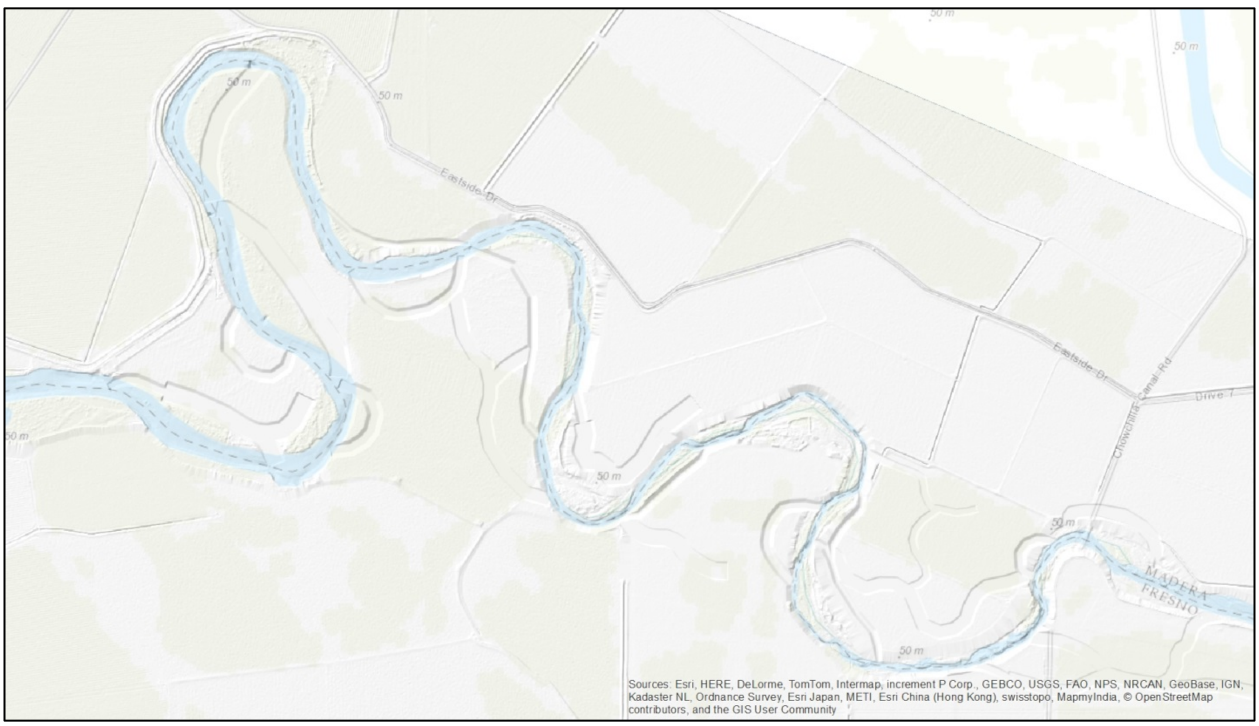
RECLAMATION
Managing Water in the West

Technical Memorandum No. 86-68260-16-01

Utilization of GIS Software to Develop As-Built Terrains for Hydraulic Modeling

Manuals and Standards Project ID: G6187



U.S. Department of the Interior
Bureau of Reclamation
Technical Service Center
Geographic Applications and Analysis Group
Denver, CO

July 2016

MISSION STATEMENTS

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Bureau of Reclamation

Technical Service Center, Denver, CO

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1.0 INTRODUCTION

The Bureau of Reclamation has established a technique to develop and modify as-built terrains for hydraulic modeling to meet the objectives of the San Joaquin River Restoration Program (SJRRP). Terrains are proprietary continuous elevation models developed by the Environmental Systems Research Institute (ESRI). The model is represented as a multiresolution, triangulated irregular network (TIN)-based surface and is generated using measurements stored as features in geodatabase feature classes. Terrains are very useful for effectively managing, processing, and integrating massive point collections of 3D data that result from collecting high-resolution elevation observations using Lidar, Sonar, and other technologies (Childs, 2011).

This technique is recognized as an improvement over a previous method which involved exporting a GIS elevation surface to contours which were then converted to CAD format for modification. After processing in CAD, the new contours were converted back into a GIS elevation surface that was then used for hydraulic modeling. The existing technique led to loss of data resolution and relied on multiple software platforms and skillsets.

