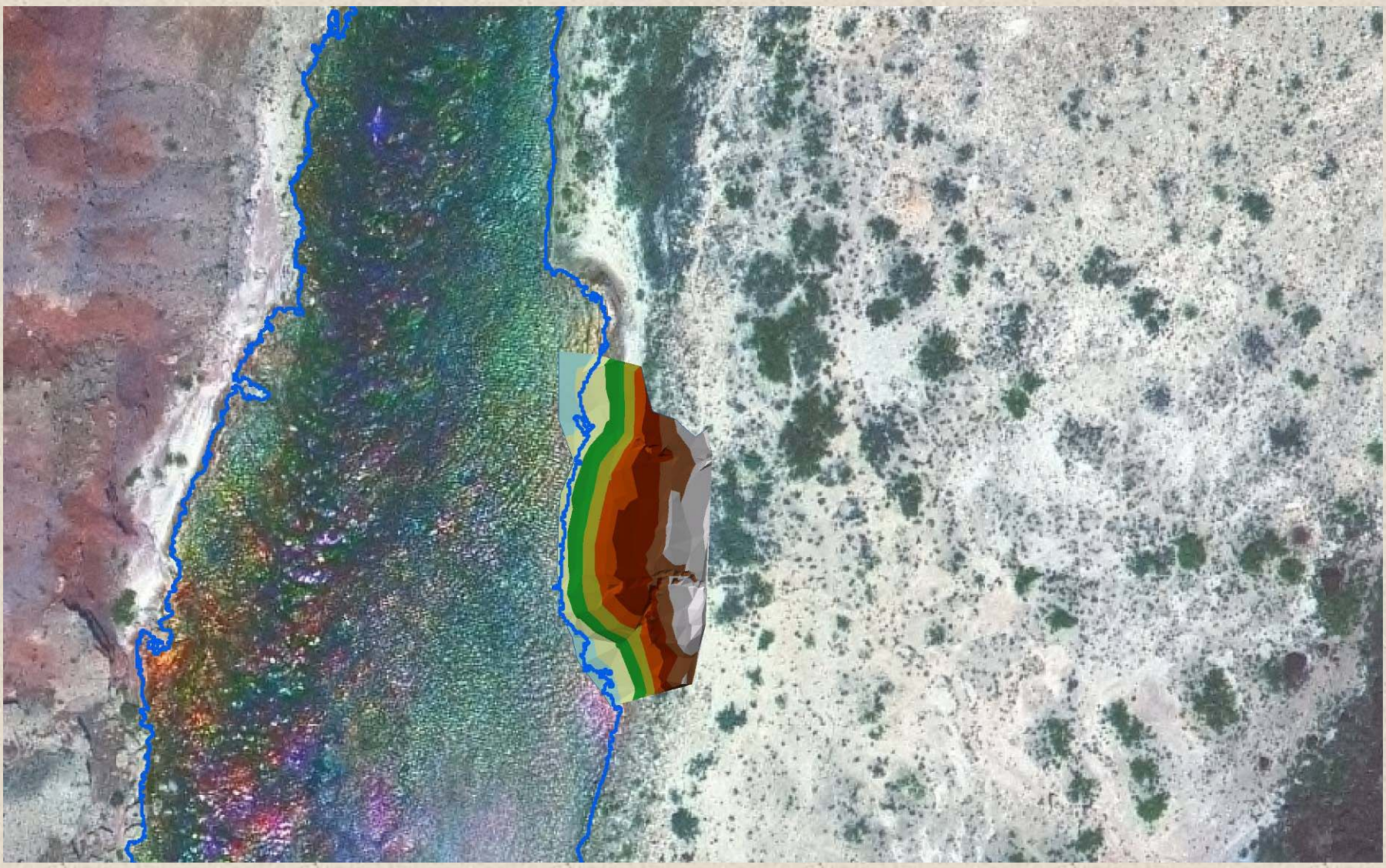
Objectives

- Compare the surveys of Yeatts to surveys of the same arroyos in 1998 and 1999.
- Develop a 3.5 year times series of arroyo change.
- Determine the long-term retention of sediment deposited in the arroyo mouths by the 1996 Controlled Flood.

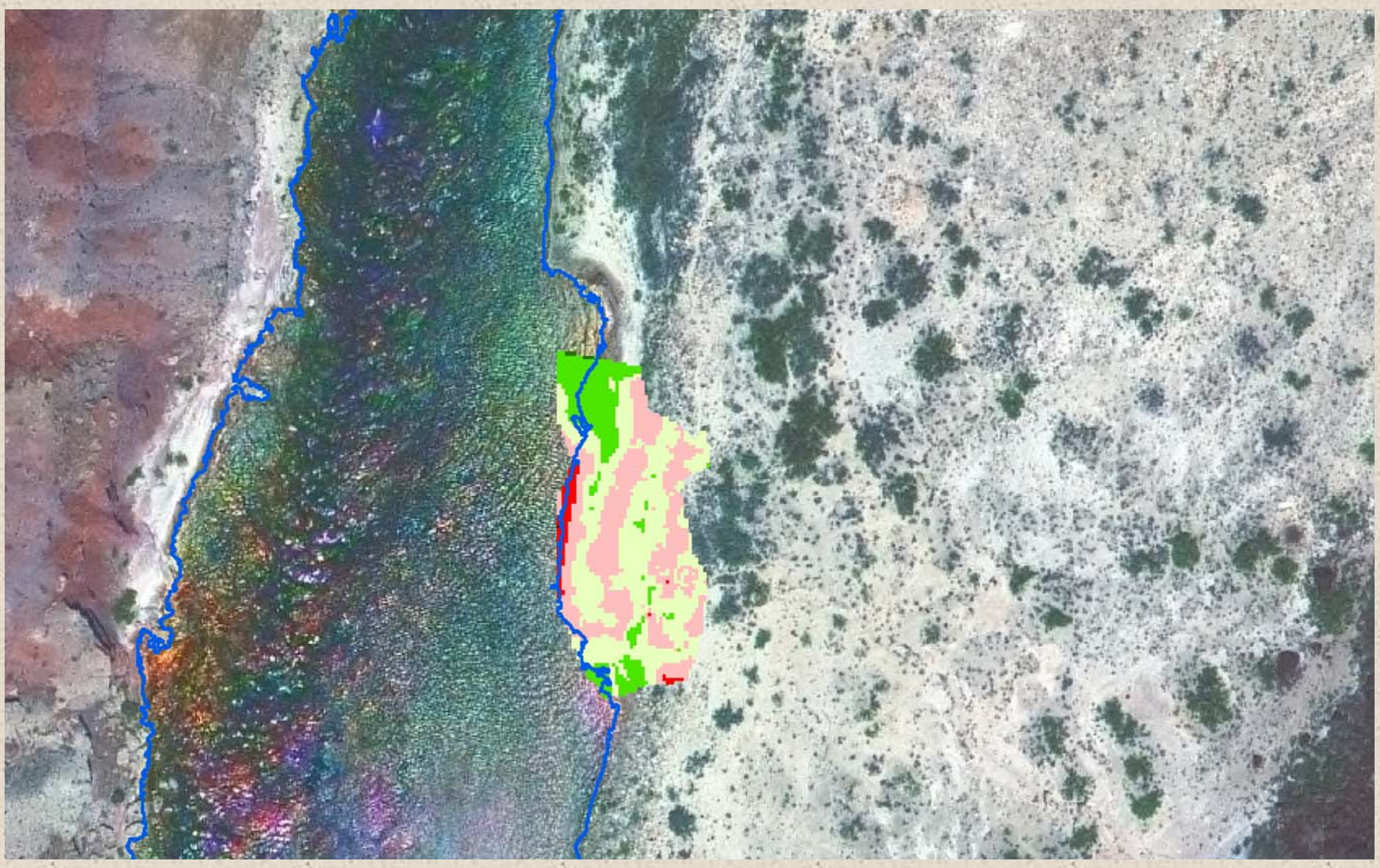
Ground points collected with conventional topographic survey in March 1996



TIN Model of the 1996 preflood Yeatts arroyo survey



Change map of the difference between the pre- and post-1996 flood surveys



Scour and Fill at the Four study arroyos after the 1996 controlled flood

Palisades arroyo #1

Comparison Interval	Scour (m^3)	Fill (m^3)	Net Change (m^3)
960217 - 960512	-3.1	6.2	**3.1**
960512 - 970422	-2.6	2.5	-0.1
970422 - 981014	-5.5	2.2	-3.3
981014 - 991007	-1.1	1.9	0.8
960217 - 991007	-3.9	5.4	**1.5**

Palisades arroyo #2

Comparison Interval	Scour (m^3)	Fill (m^3)	Net Change (m^3)
960217 - 960512	-3.9	7.5	**3.6**
960512 - 970422	-3.9	3.6	-0.3
970422 - 981014	-1.9	3.9	2.0
981014 - 991007	-2.9	1.6	-1.3
960217 - 991007	-2.4	6.5	**4.1**

