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Pre-San Clemente Dam Removal Morphological Monitoring of the Carmel River Channel in Monterey County, California

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Executive Summary

The purpose of this report is to present baseline geomorphological data for the Carmel River channel collected in 2013 in advance of San Clemente Dam removal. The CSUMB Watershed Geology Lab established fluvial geomorphological monitoring sites at five reaches below the San Clemente Dam on the Carmel River during the dry season of 2013. This project is a downstream extension of monitoring work carried out by NOAA and the USGS at four sites located immediately above and below the dam. The five river reaches monitored by CSUMB were located near the upper and lower portions of DeDampierre Park, upstream of Schulte Bridge, downstream of the San Carlos Bridge, and adjacent to the Crossroads shopping center near Highway One. Reaches are approximately 300 m in length and comprise four to six evenly spaced cross-sections. Cross-sections captured a variety of hydraulic habitat settings, but were mainly set in riffles, runs, and pools. Each cross section included a precise georeferenced and benchmarked survey to capture changes in bed elevation, and pebble counts to capture changes in substrate size distribution.

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1 Introduction

The San Clemente Dam, located in the Santa Lucia Mountains of California's Central Coast, is scheduled to be removed from the Carmel River in 2016 (Figure 1). The 32 meter tall dam, which had an initial reservoir storage capacity of 1425 acre feet, is currently more than 95% silted in with sediment. The dam is also located in a seismically active area and is considered structurally unsound, which poses a high risk to the downstream communities in the event of an earthquake or large flood. For these reasons, and others, the dam is scheduled to be removed. According to the National Oceanic and Atmospheric Administration (NOAA), the most pressing question regarding the dam removal is "how to manage these activities to allow the river's natural processes to better support viable populations of native species, on a trajectory of river rehabilitation" (NOAA 2012). This is the first major river reroute and dam removal of its kind because the sediment stored behind the dam will be engineered in place rather than washed downstream (SCDRP 2014). This approach might be a model for future dam-removal projects where downstream land-use precludes massive sediment releases. Before-and-after dam removal monitoring on the Carmel River may yield key information for future dam decommissioning efforts.

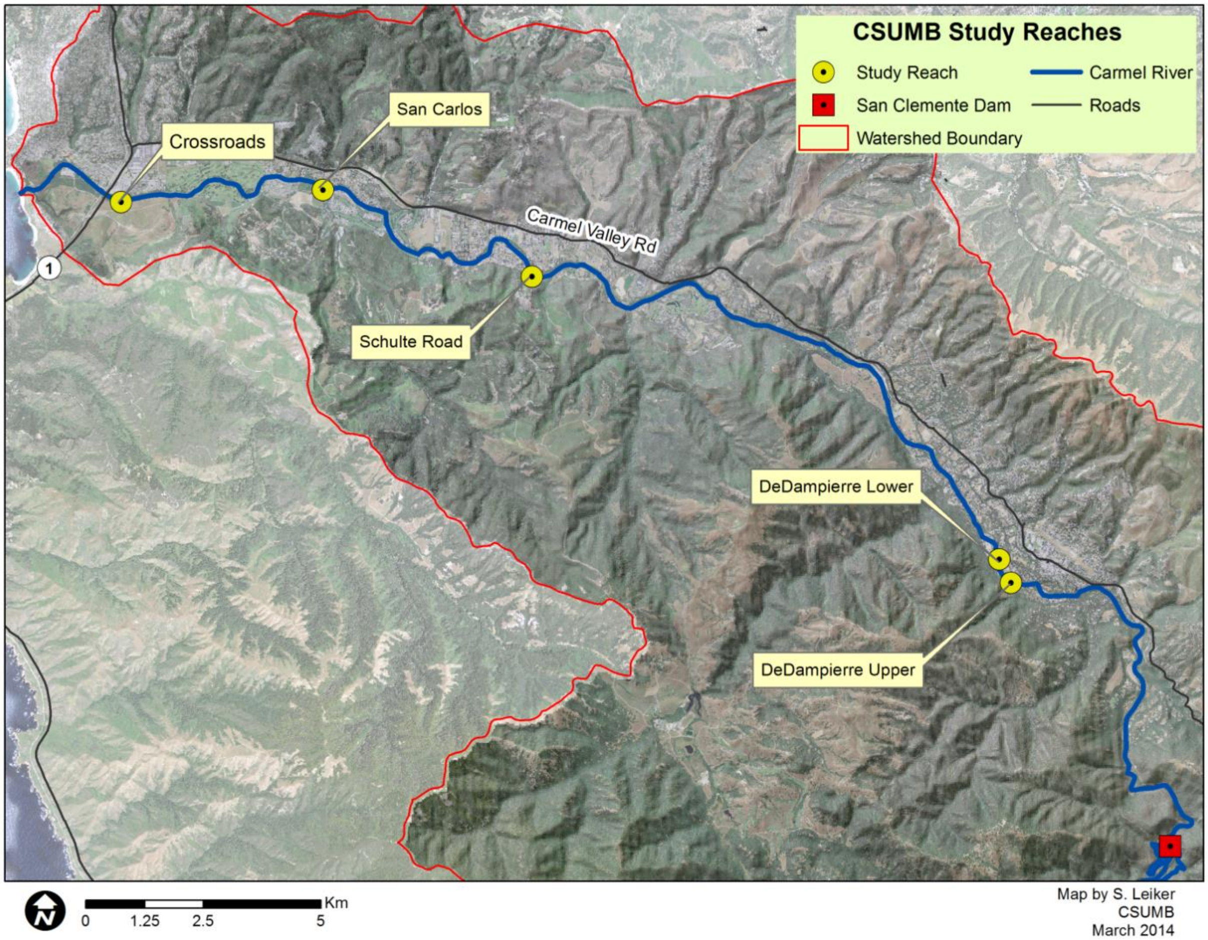


Figure 1. Location of study reaches downstream of the San Clemente Dam on the Carmel River

The dam removal may impact several linked physical and biological systems within the Carmel River, including channel shape and substrate characteristics. Prior to the San Clemente Dam removal, the Carmel River will be rerouted into San Clemente Creek approximately 3,000 feet upstream of the dam. The purpose of the reroute is to bypass the large amount of sediment trapped in the reservoir, thereby minimizing the volume of sediment entering the river (SCDRP 2012). Although the reroute approach is designed to minimize sediment transport from the site, the actual sediment transport from the site is highly dependent upon the final design of the constructed channel, the physical condition of the engineered landscape, and the subsequent environmental contexts, such as climate and seismicity.

Detailed hydraulic and sediment transport modeling has indicated that sediment impacts from the bypass project will be minimal, perhaps being limited to a low volume of gravel deposited downstream of the project (Mussetter 2005). However, if the modeling assumptions are not well met, the actual impact could be considerably different than the predicted impact. Direct monitoring of the river channel will capture unintended impacts, should they occur.

Capturing potential unintended environmental impacts requires a baseline record of the current state of the Carmel River before the dam is removed. Then, similar data sets collected during the decades following dam removal will have a before-after comparison experimental design. There is a paucity of georeferenced baseline geomorphology on the Carmel River channel (CCOWS 2012). This report documents a snapshot of pre-dam removal channel shape and substrate characteristics for the Carmel River downstream of the San Clemente Dam.

2 Methods

This study monitored the geomorphological processes of the Carmel River before the San Clemente Dam (SCD) reroute and removal at five diverse and representative reaches of the river that could change character following dam removal. Reaches were selected based on physical and/or biological importance, existence of biological data, and accessibility. The geomorphology of each reach was studied in the dry season when there were low flows and easy access to the channel. Data were collected between June 2013 and March 2014. The five reaches studied are described below (Figure 1):

- **DeDampierre Upper (DDU)**: Located in the upper portion DeDampierre Park, the reach extends from the footbridge past the baseball fields. This reach contains several pieces of large wood installed for a restoration project by the Monterey Peninsula Water Management district (MPWMD).
- **DeDampierre Lower (DL)**: This reach begins at the lower end of DeDampierre park and extends to the Carmel Valley Trail and Saddle Club downstream of the park.
- **Schulte Road (SR)**: Located upstream of the Schulte Road Bridge. This reach begins in land owned by the Big Sur Land Trust and extends to 100m upstream of the Schulte Bridge.
- **San Carlos (SC)**: Located just downstream of the San Carlos Road Bridge. The reach extends from the bridge to the California American Water (CalAm) San Carlos production well.
- **Crossroads (XR)**: Located adjacent to the Crossroads Shopping Center at the mouth of Carmel Valley.

Each reach is approximately 300 m in length and contains 4 to 6 transects evenly spaced at 60 m intervals. Cross-sections were set in a variety of hydraulic settings, but mainly in riffles and pools. Pairs of survey control points were established at the upper and lower ends of each reach using 2-4’ rebar embedded in the ground. These control points were geospatially referenced using long static GPS occupation with a Spectra Precision EPOCH 50 GNSS receiver. Cross-sections of each transect were surveyed using a 3 arcsecond precision NPR-362 Nikon Total Station (Figure 2). Permanent left and right bank benchmarks were established for each transect with 2-4’ rebar hammered into the ground or nails hammered into the base of trees. Topographic surveys were then conducted using the Total Station. Surveys were opened using the georeferenced control points previously established which allowed points within the reach to be geospatially recorded. At each cross section, a taut tape was set between the left and right benchmarks to facilitate precise resurvey of each transect and guide shot distances. Points along transect were shot at 1 m increments with additional shots to record breaks in slope. Surveys were closed at the end of every cross-section, before each turning point, and at the end of the total reach survey to conserve precision. Final closings were shot on the nearest stable georeferenced control point.

Figure 2. Researchers setting up the Total Station for a survey.

In addition to topographic surveys, Pebble counts were performed along each cross-section to determine average particle size distribution. Pebble counts included only particles within the active low flow channel as indicated by recent substrate activity. We employed a sampling technique from Bunte and Abt [2001] that uses a 60 x 60 cm sampling frame that sets sampling points based on the intersection of thin elastic bands located within the frame (Figure 3). This method reduces serial correlation by adjusting the spacing between intersections on the frame to equal the dominant large particle size (≈D95). The 60x60 cm square sampling frame was constructed from 1" PVC pipe with notches every 10cm. Elastic bands were then attached to notches according to the dominant large particle size of each transect. The sampling grid was moved repeatedly across the estimated low flow channel at fixed intervals to achieve a sample size of ≥ 100. A gravelometer was used to measure particle sizes for pebble counts. Data was analyzed by size class and frequency to determine grain size distributions for each cross section. Cross-sections were plotted and particle count data were summarized for comparison with future data sets collected after dam removal.

Figure 3. Pebble counts being carried out in the field using the constructed sampling frame.

3 Results

3.1 Overview

Total Station surveys produced geospatially referenced channel geometry for all cross-sections (Appendix). There was a 74 m change in channel bed elevation between reaches. The uppermost reach surveyed had thalweg elevations ranging between 76 m and 77 m, while the lowest reach had an average thalweg of approximately 3 m.

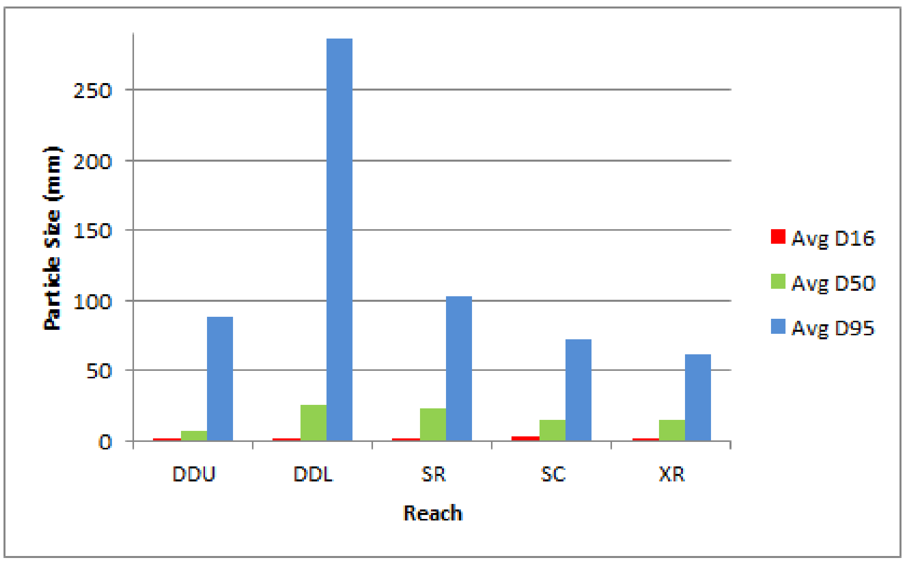


Figure 4. Particle size percentiles averaged within reaches, and arranged from upstream (DDU) to downstream (XR). Symbols are upper DeDampierre (DDU), lower DeDampierre (DDL), San Carlos Road (SCR), and Crossroads (XR). Locations in Figure 1.

Pebble counts for reaches further downstream showed a trend in decreasing mean particle size (Figure 4). There was a general lack of fine to medium gravel within reaches, and there was an abundance of sand and cobbles.

3.2 DeDampierre Upper Reach

The DeDampierre Upper Reach was the most upstream reach monitored by CSUMB (Figure 1). This reach included 4 large wood installments constructed by MPWMD. The large wood installments have created large, deep scour pools.