1.1 BACKGROUND

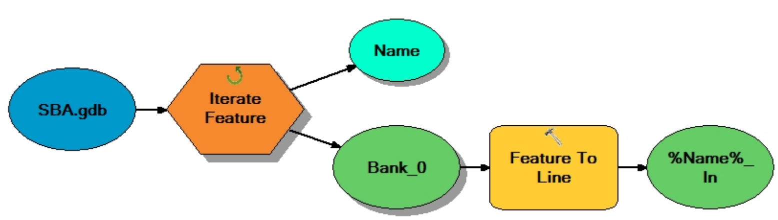
The SJRRP was established to restore flows to the San Joaquin River from Friant Dam to the confluence of Merced River and revive the Chinook salmon fishery in the river while reducing or avoiding adverse water supply impacts from restoration flows (Johnson, 2016). To accomplish this goal, Reclamation's Technical Service Center (TSC) has been tasked with completing the design of a compact bypass as well as floodplain grading and revegetation over this reach of the river. To support these efforts TSC staff developed a GIS-centric method to modify terrains for testing the hydraulic behavior of these designs. This manual serves to standardize the process resulting in consistent products from all future endeavors.

2.0 PROCESS STEPS

Note: The following process steps prepare the input data to perform a raster based substitution of calculated values that supersede the input elevations within the channel area(s) only.

1. Review Channel Cut Alignment(s) *[Figure 1]*
    a. Ensure Connectivity with Main Channel
        i. The polylines should be single features with downstream direction.
    b. Extend Into Main Channel if Necessary
        i. If a main channel centerline is available, it may be appropriate to 'snap' channel cut endpoints to the main channel centerline.

2. Create Channel Cut Buffers *[Figure 2a & 2b]*
    a. Channel Bottom Buffer Width
        i. Half of Total Bottom Width[†]
    b. Channel Bank Buffer Width
        i. Multiply Slope Ratio[†] by 10[‡]
            1. Example: 1:5 Ratio = 50
        ii. Add to Half of Total Bottom Width
    c. PARAMETERS - Side Type: Full, End Type: Flat, Dissolve Type: None
    d. Explode Multi-Part Features
    e. Spatial Join ID Field
3. Split Channel Cut Buffer(s) by ID Field *[Figure 2c]*
    a. *Split By Attribute* Tool [*Add-in*]
        i. Separates Buffers Into Singular Features
    b. Create Channel Bank and Bottom Geodatabase
4. Convert Channel Cut Buffer Polygon(s) to Polylines
    a. Model Builder Script
        i. The following script iterates through the geodatabase (Step 3b) to convert polygons to polylines.



5. Split Channel Cut Polylines At Endpoints
    a. Delete Terminus Lines *[Figure 2a]*
    b. Merge Unconnected Channel Bank and Bottom Sideline(s) (If Necessary)

[†] Information provided by client.
[‡] Choose appropriate multiplier based on topography. More rugged topography will require a larger multiplier so the resulting channel banks 'daylight' when integrated into the existing terrain.

6. Create Channel Cut Station Points *[Figure 3a]*

    a. 10 Foot Spacing

    b. Add Elevation Field (Double)

    c. Calculate Elevation *[Figure 3b]*

        i. Δ Elevation = (Upstream Elevation[§] – Downstream Elevation[§] / No. of Station Points)

        ii. (Upstream Elevation - (([OBJECTID] - 1) * Δ Elevation))

        iii. Use Six Significant Digits

        iv. Bank elevations are calculated by adding the slope ratio multiplier (Step 2b) to the upstream and downstream bottom elevation (see i. above).

Note: The following steps finalize the raster based substitution of calculated values that supersede the input elevations within the channel area(s).

7. Create Channel Cut Terrain(s) *[Figure 4]*

    a. Mass Points: Channel Cut Station Points (Step 6)

    b. Hard Clip: Channel Bank Buffer (Step 2b)

8. Convert 'Original' Area of Interest (AOI) Terrain to Raster

    a. Utilize Terrain as 'Snap Raster' for Step 9

    b. Verify Raster Cell Size Consistency

9. Convert Channel Cut Terrain to Raster(s)

10. Run *Cell Statistics* Tool on Rasters (Steps 8 & 9)

    a. PARAMETERS - Overlay Statistic: Minimum

        i. Using 'Minimum' as the overlay statistic ensures that the channel cuts supersede the elevations from the 'original' AOI.

11. Convert Output Raster (Step 10) to Terrain *[Figure 5]*

[§] Information provided by client.