Scour and Fill at the Four study arroyos after the 1996 controlled flood

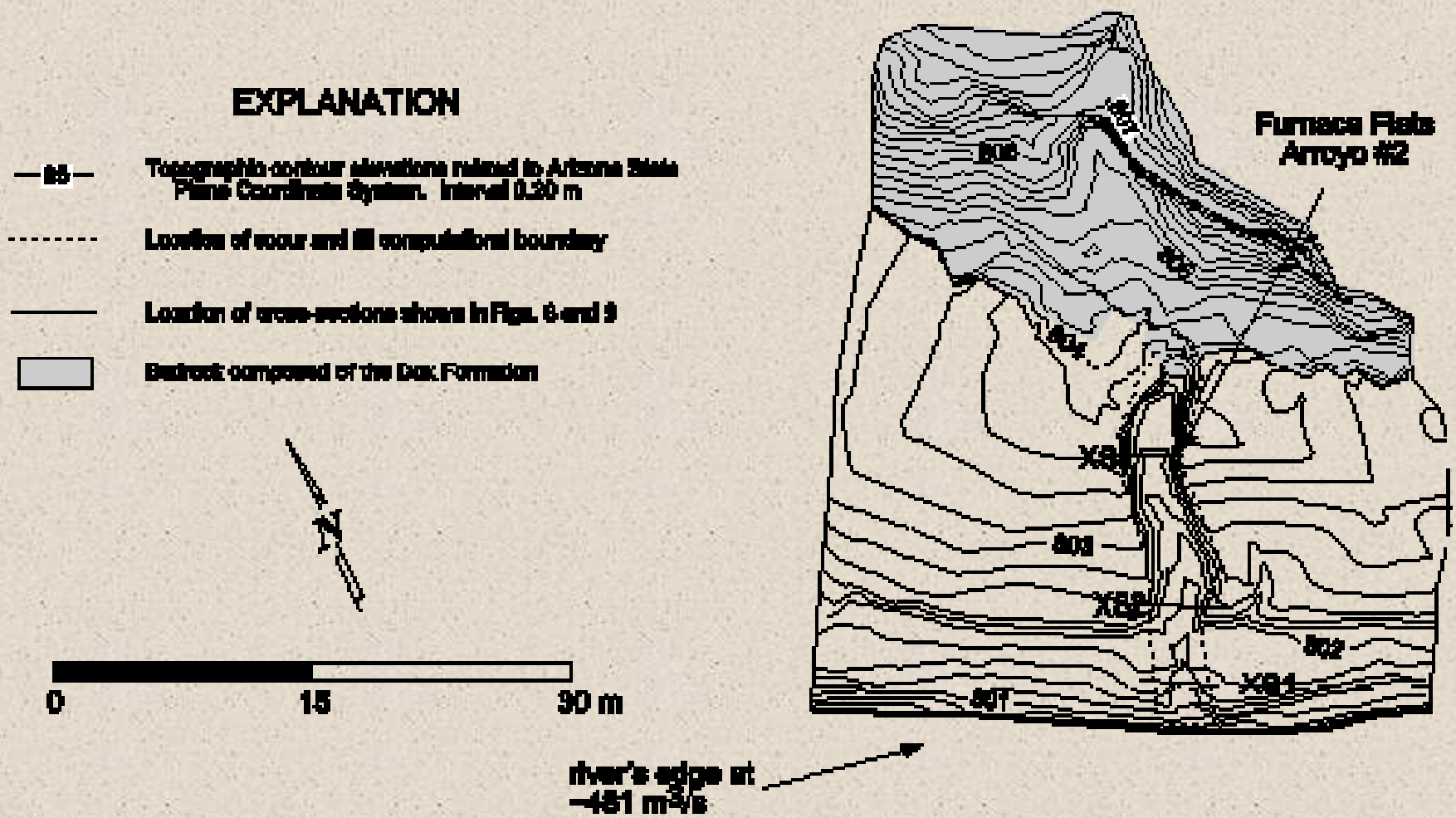
Furnace Flats arroyo #1

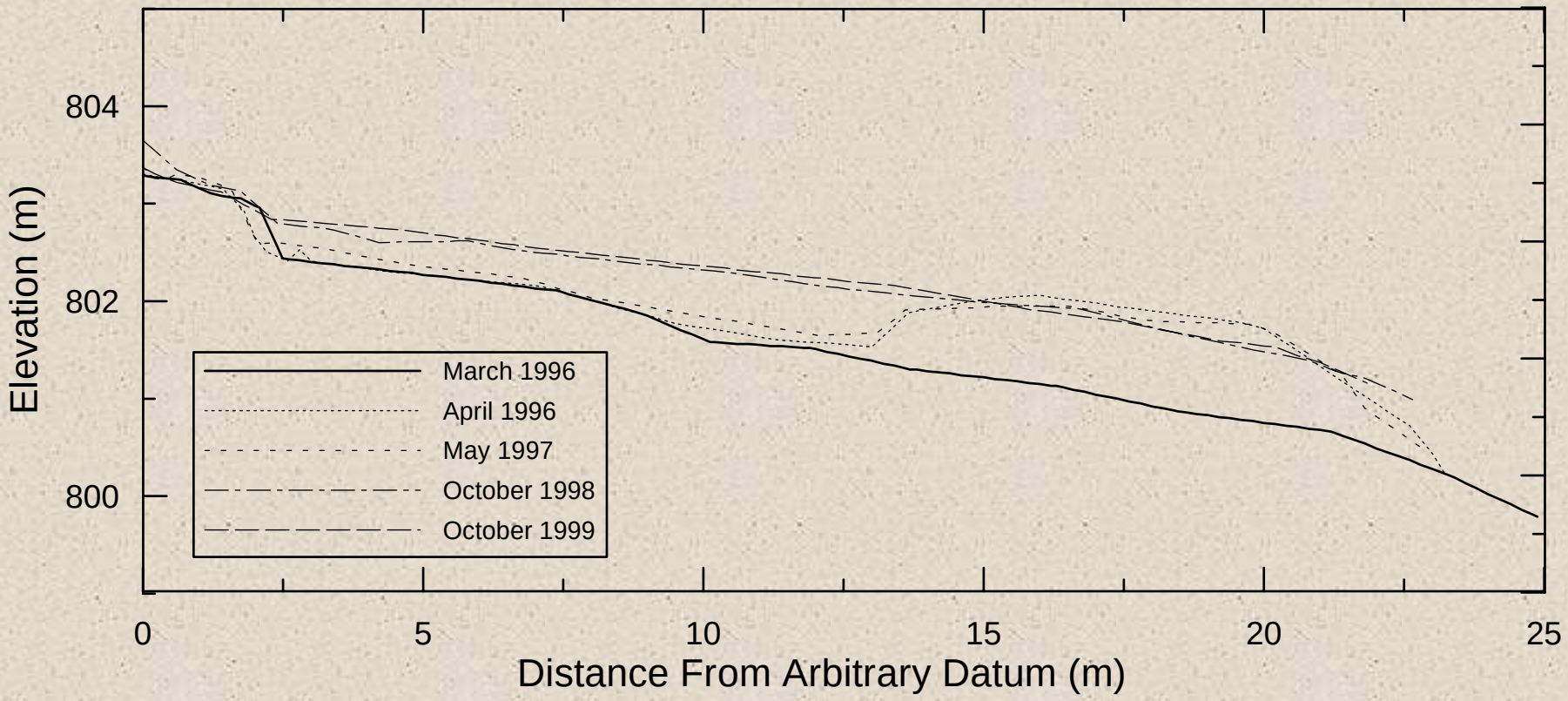
Comparison Interval	Scour (m^3)	Fill (m^3)	Net Change (m^3)
960218 - 960513	-0.9	3.3	**2.4**
960513 - 970423	-2.2	0.8	-1.4
970423 - 981014	-0.5	3.7	3.2
981014 - 991007	-1.4	0.8	-0.6
960218 - 991007	-0.8	4.1	**3.6**