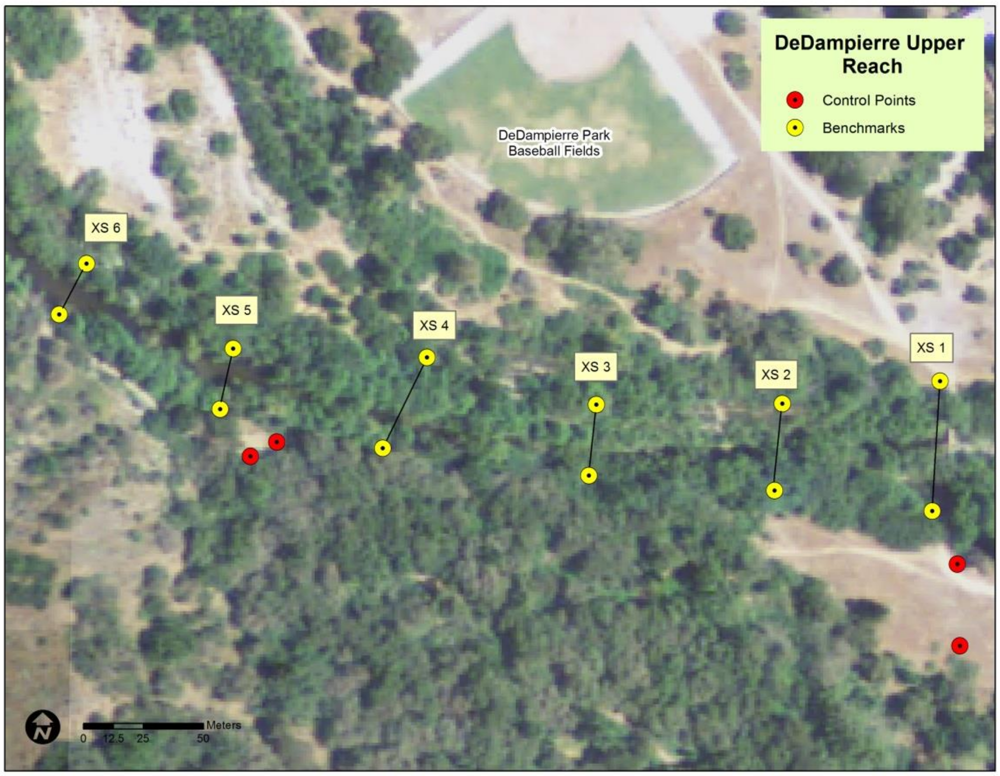


Figure 5. Location of georeferenced control points and cross-sections within the DeDampierre Upper Reach

The median grain size of this reach (D50) ranged from sand to coarse gravel (1.67-21.06 mm) among transects (Table 1). The 84th and 90th percentiles (D84 and D90) included a range of particle sizes from fine gravel and to cobbles. Cross-sections located in pools tended to have smaller particle sizes while riffles tended to have larger particle sizes. Grain size distribution analysis reveals similar distributions of smaller particles, but a higher variability, in the larger particles between transects where large boulders are found. The pools formed by the large wood installments in this reach had much smaller particle sizes than other sections of the reach. The width of cross-sections in this reach covered the active channel and potions of floodplain when

Table 1. Grain size distribution among cross-sectional transects within the DeDampierre Upper Reach. Riffles, such as T3, tended to have larger particles than pools, such as T1.

	Grain size (mm)					
D_{xx}	T1	T2	T3	T4	T5	T6
D_{16}	1.22	1.24	1.50	1.49	1.23	1.49
D_{35}	1.47	1.52	3.43	4.56	1.51	2.47
D_{50}	1.67	1.74	7.26	21.06	1.73	9.20
D_{84}	2.60	5.79	63.00	140.31	10.51	23.45
D_{95}	5.22	22.84	221.80	232.20	20.77	30.50

possible. Cross section widths ranged from 19-45 m and the average low-flow active channel observed in the field was between 10-15 m. The channel geometry of each cross-section surveyed can found in the Appendix.

3.3 DeDampierre Lower Reach

This reach is located directly downstream of the DeDampierre Upper Reach. The upstream portion of the reach is a wide and open channel with a pool and long run. The reach narrows after cross-section 3 (XS 3 of Figure 6) and has a steeper gradient.

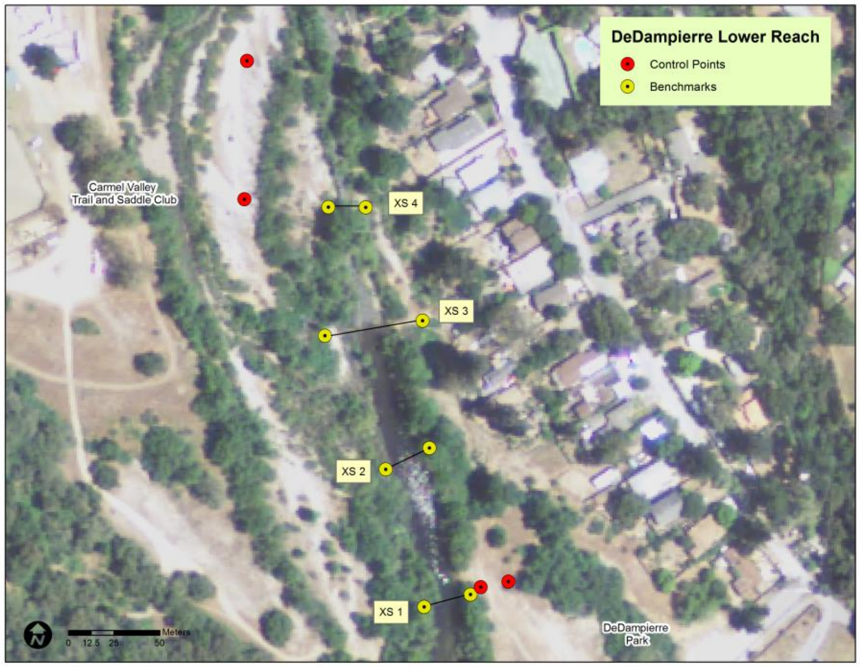


Figure 6. Location of georeferenced control points and cross sections within the DeDampierre Lower Reach

The medianD50 ranged from fine gravel to cobbles (7.14-41.75 mm) among transects (Table 2). The D84 and D90 contained a range of particle sizes from fine gravels to boulders. Cross-sections located in pools tended to have smaller particle sizes while cross section located in riffles tended to have larger particle sizes. Thewidth of cross-sections in this reach covered the active channel and portions of floodplain when possible. Cross-section widths ranged from 16-44 m and the average low-flow active channel observed in the field was between 10-20 m (Appendix).

Table 2. Grain size distribution among cross-sectional transects within the DeDampierre Lower Reach.

	Grain size (mm)			
D_{xx}	T1	T2	T3	T4
D_{16}	1.34	1.48	1.69	2.77
D_{35}	1.75	2.38	13.69	18.92
D_{50}	7.14	12.48	41.75	40.00
D_{84}	205.21	122.82	208.47	181.01
D_{95}	305.36	208.65	314.63	321.87

3.4 Schulte Reach

The Schulte reach is located ~200 m upstream of the Schulte Bridge and extends above the 'Steinbeck Pool' which is located between cross-sections 2 and 3 (Figure 7).

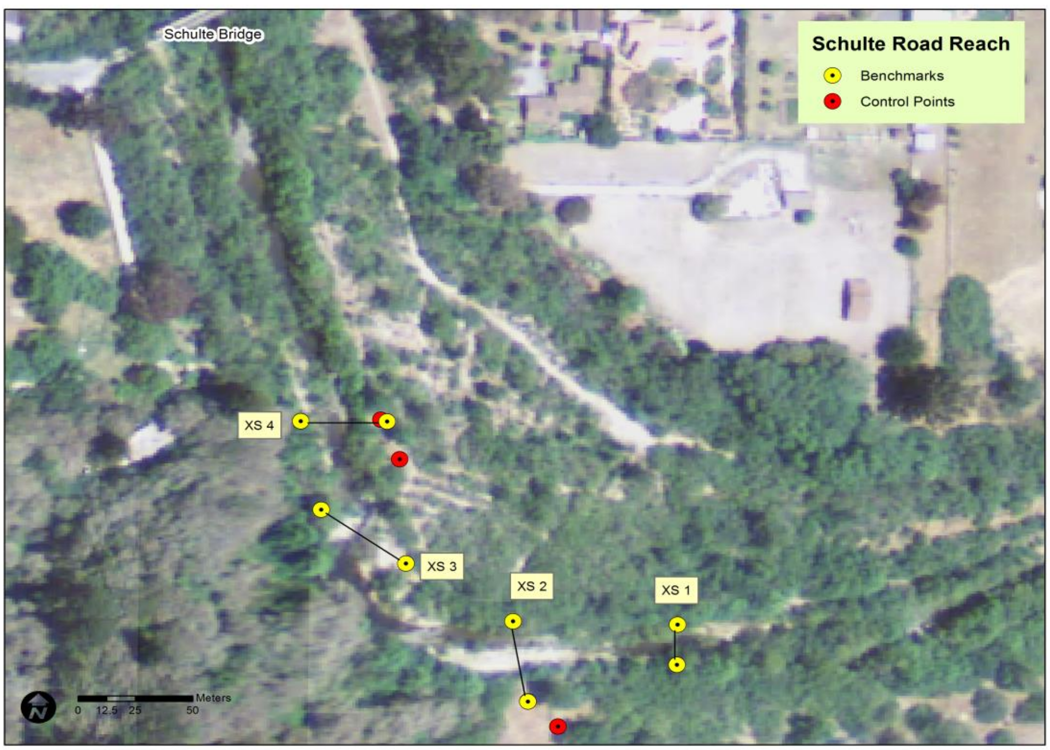


Figure 7. Locations of georeferenced control points and cross-sections within the Schulte Road Reach

The D50 ranged from sand to coarse gravel (1.79-31.33 mm) among transects (Table 3). The D84 and D90 contained a wide range of particle sizes from coarse gravel to large cobbles. The variability of sand and fine gravel to large cobbles and boulders is highest in pools, evidenced by cross-section 1 (D_{50}= 1.79 mm, D_{84}= 45.0 mm). The channel width of cross-sections in this reach covered the active channel and portions of floodplain when possible. Cross-section widths ranged from 15-35 m and the average low-flow active channel observed in the field was between 10-15 m (Appendix).

Table 3. Grain size distribution among cross-sectional transects within the Schulte Road Reach.

	Grain size (mm)			
D_{xx}	T1	T2	T3	T4
D_{16}	1.25	2.73	3.34	1.86
D_{35}	1.56	19.22	17.72	10.87
D_{50}	1.79	31.33	30.87	29.36
D_{84}	45.00	82.48	62.82	66.65
D_{95}	126.00	113.59	85.70	87.58

3.5 San Carlos Reach

The D50 ranged from sand to coarse gravel (1.79-31.33 mm) among transects with a more frequent occurrence of sand (Table 4). The D84 and D90 contained small, medium, and large cobbles. Large boulders are less frequent this far downstream. Although there is gravel present, there is a lack of fine to medium size gravel. The channel width of cross-sections in this reach covered the active channel and potions of floodplain when possible. Cross section widths ranged from 19-45 m and the average low-flow active channel observed in the field was between 10-15 m.

Figure 8. Locations of georeferenced control points and cross sections within the San Carlos Reach

Table 4. Grain size distribution among cross-sectional transects within the San Carlos Reach.

	Grain size (mm)					
D_{xx}	T1	T2	T3	T4	T5	T6
D_{16}	3.43	10.79	1.25	1.25	1.55	1.26
D_{35}	15.58	24.87	1.56	1.55	2.75	1.57
D_{50}	25.42	34.38	1.79	1.79	23.85	1.81
D_{84}	57.30	62.28	19.30	25.61	47.20	22.16
D_{95}	126.90	81.55	54.50	62.67	61.50	45.00

3.6 Crossroads Reach

Crossroads is the lowermost reach monitored, and is located adjacent to the Crossroads shopping center near the mouth of Carmel Valley (Figure 9). The D50 ranged from fine gravel to coarse gravel (3.40-27.82mm) among transects (Table 5). The D84 and D90 contained a range of particle sizes from coarse gravels and to small cobbles. Cross-sections located in pools tended to have smaller particle sizes while cross section located in riffles tended to have larger particle sizes. The channel width of cross-sections in this reach covered the active channel and potions of floodplain when possible. Cross section widths ranged from ~16-25 m and the average low-flow active channel observed in the field was between 10-15 m.

Table 5. Grain size distribution among cross-sectional transects within the Crossroads Reach.

	Grain size (mm)					
D_{xx}	T1	T2	T3	T4	T5	T6
D_{16}	4.22	1.72	1.45	1.83	2.34	1.67
D_{35}	19.52	2.90	1.97	4.35	12.71	4.09
D_{50}	27.82	11.30	3.40	13.96	22.09	8.28
D_{84}	45.53	36.65	35.61	43.04	47.72	38.40
D_{95}	62.25	50.70	56.04	65.46	72.32	60.52

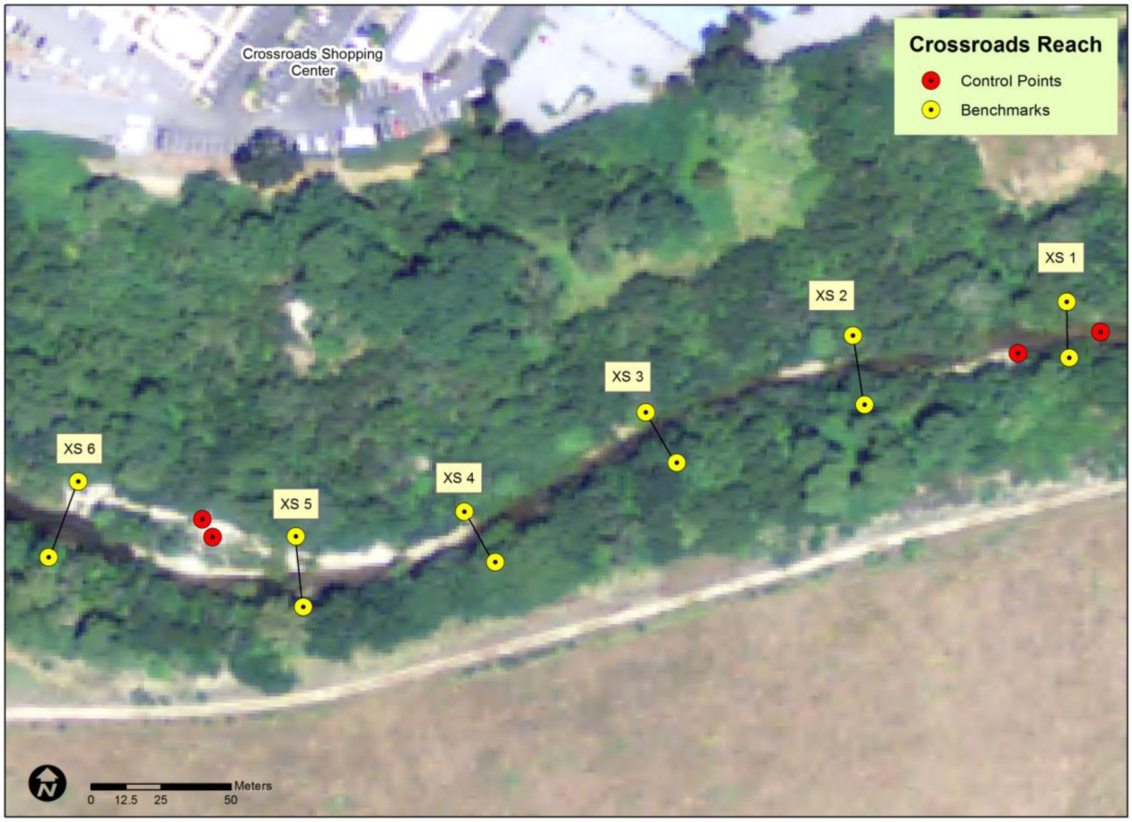


Figure 9. Locations of georeferenced control points and cross-sections within the Crossroads Reach

4 Limitations

Reach locations were limited by accessibility and vegetation coverage. Much of the land located directly adjacent to the river is privately owned, making access difficult. Dense riparian vegetation canopy limited areas where GPS control points could be established.

