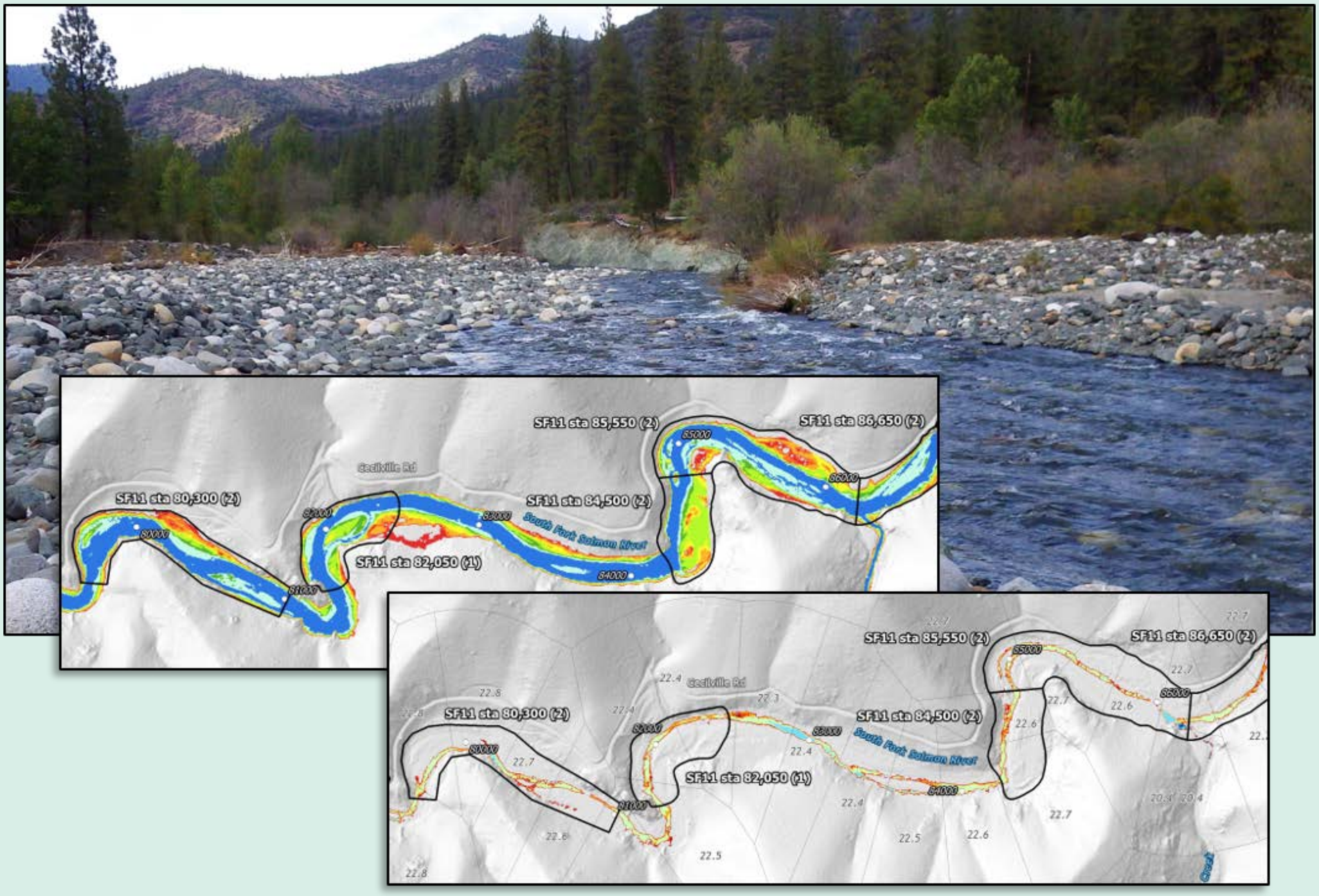
TECHNICAL MEMORANDUM ◦ JANUARY 2018

Salmon River Floodplain Habitat Enhancement and Mine Tailing Remediation Project

Phase 1: Technical Analysis of Opportunities and Constraints



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Cover photo: South Fork Salmon River near Petersburg Station.
Cover maps: Thermally suitable habitat, flow inundation mapping, and potential habitat enhancement segments in South Fork Salmon River near Saint Claire Creek.

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1 INTRODUCTION

The Salmon River Restoration Council (SRRC), in collaboration with the US Forest Service, Karuk Tribe Department of Natural Resources, and other State and Federal resource agencies, initiated the Salmon River Floodplain Habitat Enhancement and Mine Tailing Remediation Project (Project) in 2014. The Project is a collaborative, science-based process focused on strategically restoring and enhancing thermal integrity, geomorphic functions, aquatic habitat, and biological productivity of at-risk salmonids in the Salmon River. The SRRC and its partners have addressed many of the high-priority fish passage barriers and treatable sediment sources within the watershed. Restoration and enhancement of degraded floodplains, mine tailings, and aquatic habitats within lower gradient, predominantly alluvial reaches of the mainstem, North Fork, and South Fork remains the highest priority watershed work and is the focus of this process. An instream work group is implementing a parallel effort to improve aquatic habitat and salmonid productivity throughout the major tributary watersheds in the Salmon River. If these impairments are promptly addressed, the Salmon River will have exceptional value as a long-term refuge for salmon, steelhead, and other cold-water dependent aquatic species.

1.1 Project Area

The Project area includes the channel, tributary confluences, floodplains, and adjacent river terraces within the 55 river miles of the mainstem Salmon River (6.8 mi), mainstem North Fork Salmon River (19 mi), and mainstem South Fork Salmon River (29 mi). The Project area spans from the confluence of Morehouse Creek upstream to the Marble Mountain Wilderness Area boundary near Russian Creek on the North Fork and the Trinity Alps Wilderness Area boundary near Rush Creek on the South Fork (Figure 1). The Project area encompasses most of the basin-wide channel network that is relatively low-gradient (typically less than 3 percent) (Figure 2); has predominantly alluvial morphology; and provides critical spawning, over-wintering, and over-summering habitat for multiple species and runs of salmon and steelhead (Elder et al. 2002). The potential for floodplain and associated aquatic habitat enhancement in the lower mainstem Salmon River downstream of the Project area is relatively low due to the predominantly bedrock-controlled channel, high stream power, and fewer hydraulically mined areas. Floodplain and associated aquatic habitat enhancement opportunities are similarly limited in the steep, confined, and bedrock-controlled tributary channel network within the Project area, much of which occurs in wilderness areas with limited access and is upstream of the extent of anadromy.

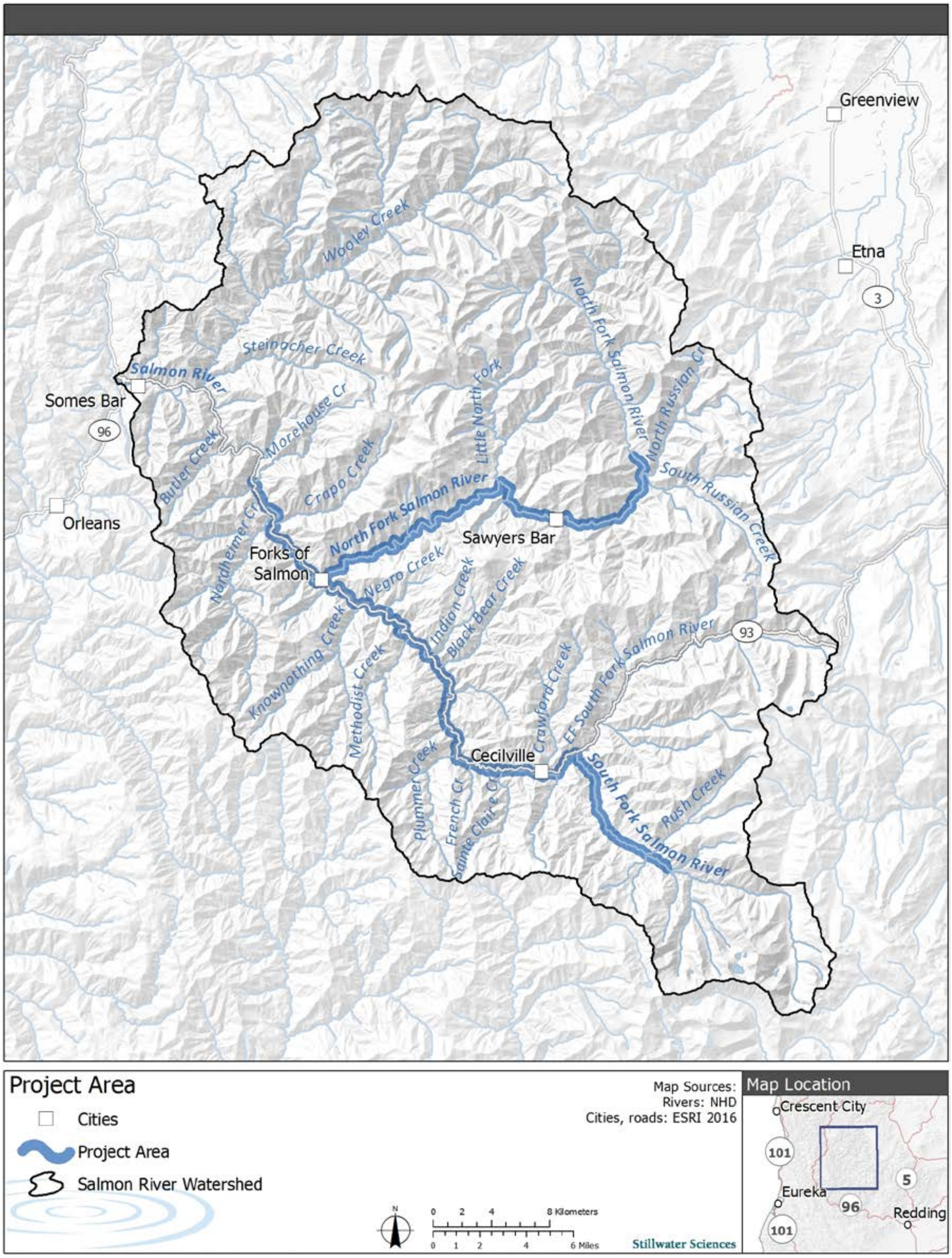

Figure 1. Salmon River Project area.

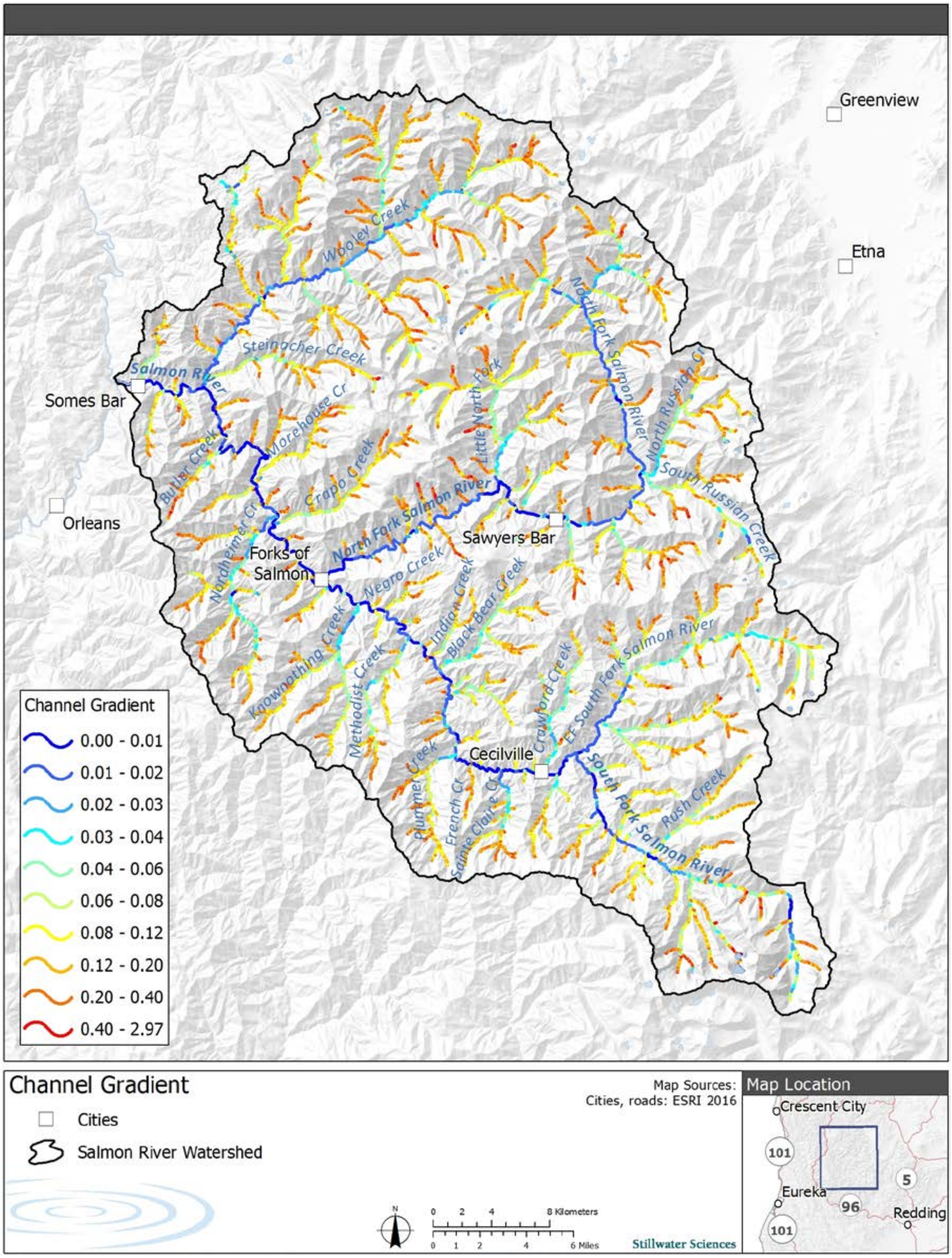

Figure 2. Channel gradient in the Salmon River basin. Salmonids predominately use channels with slopes of less than 0.04 (4%).