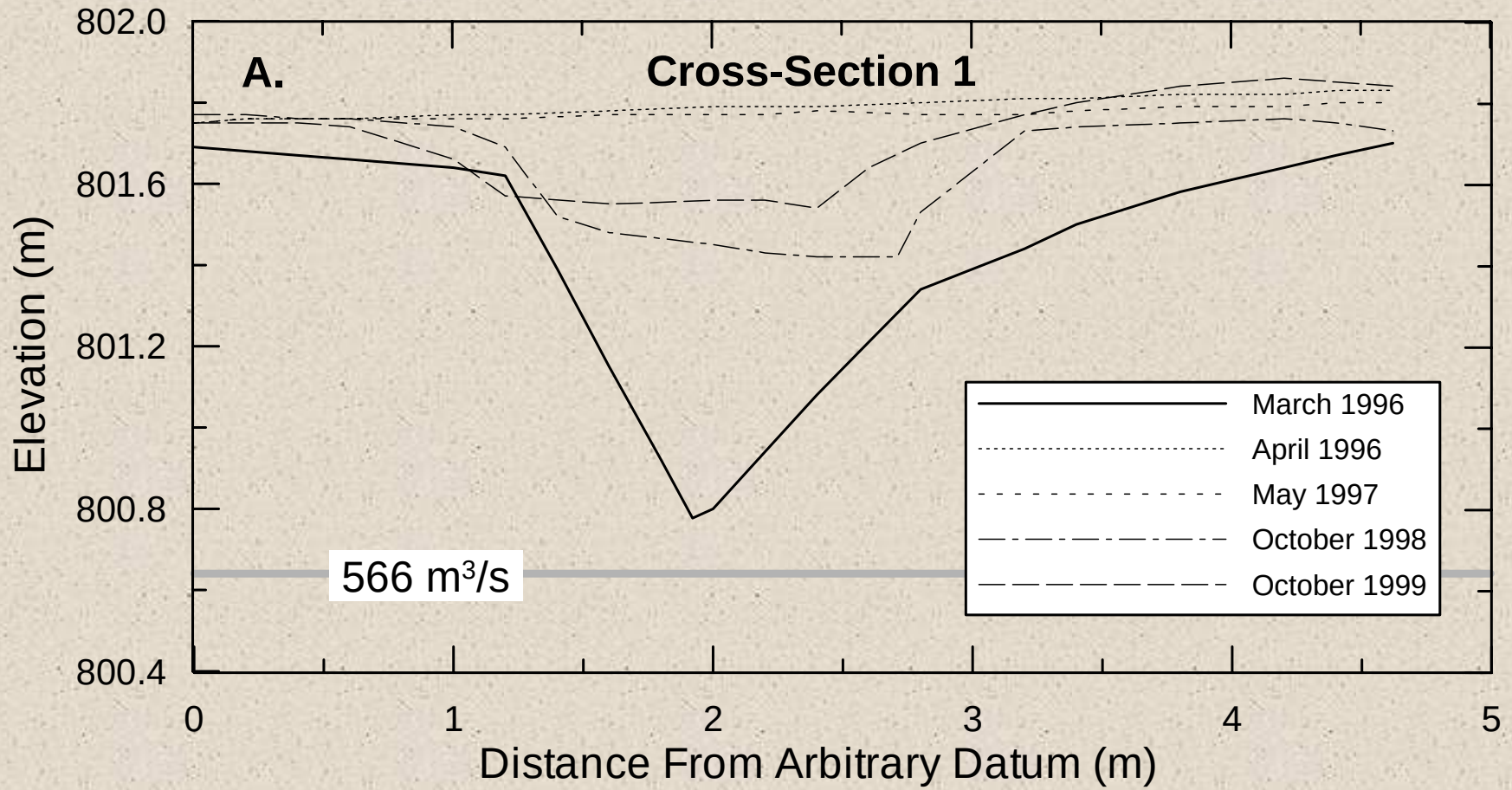
Furnace Flats arroyo #2

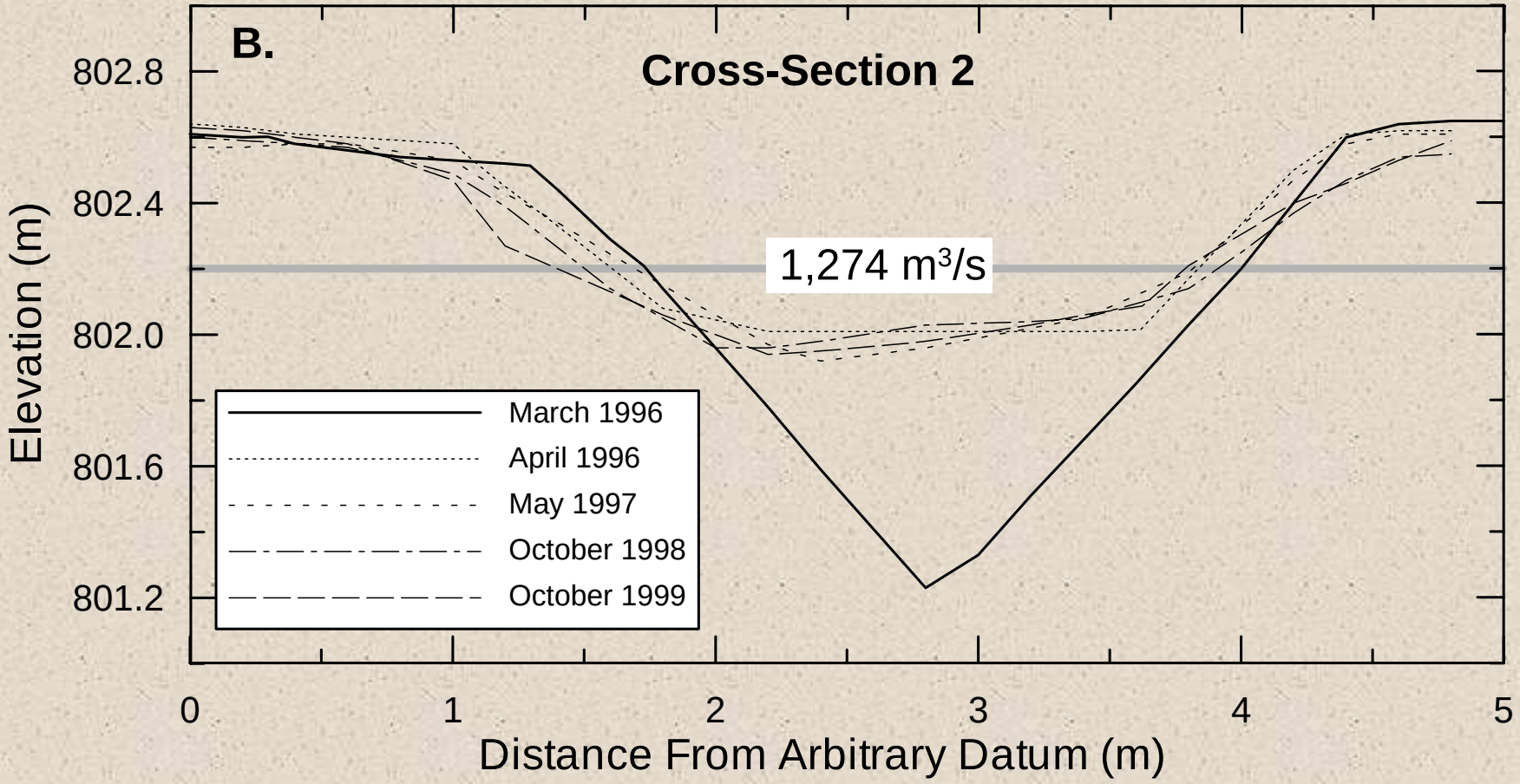
Comparison Interval	Scour (m^3)	Fill (m^3)	Net Change (m^3)
960218 - 960513	-1.7	13.7	**12.0**
960513 - 970423	-3.2	2.8	-0.4
970423 - 981014	-5.0	4.4	-0.6
981014 - 991007	-0.9	5.7	4.8
960218 - 991007	-2.3	16.4	**14.1**

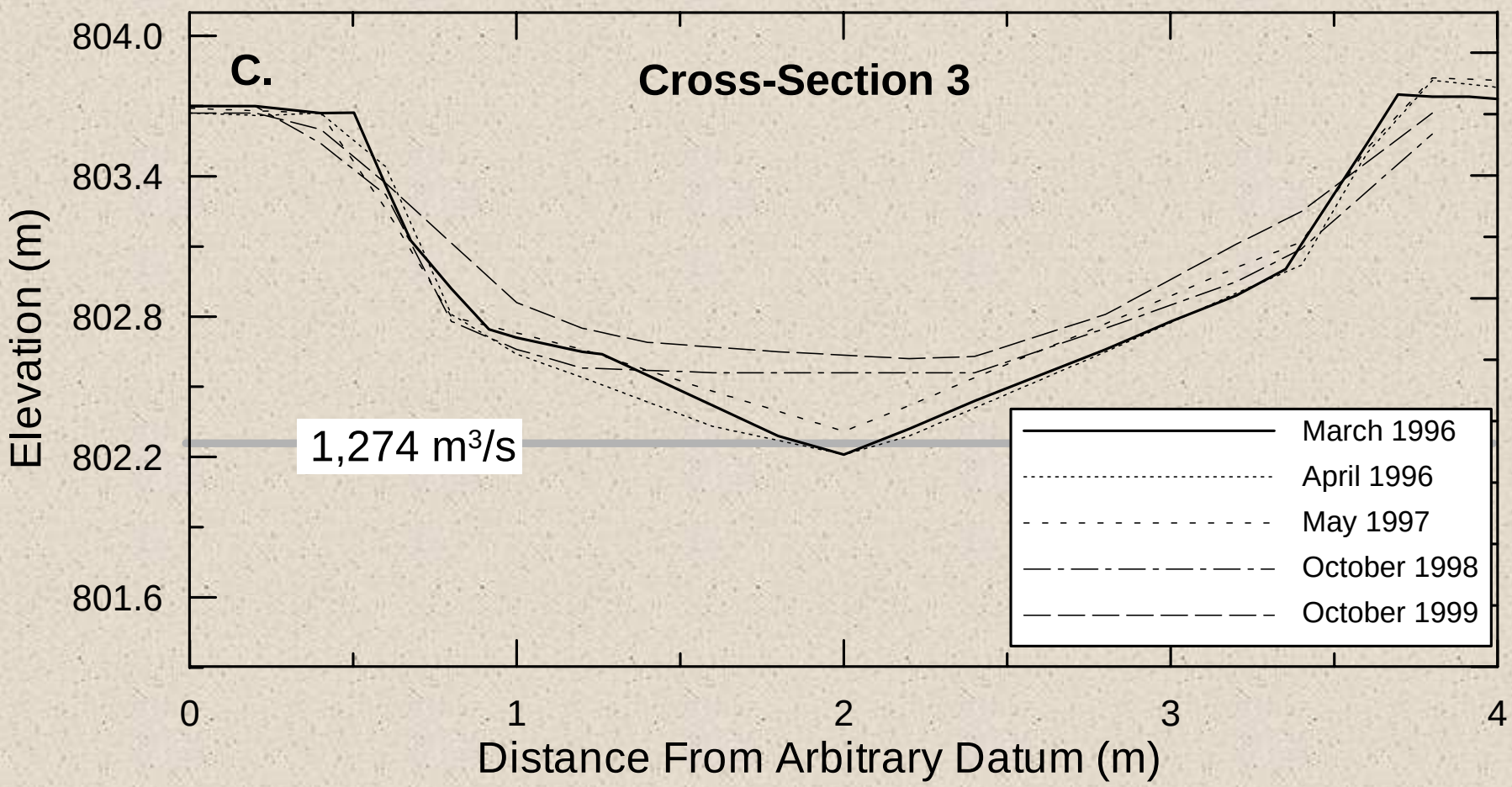
Furnace Flats Arroyo #2
October 15, 1998