5 References

Bunte K., Abt S. 2001. Sampling Frame for Improving Pebble Count Accuracy in Coarse Gravel-bed Streams. Journal of the American Water Resources Association. Vol. 37, No. 4:1001-1014.

[CCOWS] Central Coast Watershed Studies. 2012. San Clemente Dam Removal and Carmel River Reroute Monitoring Plan: Carmel, CA. The Watershed Institute, Seaside, CA. Available from: http://ccows.csumb.edu/pubs/proj_pubs/2012/ENVS660_Carmel_Monitoring/CSUMB_ENVS660_ClassReport_DamRemovalMonitoring_121024.pdf

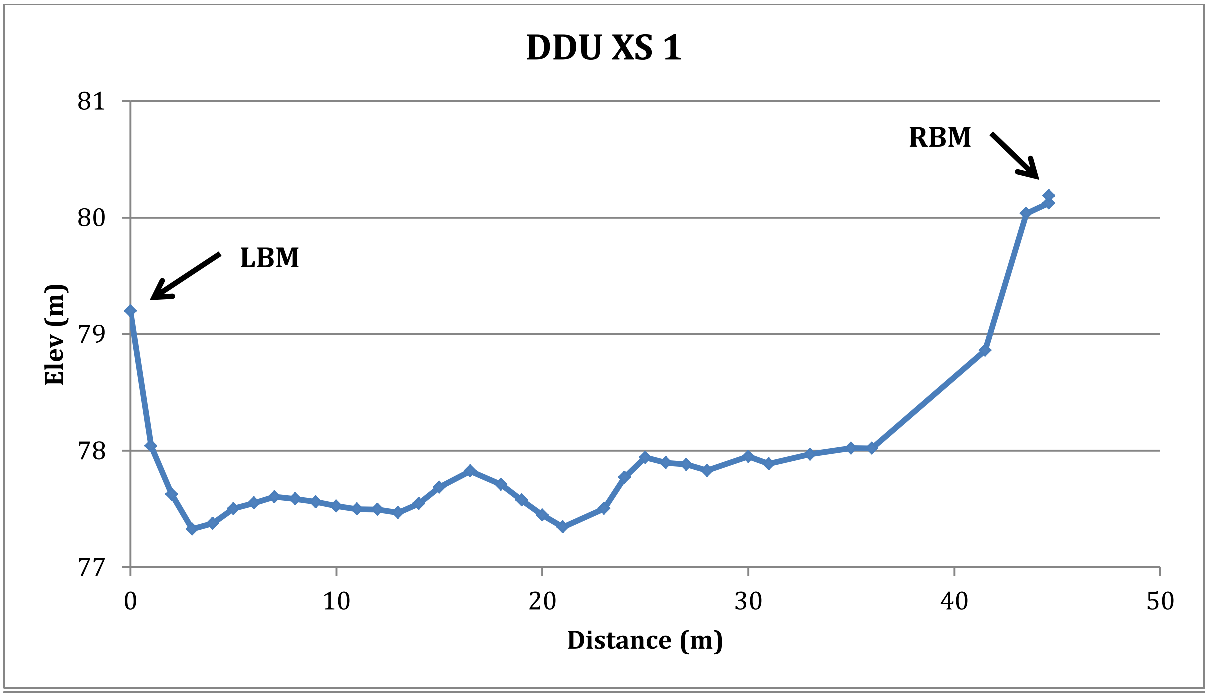
Mussetter Engineering, Inc., 2005. Hydraulic and Sediment-transport Analysis of the Carmel River Bypass Option, California. Prepared for California American Water. April 25,2005. 74pp.

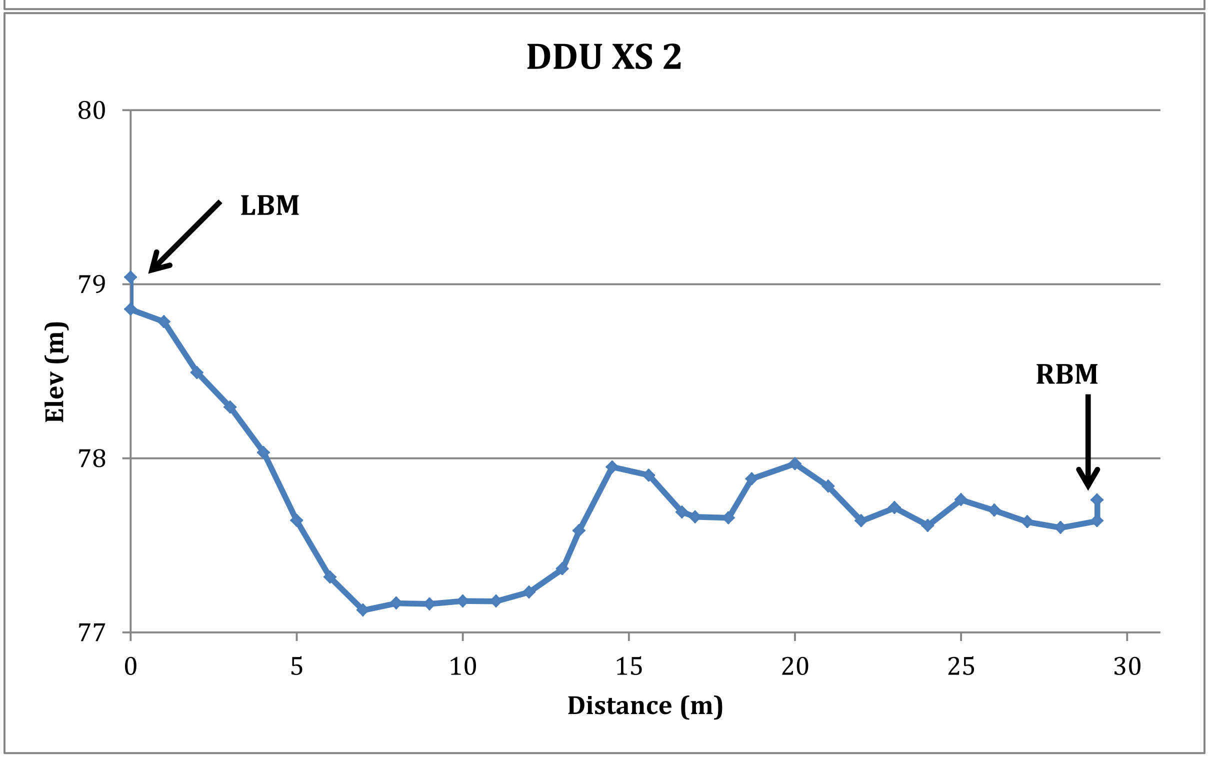
[NOAA] National Oceanic and Atmospheric Administration. Fisheries Staff and Collaborators. Nov 2012. DRAFT Conceptual Model of the Carmel River System. SW Fisheries Science Center, Santa Cruz, CA.

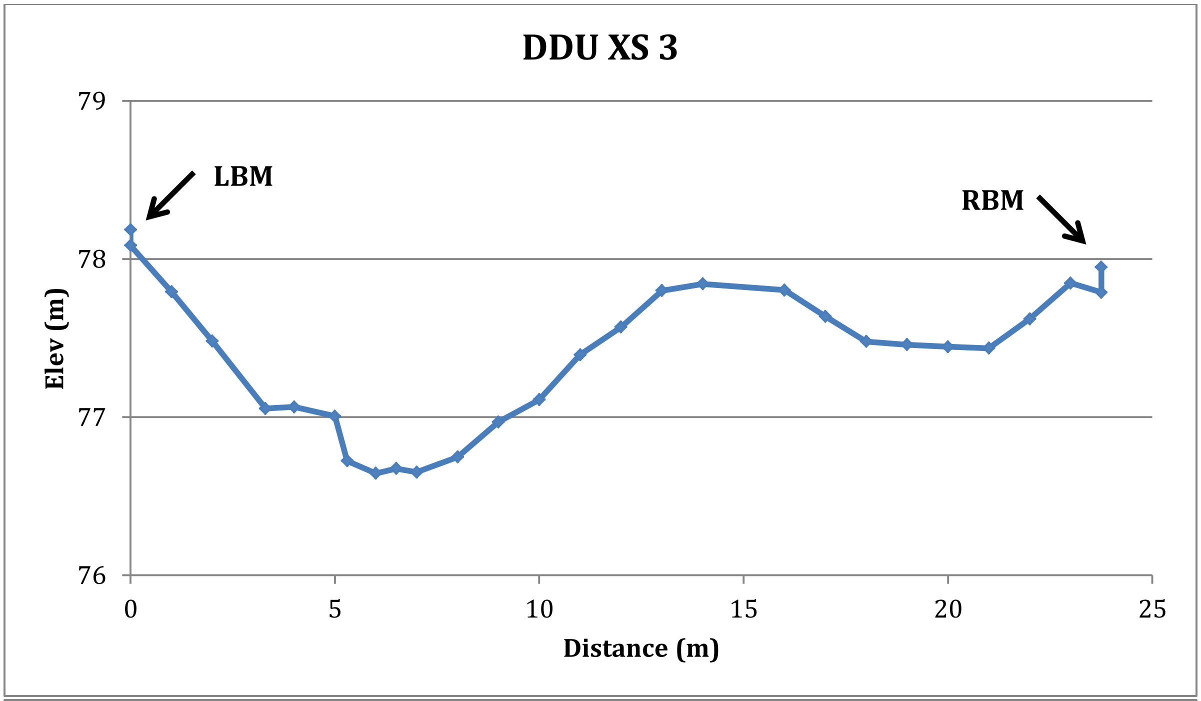
[SCDRP] San Clemente Dam Removal Project. 2014. Project Overview. Available from: http://www.sanclementedamremoval.org/

6 Appendix

Channel geometry for each cross-section surveyed within each reach.