2.1 VISUAL AIDS

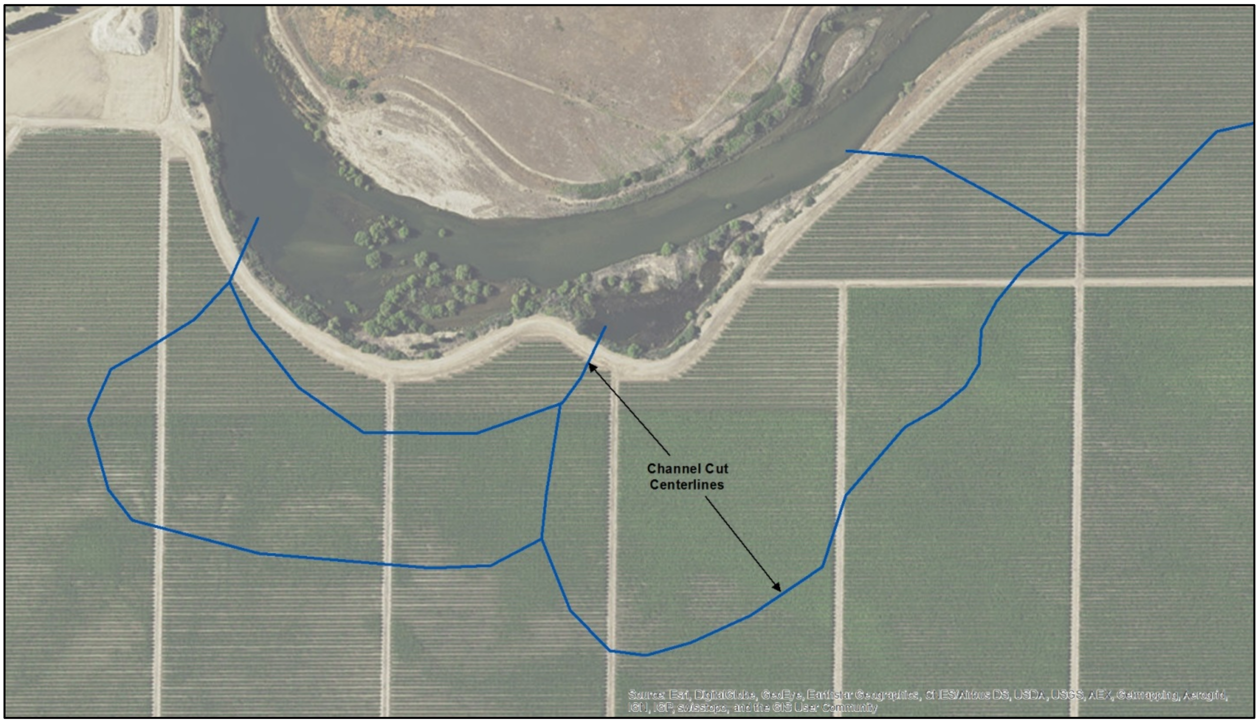


Figure 1. Extension of channel cut lines into main river channel.

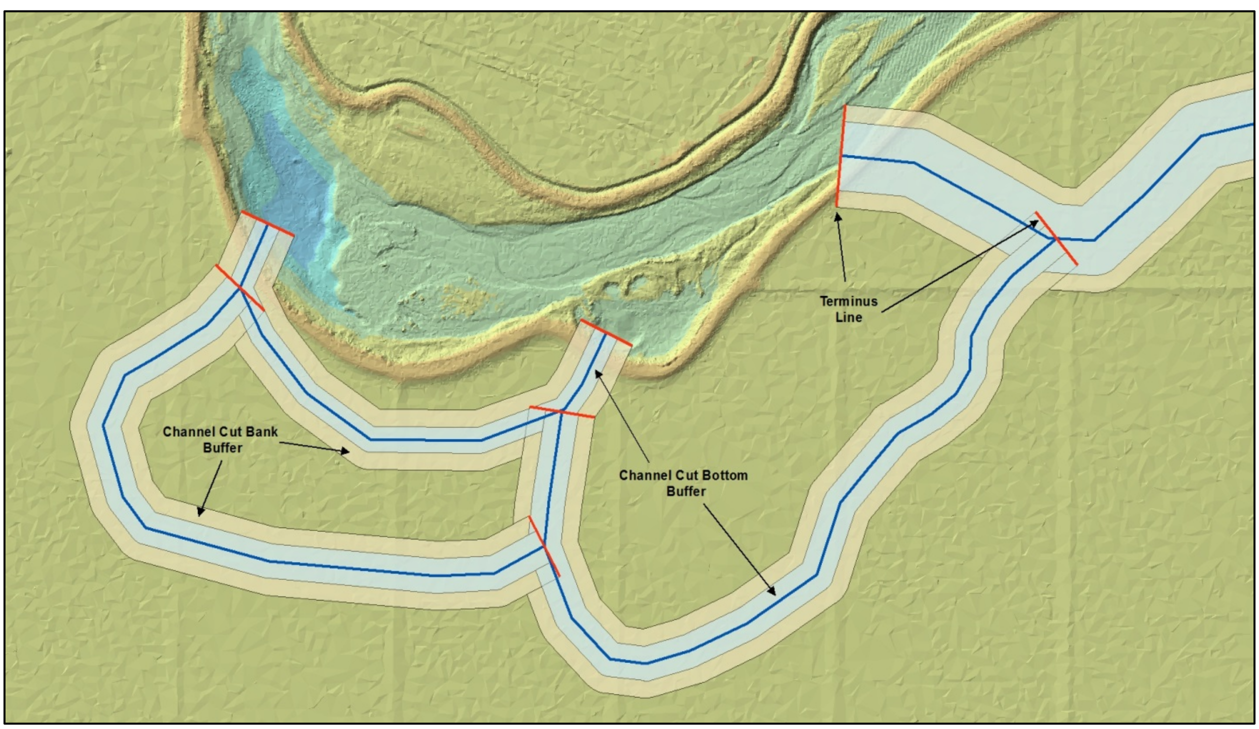


Figure 2a. Bank and bottom width channel cut buffers.