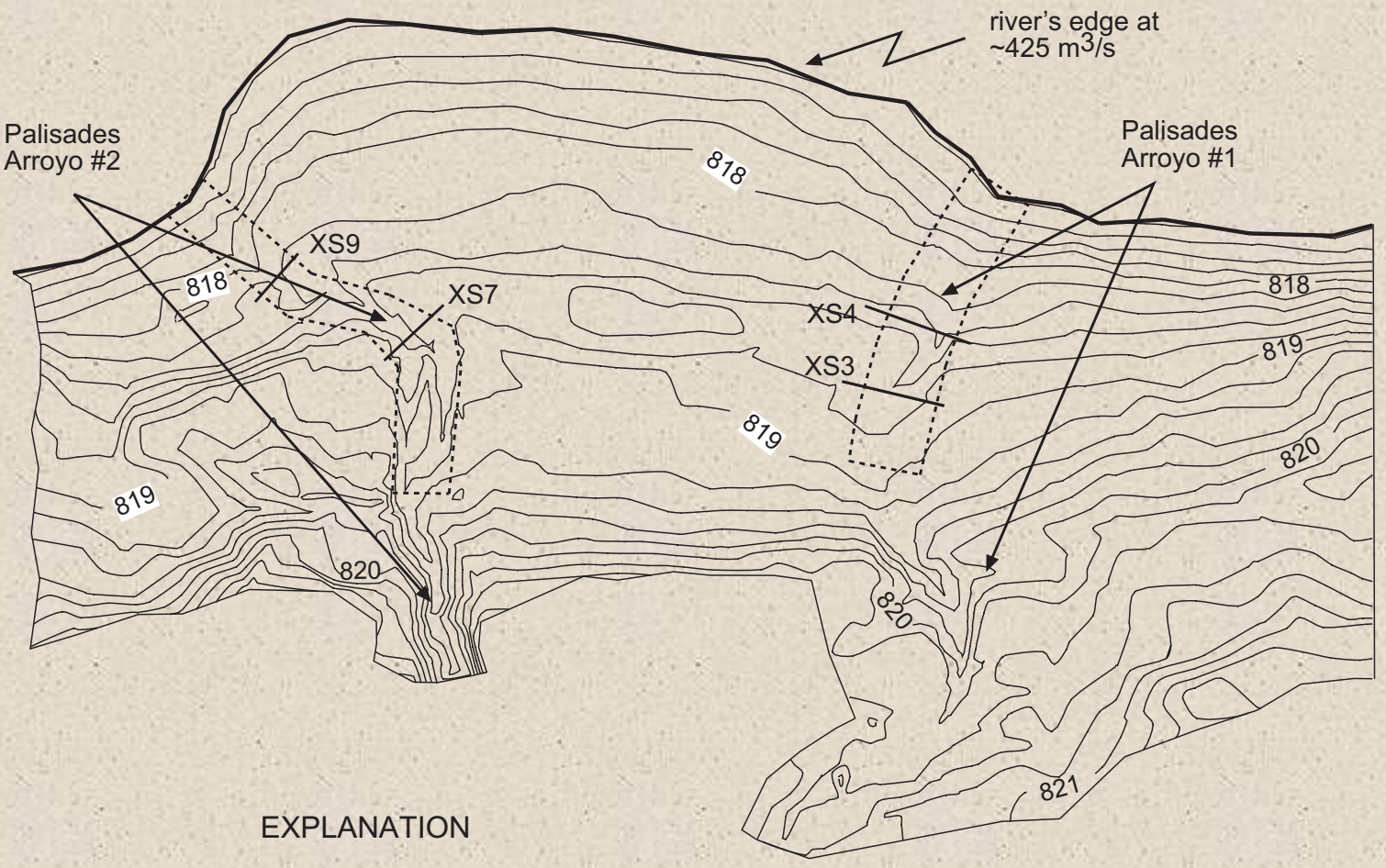

THALWEG 2 upper FURNACE FLATS
804
802
800
Elevation (m)
0
5
10
15
20
25
Distance From Arbitrary Datum (m)
March 1996
April 1996
May 1997
October 1998
October 1999


A.
Cross-Section 1
802.0
801.6
801.2
800.8
800.4
Elevation (m)
0
1
2
3
4
5
Distance From Arbitrary Datum (m)
566 m³/s
March 1996
April 1996
May 1997
October 1998
October 1999

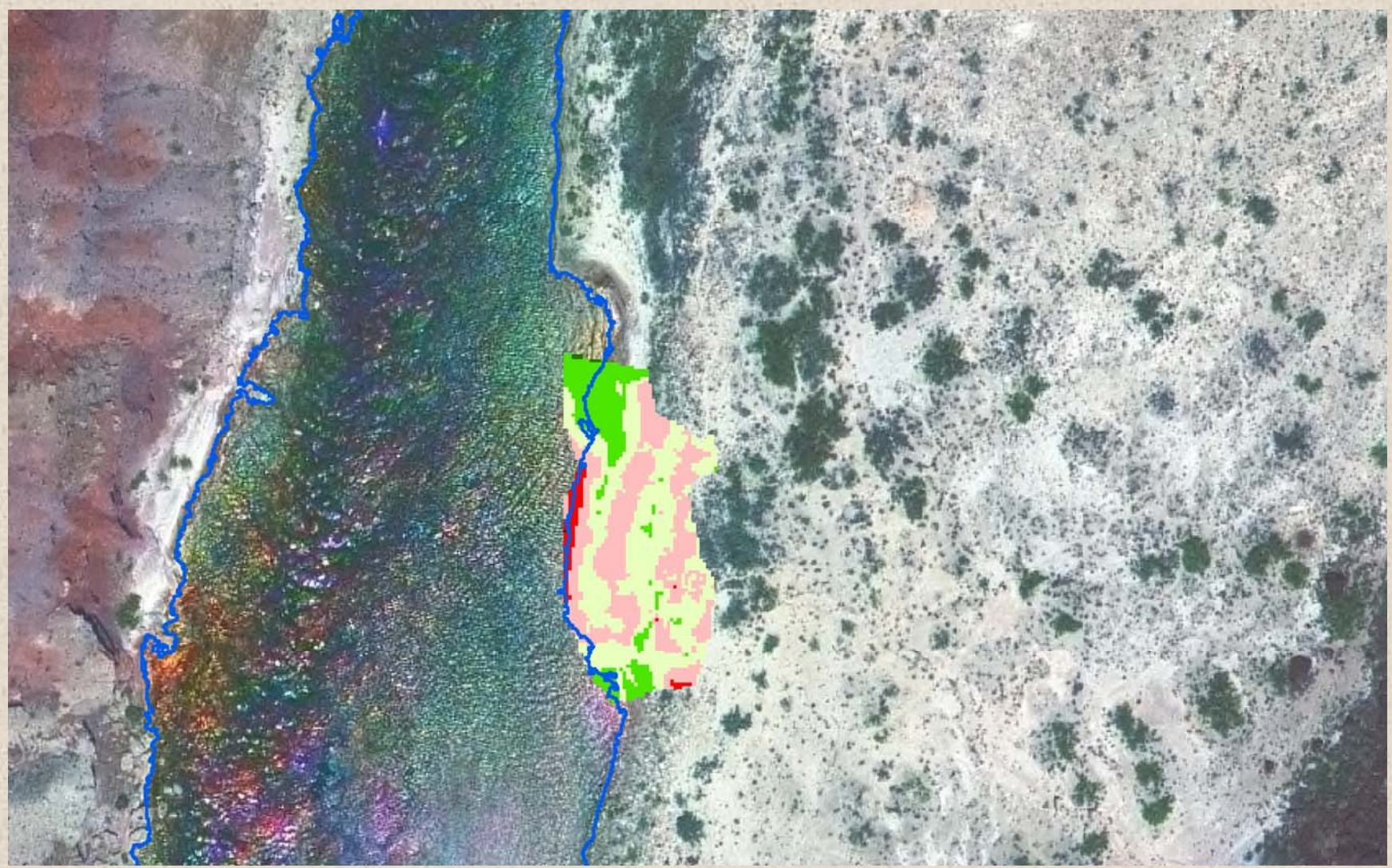

B.
Cross-Section 2
802.8
802.4
802.0
801.6
801.2
Elevation (m)
1,274 m³/s
March 1996
April 1996
May 1997
October 1998
October 1999
0
1
2
3
4
5
Distance From Arbitrary Datum (m)

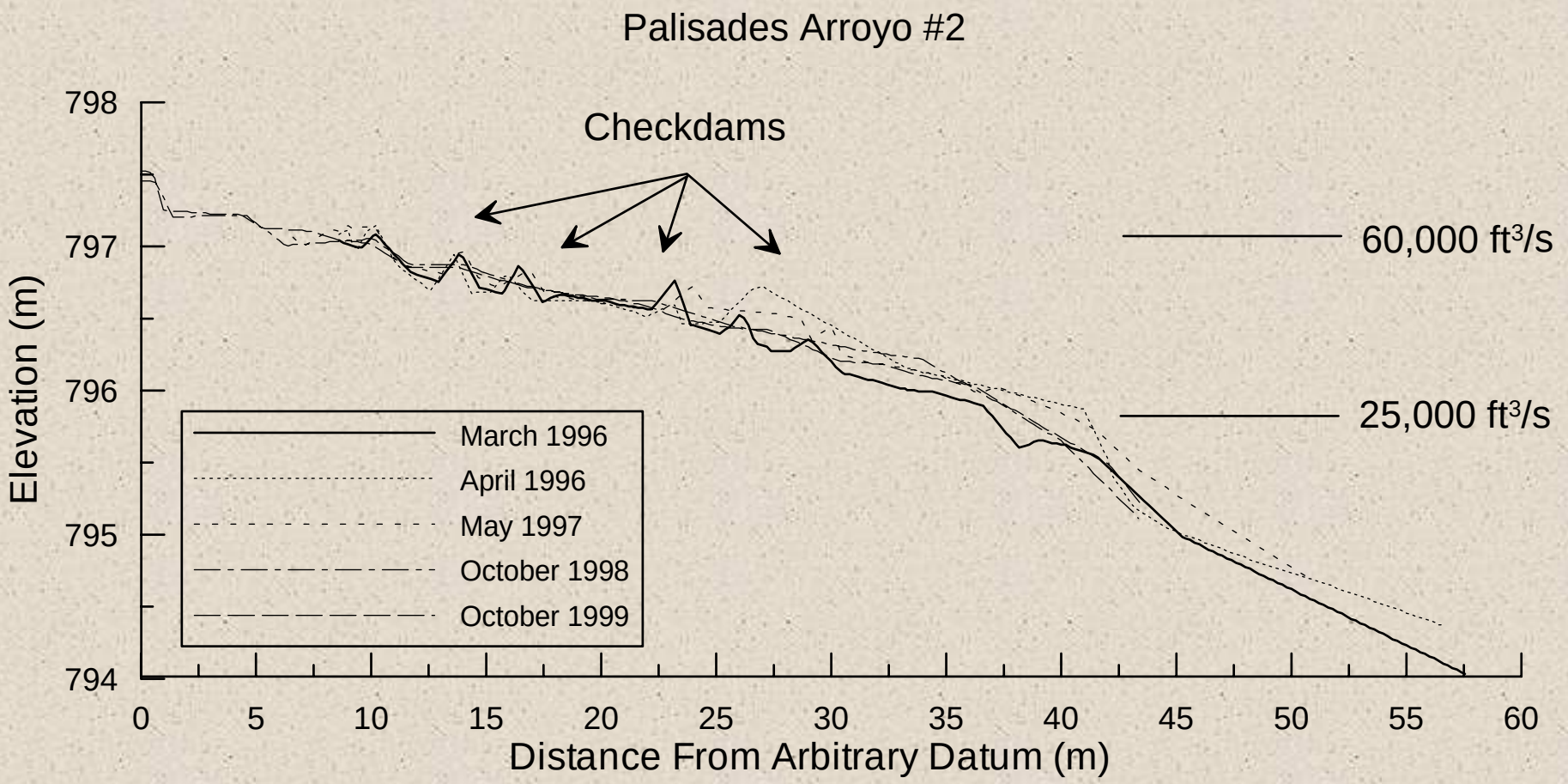

C.
Cross-Section 3
804.0
803.4
802.8
802.2
801.6
Elevation (m)
1,274 m³/s
March 1996
April 1996
May 1997
October 1998
October 1999
0
1
2
3
4
Distance From Arbitrary Datum (m)