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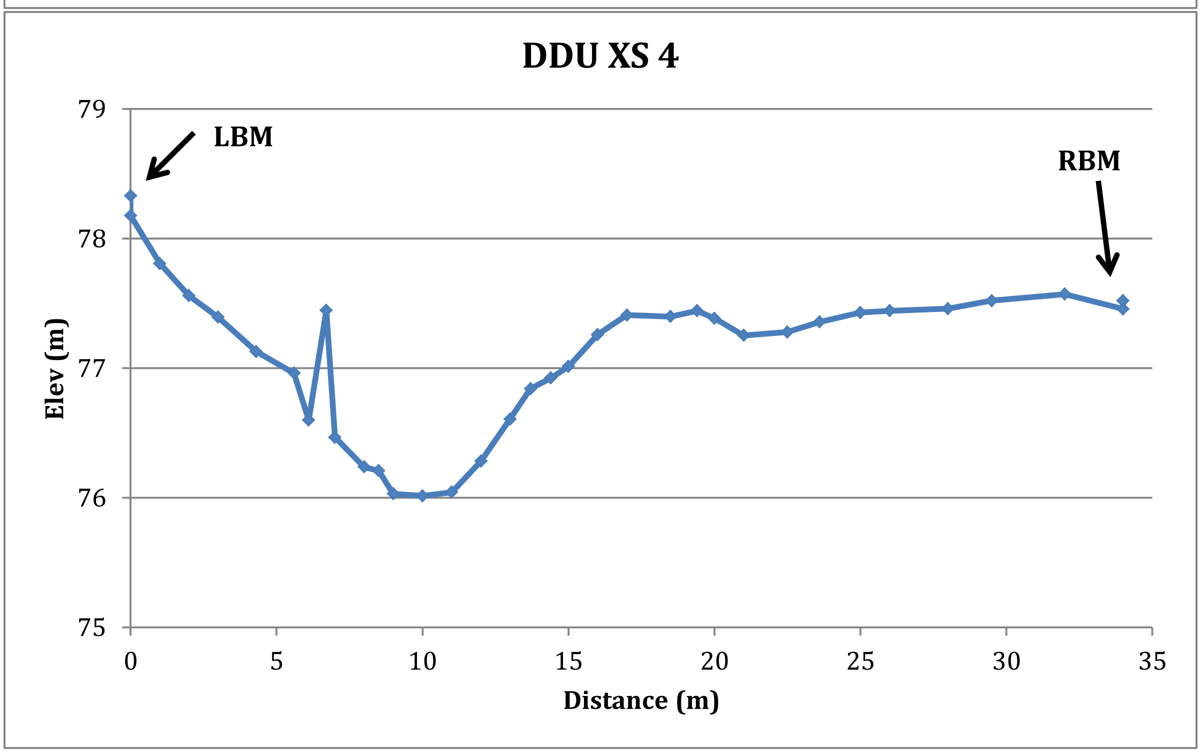
78
77
76
LBM
RBM
Elev (m)
0
5
10
15
20
25
Distance (m)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30
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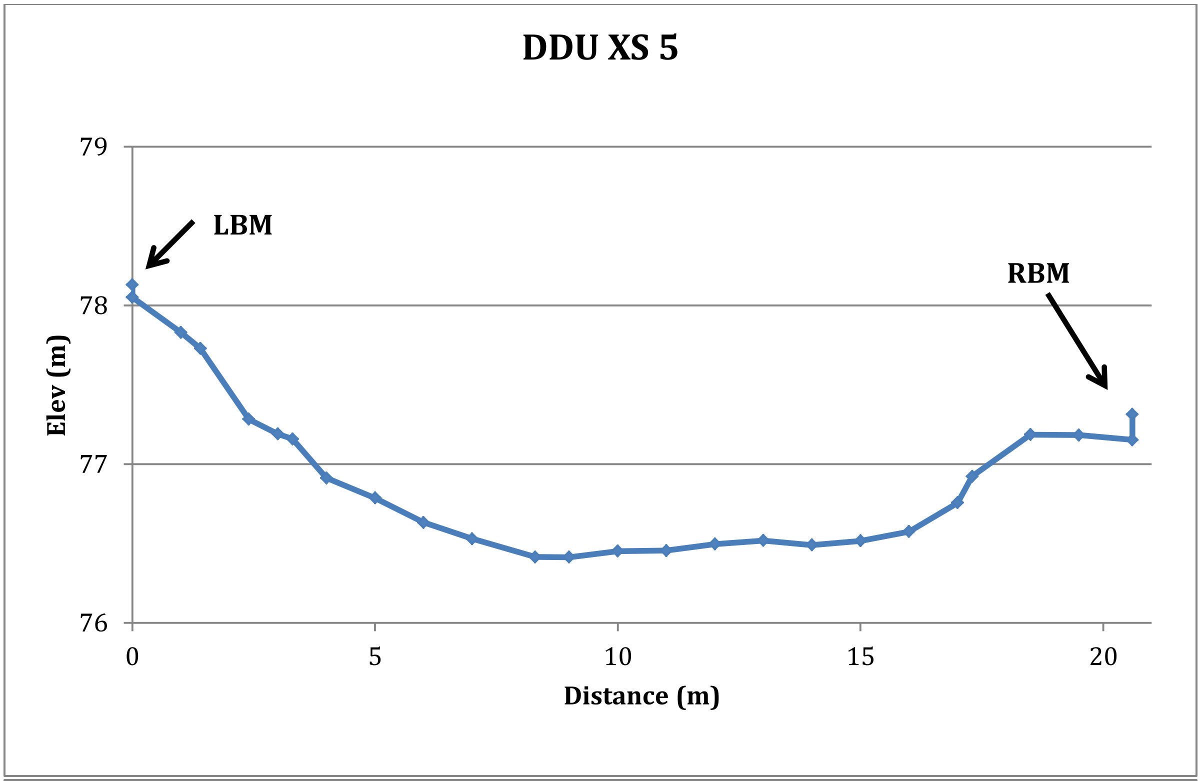
Distance (m)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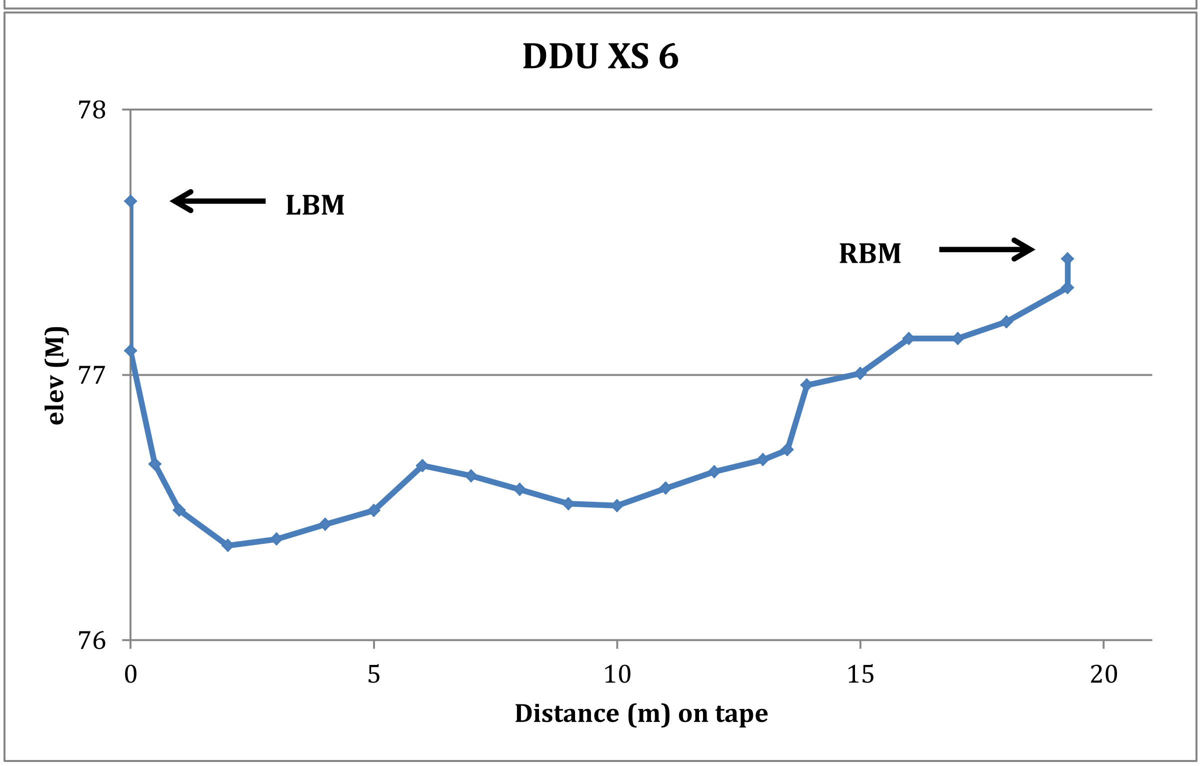
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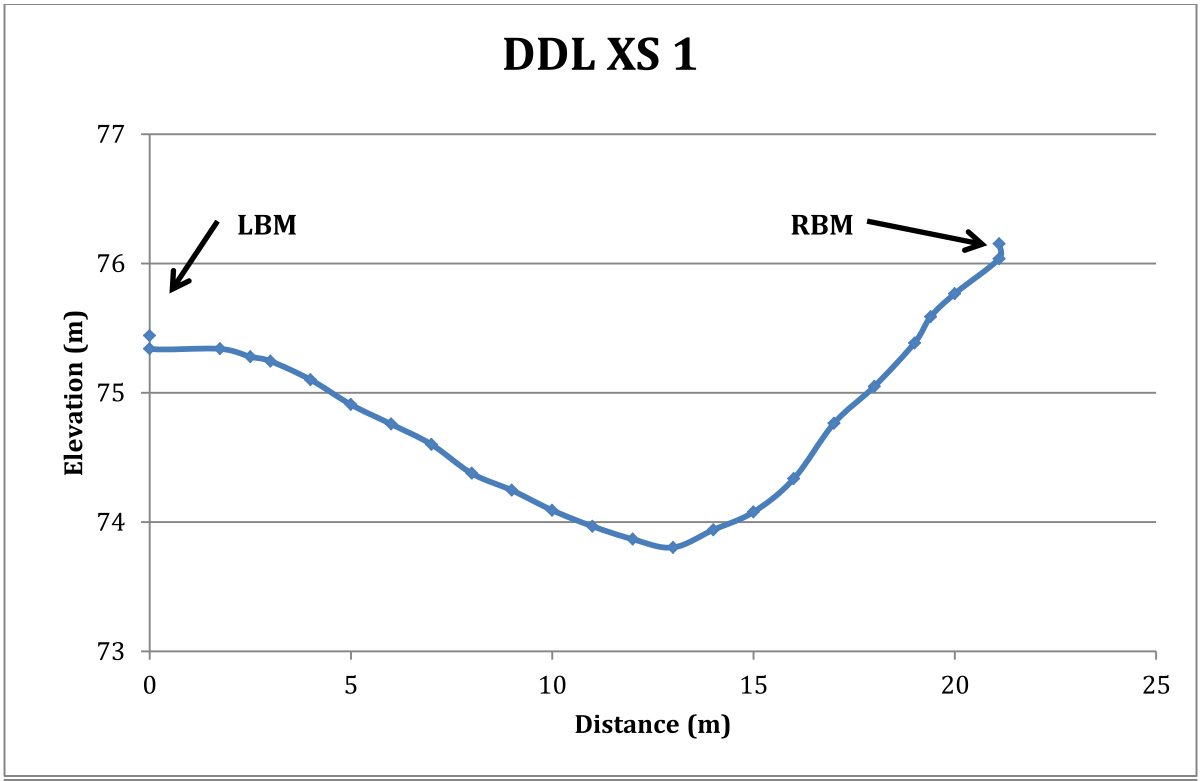
77
76
elev (M)
LBM
RBM
0
5
10
15
20
Distance (m) on tape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LBM
RBM
Elevation (m)
Distance (m)
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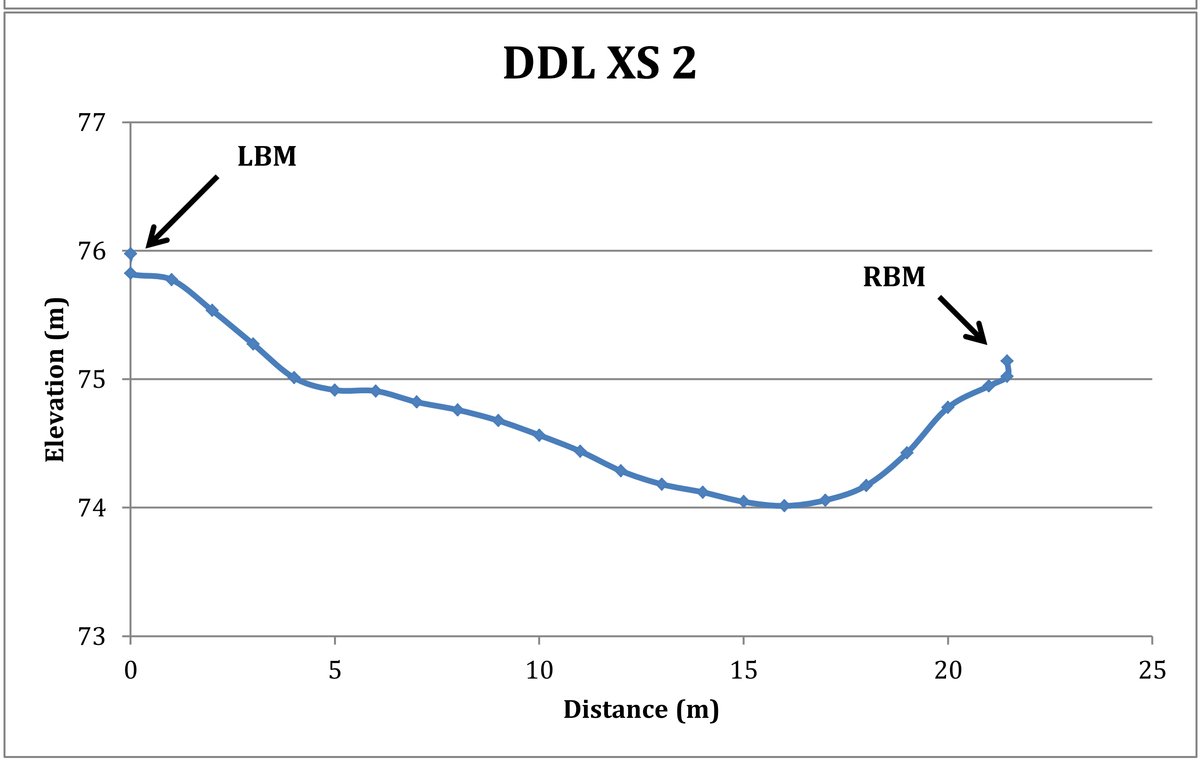
75
74
73
0
5
10
15
20
25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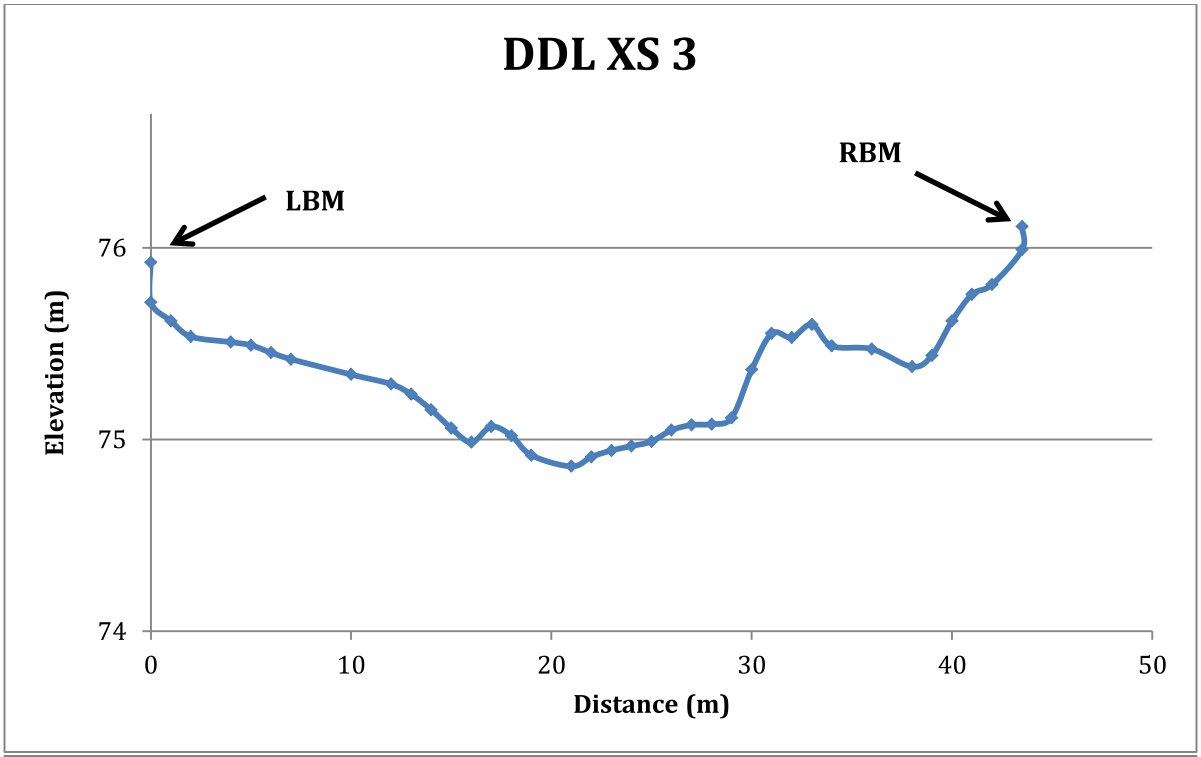
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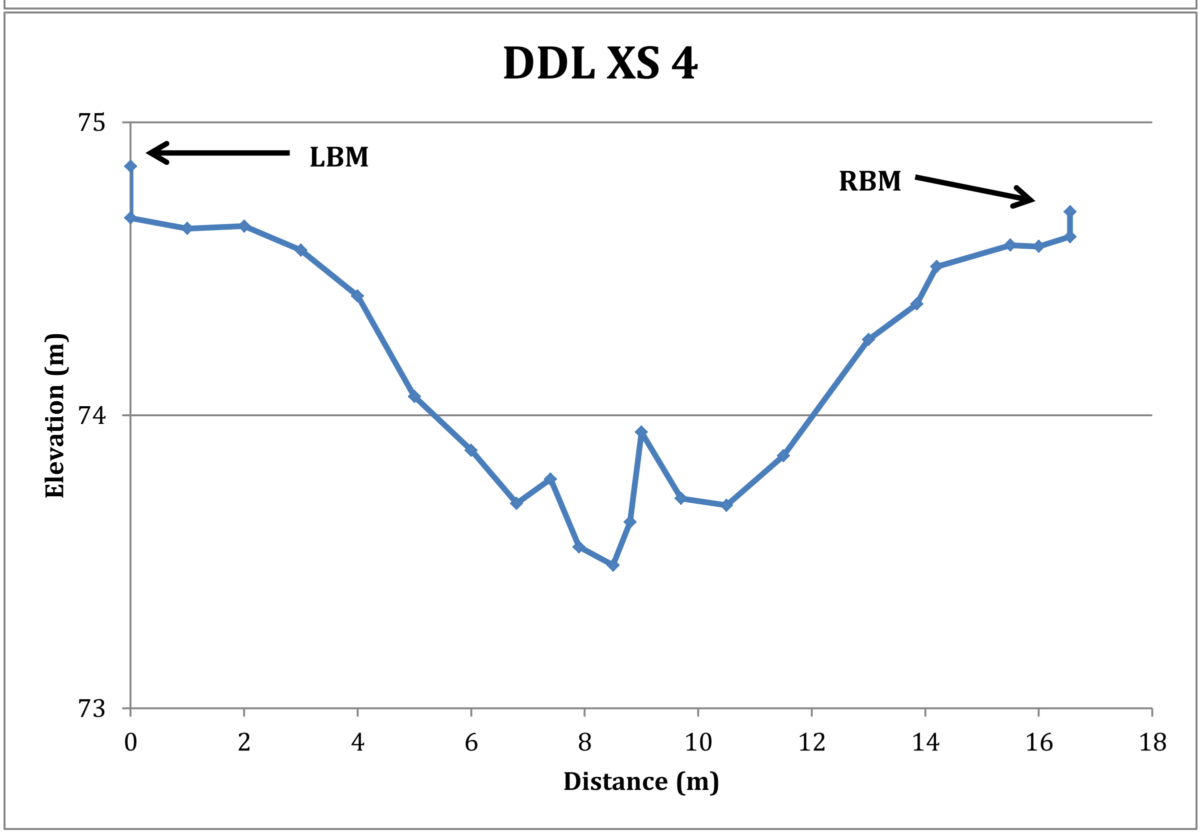
Distance (m)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16
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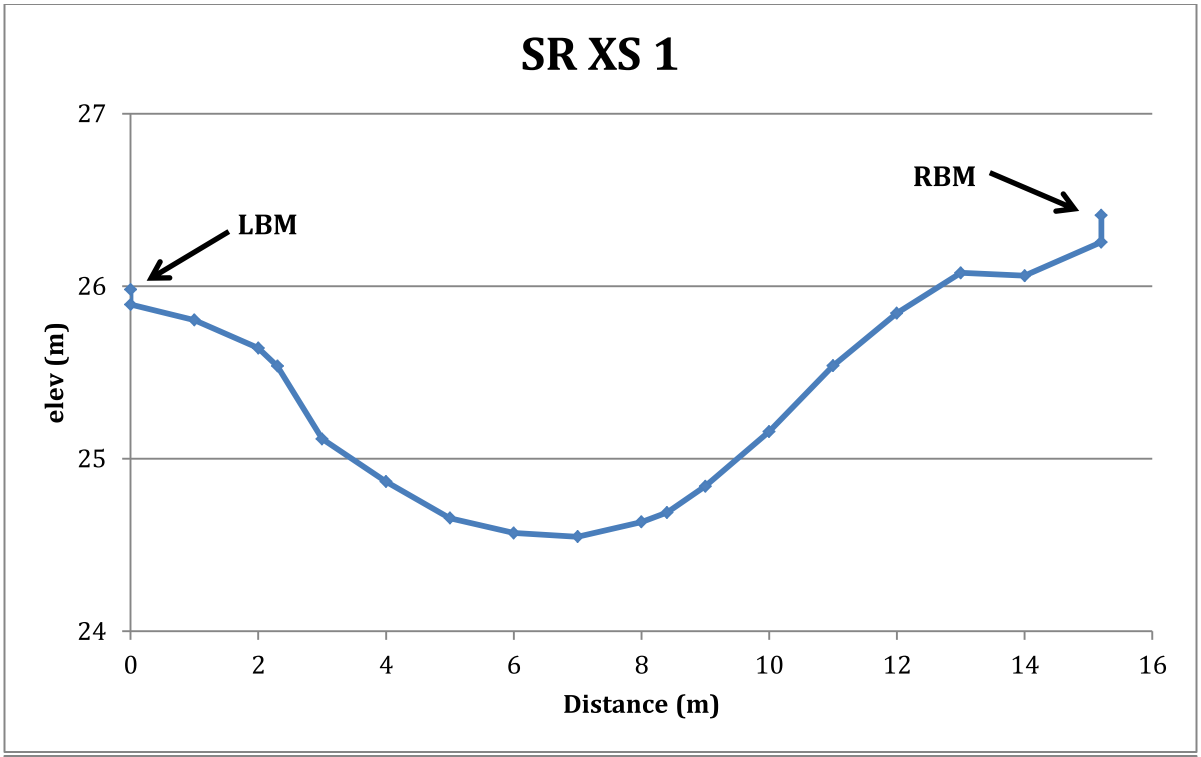
Distance (m)