1.2 Background

The Salmon River hosts all of the native anadromous fish runs present in the Klamath River, including Southern Oregon/Northern California Coast (SONCC) coho salmon (*Oncorhynchus kisutch*), Upper Klamath-Trinity Rivers (UKTR) fall-run Chinook salmon (*Oncorhynchus tshawytscha*) and spring-run Chinook salmon (*Oncorhynchus tshawytscha*), Klamath Mountains Province (KMP) summer steelhead (*Oncorhynchus mykiss irideus*) and winter steelhead (*Oncorhynchus mykiss irideus*), Pacific lamprey (*Entosphenus tridentatus*), and green sturgeon (*Acipenser medirostris*). As one of the highest elevation Klamath River sub-basins that is primarily in federal ownership and has few consumptive water diversions, the Salmon River has some of the highest anadromous fisheries value in the basin (Elder et al. 2002) and is a key long-term refuge for these fish and other cold-water dependent aquatic species.

The Salmon River watershed is particularly important to the resiliency of threatened SONCC coho salmon (NMFS 2014), KMP summer steelhead, and UKTR spring-run Chinook salmon; all of which have juvenile life-histories that require over-summering in habitats with suitably cool water. The Salmon River has the largest self-sustaining population of UKTR spring-run Chinook salmon in the Klamath Basin and is the least influenced by hatcheries (SRF 2016). Approximately 110 miles of habitat is accessible to spring-run Chinook in the Salmon River (West 1991). The South Fork and North Fork of the Salmon River support the majority of the remaining spawning population, although spawning also occurs in some of the larger tributaries, including Nordheimer, Knownothing, Methodist, and Wooley creeks (Moyle et al. 2017).

Wild spring Chinook and coho salmon runs in the Salmon River face a high risk of extinction, however, due to major stressors. These stressors include (NMFS 2014):

- Diminished structure in the baseflow channel, reduced floodplain connectivity, and degraded riparian conditions that limit juvenile rearing and overwintering habitat;
- Elevated summer water temperatures and a dependence on impacted summer thermal refuges that limit juvenile over-summering carrying capacity; and
- Coarsened bed material that limits suitable spawning habitat.

These stressors result from hydrologic, geomorphic, and vegetation changes related to disruption of the natural fire regime, timber harvest, sediment delivery from roads and landslides, scour by large floods and debris torrents, and historical mining (USFS 1994a, 1994b, 1995a, 1995b). The North Coast Regional Water Quality Control Board lists the Salmon River as temperature impaired and attributes the impairment largely to loss of riparian shade cover and changes in channel geometry associated with aggradation (NCRWQCB 2005). As the primary federal land owner in the Salmon River watershed, the USFS is responsible for managing the Salmon River as a Wild and Scenic River and taking actions to reduce temperature impairments.

One of the most important factors leading to the decline and continued low abundance of anadromous salmonids in the Salmon River is the legacy effect of historical placer mining on channel and floodplain habitat conditions throughout the mainstem and larger tributary reaches (Stumpf 1979, SRRC 2017). Hydraulic and dredge placer mining in the Salmon River between about 1870 and 1950 led to profound and lasting changes, eroding over 1,859 acres adjacent to the mainstem and larger tributary channels and delivering an estimated 20.3 million cubic yards of sediment to the river (Figure 3) (Hawthorne 2017, de la Fuente and Haessig 1993). Placer mining denuded floodplains and adjacent river terraces and hillslopes, reduced riparian shade cover, and exposed the stream channel and surrounding areas to increased solar radiation.

Delivery of hydraulic mine debris resulted in as much as 5 meters of channel aggradation, on average, throughout the predominantly alluvial reaches within the Project area. Aggradation by hydraulically mined sediment widened and shallowed alluvial reaches, filled pools, reduced the complexity and connectivity of floodplain habitats, and led to coarsening and armoring of the channel bed. Coarse sediment stored in the bankfull channel, denuded floodplains, and mine tailings on terraces along the river corridor continues to prevent riparian vegetation establishment, and due to the increased exposure to solar radiation and thermal mass, creates a significant heating effect. These impacts significantly reduce the amount and quality of spawning, over-summering, and over-wintering habitat and decrease the cumulative channel length that remains thermally suitable for salmonids during the summer, thereby constraining population productivity and increasing extinction risk. These legacy impacts to the channel and floodplain inhibit natural recovery and require intervention to recover within human and salmon population time scales.

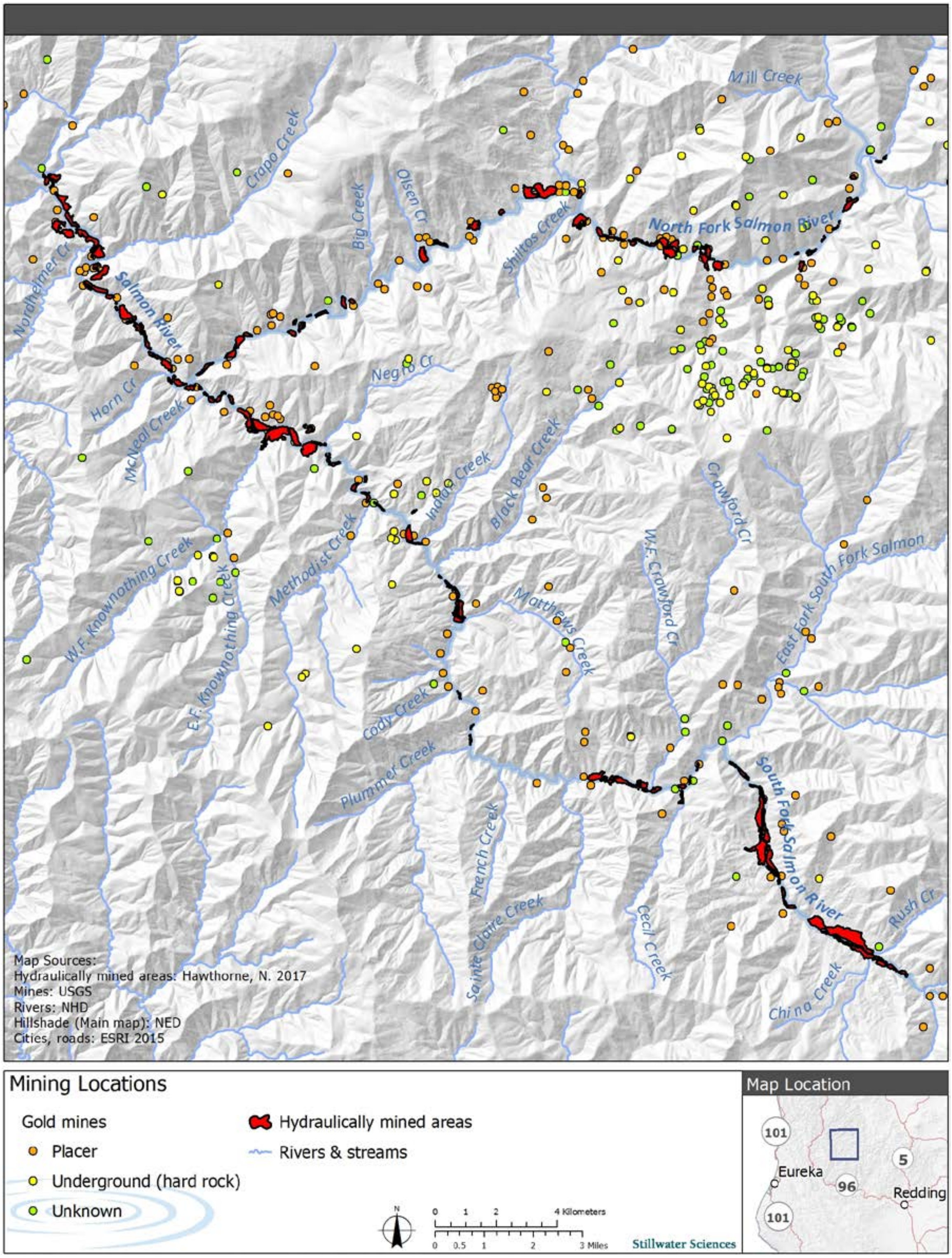

Figure 3. Gold mines and hydraulically mined areas within the Salmon River Project area.

1.3 Objectives and Approach

The Salmon River Floodplain Habitat Enhancement and Mine Tailing Remediation Project is a comprehensive, sequential, and prioritized approach to strategically improving stream temperatures, geomorphic functions, and aquatic habitat in the Salmon River. Its goal is to increase long-term salmonid productivity and ensure that the Salmon River remains a long-term refuge for cold-water dependent aquatic species as climate change progresses. The specific Project objectives include: (1) increasing the availability and quality of limiting habitat for salmonids (e.g., over-wintering, over-summering, and spawning); (2) improving riparian functions (e.g., shade cover from riparian vegetation); (3) improving hydrologic functions (e.g., floodplain inundation and hyporheic exchange); and (4) protecting and enhancing thermally suitable habitats (e.g., cool-water reaches, thermally stratified pools, and summer thermal refuges).

Potential restoration and enhancement actions include the following:

- Protecting and expanding cold water refuges at summer baseflow within the mainstem channels and lower reaches of major tributaries to improve holding and summer rearing habitat conditions;
- Adding structure within simplified channel reaches (e.g., plane-bed morphology) that promotes hydraulic complexity and pool depth, increases the amount and quality of low-velocity rearing habitat, and sorts spawning gravel;
- Manipulating (e.g., grading and/or adding structure) and revegetating floodplains to improve hydrologic function and processes, primarily by increasing flow connectivity (e.g., frequency and duration of inundation) and hyporheic exchange between the winter baseflow channel (20% exceedance flow), bankfull side channels (1.5- to 2-year flow), and high flow side channels (≥5-year flow);
- Adding structural complexity to side channels to improve rearing habitat;
- Creating, enhancing, and connecting off-channel ponds and wetlands to improve rearing habitat; and
- Grading and revegetating mine tailings on floodplains and adjacent terraces to increase riparian shading, reduce heating, and improve hyporheic exchange.

The Project is organized into the following four phases:

Phase 1. Comprehensively assessing opportunities for and constraints to floodplain and associated aquatic habitat restoration and enhancement, including identifying and prioritizing channel segments for treatment;

Phase 2. Developing conceptual restoration and enhancement designs within priority channel segments;

Phase 3. Conducting programmatic environmental review; and

Phase 4. Comprehensively implementing sequential, prioritized restoration and enhancement projects.

The highest priority actions include those identified in the SONCC coho salmon recovery plan (See Table 35-3 in NMFS 2014) and Salmon River Temperature TMDL implementation plan (See Appendix C in NCRWQCB 2005), as well as measures most effective at recovering the spring-run Chinook salmon population within the Salmon River (West 1991, Moyle et al. 2017).

The overall approach to Phase 1 of the Project involves first delineating reaches with wider and predominantly alluvial channels and floodplains that historically provided the greatest floodplain habitat values, have been most impacted by historical hydraulic mining and other disturbances, and provide the greatest opportunities for restoring floodplain habitat and remediating mine tailings. Once geomorphic reaches were delineated, additional analyses were conducted to identify restoration and enhancement opportunities. These analyses included evaluating the spatial distribution of summer water temperature deviations (i.e., relatively warmer and colder water) throughout the 55-mile Project area to identify thermally suitable habitat and help distinguish between cool-water reaches, thermally stratified pools, and localized cold-water inputs. Flow inundation was modeled within the approximately 37 miles of predominantly alluvial reaches to assess existing and potential floodplain inundation, high flow paths, and winter and spring rearing habitats for salmonids. Historical aerial photos were used in combination with LiDAR topography and the results of thermally suitable habitat and flow inundation analyses to identify channel segments within predominantly alluvial reaches that provide site-specific opportunities to restore and enhance floodplain habitats and remediate mine tailings. These segments offering site-specific restoration opportunities were assigned a preliminary suitability rating (1–3) based on physical and biological site conditions, anticipated benefits of potential treatments, and feasibility. Field investigations were conducted within each potential enhancement segment to confirm analysis results, further assess opportunities and constraints to floodplain habitat restoration and mine tailing remediation, and refine preliminary suitability ratings. Lastly, potential floodplain habitat enhancement segments and the intervening segments within the river corridor were aggregated into planning units intended to facilitate a programmatic and tiered NEPA review and to ensure that implementation comprehensively considers interrelated actions that could more broadly affect channel and floodplain conditions throughout a reach.

The following sections describe the methods and results of steps conducted during Phase 1 of the Project.

2 GEOMORPHIC REACHES

The channel network in the Project area was classified into functionally similar geomorphic reaches (i.e., reaches with similar sediment transport and storage potential) based on channel gradient, valley and channel width derived from 2014 LiDAR data (Quantum Spatial 2014), and the extent of bedrock control and alluvial sediment storage in channel and floodplain areas observed in historical aerial photography. Resistant bedrock exposed in the channel boundaries controls channel bed elevation and width, lateral migration, and active meandering. More bedrock control typically leads to greater channel and floodplain confinement and therefore less flow inundation, less alluvial sediment storage, higher flood flow velocities, and lower overall floodplain enhancement potential. Most of the channel network in the Project area is composed of mixed alluvial-bedrock channels.

During geomorphic reach delineation and prior to hydraulic modeling of flow inundation, a combination of 2014 LiDAR data and 2013 aerial imagery were used to delineate the approximate valley bottom throughout the Project area. The delineation was based on floodplain and terrace elevations with respect to the channel thalweg, as well as topographic evidence of historical fluvial processes in floodplain areas and the presence of low river terraces with the potential to directly shade channel and floodplain areas. The delineation was generally conservative, erring on the side of including areas that could potentially be restored to functioning floodplains and adjacent river terraces, especially in areas where historical hydraulic mining activity and tailing piles were evident. Channel reaches with wider alluvial floodplains, lower gradient and less confined bankfull channels, cobble and gravel sediment storage in bars, and less bedrock control historically offered more spawning and rearing habitat for anadromous salmonids. Channel reaches with these conditions are therefore considered to have higher habitat enhancement potential.

In addition to the geomorphic conditions within a reach, the magnitude and persistence of anthropogenic disturbance is a key component in assessing floodplain restoration and enhancement potential. Areas that experienced extensive hydraulic placer mining disturbance within and adjacent to the 100-year floodplain (hydraulically mined areas shown in Figure 2) were identified based on mapping by de la Fuente and Haessig (1993) supplemented by additional mapping of hydraulic mining features observed in aerial photographs and hillshade maps produced from 2014 LiDAR data.