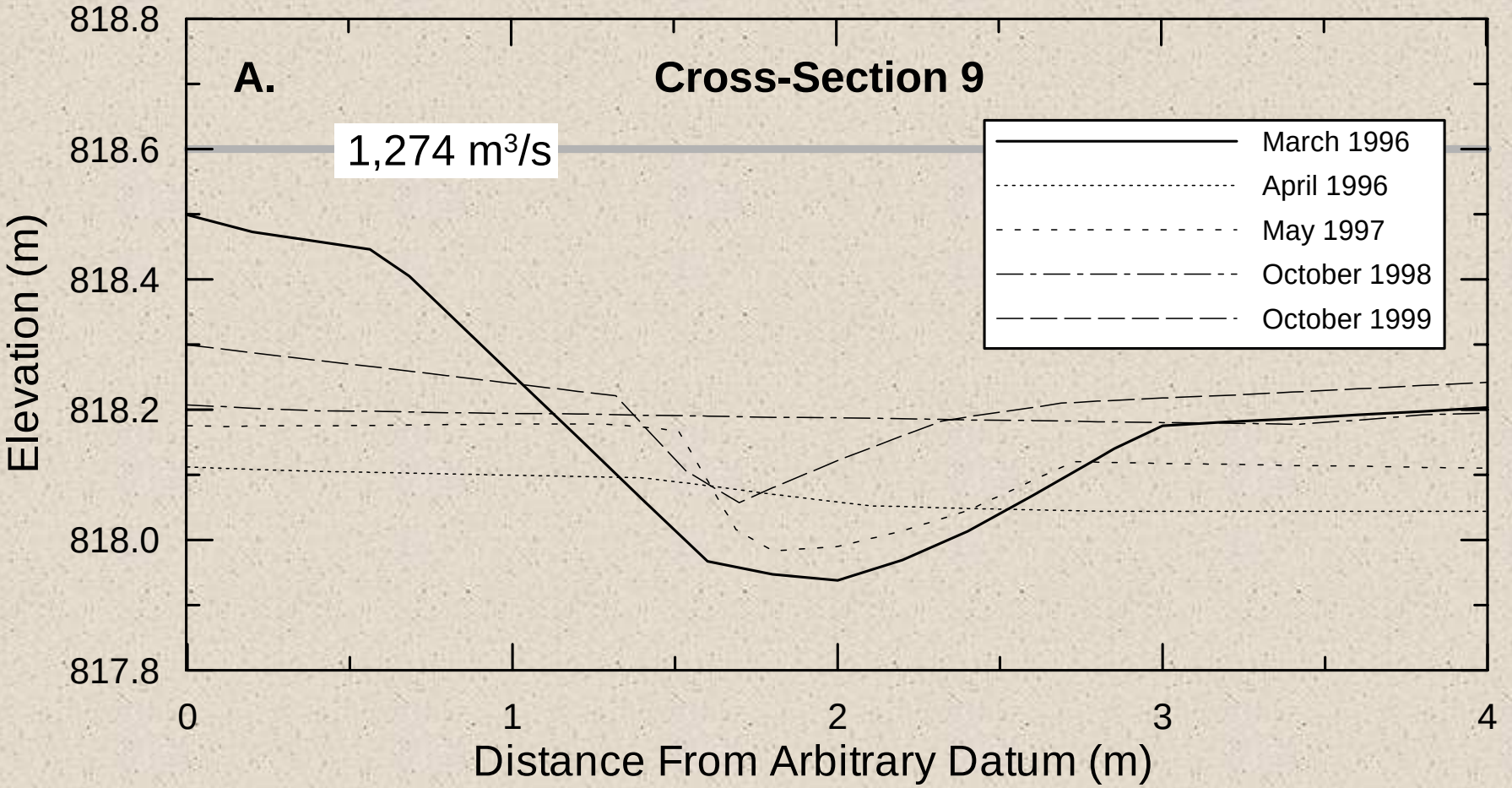
Palisades
October 7, 1999

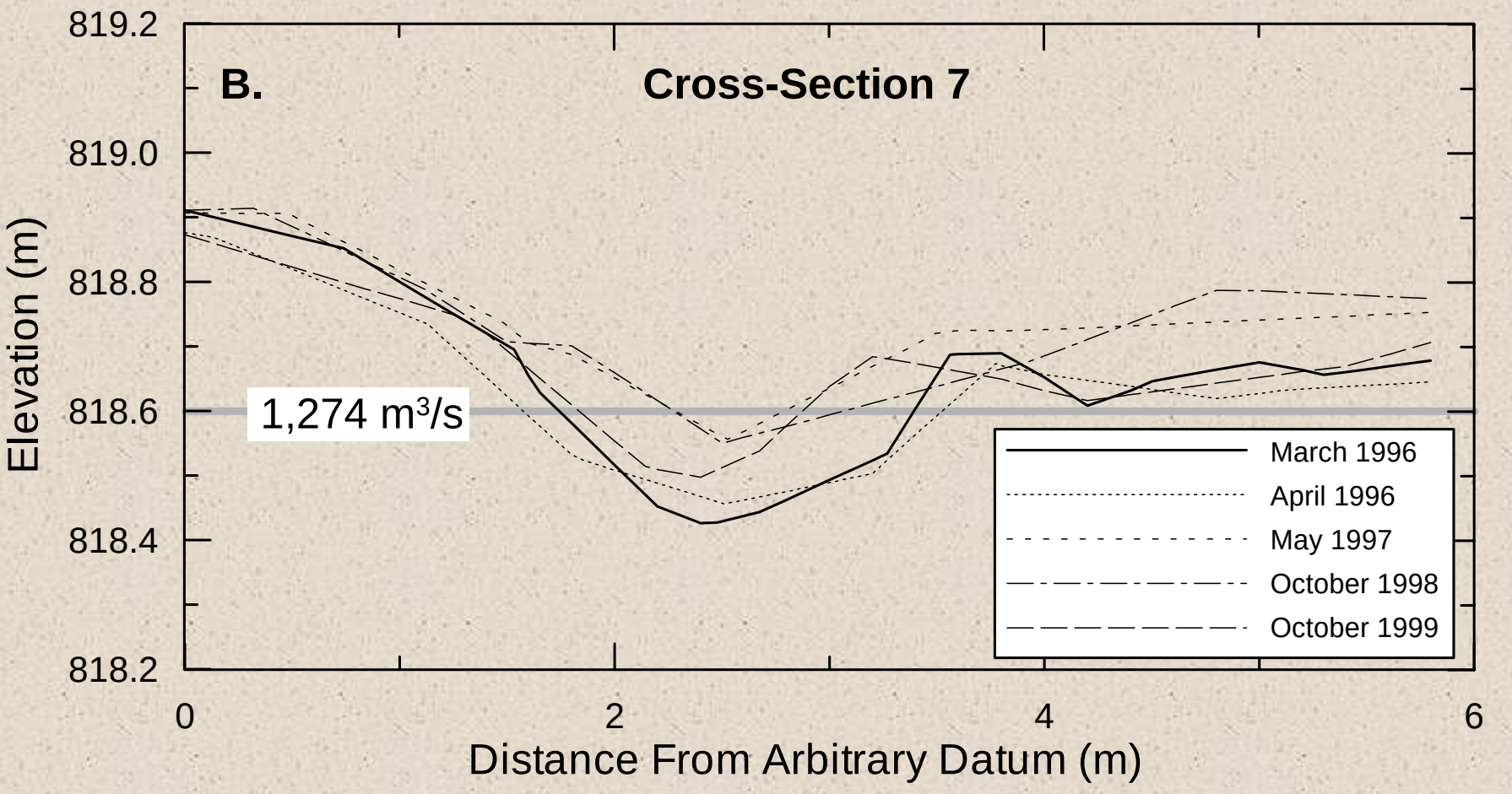


Change map of the difference between the pre- and post-1996 flood surveys

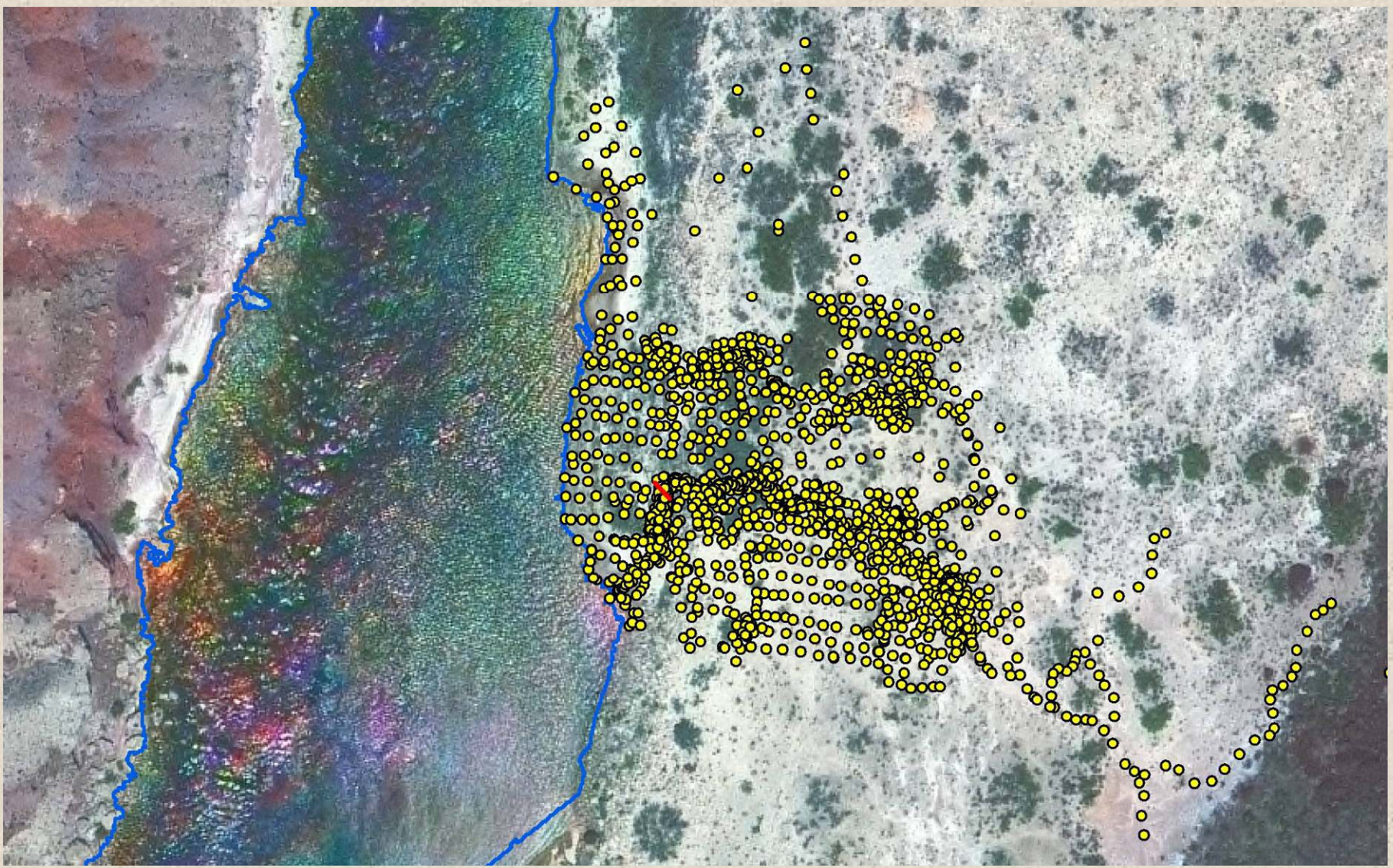



Palisades Arroyo #2
Checkdams
60,000 ft3/s
25,000 ft3/s
March 1996
April 1996
May 1997
October 1998
October 1999
Elevation (m)
798
797
796
795
794
0
5
10
15
20
25
30
35
40
45
50
55
60
Distance From Arbitrary Datum (m)

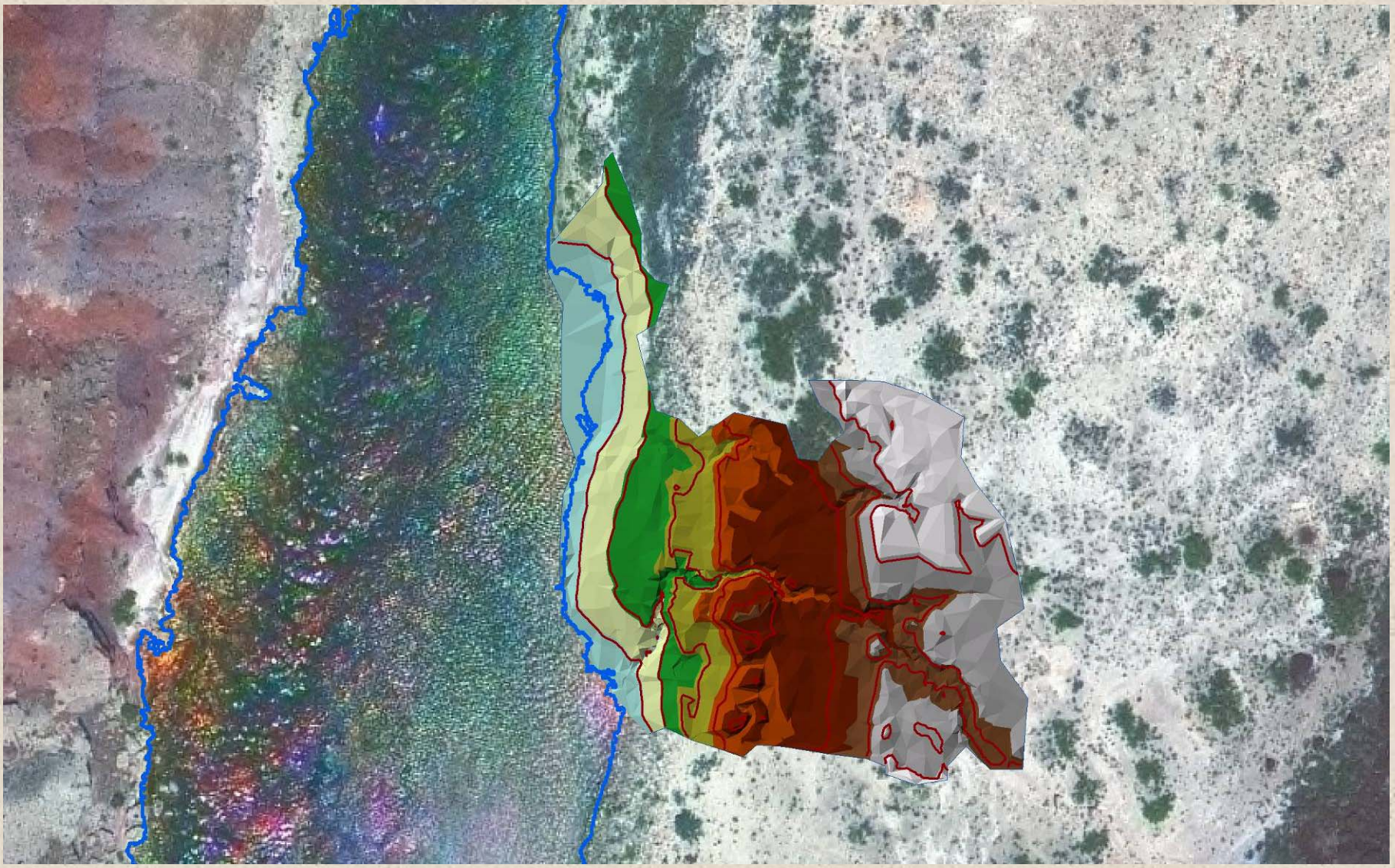