SR XS 1
RBM
LBM
elev (m)
Distance (m)
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26
25
24
0
2
4
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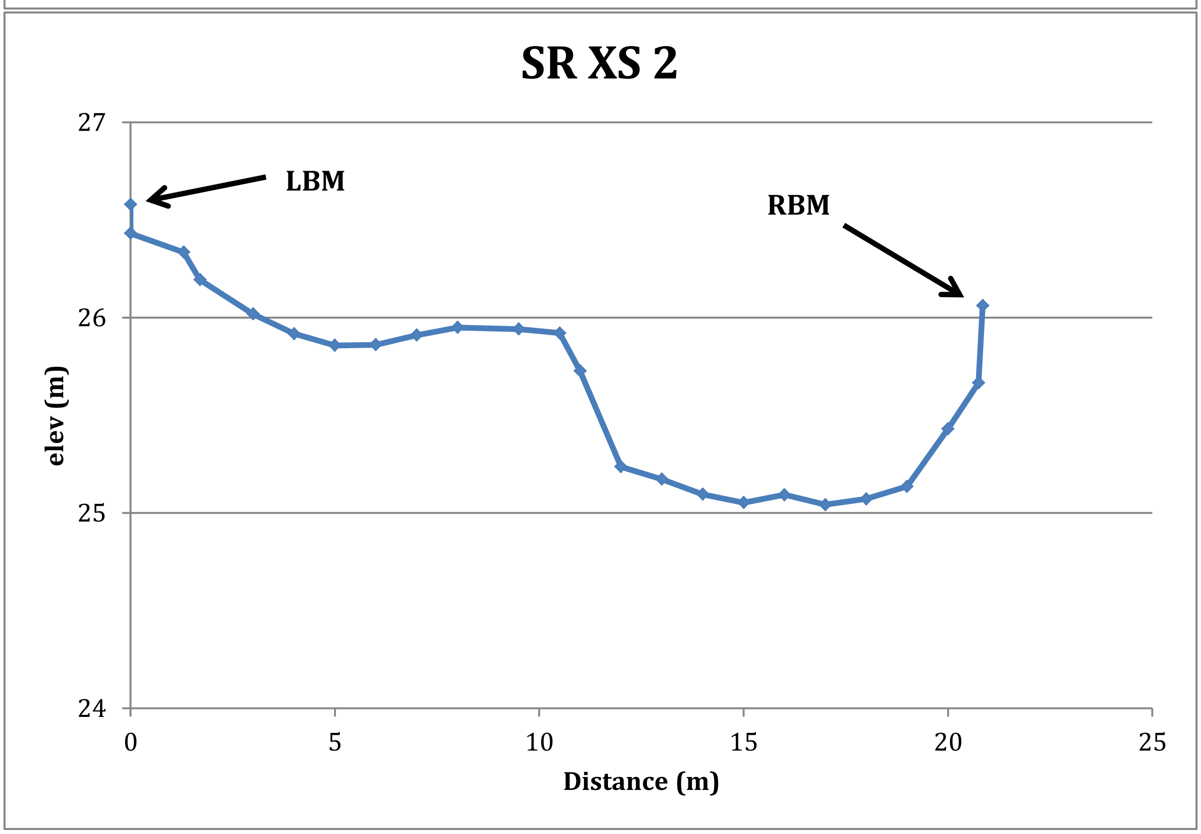
8
10
12
14
16


SR XS 2
LBM
RBM
elev (m)
Distance (m)
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26
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24
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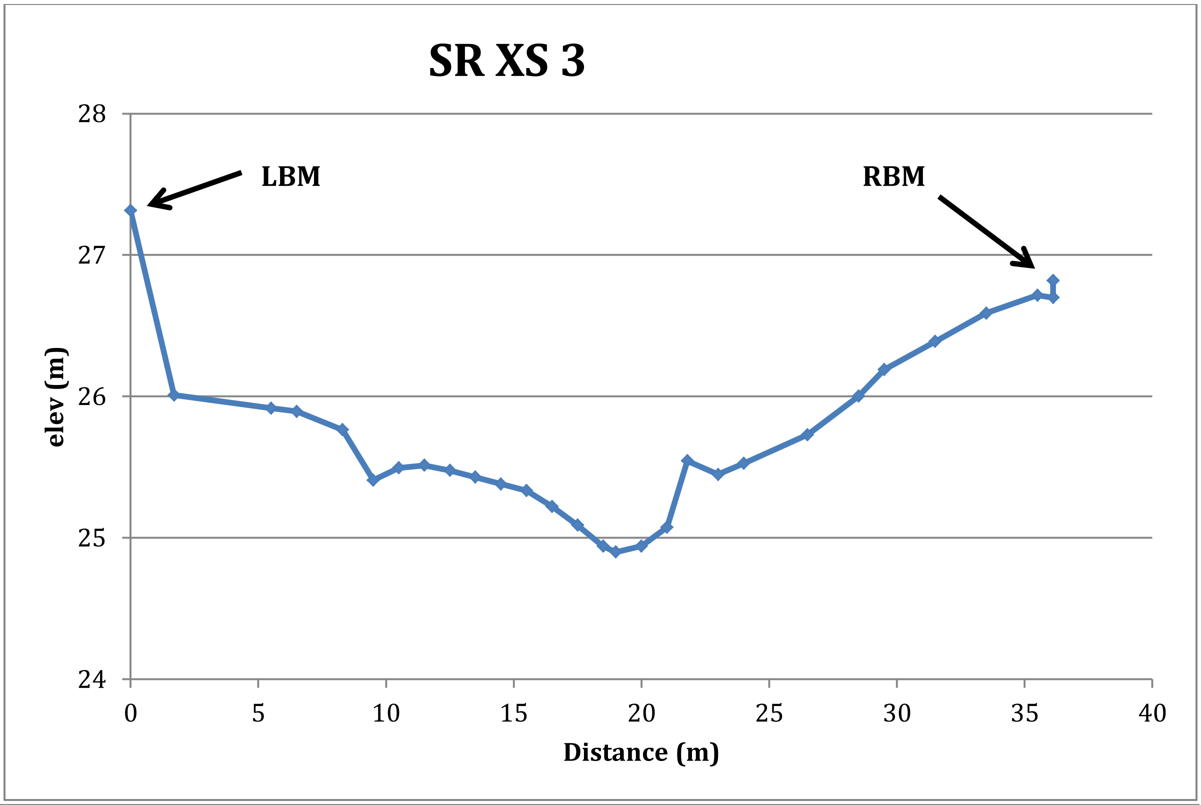
5
10
15
20
25