The project area was divided into 25 reaches according to these assessments and criteria (Figure 4, Table 1). Three of these reaches (Reach 7 on the South Fork and Reaches 21 and 23 on the North Fork) were further subdivided based on tributary influences. Eighteen reaches totaling 37 river miles (65% of the total Project channel length) were classified as predominantly alluvial with higher floodplain habitat enhancement potential. Geomorphic features particularly relevant to floodplain habitat enhancement and mine-tailing remediation (e.g., hydraulically mined areas and tailings on river terraces and adjacent hillslopes, plane bed channel types, and side channels) were identified within each geomorphic reach/sub-reach. Further geomorphic mapping is being conducted during Phase 2 development of conceptual restoration and enhancement designs within priority channel segments.

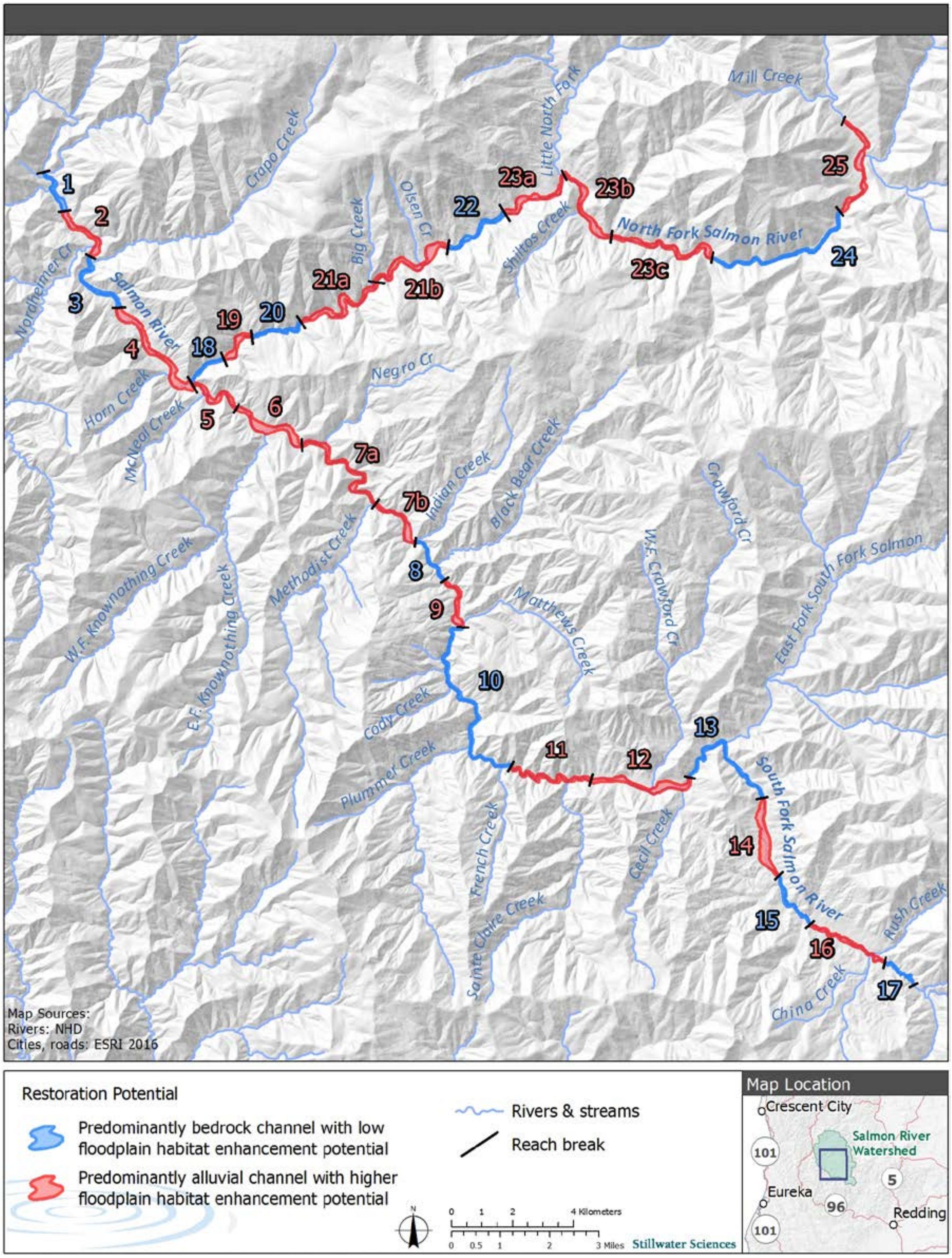

Figure 4. Predominantly bedrock and alluvial reaches in the Salmon River Project area.

Table 1. Geomorphic reaches in the Salmon River Project area.

Reach	River	Length (mi)	Gradient (%)	Valley confinement[1]	Bedrock control	Hydraulic mining	Enhancement potential[2]
1	Main	1.0	0.96	Narrow	Yes	No	Low
2	Main	1.3	0.55	Moderate	Yes	Yes	High
3	Main	1.7	0.45	Narrow	Yes	No	Low
4	Main	2.4	0.54	Wide	No	Yes	High
5	SF	1.4	0.95	Moderate	Yes	Yes	High
6	SF	1.8	0.72	Wide	Yes	Yes	High
7a	SF	2.9	0.84	Moderate	Yes	Yes	High
7b	SF	1.4	1.06	Moderate	Yes	Yes	High
8	SF	1.1	1.11	Narrow	Yes	No	Low
9	SF	1.3	0.92	High	Yes	Yes	High
10	SF	5.1	1.69	Narrow	Yes	No	Low
11	SF	1.5	1.16	Moderate	Yes	No	High
12	SF	2.3	0.76	Moderate	No	Yes	High
13	SF	2.7	1.13	Narrow	Yes	No	Low
14	SF	1.7	1.22	Wide	No	Yes	High
15	SF	1.4	1.45	Narrow	Yes	No	Low
16	SF	1.8	1.44	Moderate	No	Yes	High
17	SF	0.9	2.02	Narrow	No	No	Low
18	NF	0.9	0.71	Narrow	Yes	No	Low
19	NF	1.0	0.76	Wide	Yes	Yes	High
20	NF	1.2	1.45	Narrow	Yes	Yes	Low
21a	NF	2.7	1.31	Moderate	Yes	Yes	High
21b	NF	2.4	1.62	Moderate	Yes	Yes	High
22	NF	1.5	1.65	Narrow	Yes	No	Low
23a	NF	1.9	0.76	Moderate	Yes	Yes	High
23b	NF	2.1	0.78	Moderate	Yes	Yes	High
23c	NF	2.7	1.05	Moderate	Yes	Yes	High
24	NF	3.4	1.49	Narrow	Yes	No	Low
25	NF	2.5	1.29	Moderate	No	No	High

[1] Valley confinement is defined based on average valley bottom width as follows:
Mainstem: narrow < 400 ft.; moderate 400–600 ft.; wide > 600 ft.
North Fork and South Fork: narrow < 300 ft.; moderate 300–450 ft.; wide > 450 ft.

[2] Shading indicates predominantly alluvial reaches with higher potential for floodplain habitat enhancement and mine tailing remediation.

3 THERMALLY SUITABLE HABITAT

Areas within the summer low flow channel that maintain cool water suitable for salmonid rearing, migration, and pre-spawn holding are critically important for salmonid populations (Torgersen et al. 2012). Because climate changes and the legacy of past land uses have impaired summer water temperatures and degraded over-summering habitat conditions in the Salmon River, thermally suitable habitats are particularly critical to the survival and resilience of salmon and steelhead populations in the watershed. Under current conditions, large areas of the Salmon River have summer temperatures that are unsuitable for salmonids, which increases the importance of actions to reduce water temperatures and increase the size and persistence of areas that provide suitable thermal conditions. Aside from cool-water reaches at the upstream ends of the Project area, thermal refuges in mainstem reaches of the Salmon River typically occur as thermally stratified pools, areas near the confluences of tributaries that supply cold surface water relative to the mainstem, areas associated with seeps and springs, and areas where hyporheic flow emerges at the downstream extents of transverse alluvial bars. The magnitude and spatial distribution of these thermal refuges within the watershed and within a reach can vary over daily and seasonal time scales, including the flow-dependent buoyancy factors responsible for thermally stratified pools. The spatial distribution of thermal refuges at watershed and reach scales exerts important controls on the way salmonids and other aquatic organisms move, grow, reproduce, and survive (Steel et al. 2017). The spatial distribution of thermally suitable summer habitats is therefore an important consideration in identifying and prioritizing floodplain and aquatic habitat restoration and mine tailing remediation opportunities within the Salmon River Project area.

Thermally suitable habitat within a river can be identified and described using a variety of techniques, including installing devices that measure temperatures over time at a fixed point, fiber optic technologies that can be used to synoptically measure water temperatures along a river's longitudinal profile or at depth within a pool, and thermal infrared (TIR) imaging that enables distributed water temperature measurements at a very fine spatial resolution based on radiation emitted from the water surface (Torgersen et al. 2012, Tan and Cherkauer 2013, Dugdale 2016, Steel et al. 2017, Fullerton et al. 2018). We analyzed the fine-scale spatial distribution of summer thermal refuges in the Salmon River Project area using airborne TIR imagery acquired for 85 miles of the Salmon River in 2009 (Watershed Sciences 2010). TIR imagery for the Salmon River was acquired by helicopter during the period with the highest annual temperatures and maximum temperature heterogeneity (between approximately 2:15 pm and 4:45 pm on July 22 and 23). Radiant temperatures were sampled at a spacing of approximately 0.6 m (2.0 ft.). Kinetic temperatures from 13 in-stream sensors were used to calibrate radiant temperatures from TIR imagery. Calibrated temperatures are accurate to ±0.5°C. Water surface temperatures measured by TIR are representative of the water column where turbulent mixing minimizes thermal stratification. Refuges provided by deep, thermally stratified pools may not be identified by TIR if cooling effects do not extend to the surface.

We used gridded TIR data (0.6 m grid size) to calculate temperature departures and to define thermally suitable habitat and localized thermal refuges based on threshold temperature criteria. We first excluded all TIR grid cell values that occurred in terrestrial environments outside the wetted channel by applying an upper temperature criterion of 25ºC. We then established continuous 100-meter-long sampling zones throughout the Project area by placing points spaced 100 meters apart along the channel centerline and creating Thiessen polygons centered on each point. Finally, a moving median temperature was calculated for each sample zone based on all temperature values within a 500-meter distance including the two zones upstream and two zones downstream of the sample zone. Temperature departures were calculated by subtracting median zone temperatures from measured zone temperatures, where resulting positive values indicate a warm departure and negative values indicate a cool departure. Thermal refuges were then defined based on a 22ºC threshold (McCullough 1999, Torgersen et al. 1999, EPA 2003, Strange 2010).

Median surface water temperatures for 100-m sample zones shown at the watershed scale illustrate a general warming trend from upstream to downstream, with significant reach-scale departures from this trend (Figure 5 and Figure 6). Localized cooling is apparent due to cold-water inputs from the larger tributaries (e.g., Nordhiemer and Crapo Creek on the mainstem, Little North Fork on the North Fork). Relatively cool (e.g., <22ºC) reaches also occur in association with predominantly bedrock-confined canyons with more topographic shading and cold-water storage in deep pools (e.g., downstream of Reach 1 on the mainstem; Reaches 8, 9, and 10 on the South Fork; and Reaches 22 and 24 on the North Fork). Reaches near the confluence of the North Fork and South Fork are also relatively cool, likely due to groundwater interactions. Relatively warm (e.g., >22ºC) reaches typically occur in areas with wide and shallow alluvial channels, wider floodplains, and more disturbance from hydraulic mining (e.g., Reaches 3 and 4 on the mainstem; Reaches 6 and 7 on the South Fork; and Reaches 21 and 23 on the North Fork). Appendix A shows reach-specific temperature departures, thermally suitable habitat, and localized thermal refuges in the 18 predominantly alluvial reaches with higher floodplain habitat enhancement potential. Figure 7 illustrates an example of these results in Reach 2 near the Nordheimer Creek confluence with the mainstem Salmon River.

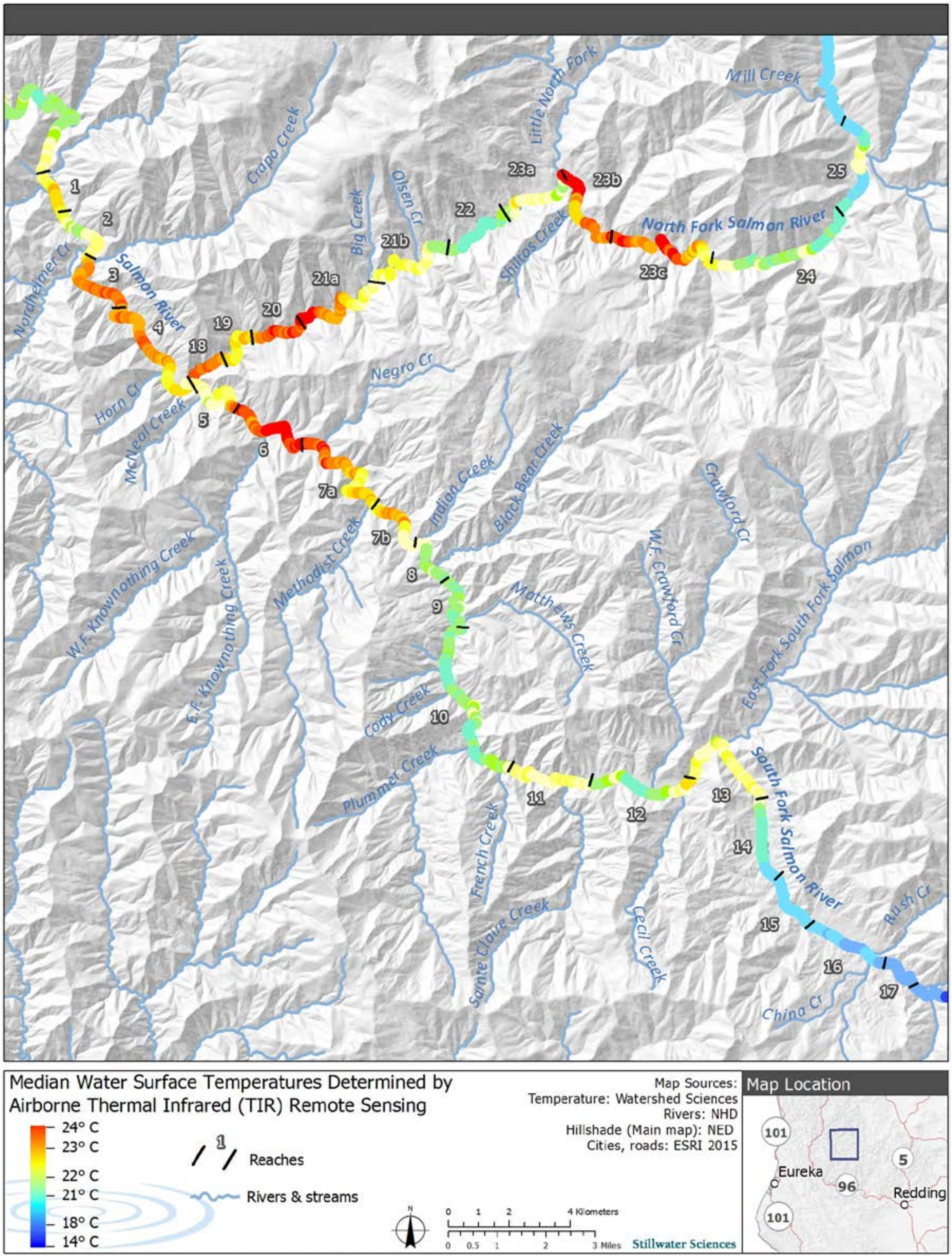

Figure 5. Median water surface temperatures in 100-meter reaches of the Salmon River Project area based on 2009 TIR data.