A.
Cross-Section 9
1,274 m3/s
March 1996
April 1996
May 1997
October 1998
October 1999
818.8
818.6
818.4
818.2
818.0
817.8
Elevation (m)
0
1
2
3
4
Distance From Arbitrary Datum (m)


B.
Cross-Section 7
819.2
819.0
818.8
818.6
818.4
818.2
Elevation (m)
1,274 m³/s
March 1996
April 1996
May 1997
October 1998
October 1999
0
2
4
6
Distance From Arbitrary Datum (m)

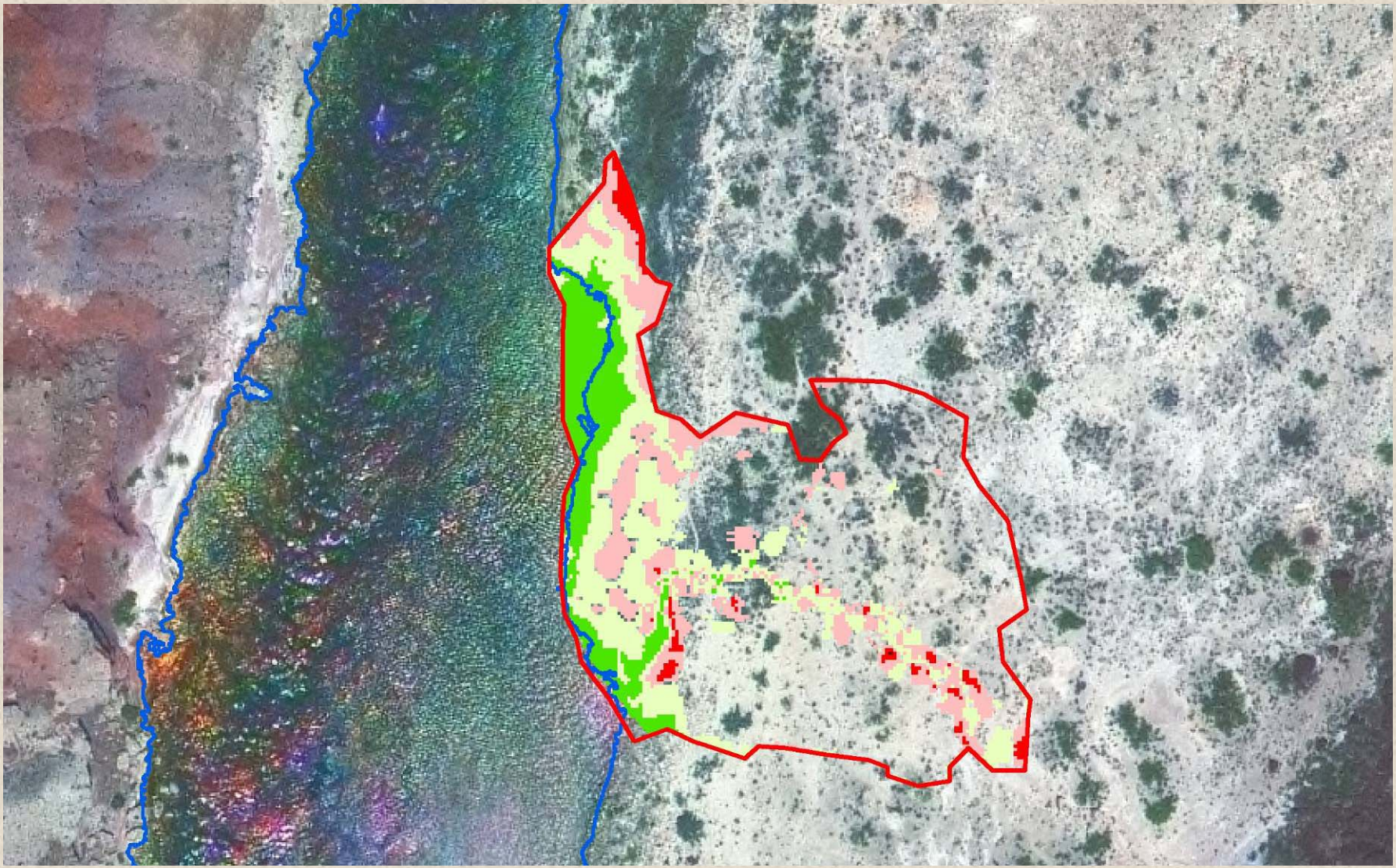
Ground points collected with conventional topographic survey in November 2004