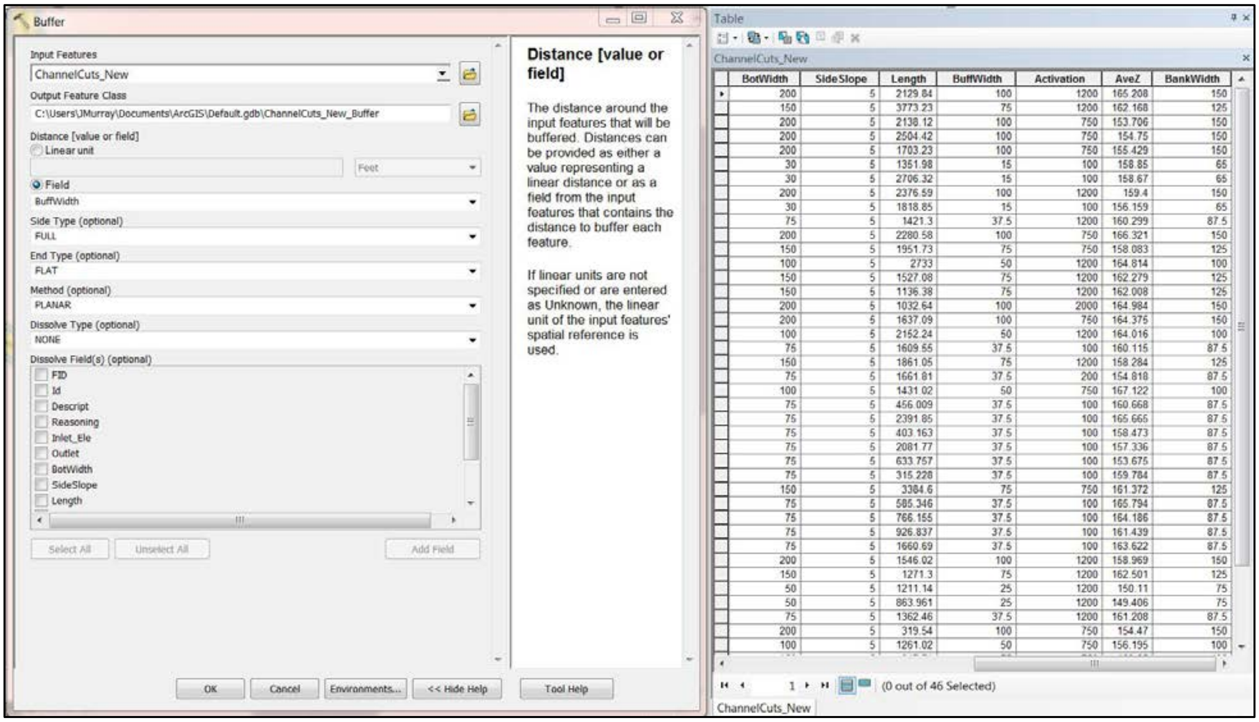


Figure 2b. ***Buffer Tool*** **GUI and** ***Buffer Table*** **with calculated attributes.**