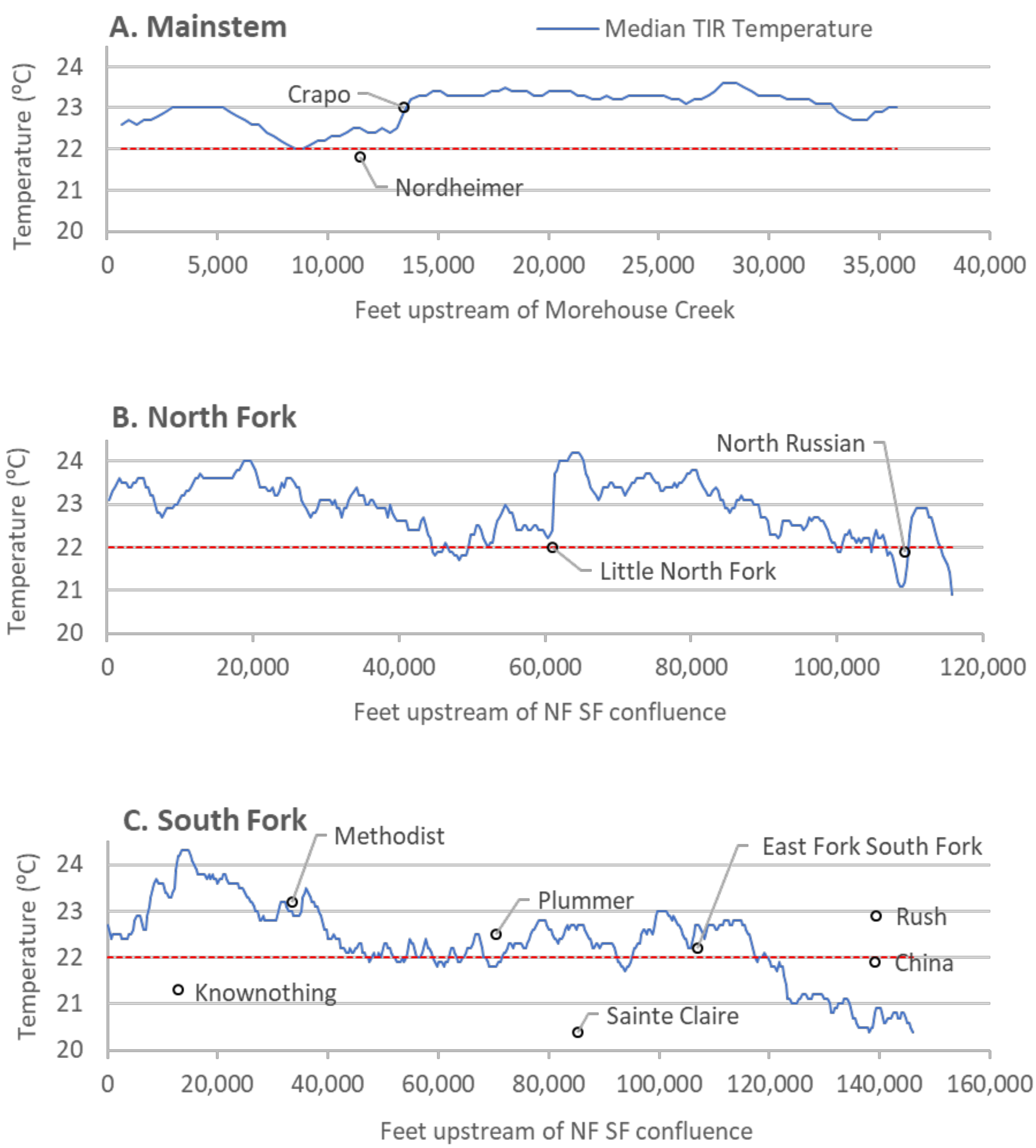

Figure 6. Longitudinal profiles of median water surface temperatures in 100-meter reaches of the mainstem (A), North Fork (B), and South Fork (C) Salmon River based on 2009 TIR data. Red line indicates 22°C threshold.

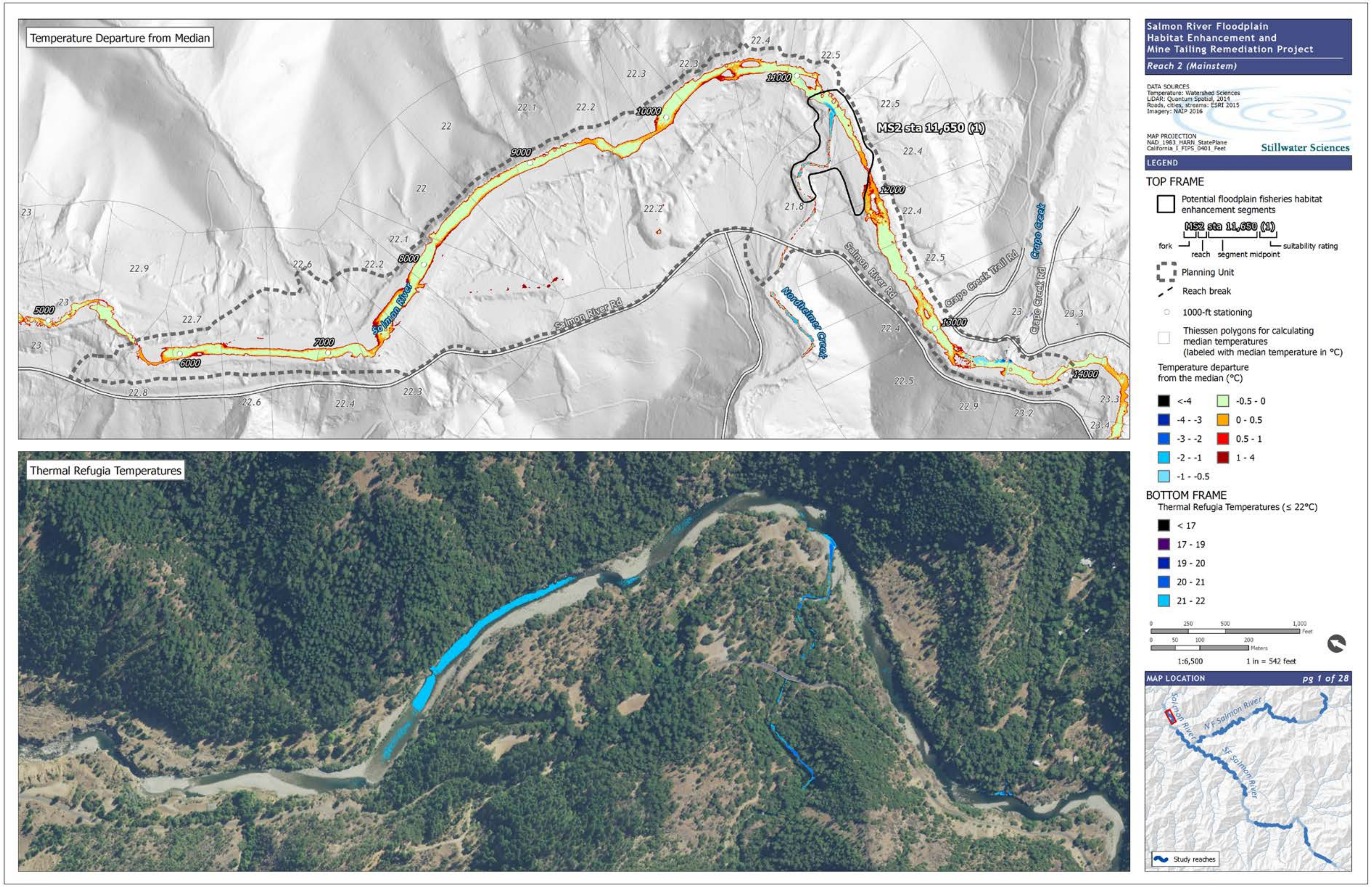

Figure 7. Temperature departures, thermally suitable habitat, and localized thermal refuges in Reach 2 near the Nordheimer Creek confluence with the mainstem Salmon River.

4 FLOW INUNDATION

To better understand floodplain inundation and flow paths, hydraulics in predominantly alluvial reaches within the Project area were modeled using the US Army Corps of Engineers Hydrologic Engineering Center's River Analysis System (HEC-RAS). HEC-RAS 5.0 is a hydrologic modeling system designed to describe the physical properties of streams and rivers, and to route flows through them by performing two-dimensional (2D) hydrodynamic routing within the unsteady flow analysis portion of HEC-RAS (Burnner 2016).

A HEC-RAS 2D model was developed by importing a DEM derived from 2014 LiDAR data (Quantum Spatial 2014) into HEC-RAS. A 2D area boundary was drawn for each predominantly alluvial reach and a mesh cell center spacing of 20 DX by 20 DY was assigned. Due to the large size of the Project area and limited detail in available land cover data for channel and floodplain areas, a Manning's n roughness value of 0.045 was assigned to all cells. Next, the upstream and downstream ends of the mainstem reaches and larger tributary reaches were assigned 2D area boundary condition lines and flows. Due to the significant differences between upstream and downstream water surface elevations, the 2D area was initiated dry. To compensate, a 4-hour initial conditions ramp-up time assigned in the unsteady computation options and tolerances window allowed for the model to set up with a more appropriate initial conditions solution. After performing several runs, the 2D mesh was refined by adding resolution and strategic cell center orientation to minimize inundation fragmentation.

Flow inundation within the predominantly alluvial reaches was modeled at eight discharges ranging from the 20% exceedance flow to the 100-year recurrence interval flood flow (Table 2). Exceedance flows and recurrence intervals are two different methods of identifying reference discharges significant to habitat function and restoration design. Exceedance flows represent the percent of time throughout the year when flows are above a specific discharge. Recurrence interval or flood frequency flows represent higher flows that are expected to occur at a specific frequency (e.g., a 100-year flow statistically has a 1-percent chance of occurring in any given year and would be expected to occur every 100 years, on average). Reference discharges determined by these methods have biological significance for restoration, especially related to over-wintering and spring rearing habitat for salmonids. The 20% exceedance flow represents typical winter and spring base flows (i.e., average snowmelt flows) that commonly occur during important rearing periods for juvenile salmonids. Higher flows, especially the 1.5-year (e.g., bankfull) to 5-year discharges, are also biologically significant because they occur relatively frequently and are swift enough to flush salmonids out of the system and/or cause mortality if sufficient low-velocity habitat is not available as refuge.

A 0.5-second computational interval was used in simulating the 20% exceedance flow, 1.5-year, and 2-year discharges; and a 1-second interval was used for the 5, 10, 25, 50, and 100-year discharges. This criterion was chosen by model stability and resulting output. The mapping of 2D flow areas in HEC-RAS is based on the detailed underlying terrain. Computationally, cells can be partially wet or dry. Inundation mapping therefore reflects the underlying terrain details rather than being limited to showing a computational cell as either all wet or all dry.

Table 2. Discharge estimates for predominantly alluvial reaches and tributaries.