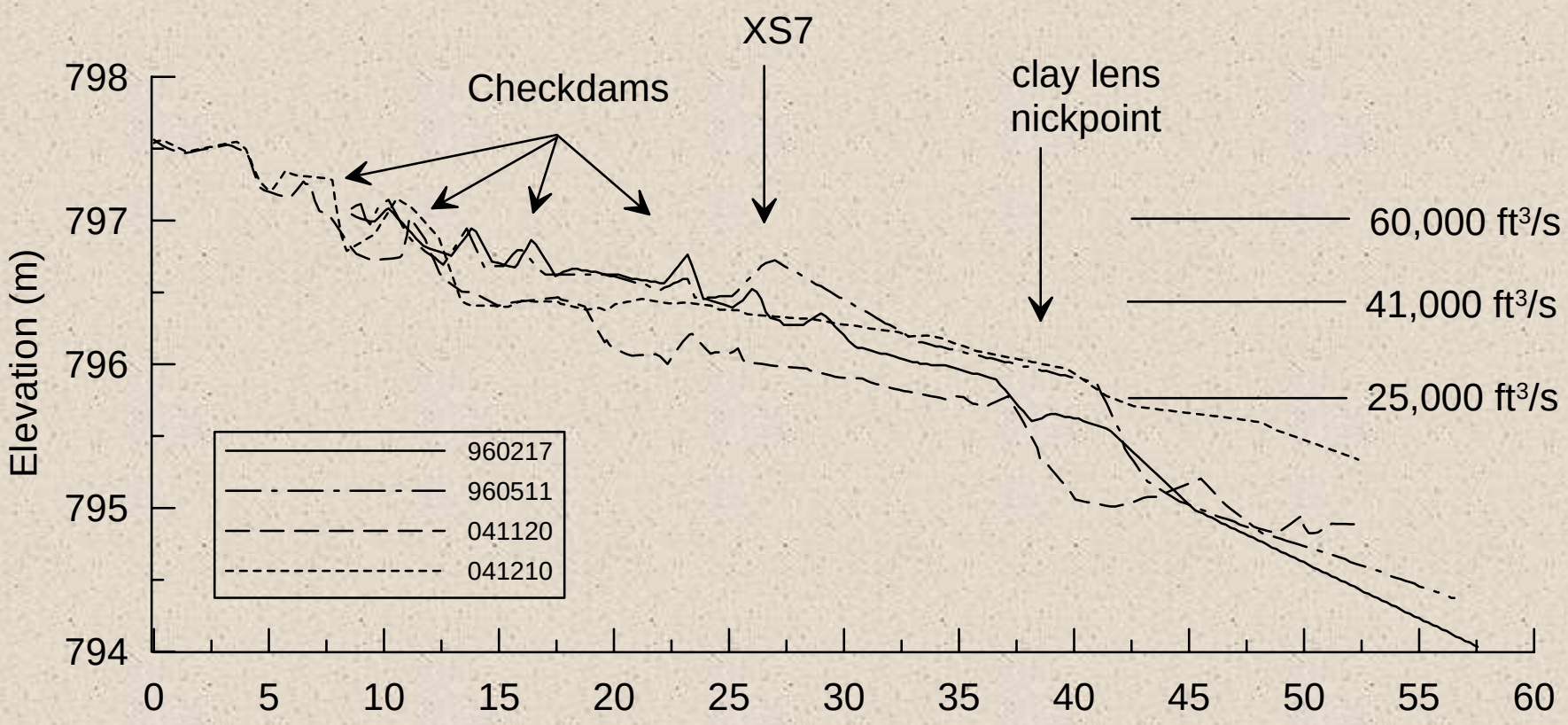
TIN Model of the 2004 preflood survey

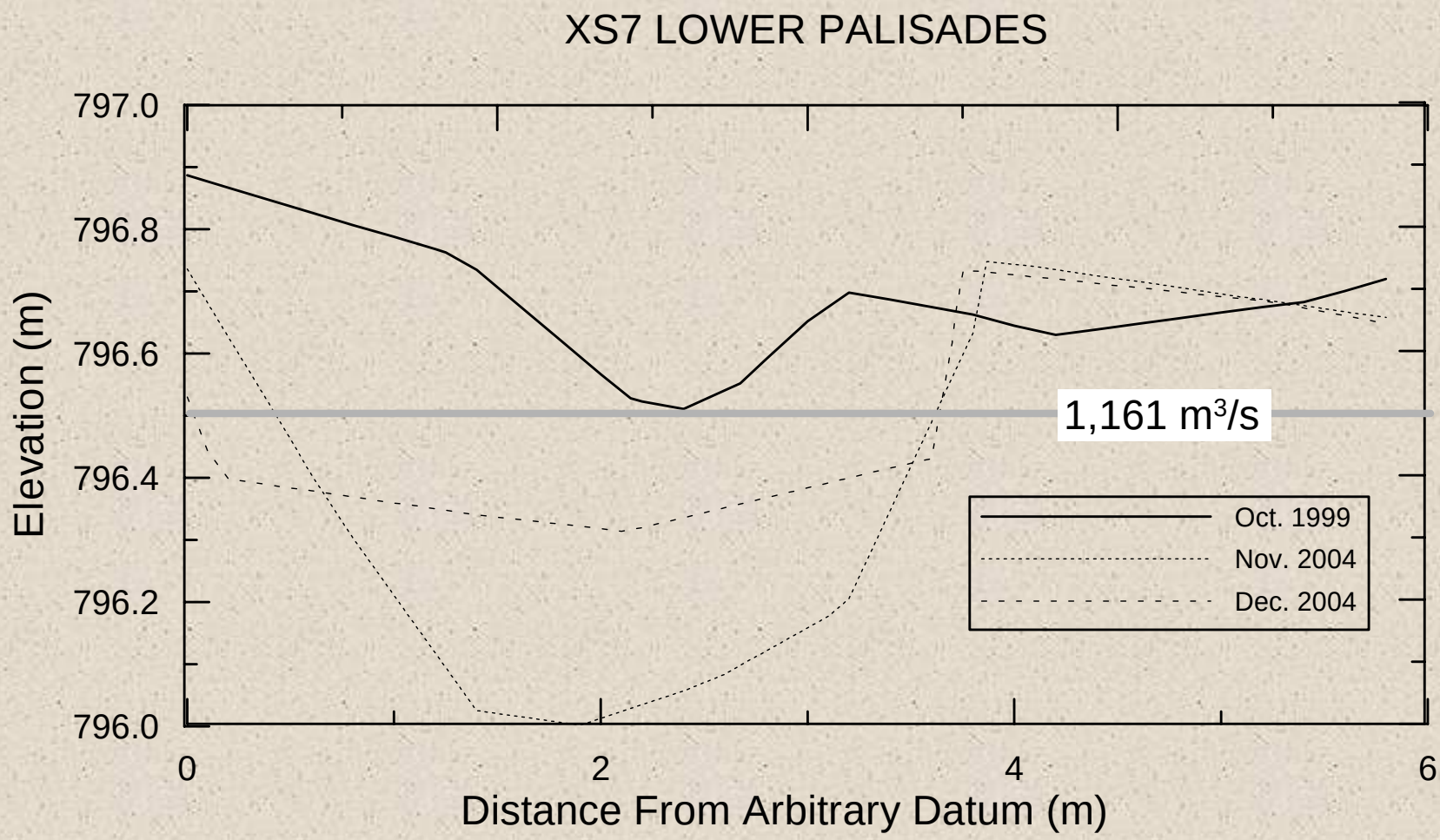


Change map of the difference between the pre- and post-1996 flood surveys



1996 controlled flood compared to the 2004 High Experimental Flow

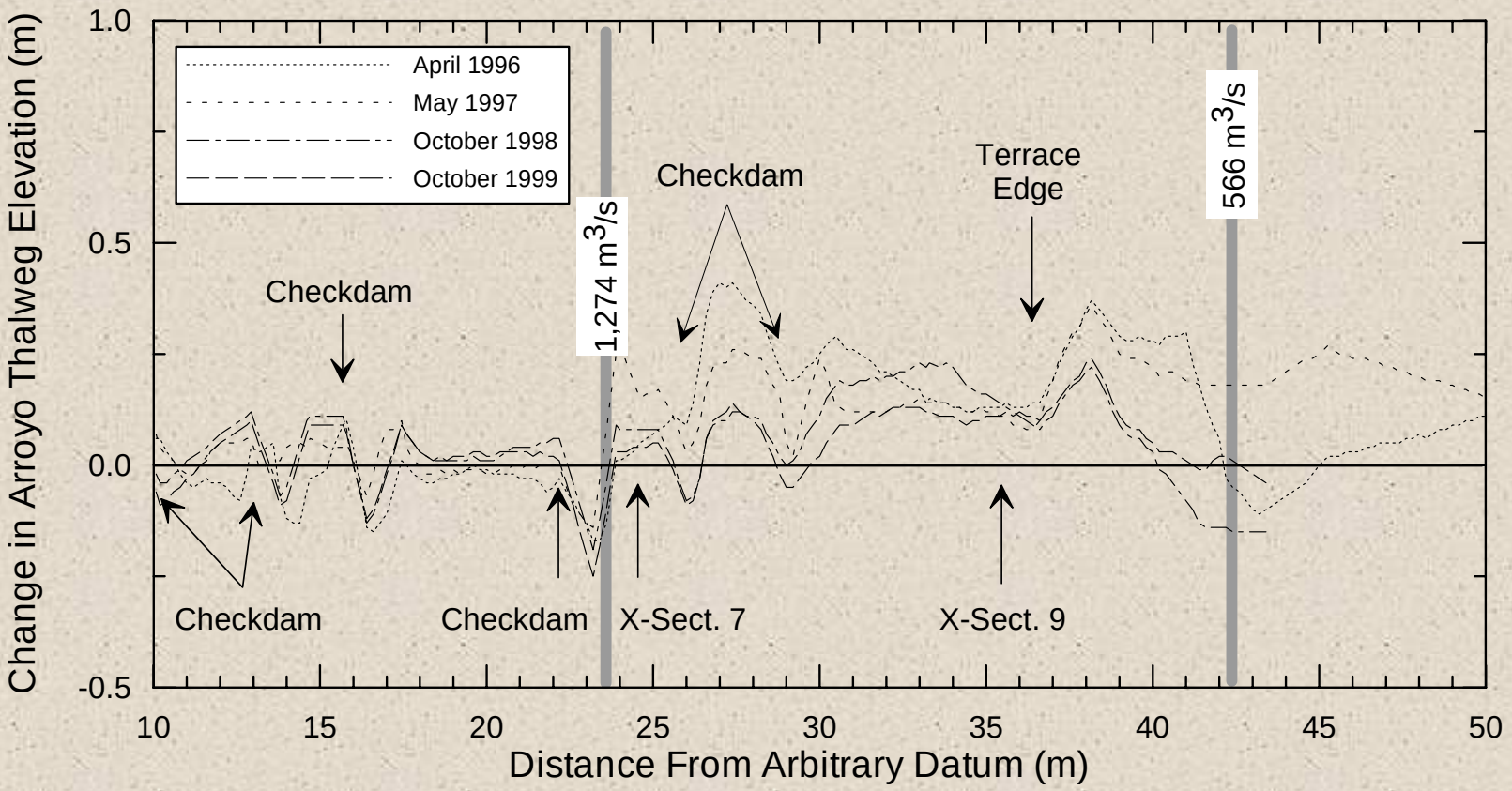



XS7 LOWER PALISADES
797.0
796.8
796.6
796.4
796.2
796.0
Elevation (m)
0
2
4
6
Distance From Arbitrary Datum (m)
1,161 m3/s
Oct. 1999
Nov. 2004
Dec. 2004

long-term time series of arroyo change?