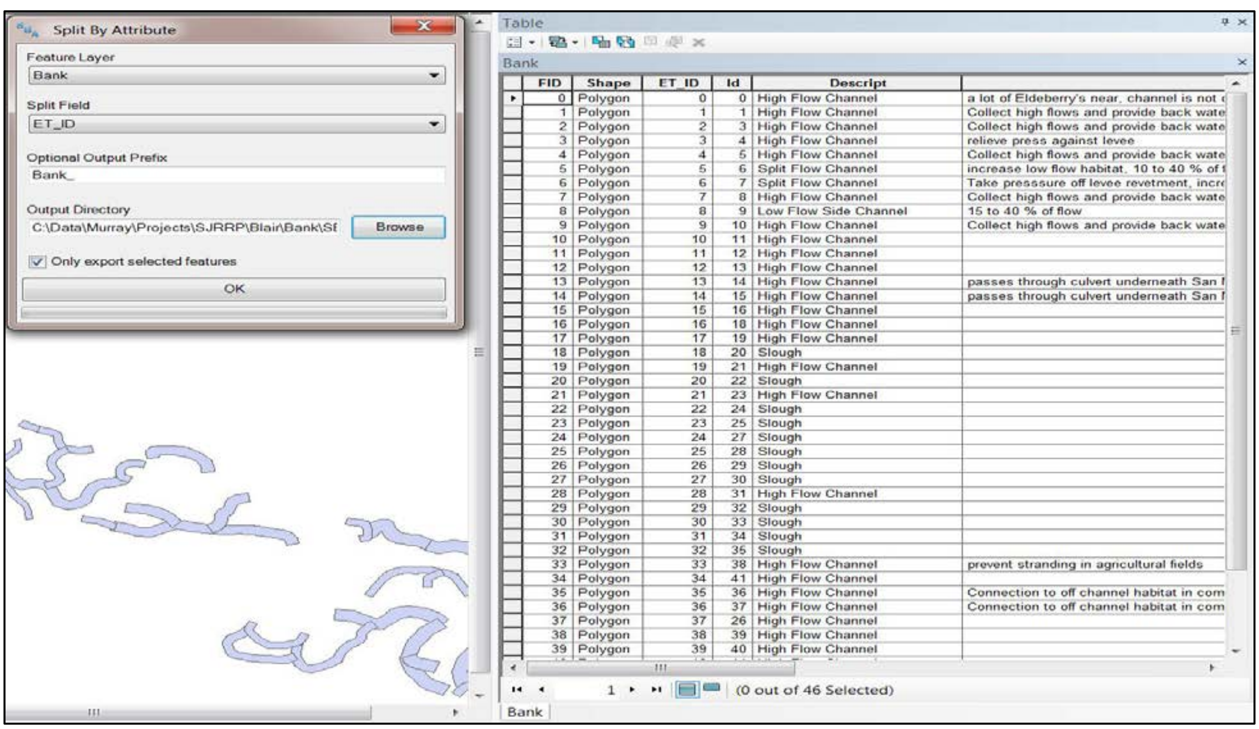


Figure 2c. Split By Attribute Tool GUI and Bank Table with ID (i.e. 