SR XS 3
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RBM
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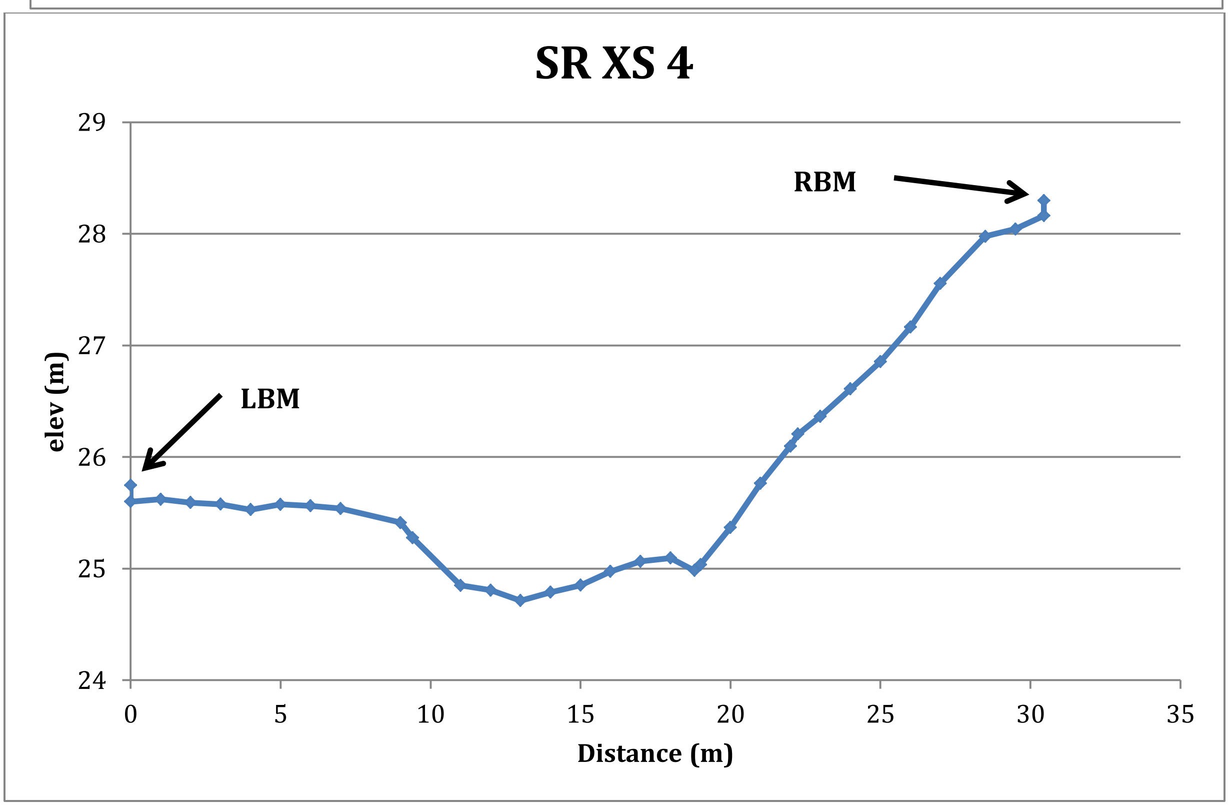
Distance (m)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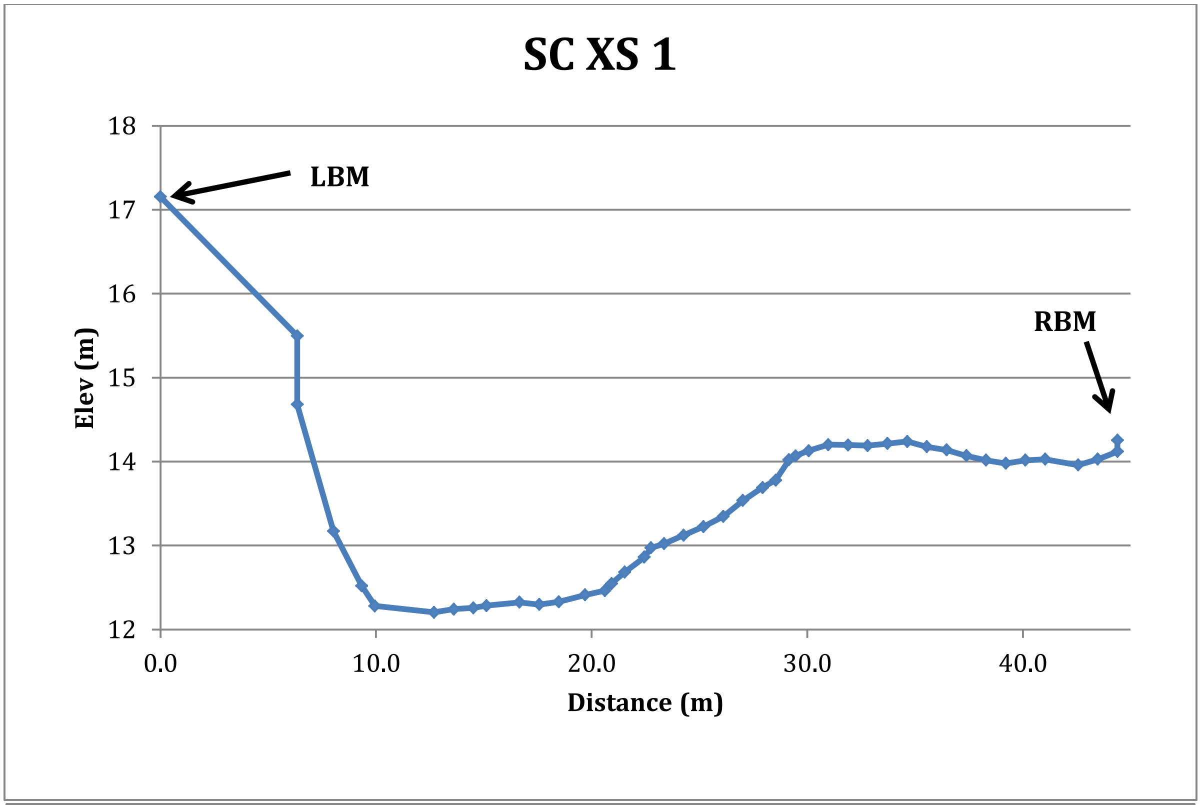
Distance (m)


SC XS 1
LBM
RBM
Elev (m)
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16
15
14
13
12
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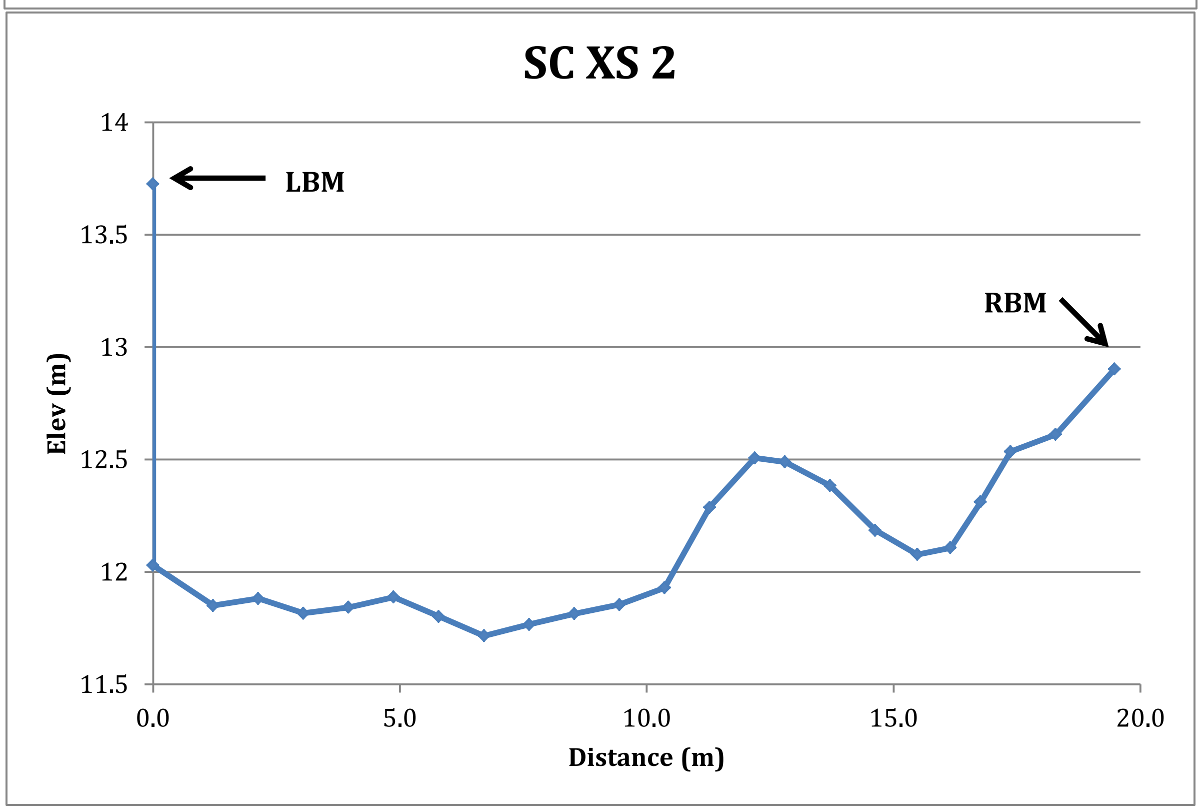
Distance (m)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LBM
RBM
Elev (m)
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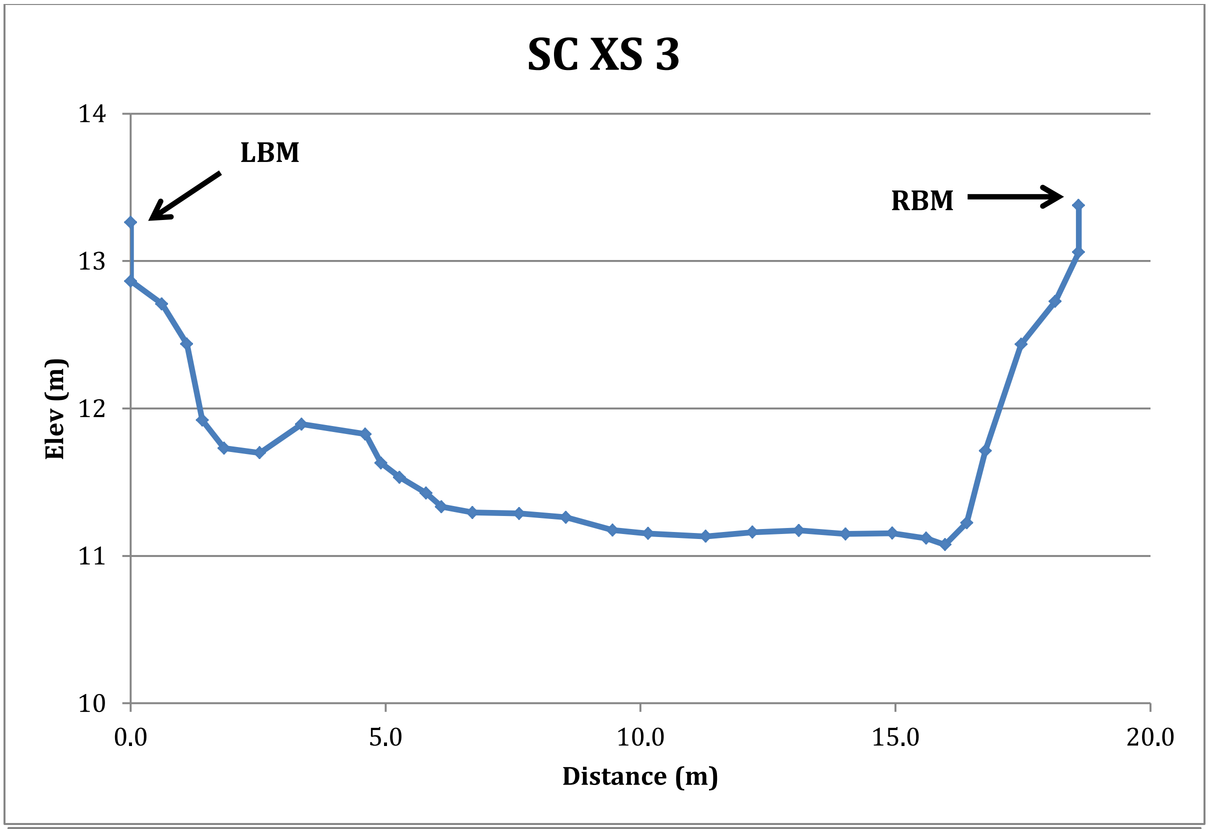
13
12.5
12
11.5
0.0
5.0
10.0
15.0
20.0
Distance (m)