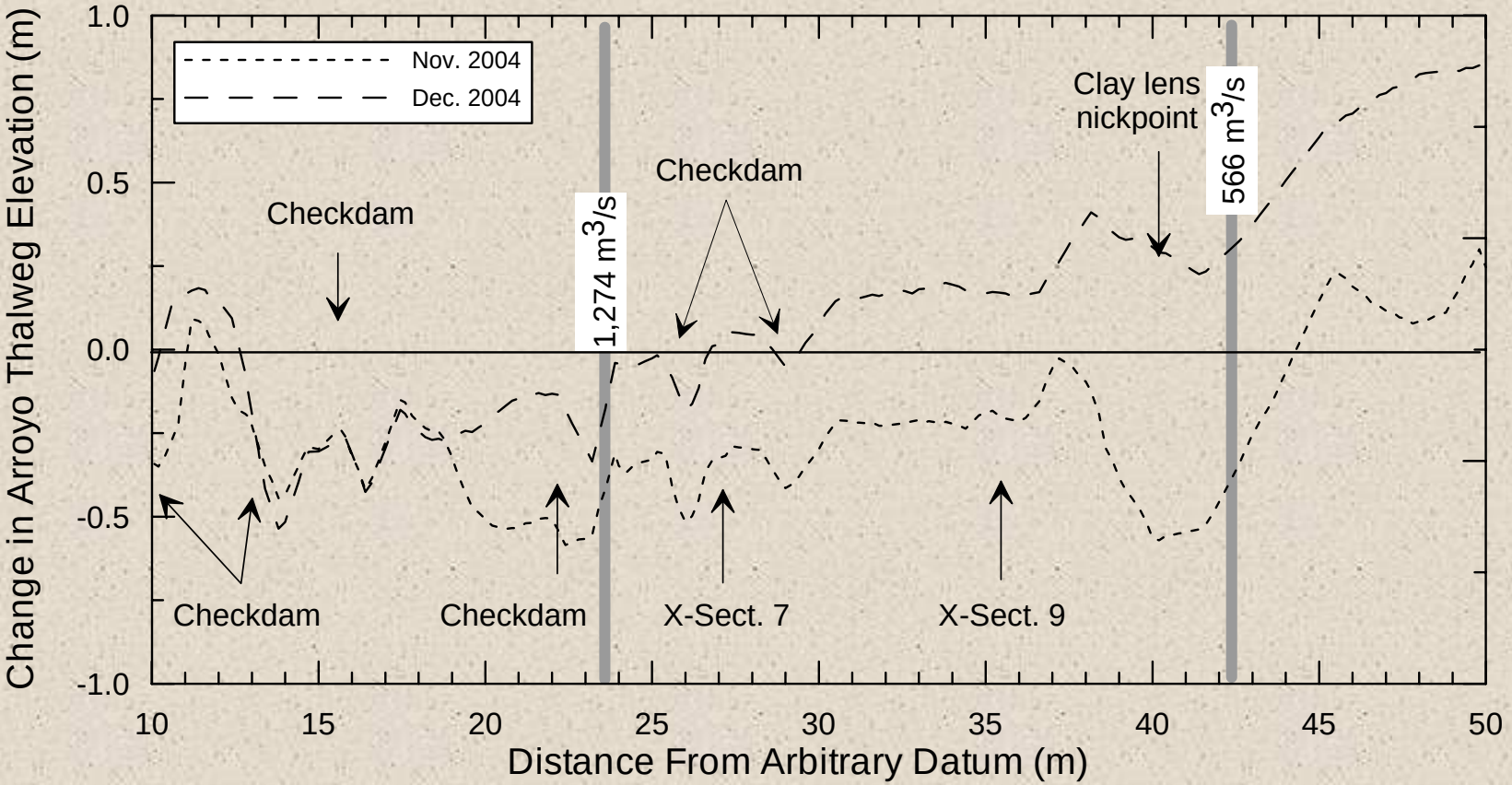
Comparison Interval	Scour (m^3)	Fill (m^3)	Net Change (m^3)
991007 - 041120	-66.5	2.7	**-63.8**
041120 - 041210	-12.0	24.7	**12.7**
960217 - 041210	-54.8	2.1	**-52.7**

Changes in arroyo thalweg elevation: 1996-1999



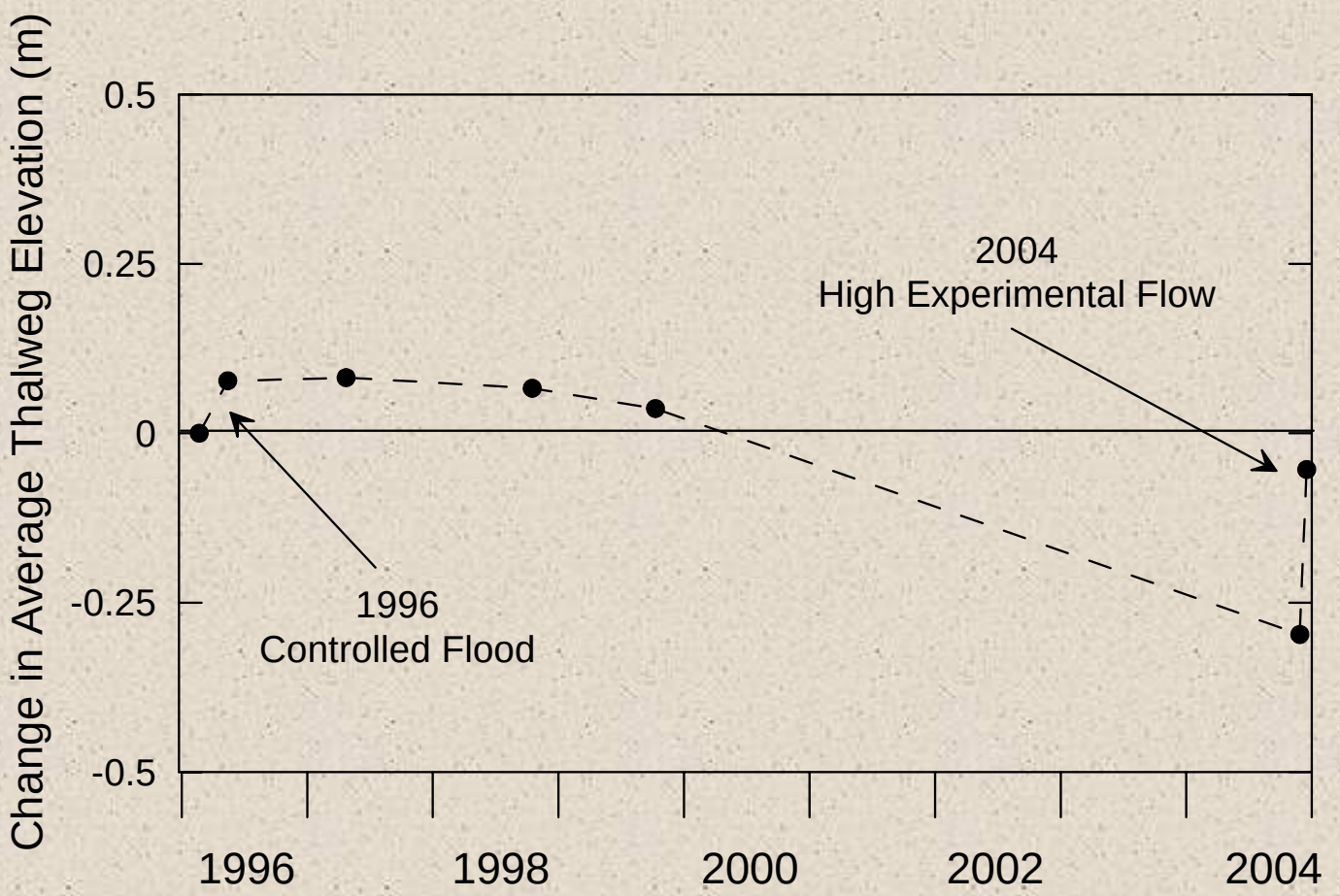
Changes in thalweg elevation are with reference to a common datum defined by the 1996 pre-flood elevation; data above the horizontal solid line at 0.0 indicate depostion, data below indicate erosion.

Changes in arroyo thalweg elevation: 1996-2004



Changes in thalweg elevation are with reference to a common datum defined by the 1996 pre-flood elevation; data above the horizontal solid line at 0.0 indicate depostion, data below indicate erosion.

Time series of average arroyo thalweg elevation: 1996-2004



Conclusions

- The 1996 controlled flood resulted in net sediment volume gains in the arroyo mouths.
- The deposits were incised at 3 sites between 1996 and 1999 but the channels were not eroded to depths that existed prior to the flood.
- Infilling of the arroyos at terrace elevation higher that the arroyo mouth deposits caused gully depths to progressively decrease and is attributed to eolian deposition.
- Are temporary base level effects from controlled flooding important for short-term slowing of gully erosion rates?