'Split') field.

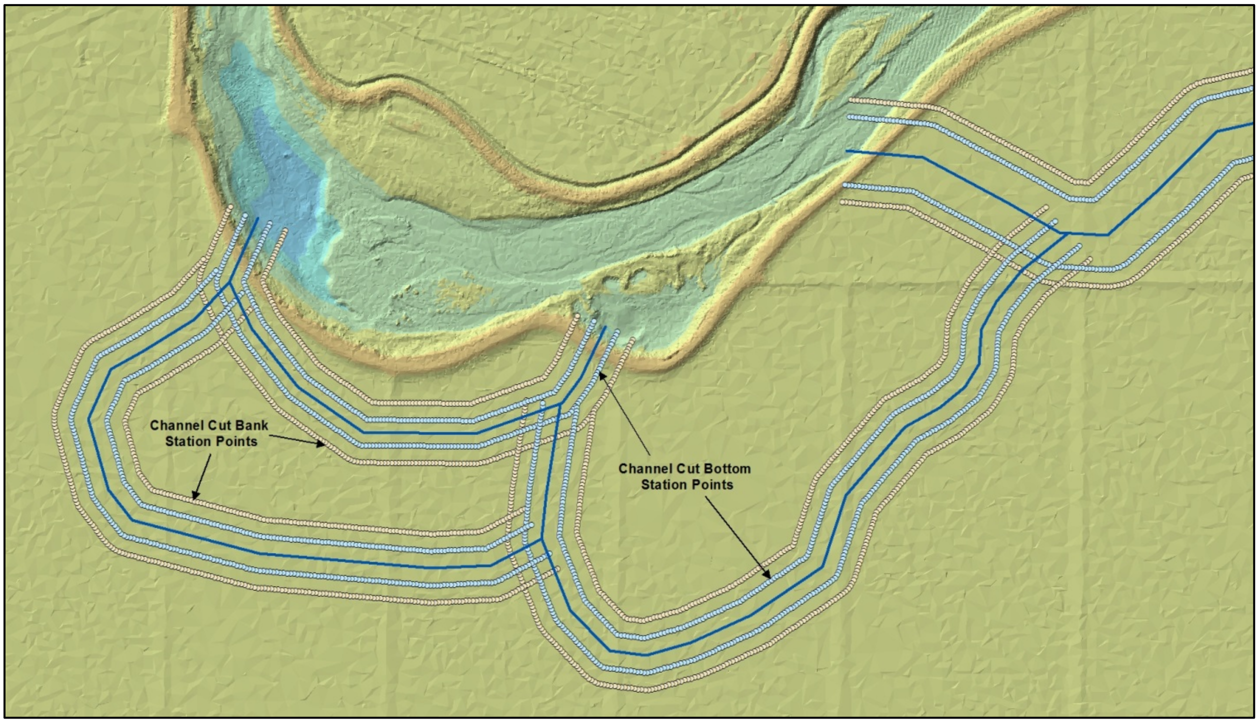
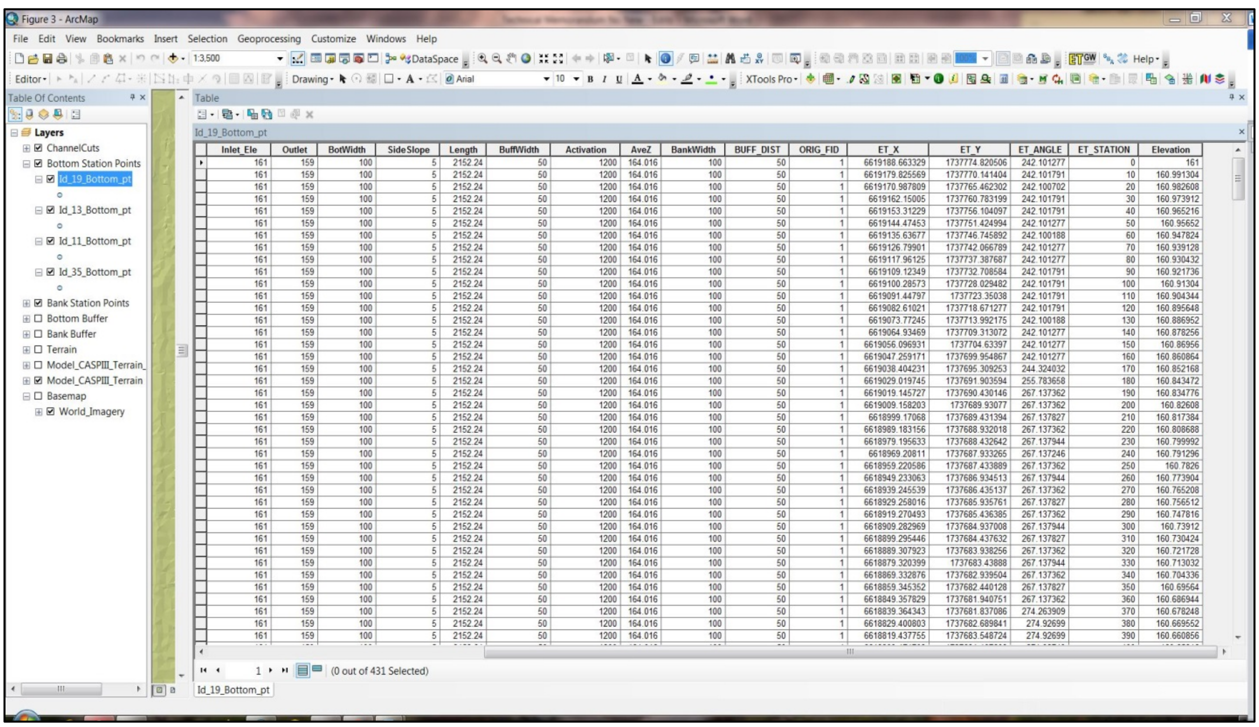