Reach and tributaries	20% Exceedance discharge (cfs)	1.5-Year discharge (cfs)	2-Year discharge (cfs)	5-Year discharge (cfs)	10-Year discharge (cfs)	25-Year discharge (cfs)	50-Year discharge (cfs)	100-Year discharge (cfs)
Reach 2—Unnamed Tributary	4	30	42	80	111	156	187	219
Reach 2—Crapo Creek	67	386	539	998	1,364	1,871	2,241	2,622
Reach 2—Nordheimer Creek	120	667	930	1,717	2,337	3,192	3,824	4,474
Reach 2	1,950	9,292	1,2953	23,519	31,475	42,270	50,644	59,257
Reach 4-7—Horn Creek	7	47	65	123	171	238	286	334
Reach 4–7—North Fork	792	3,957	5,516	10,066	13,537	18,271	21,891	25,614
Reach 4–7—Knownothing Creek	88	500	696	1,288	1,757	2,405	2,882	3,372
Reach 4–7—Negro Creek	16	98	137	257	355	492	590	690
Reach 4–7—Methodist Creek	49	288	402	746	1,022	1,405	1,683	1,969
Reach 4–7—Indian Creek	20	123	172	321	443	614	735	860
Reach 4–7	902	4,473	6,235	11,369	15,278	20,605	24,687	28,886
Reach 9—Matthews Creek	28	170	237	442	607	839	1,005	1,176
Reach 9	805	4,016	5,599	10,215	13,737	18,539	22,212	25,990
Reach 11–12—Saint Claire Creek	41	244	340	633	868	1,194	1,431	1,674
Reach 11-–12—Crawford Creek	51	296	413	767	1,050	1,443	1,729	2,023
Reach 11–12—Cecil Creek	22	136	190	355	489	677	811	949
Reach 11–12	572	2,906	4,051	7,406	9,980	13,495	16,169	18,919
Reach 14	289	1,523	2,123	3,898	5,274	7,162	8,581	10,041
Reach 16—Rush Creek	46	269	375	697	955	1,314	1,575	1,842
Reach 16—China Creek	18	114	159	298	412	570	683	799
Reach 16	230	1,228	1,712	3,148	4,266	5,802	6,951	8,133
Reach 19	782	3,909	5,448	9,942	13,372	18,050	21,626	25,304
Reach 21	721	3,621	5,048	9,215	12,400	16,746	20,063	23,475

Reach and tributaries	20% Exceedance discharge (cfs)	1.5-Year discharge (cfs)	2-Year discharge (cfs)	5-Year discharge (cfs)	10-Year discharge (cfs)	25-Year discharge (cfs)	50-Year discharge (cfs)	100-Year discharge (cfs)
Reach 23—Jackass Gulch	169	921	1,284	2,364	3,210	4,375	5,242	6,133
Reach 23—Little North Fork	126	699	975	1,799	2,448	3,343	4,005	4,686
Reach 23—Jessups Gulch	12	76	106	199	276	383	459	537
Reach 23—Eddy Gulch	27	164	228	425	585	808	968	1,133
Reach 23—Shiltos Creek	9	59	82	154	213	297	356	417
Reach 23	473	2,428	3,385	6,194	8,356	11,313	13,554	15,859
Reach 25—North Russian Creek	70	403	561	1,040	1,421	1,948	2,334	2,731
Reach 25—South Russian Creek	72	410	572	1,059	1,447	1,984	2,377	2,781
Reach 25	244	1,298	1,809	3,324	4,503	6,122	7,334	8,582

Because no discharge records exist for Project reaches, flows were estimated using data from USGS Gaging Station No. 11522500 (Salmon River at Somes Bar). Exceedances in alluvial reaches were estimated by prorating exceedances calculated from average daily discharge at USGS No. 11522500. Proration was conducted using the ratio of drainage areas at USGS No. 11522500 (751 mi^2) and the alluvial reaches. Recurrence interval flows were determined by averaging two flow estimation methodologies. The first method utilized a Log-Pearson Type III distribution to determine the peak flows at the USGS Gage No. 11522500. These values were then prorated by the ratio of drainage areas. The second method also used the Log-Pearson Type III distribution, but flows in the predominantly alluvial reaches were determined using the USGS formula for calculating magnitude and frequency of floods in California:

Qu = Qg(Au/Ag)b

Where: b = 0.9 for a 2-year event and b = 0.87 for a 100-year event
Qu = Ungaged discharge
Qg = Gaged discharge
Au = Ungaged drainage area
Ag = Gaged drainage area.

This combined approach led to a 5% to 7% increase in peak flow estimates from the simple drainage area proration. Values in Table 2 are rounded to reflect uncertainty in these estimates.

Figure 8 illustrates flow inundation area per unit length in the 18 predominantly alluvial reaches with higher potential for floodplain habitat enhancement and mine tailing remediation. Summer baseflow area was derived from TIR data (see Section 3), while inundation area at higher flows was derived from hydraulic modeling. Appendix A shows reach-scale inundation mapping results. Figure 9 illustrates an example of these results in Reach 21b near Red Bank on the North Fork Salmon River.

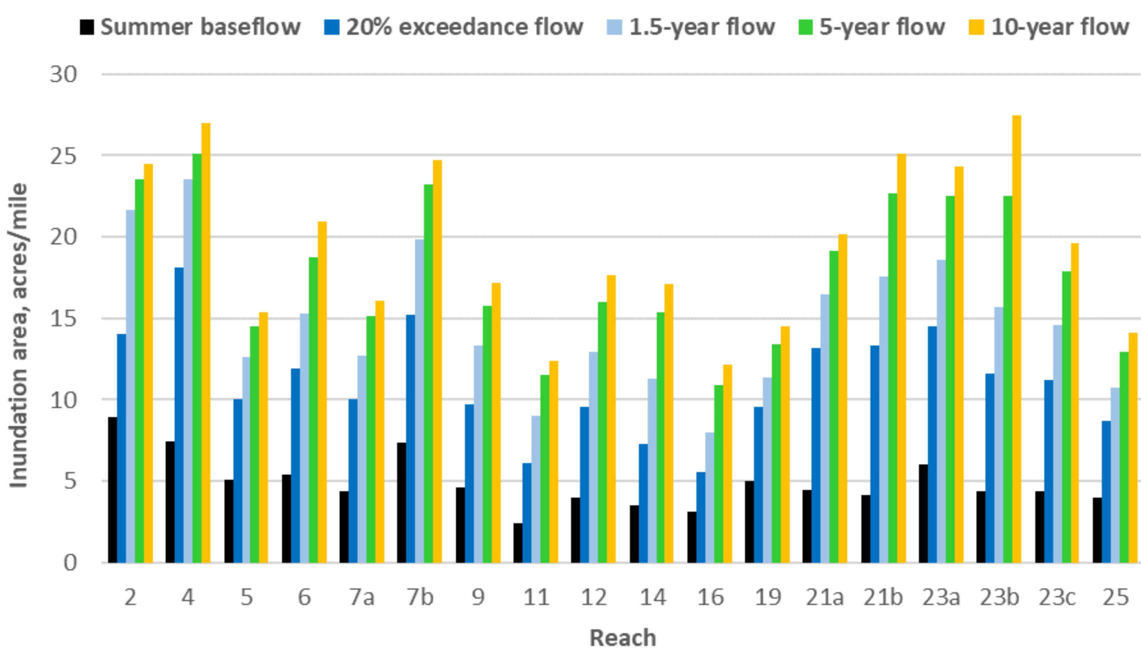

Figure 8. Flow inundation area per unit channel length in predominantly alluvial reaches.

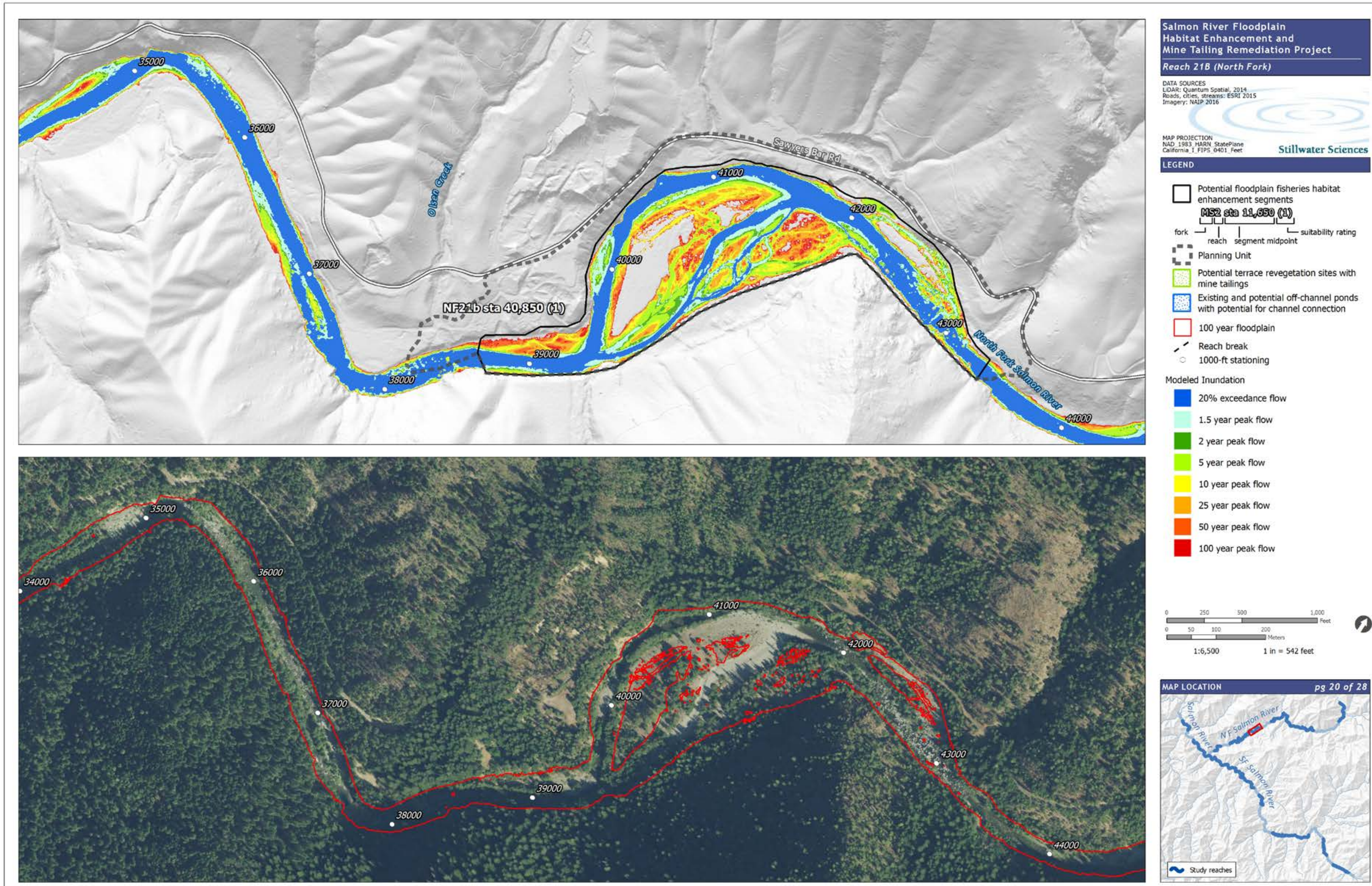

Figure 9. Reach-scale inundation mapping results in Reach 21b near Red Bank on the North Fork Salmon River.

5 CHANNEL SEGMENTS WITH RESTORATION AND ENHANCEMENT POTENTIAL

As previously discussed, the approach to Phase 1 of the Project involved (1) delineating reaches with wider and predominantly alluvial channels and floodplains that historically provided the greatest floodplain habitat values and offer the best opportunities for restoring floodplain habitat, (2) evaluating the spatial distribution of summer water temperature deviations and thermally suitable summer habitat within predominantly alluvial reaches, and (3) hydraulic modeling within predominantly alluvial reaches to assess existing and potential floodplain inundation and associated winter and spring rearing habitats. The fourth step involved identifying channel segments within predominantly alluvial reaches that provide site-specific opportunities to restore and enhance floodplain habitats and remediate mine tailings.

Historical aerial photos were used in combination with LiDAR topography and the results of temperature and flow inundation analyses to identify channel segments that offer significant site-specific restoration opportunities (Figure 10). We identified 36 potential floodplain habitat enhancement segments in predominantly alluvial reaches: 4 in the mainstem, 17 in the South Fork, and 15 in the North Fork. Potential floodplain habitat enhancement segments encompass 12.9 miles (23% of the total Project channel length and 38% of the total predominantly alluvial reach length).

A preliminary suitability rating of 1, 2, or 3 (1=higher suitability; 3=lower suitability) was assigned to each channel segment identified as having significant restoration potential (Table 3). Preliminary suitability ratings were assigned to each channel segment based on physical and biological criteria. Physical criteria included existing geomorphic characteristics and sediment dynamics; the type, areal extent, and frequency of flow inundation; physical constraints (i.e., bedrock control and developed infrastructure); and anticipated hydraulic and geomorphic responses to potential treatments. Biological criteria included the quantity and quality of existing spawning, over-wintering, and over-summering habitat; presence, size, and importance of thermally suitable habitat; location of the channel segments with respect to warming and cooling trends over the riverine longitudinal profile revealed in the analysis of median water temperatures; extent and quality of riparian cover (SRRC 2008); and anticipated ecological responses (e.g., spawning and rearing habitat creation) to potential treatments.

More geomorphically complex segments (e.g., containing side channels and split-flow channels, alluvial bars, alcoves, off-channel ponds, etc.) with larger areas of low-lying topography that inundate more frequently and for longer duration but are highly disturbed and contain impaired in-stream and/or floodplain habitats were rated with higher suitability. Sites were also considered more suitable if they lacked lateral and/or vertical bedrock controls that could inhibit implementation (e.g., floodplains underlain by a bedrock strath surface or bedrock outcrop at the head/entrance of side channels, alcoves, ponds, etc.). The technical Project team conducted on-site field review of all potential floodplain habitat enhancement segments to confirm analysis results, further assess opportunities and constraints to habitat restoration and mine tailing remediation, and refine preliminary suitability ratings. Channel segments with higher restoration potential (i.e., suitability rating 1 and 2) received more detailed field scrutiny than segments with relatively lower potential (i.e., suitability rating 3). Ratings for individual channel segments are being further refined during detailed field studies conducted in support of Phase 2 development of conceptual restoration and enhancement designs.

Figure 11 illustrates the distribution of all potential floodplain habitat enhancement segments with respect to the channel longitudinal profile. Figure 12 illustrates the cumulative length of enhancement segments with increasing distance upstream from Morehouse Creek (the downstream Project extent). Appendix B describes the physical and biological conditions, opportunities and constraints, suitability rating, and initial conceptual approaches to floodplain habitat enhancement and mine tailing remediation within each segment. Refer to Appendix A for the location and extent of floodplain habitat enhancement segments with respect to thermally suitable habitat and flow inundation.

Lastly, potential floodplain habitat enhancement segments and the intervening segments within the river corridor were aggregated into planning units intended to facilitate a programmatic and tiered NEPA review and to ensure that implementation comprehensively considers interrelated actions that could more broadly affect channel and floodplain conditions throughout a reach. This step in the Phase 1 planning process also allows for inclusion of various types and scales of potential actions that may not otherwise be explicitly identified in the opportunities and constraints analysis described herein (e.g., revegetation of hydraulically mined river terraces that experience infrequent flooding and aquatic habitat enhancement in reaches with plane bed morphology). Planning units may encompass portions of both predominantly alluvial and bedrock reaches.