SC XS 3
LBM
RBM
Elev (m)
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12
11
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0.0
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10.0
15.0
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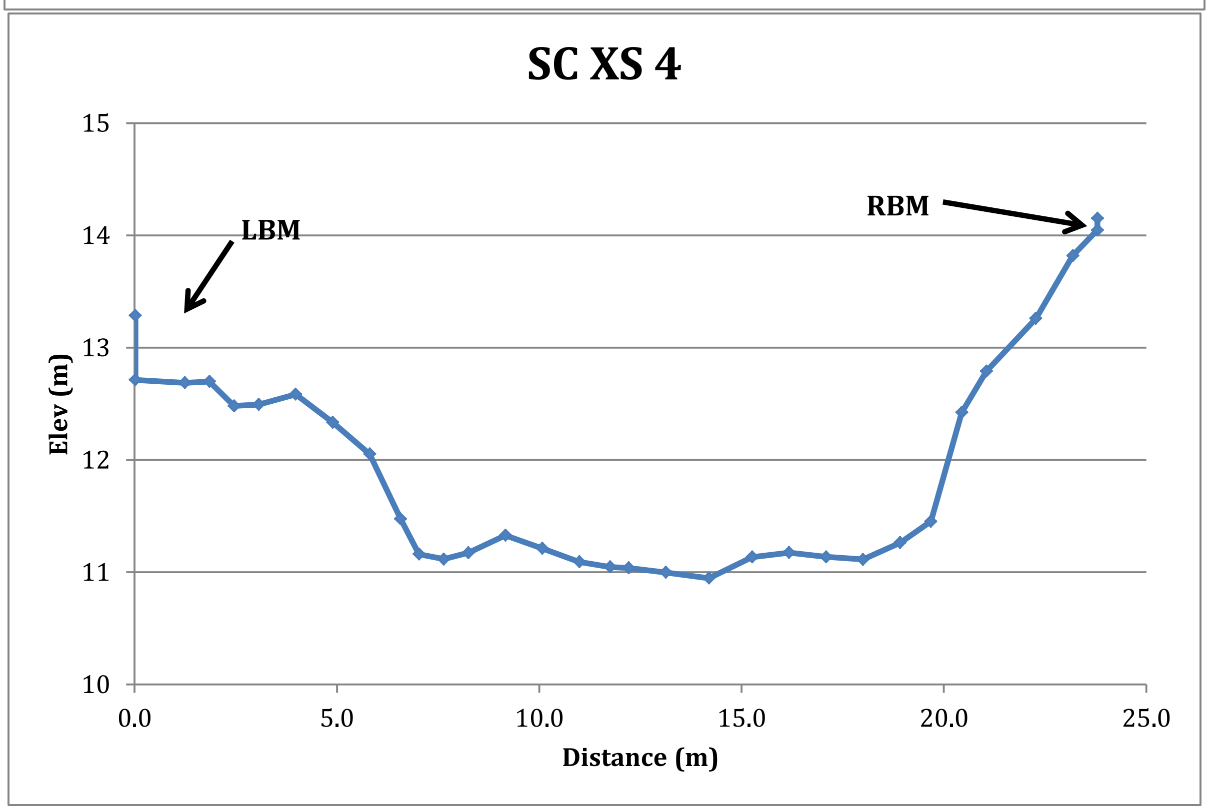
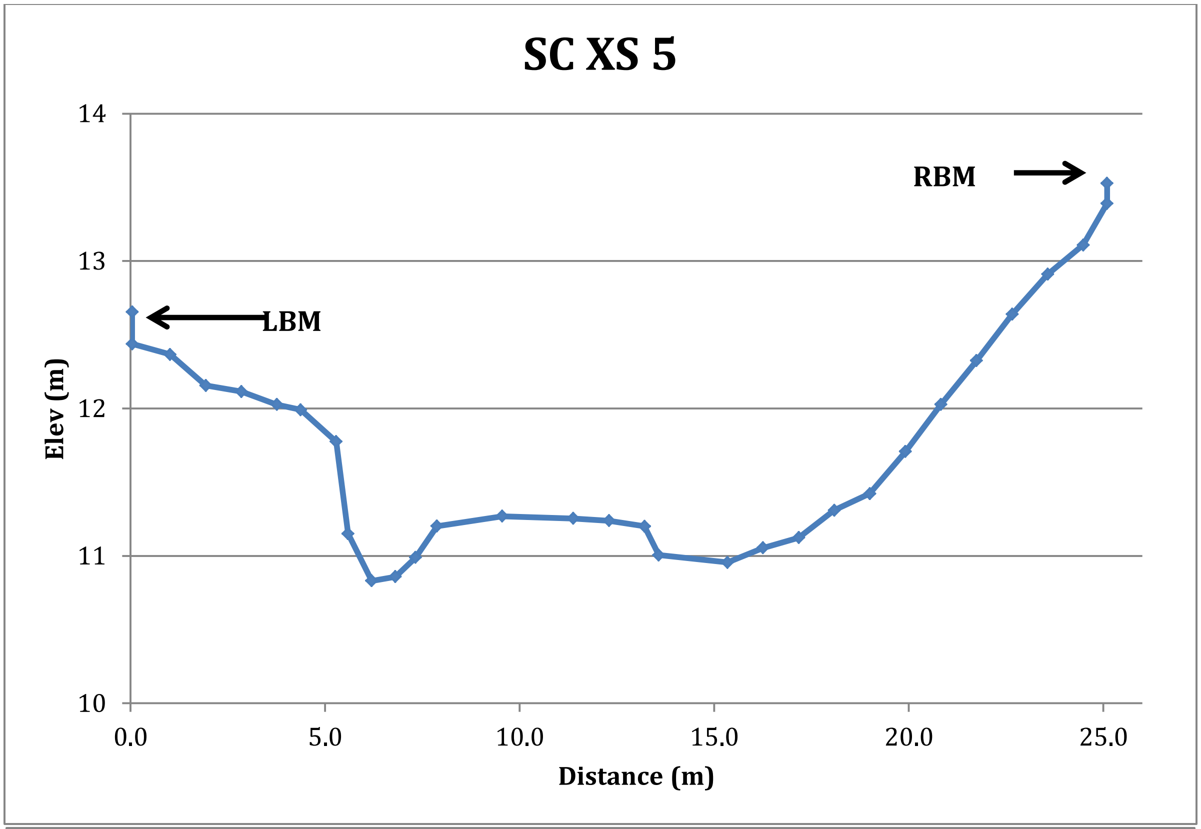
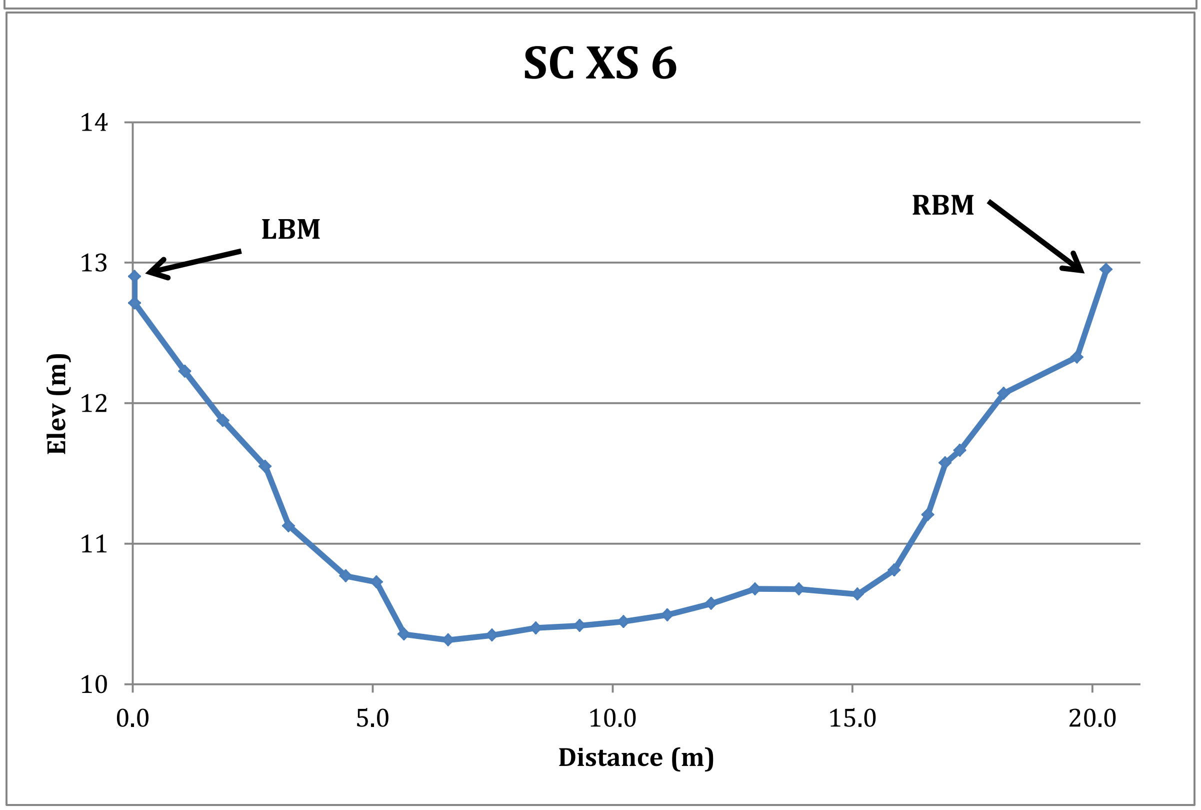
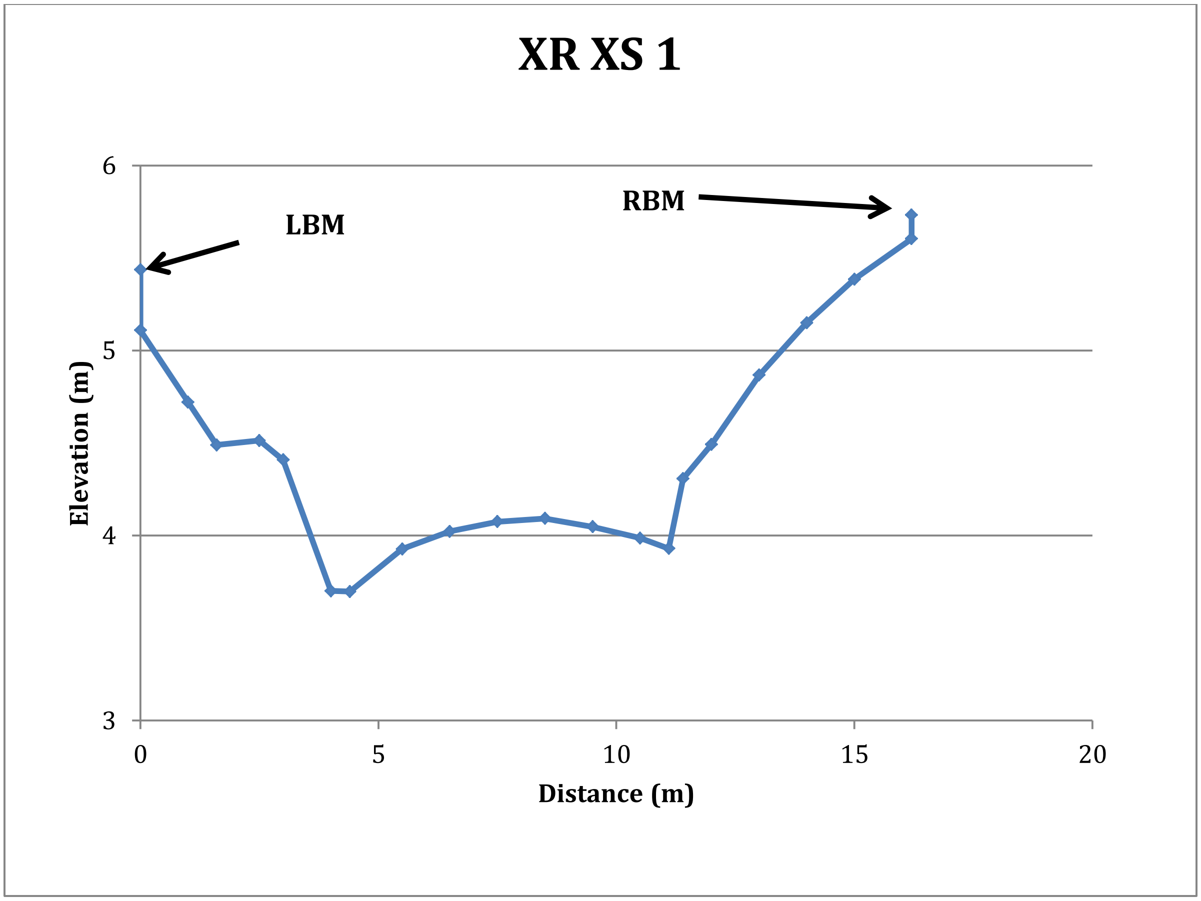
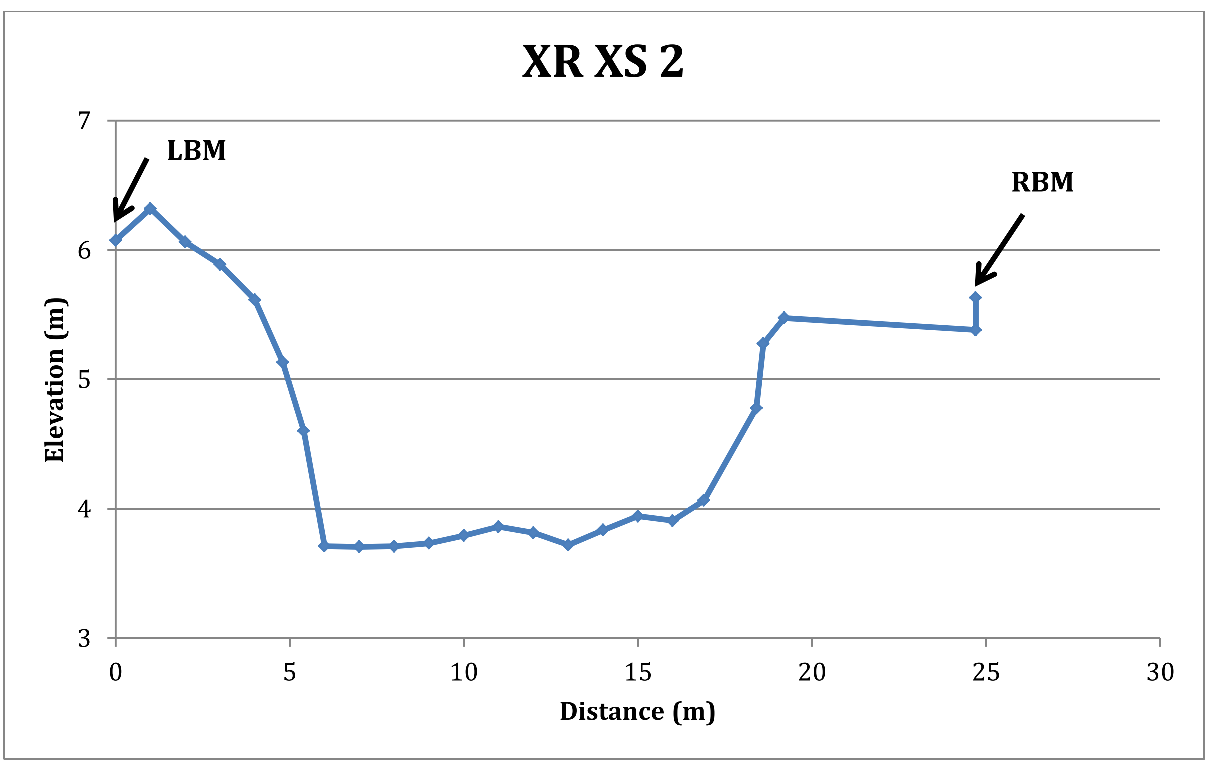
Distance (m)