Figure 3a. Bank and bottom width channel cut station points.



Inlet_Ele	Outlet	BotWidth	SideSlope	Length	BuffWidth	Activation	AveZ	BankWidth	BUFF_DIST	ORIG_FID	ET_X	ET_Y	ET_ANGLE	ET_STATION	Elevation
161	159	100	5	2152.24	50	1200	164.016	100	50	1	6619188.663329	1737774.820506	242.101277	0	161
161	159	100	5	2152.24	50	1200	164.016	100	50	1	6619179.825569	1737770.141404	242.101791	10	160.991304
161	159	100	5	2152.24	50	1200	164.016	100	50	1	6619170.987809	1737765.462302	242.100702	20	160.982608
161	159	100	5	2152.24	50	1200	164.016	100	50	1	6619162.15005	1737760.783199	242.101791	30	160.973912
161	159	100	5	2152.24	50	1200	164.016	100	50	1	6619153.31229	1737756.104097	242.101791	40	160.965216
161	159	100	5	2152.24	50	1200	164.016	100	50	1	6619144.47453	1737751.424994	242.101277	50	160.95652
161	159	100	5	2152.24	50	1200	164.016	100	50	1	6619135.63677	1737746.745892	242.100188	60	160.947824
161	159	100	5	2152.24	50	1200	164.016	100	50	1	6619126.79901	1737742.066789	242.101277	70	160.939128
161	159	100	5	2152.24	50	1200	164.016	100	50	1	6619117.96125	1737737.387687	242.101277	80	160.930432
161	159	100	5	2152.24	50	1200	164.016	100	50	1	6619109.12349	1737732.708584	242.101791	90	160.921736
161	159	100	5	2152.24	50	1200	164.016	100	50	1	6619100.28573	1737728.029482	242.101791	100	160.91304
161	159	100	5	2152.24	50	1200	164.016	100	50	1	6619091.44797	1737723.35038	242.101791	110	160.904344
161	159	100	5	2152.24	50	1200	164.016	100	50	1	6619082.61021	1737718.671277	242.101791	120	160.895648
161	159	100	5	2152.24	50	1200	164.016	100	50	1	6619073.77245	1737713.992175	242.100188	130	160.886952
161	159	100	5	2152.24	50	1200	164.016	100	50	1	6619064.93469	1737709.313072	242.101277	140	160.878256
161	159	100	5	2152.24	50	1200	164.016	100	50	1	6619056.096931	1737704.63397	242.101277	150	160.86956
161	159	100	5	2152.24	50	1200	164.016	100	50	1	6619047.259171	1737699.954867	242.101277	160	160.860864
161	159	100	5	2152.24	50	1200	164.016	100	50	1	6619038.404231	1737695.309253	244.324032	170	160.852168
161	159	100	5	2152.24	50	1200	164.016	100	50	1	6619029.019745	1737691.903594	255.783658	180	160.843472
161	159	100	5	2152.24	50	1200	164.016	100	50	1	6619019.145727	1737690.430146	267.137362	190	160.834776
161	159	100	5	2152.24	50	1200	164.016	100	50	1	6619009.158203	1737689.93077	267.137362	200	160.82608
161	159	100	5	2152.24	50	1200	164.016	100	50	1	6618999.17068	1737689.431394	267.137827	210	160.817384
161	159	100	5	2152.24	50	1200	164.016	100	50	1	6618989.183156	1737688.932018	267.137362	220	160.808688
161	159	100	5	2152.24	50	1200	164.016	100	50	1	6618979.195633	1737688.432642	267.137944	230	160.799992
161	159	100	5	2152.24	50	1200	164.016	100	50	1	6618969.20811	1737687.933265	267.137246	240	160.791296
161	159	100	5	2152.24	50	1200	164.016	100	50	1	6618959.220586	1737687.433889	267.137362	250	160.7826
161	159	100	5	2152.24	50	1200	164.016	100	50	1	6618949.233063	1737686.934513	267.137944	260	160.773904
161	159	100	5	2152.24	50	1200	164.016	100	50	1	6618939.245539	1737686.435137	267.137362	270	160.765208
161	159	100	5	2152.24	50	1200	164.016	100	50	1	6618929.258016	1737685.935761	267.137827	280	160.756512
161	159	100	5	2152.24	50	1200	164.016	100	50	1	6618919.270493	1737685.436385	267.137362	290	160.747816
161	159	100	5	2152.24	50	1200	164.016	100	50	1	6618909.282969	1737684.937008	267.137944	300	160.73912
161	159	100	5	2152.24	50	1200	164.016	100	50	1	6618899.295446	1737684.437632	267.137827	310	160.730424
161	159	100	5	2152.24	50	1200	164.016	100	50	1	6618889.307923	1737683.938256	267.137362	320	160.721728
161	159	100	5	2152.24	50	1200	164.016	100	50	1	6618879.320399	1737683.43888	267.137944	330	160.713032
161	159	100	5	2152.24	50	1200	164.016	100	50	1	6618869.332876	1737682.939504	267.137362	340	160.704336
161	159	100	5	2152.24	50	1200	164.016	100	50	1	6618859.345352	1737682.440128	267.137827	350	160.69564
161	159	100	5	2152.24	50	1200	164.016	100	50	1	6618849.357829	1737681.940751	267.137362	360	160.686944
161	159	100	5	2152.24	50	1200	164.016	100	50	1	6618839.364343	1737681.837086	274.263909	370	160.678248
161	159	100	5	2152.24	50	1200	164.016	100	50	1	6618829.400803	1737682.689841	274.92699	380	160.669552
161	159	100	5	2152.24	50	1200	164.016	100	50	1	6618819.437755	1737683.548724	274.92699	390	160.660856

Figure 3b. *Station Point Table* with Elevation field calculations.