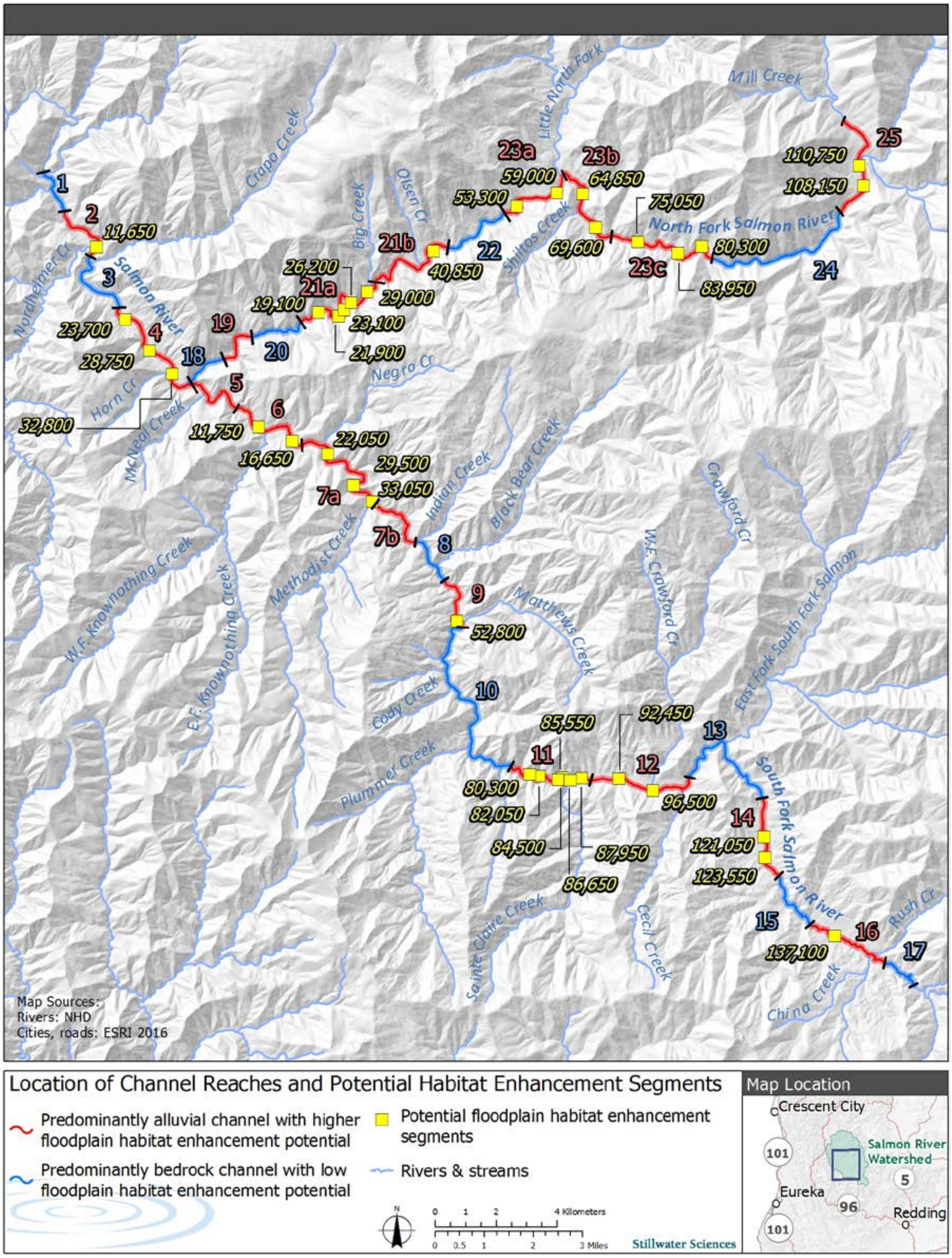

Figure 10. Potential floodplain habitat enhancement segments in the Salmon River Project area. Segments are identified based on their station midpoint. Refer to Table 3 for segment naming conventions.

Table 3. Potential floodplain habitat enhancement segments in the Salmon River Project area.

Segment[1]	Name	Reach Station (sta)		Length (mi)	Gradient (%)	Suitability rating
		Up	Down			
SF16 sta 137,100	Downstream of China Creek (Sommerville)	140,500	133,700	1.29	1.41	1
SF14 sta 123,550	Blue Gulch (Upper Petersburg)	124,900	122,200	0.51	1.23	1
SF14 sta 121,050	Lower Petersburg	122,100	120,000	0.40	1.43	2
SF12 sta 96,500	Crawford Creek	96,800	96,200	0.11	1.04	3
SF12 sta 92,450	Indian Gulch/Timber Gulch	93,400	91,500	0.36	0.60	2
SF11 sta 87,950	Downstream of Orton Gulch	89,000	86,900	0.40	0.73	2
SF11 sta 86,650	Upstream of Saint Claire Creek	87,000	86,300	0.13	0.84	2
SF11 sta 85,550	Downstream of Saint Claire Creek	86,300	84,800	0.28	1.01	2
SF11 sta 84,500	Mining site downstream of Saint Claire Creek	84,800	84,200	0.11	0.70	2
SF11 sta 82,050	Footbridge	82,400	81,700	0.13	0.67	1
SF11 sta 80,300	Upstream of Limestone Gulch	81,000	79,600	0.27	1.12	2
SF9 sta 52,800	Matthews Creek	54,000	51,600	0.45	1.03	1
SF7a sta 33,050	Methodist Creek	33,500	32,600	0.17	0.73	3
SF7a sta 29,500	Downstream of Methodist Creek	30,100	28,900	0.23	1.21	3
SF7a sta 22,050	Negro Creek	23,200	20,900	0.44	0.99	1
SF6 sta 16,650	Henry Bell Gulch	17,200	16,100	0.21	0.84	2
SF6 sta 11,750	Knownothing Creek	13,500	10,000	0.66	0.69	1
NF25 sta 110,750	North Russian Creek	111,300	110,200	0.21	1.42	1
NF25 sta 108,150	Near Robinson Flat	108,800	107,500	0.25	1.84	1
NF23c sta 83,950	Eddy Gulch to Tanner Creek (Finley and Judge Mines)	84,700	83,200	0.28	1.33	2
NF23c sta 80,300	Jessup Gulch (Sawyers Bar)	81,500	79,300	0.42	1.41	1
NF23c sta 75,050	Upstream of Jackass Gulch (near Bestville)	76,300	73,800	0.47	1.05	2
NF23b sta 69,600	Jackass Gulch to Shiltos Creek	71,500	67,700	0.72	0.92	1
NF23b sta 64,850	Kelly Gulch	66,000	63,700	0.44	0.89	1

Segment[1]	Name	Reach Station (sta)		Length (mi)	Gradient (%)	Suitability rating
		Up	Down			
NF23a sta 59,000	Downstream of Little North Fork	59,600	58,400	0.23	1.05	2
NF23a sta 53,300	Downstream of Cronan Gulch/Gallia Mine	55,200	51,400	0.72	0.80	2
NF21b sta 40,850	Red Banks	43,200	38,500	0.89	1.37	1
NF21a sta 29,000	Downstream of Big Creek	29,900	28,100	0.34	2.67	3
NF21a sta 26,200	Dougherty Bluff	26,700	25,700	0.19	1.45	3
NF21a sta 23,100	Downstream of China Gulch	23,600	22,600	0.19	1.07	2
NF21a sta 21,900	Upstream of Sawpit Flat	22,600	21,200	0.27	1.12	2
NF21a sta 19,100	Downstream of Sawpit Flat	19,800	18,400	0.27	0.81	3
MS4 sta 32,800	Horn Creek	33,600	32,000	0.30	0.92	1
MS4 sta 28,750	Lower Horn Field/Upper Brazille Flat/Fong Wah Gulch	29,300	28,200	0.21	0.77	3
MS4 sta 23,700	Fong Wah Bar	24,200	23,200	0.19	0.80	3
MS2 sta 11,650	Nordheimer Creek	12,100	11,200	0.17	0.59	1
Total				**12.90**		

[1] Floodplain habitat enhancement segments are identified based on the Project reach and geomorphic reach in which they occur and the river station at the segment midpoint (e.g., SF16 sta 137000 occurs in South Fork Salmon River in geomorphic reach 16 with the midpoint at sta 137,000).

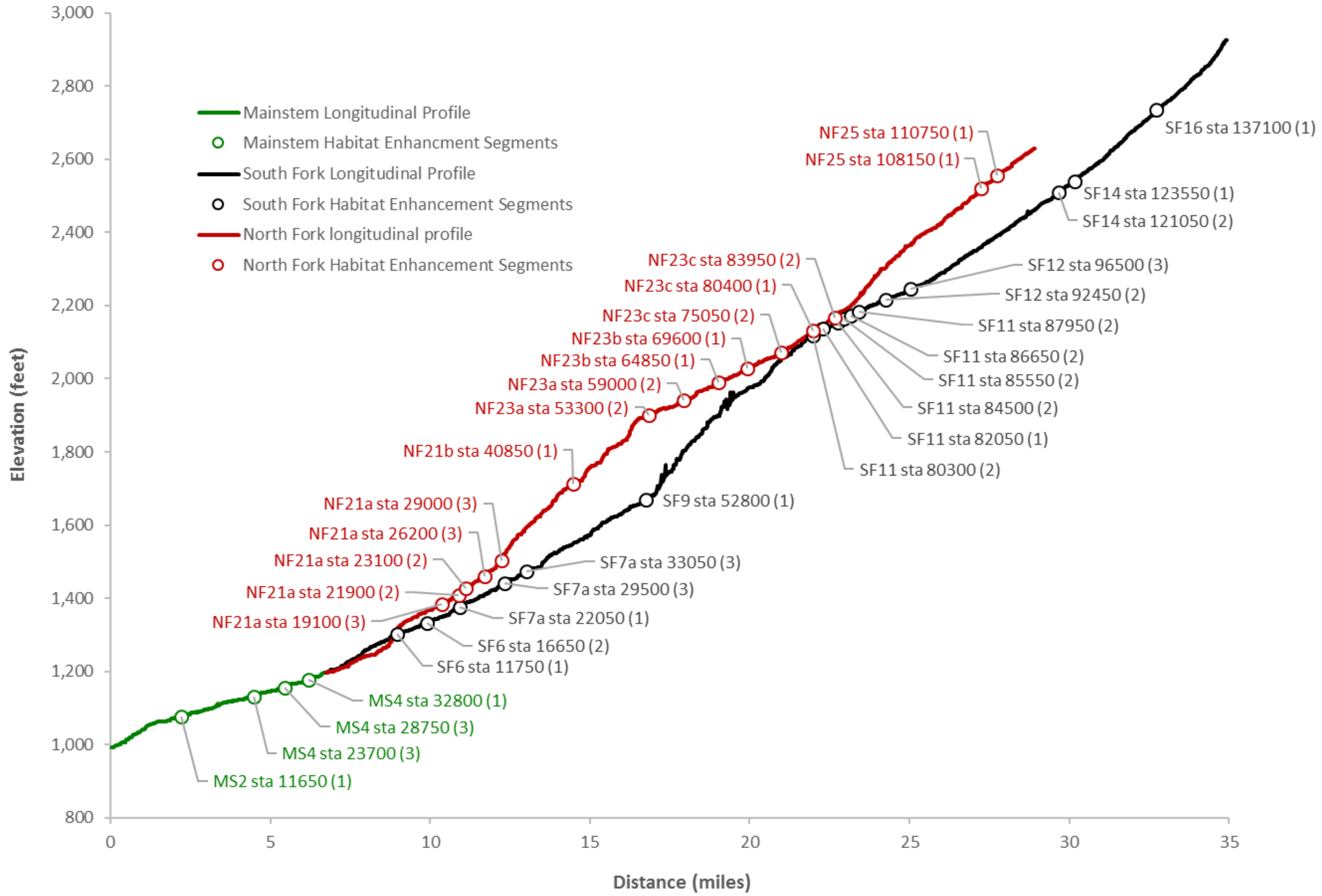

Figure 11. Location of potential floodplain habitat enhancement segments with respect to channel longitudinal profiles. Segments are identified based on the Project reach and geomorphic reach in which they occur, the river station at the segment midpoint, and their suitability rating (e.g., SF16 sta 137000 (1) occurs in South Fork Salmon River in geomorphic reach 16 with a midpoint of station 137,000 and suitability rating of 1).

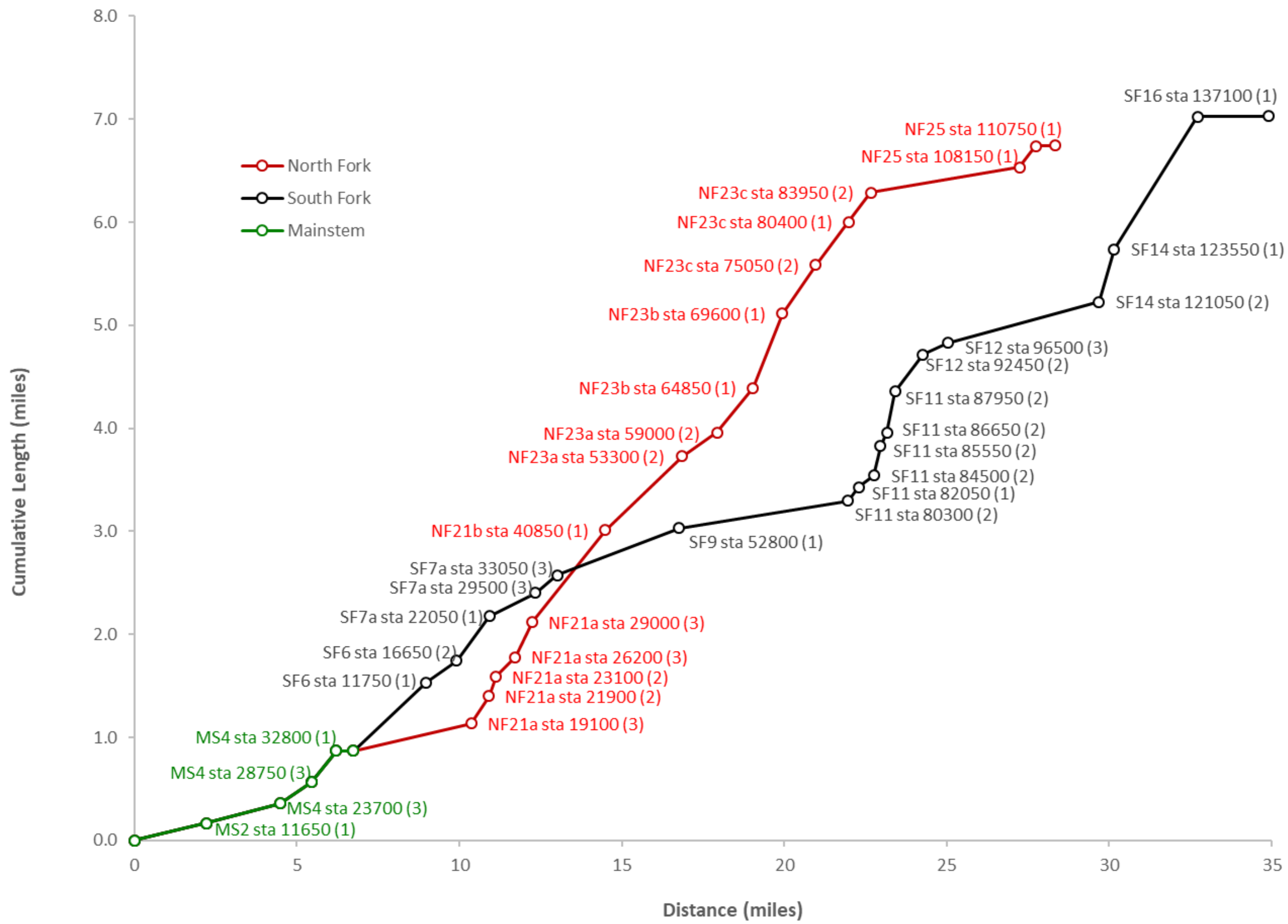

Figure 12. Cumulative length of potential floodplain habitat enhancement segments. Segments are identified based on the Project reach and geomorphic reach in which they occur, the river station at the segment midpoint, and their suitability rating (e.g., SF16 sta 137000 (1) occurs in South Fork Salmon River in geomorphic reach 16 with a midpoint of station 137,000 and suitability rating of 1).