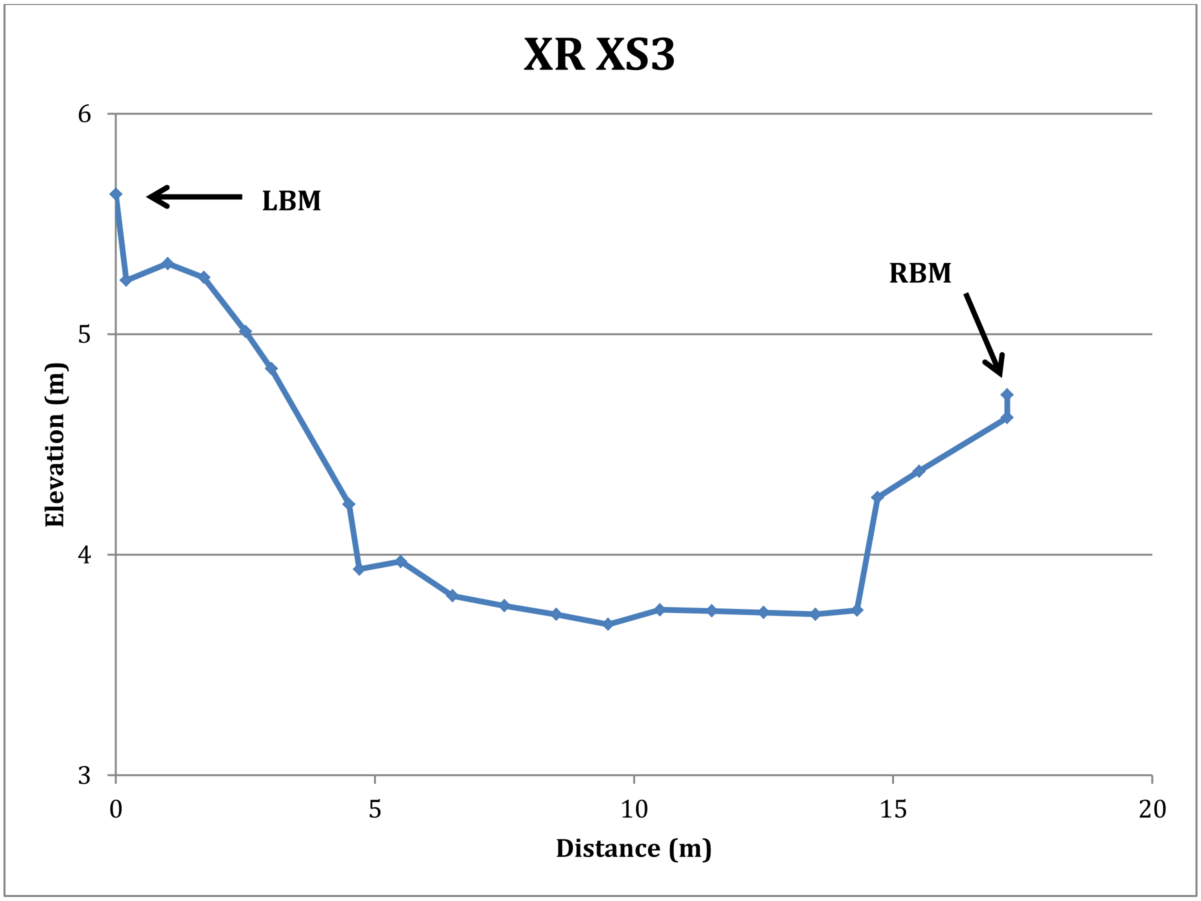

SC XS 4
LBM
RBM
Elev (m)
15
14
13
12
11
10
0.0
5.0
10.0
15.0
20.0
25.0
Distance (m)

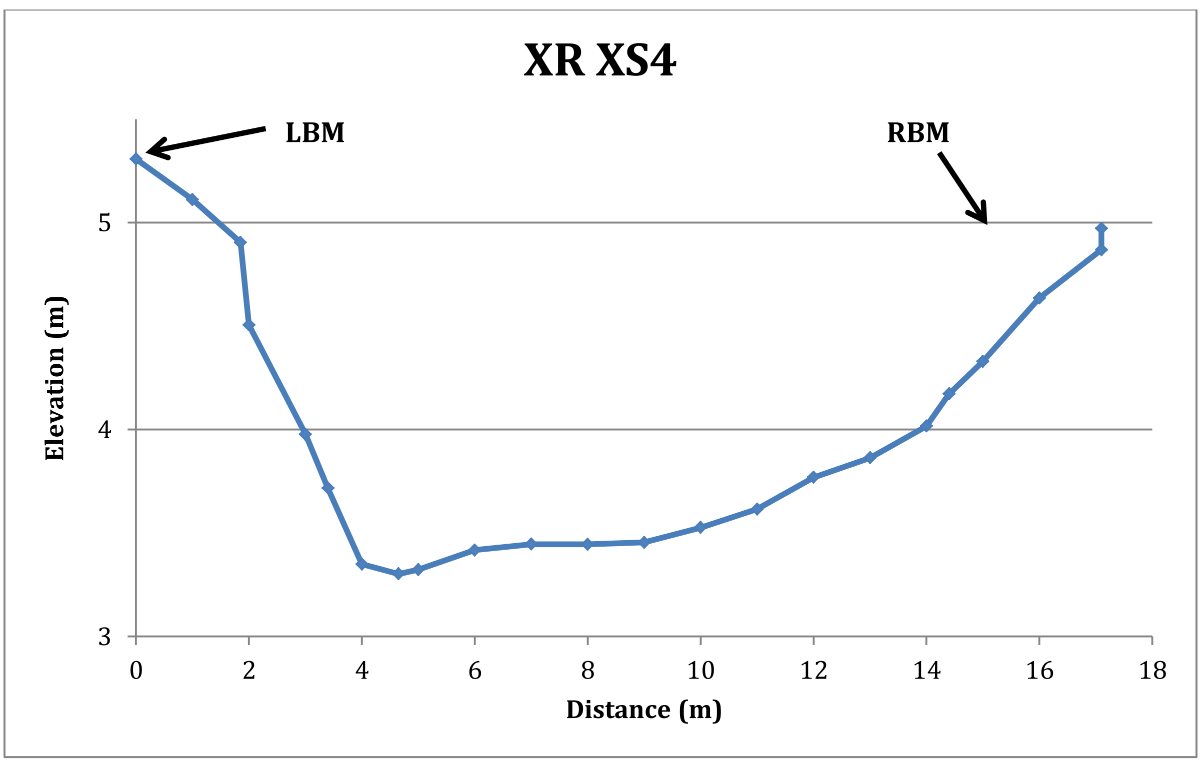

SC XS 5
14
13
12
11
10
Elev (m)
RBM
LBM
0.0
5.0
10.0
15.0
20.0
25.0
Distance (m)

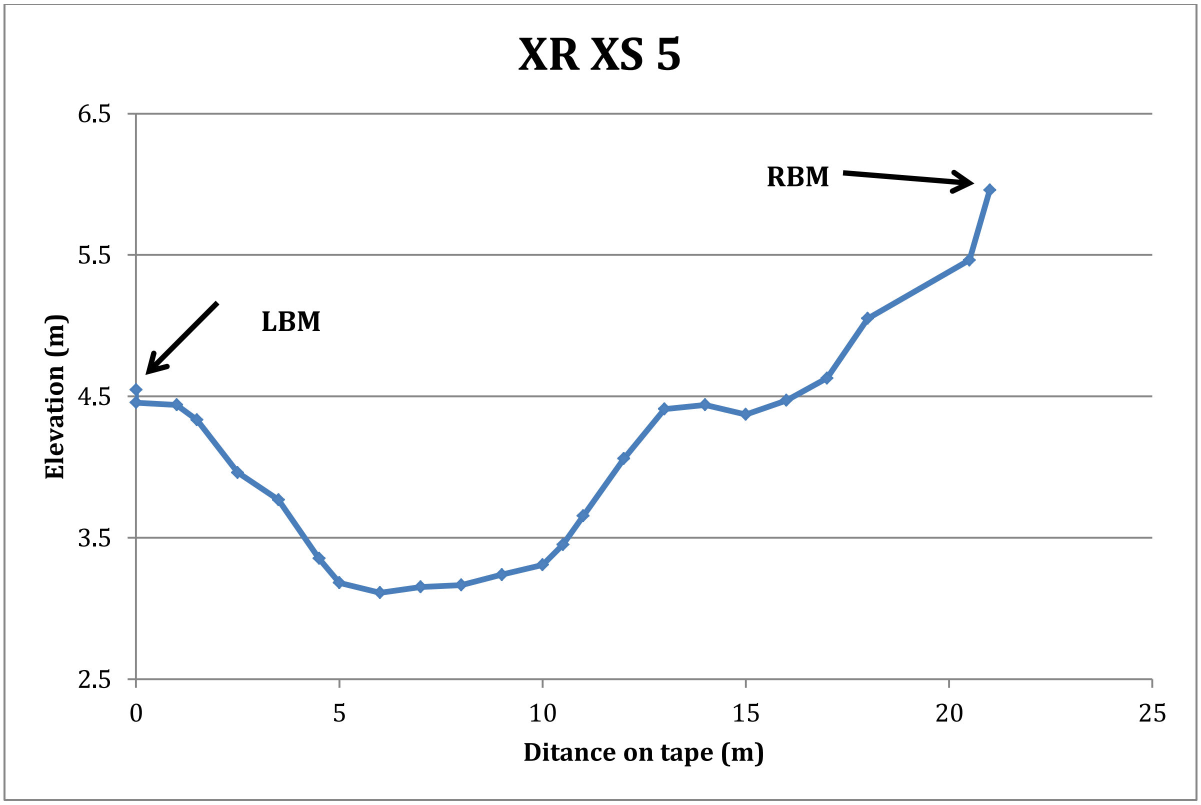

SC XS 6
14
13
12
11
10
Elev (m)
LBM
RBM
0.0
5.0
10.0
15.0
20.0
Distance (m)

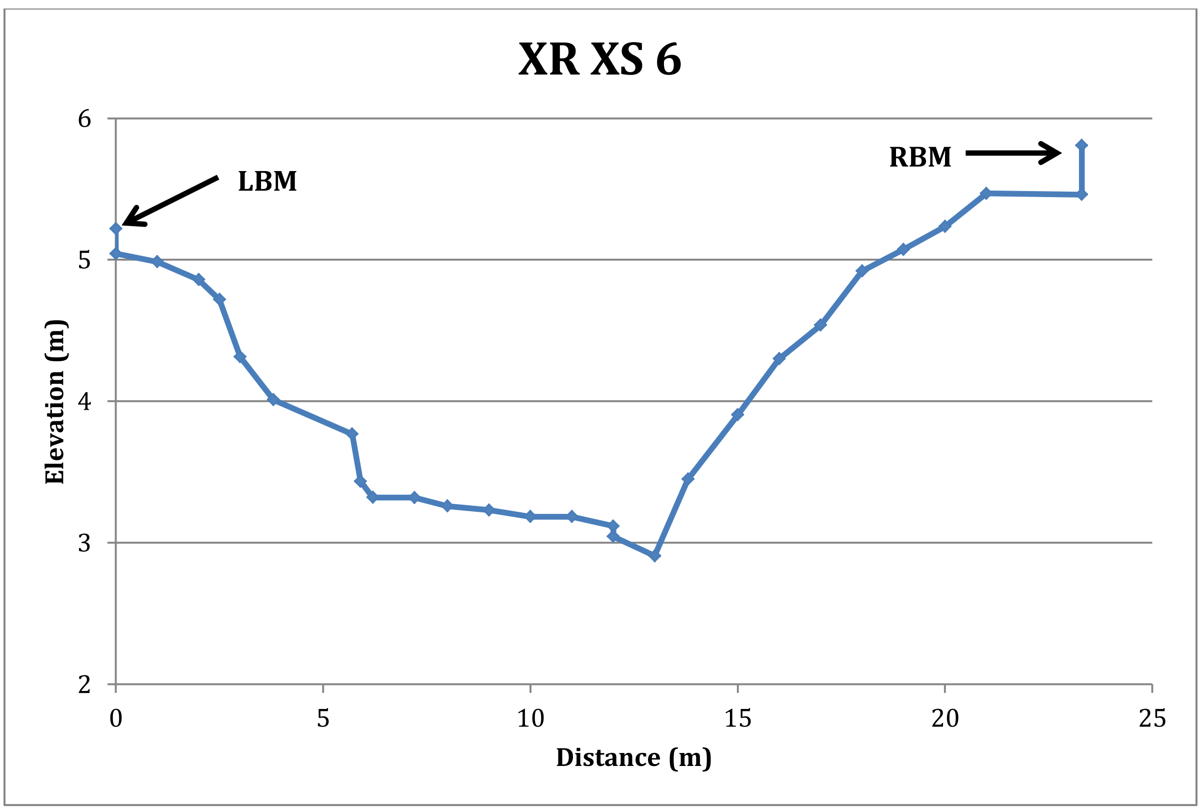

XR XS 1
LBM
RBM
6
5
4
3
Elevation (m)
0
5
10
15
20
Distance (m)


XR XS 2
LBM
RBM
7
6
5
4
3
Elevation (m)
0
5
10
15
20
25
30
Distance (m)


XR XS3
LBM
RBM
Elevation (m)
Distance (m)
6
5
4
3
0
5
10
15
20


XR XS4
LBM
RBM
Elevation (m)
Distance (m)
5
4
3
0
2
4
6
8
10
12
14
16
18


XR XS 5
RBM
LBM
Elevation (m)
6.5
5.5
4.5
3.5
2.5
0
5
10
15
20
25
Ditance on tape (m)


XR XS 6
RBM
LBM
Elevation (m)
6
5
4
3
2
0
5
10
15
20
25
Distance (m)