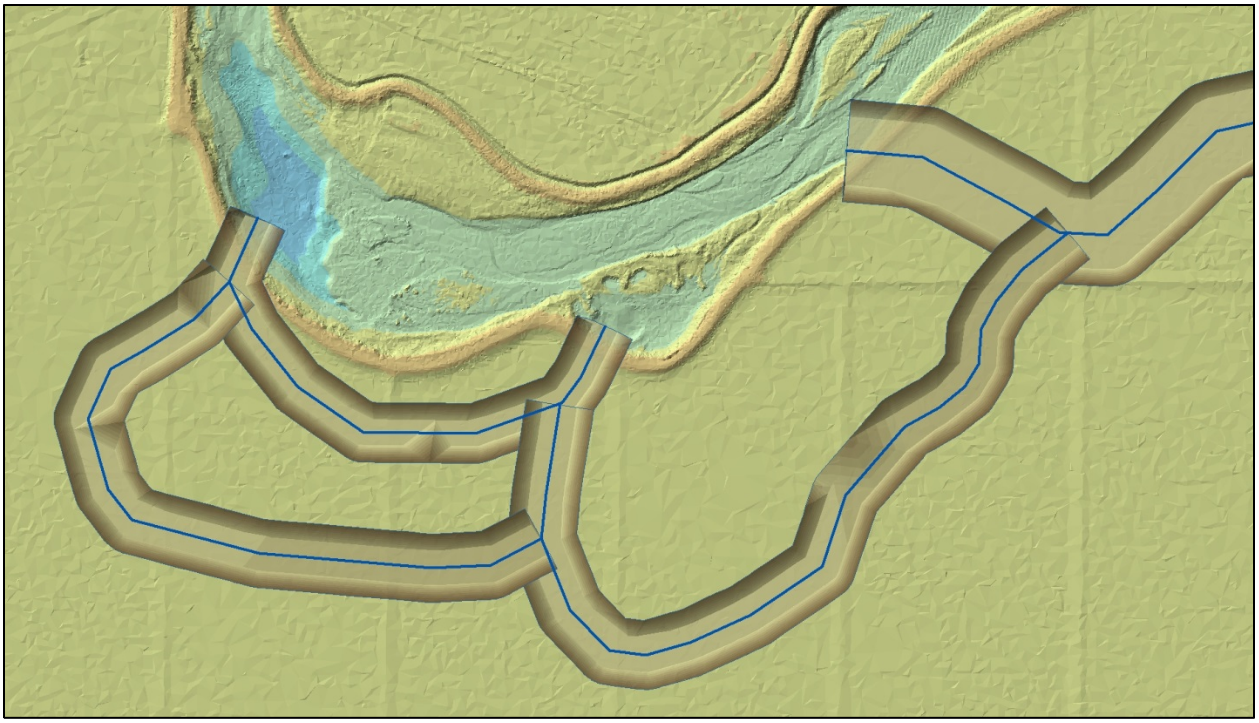


Figure 4. Channel cut terrains.

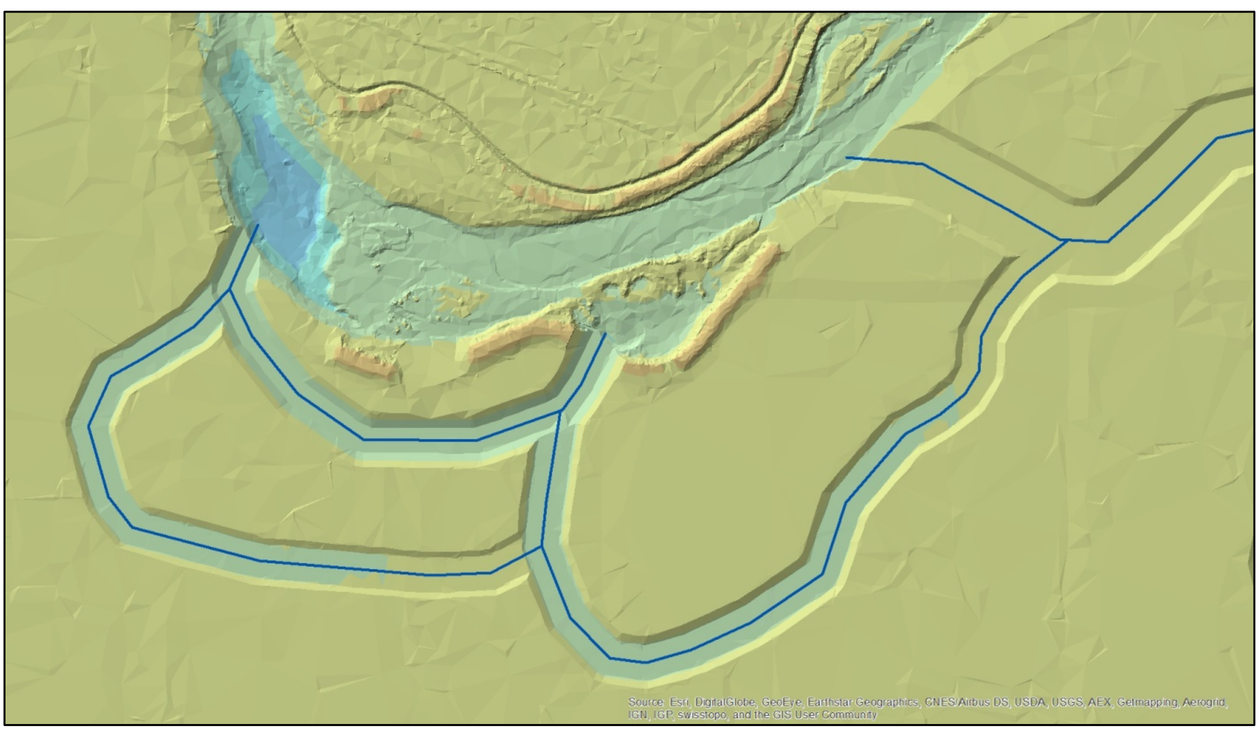


Figure 5. Final terrain with channel cuts.

3.0 REFERENCES

Childs, C. (2011). Terrain Datasets: The Top 10 Reasons to Use Them. *ArcUser Spring 2011*.

Johnson, T. (Ed.). (2016). San Joaquin River Restoration Program (SJRRP). Retrieved January 4, 2016, from http://www.restoresjr.net.