6 SUMMARY

As one of the highest elevation Klamath River sub-basins with primarily federal ownership and few consumptive water diversions, the Salmon River has some of the highest value for the native, cold-water dependent anadromous fish species present in the basin (coho salmon, fall-run and spring-run Chinook salmon, summer and winter steelhead, Pacific lamprey, and green sturgeon). Wild spring Chinook and coho salmon runs in Salmon River face a high risk of extinction due to major stressors that limit juvenile rearing and overwintering habitat, juvenile over-summer carrying capacity, and suitable spawning habitat. These stressors result from hydrologic, geomorphic, and vegetation changes related to disruption of the natural fire regime, timber harvest, sediment delivery from roads and landslides, scour by large floods and debris torrents, and historical mining. Channel and floodplain aggradation resulting from historical hydraulic mining widened and shallowed alluvial reaches, filled pools, reduced the complexity and connectivity of floodplain habitats, and led to coarsening and armoring of the channel bed. Coarse sediment stored in the river channel, denuded floodplains, and mine tailings along the river corridor continue to create a significant heating effect. These legacy impacts to the channel and floodplain inhibit natural recovery and require intervention to recover within human and salmon population time scales.

The Salmon River Restoration Council is leading development of the Salmon River Floodplain Habitat Enhancement and Mine Tailing Remediation Plan; a collaborative, science-based process to strategically address limiting factors by comprehensively implementing actions that improve stream temperatures, geomorphic functions, aquatic habitats, and biological productivity throughout the Salmon River. This process is being conducted with the goal of increasing the abundance and long-term productivity of anadromous fish populations to ensure that the Salmon River remains a long-term refuge for cold-water dependent species as climate change progresses. The Project includes the following four phases:

- Phase 1. Comprehensively assessing system-wide opportunities for and constraints to floodplain habitat restoration and enhancement, including identifying and prioritizing channel segments for treatment;
- Phase 2. Developing conceptual restoration and enhancement designs within priority channel segments;
- Phase 3. Conducting programmatic environmental review; and
- Phase 4. Implementing sequential, prioritized restoration and enhancement projects.

Phase 1 of the Project (reported herein) involved delineating 25 geomorphic reaches, including 14 reaches with lower gradient, wider, and predominantly alluvial channels and floodplains that historically provided the greatest floodplain habitat values; have been most impacted by historical hydraulic mining and other disturbances; and provide the greatest opportunities for restoring floodplain habitat. Predominantly alluvial reaches total 37 river miles and encompass 65% of the total 55-mile Project channel length.

Because climate changes and the legacy of past land uses have impaired summer water temperatures and impacted over-summering habitat conditions in the Salmon River, thermally suitable habitats are particularly critical to the survival and resilience of salmon and steelhead populations in the watershed. The spatial distribution of summer water temperature deviations and thermally suitable habitats were analyzed throughout the 55-mile Project area using airborne TIR imagery. Aside from cool-water reaches at the upstream ends of the Project area, thermal refuges in the mainstem reaches of the Salmon River typically occur as thermally stratified pools, areas near the confluences of tributaries that supply cold surface water relative to the mainstem, areas associated with seeps and springs, and areas where hyporheic flow emerges at the downstream extents of transverse alluvial bars.

Exchange of flow, sediment, and wood between the bankfull channel and adjacent floodplains creates and maintains low velocity off-channel habitat critical to feeding, growth, and survival of anadromous salmonids. The legacy of past land uses in the Salmon River has contributed to a lack of complex, accessible floodplain habitat that limits overwintering carrying capacity. Flow inundation was modeled within the 37 miles of predominantly alluvial reaches to assess existing and potential floodplain inundation, flow paths, and winter and spring habitats for salmonids.

Historical aerial photos were used in combination with LiDAR topography and the results of thermally suitable habitat and flow inundation analyses to identify 36 potential floodplain habitat enhancement segments encompassing 35% of the total predominantly alluvial reach length and 23% of the total Project channel length. These channel segments within predominantly alluvial reaches offer the most suitable site-specific opportunities to effectively restore and enhance floodplain habitats and remediate mine tailings. Potential floodplain habitat enhancement segments were assigned a preliminary suitability rating (1–3) based on physical and biological site conditions, anticipated benefits of potential treatments, and feasibility. Field investigations were conducted within each channel segment to confirm analysis results, further assess opportunities and constraints to floodplain habitat restoration and mine tailing remediation, and refine preliminary suitability ratings. Table 4 summarizes the length of potential floodplain habitat enhancement segments with respect to the total alluvial reach length and Project channel length.

Table 4. Summary of potential floodplain habitat enhancement segments in the Salmon River Project area.

Suitability rating	Count	Length (miles)	Percent of total length		
			Enhancement segments	Alluvial reaches	Project channels
1	14	6.9	53	20	12
2	14	4.3	34	13	8
3	8	1.7	13	5	3
Total	**36**	**12.9**	**100**	**38**	**23**

Lastly, potential floodplain habitat enhancement segments and the intervening segments within the river corridor were aggregated into planning units intended to facilitate a programmatic and tiered NEPA review and to ensure that implementation comprehensively considers interrelated actions that could more broadly affect channel and floodplain conditions throughout a reach.

Phase 2 (conceptual restoration and enhancement designs within priority channel segments) and Phase 3 (programmatic environmental review and permitting) of the Salmon River Floodplain Habitat Enhancement and Mine Tailing Remediation Project have been initiated with partial funding from the California Department of Fish and Wildlife Proposition 1 Watershed Restoration Grant Program. Engineering designs have been developed for the Red Bank and Kelly Bar fisheries and off-channel habitat enhancement project sites (Michael Love and Associates 2016, 2017), two priority segments identified on the North Fork. The Salmon River Restoration Council developed conceptual engineering designs for a project site on the South Fork near the Knownothing Creek confluence (Stillwater Sciences 2014), and is in the process of designing structures for a project site on the mainstem Salmon River at the Nordheimer Creek confluence in partnership with Fiori Geosciences. These projects, initiated in priority segments of mainstem Salmon River channel reaches, provide an opportunity to learn from restoration actions in this dynamic system.

Comprehensive, prioritized, and sequential implementation of the Salmon River Floodplain Habitat Enhancement and Mine Tailing Remediation Project will increase the availability and quality of limiting habitats (e.g., over-wintering, over-summering, and spawning) for salmonids; improve riparian functions and thermal suitability (e.g., shade cover from riparian vegetation and hyporheic exchange between the floodplain and channel); and restore geomorphic processes important in renewing and maintaining floodplain and aquatic habitat. Once these impairments are addressed, the Salmon River will have exceptional value as a long-term refuge for salmon, steelhead and other cold-water dependent aquatic species.

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Appendices

Appendix A

Thermally suitable habitat and flow inundation in predominantly alluvial reaches within the Salmon River Project area

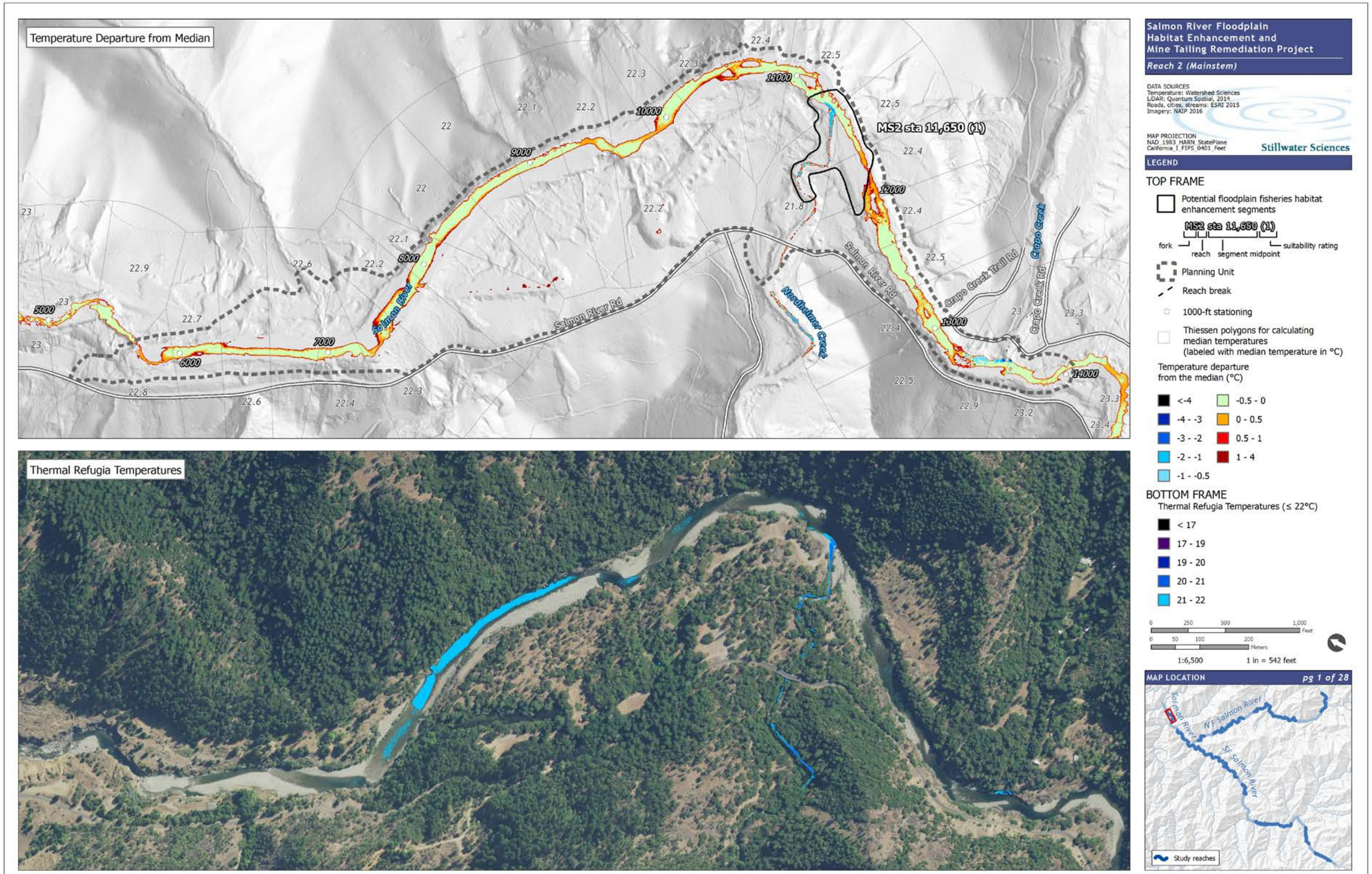


Figure A-1. Thermally suitable habitat and localized thermal refuges in predominantly alluvial reaches within the Salmon River Project area based on 2009 TIR data, Tile 1 of 28.

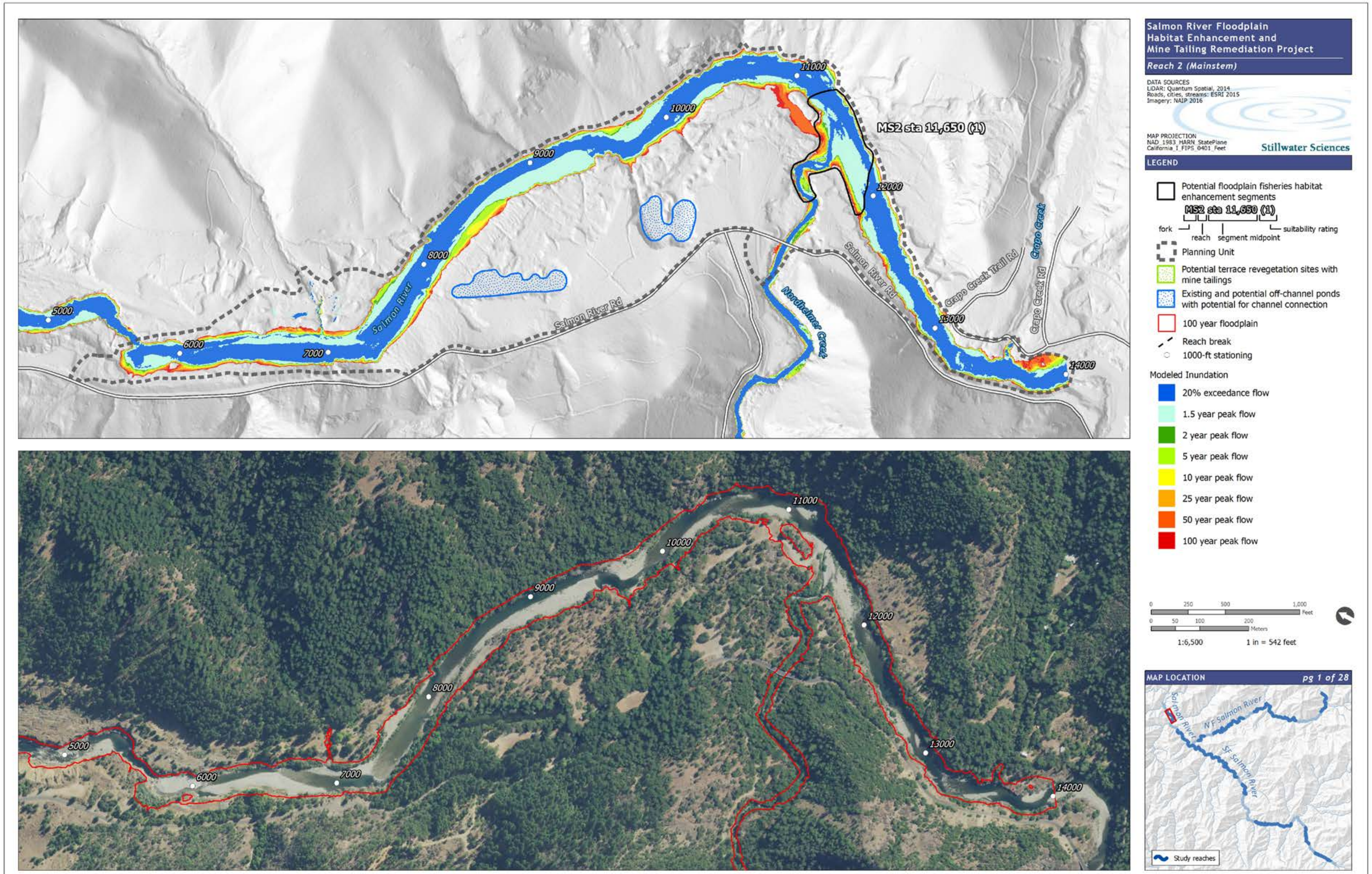


Figure A-2. Flow inundation in predominantly alluvial reaches within the Salmon River Project area, Tile 1 of 28.

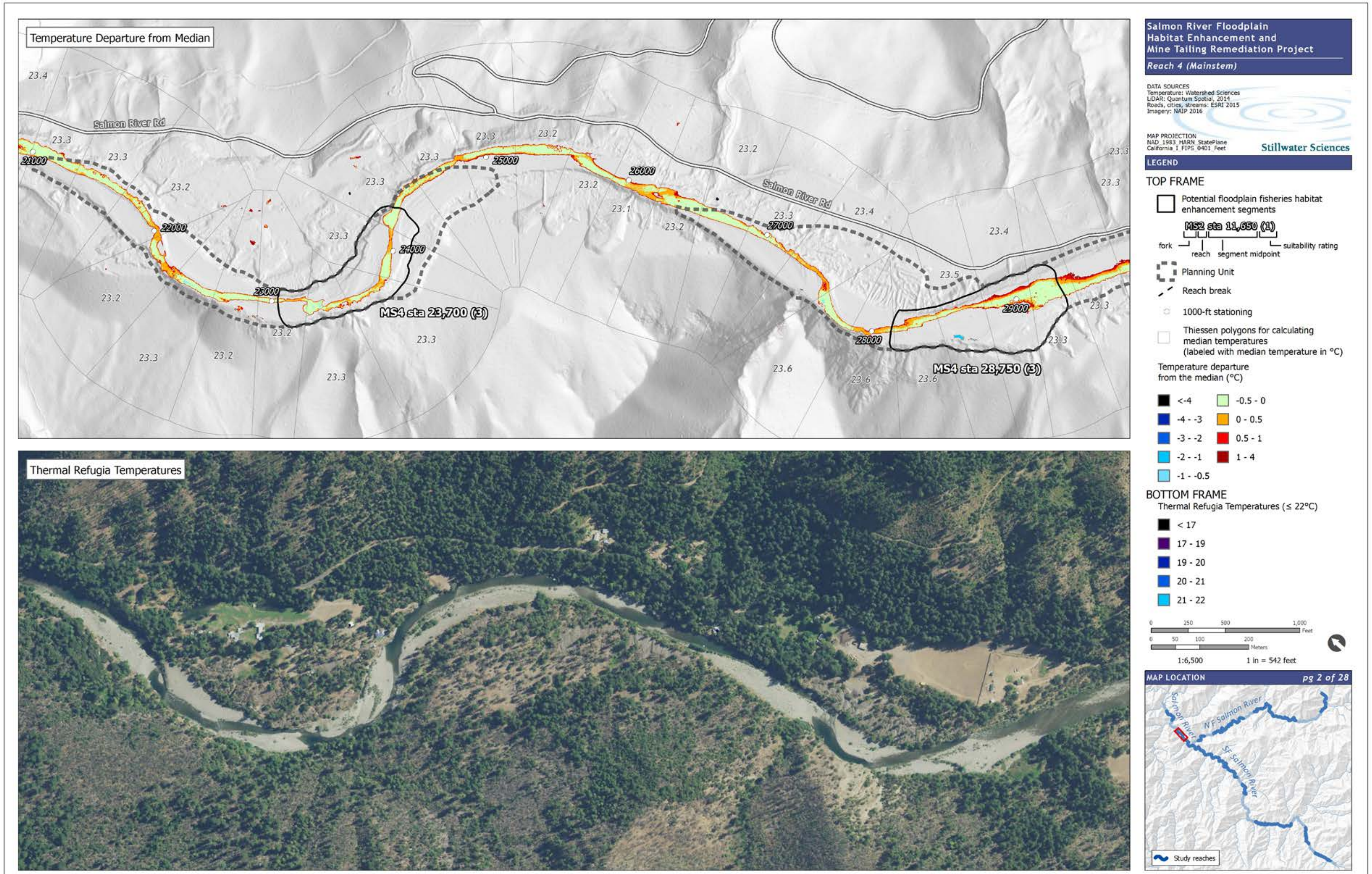


Figure A-3. Thermally suitable habitat and localized thermal refuges in predominantly alluvial reaches within the Salmon River project area based on 2009 TIR data, Tile 2 of 28.

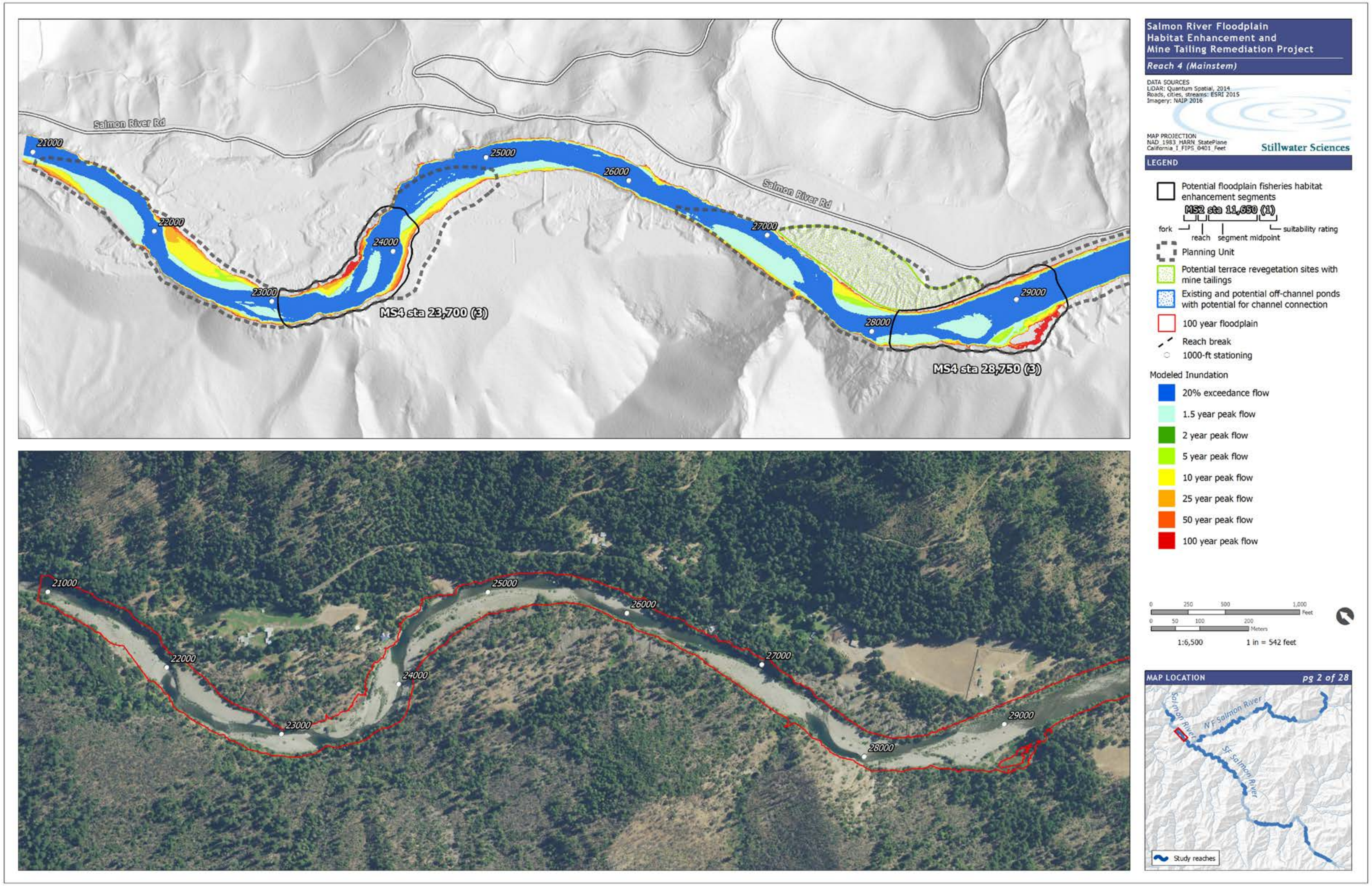


Figure A-4. Flow inundation in predominantly alluvial reaches within the Salmon River project area, Tile 2 of 28.

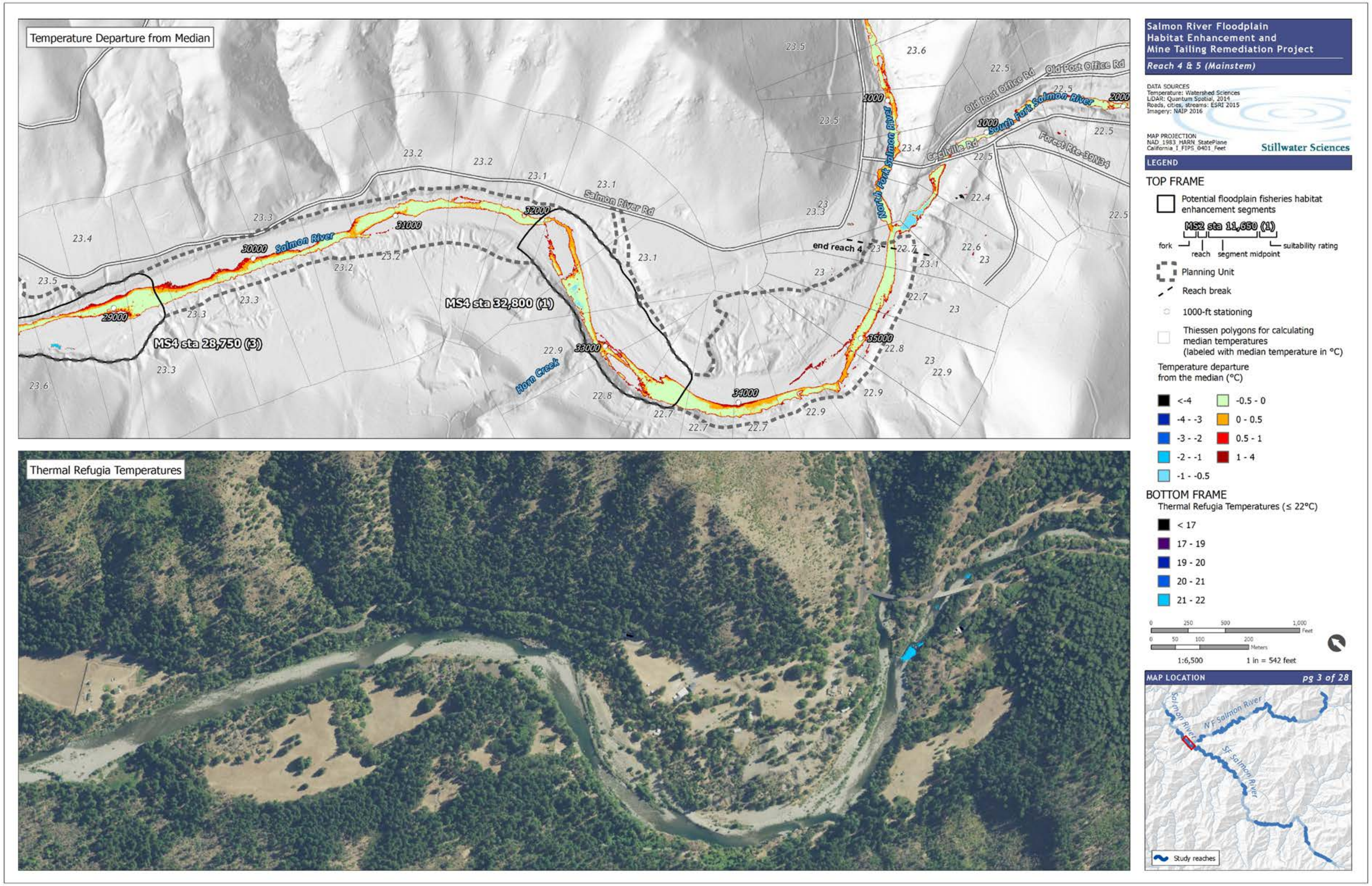


Figure A-5. Thermally suitable habitat and localized thermal refuges in predominantly alluvial reaches within the Salmon River project area based on 2009 TIR data, Tile 3 of 28.

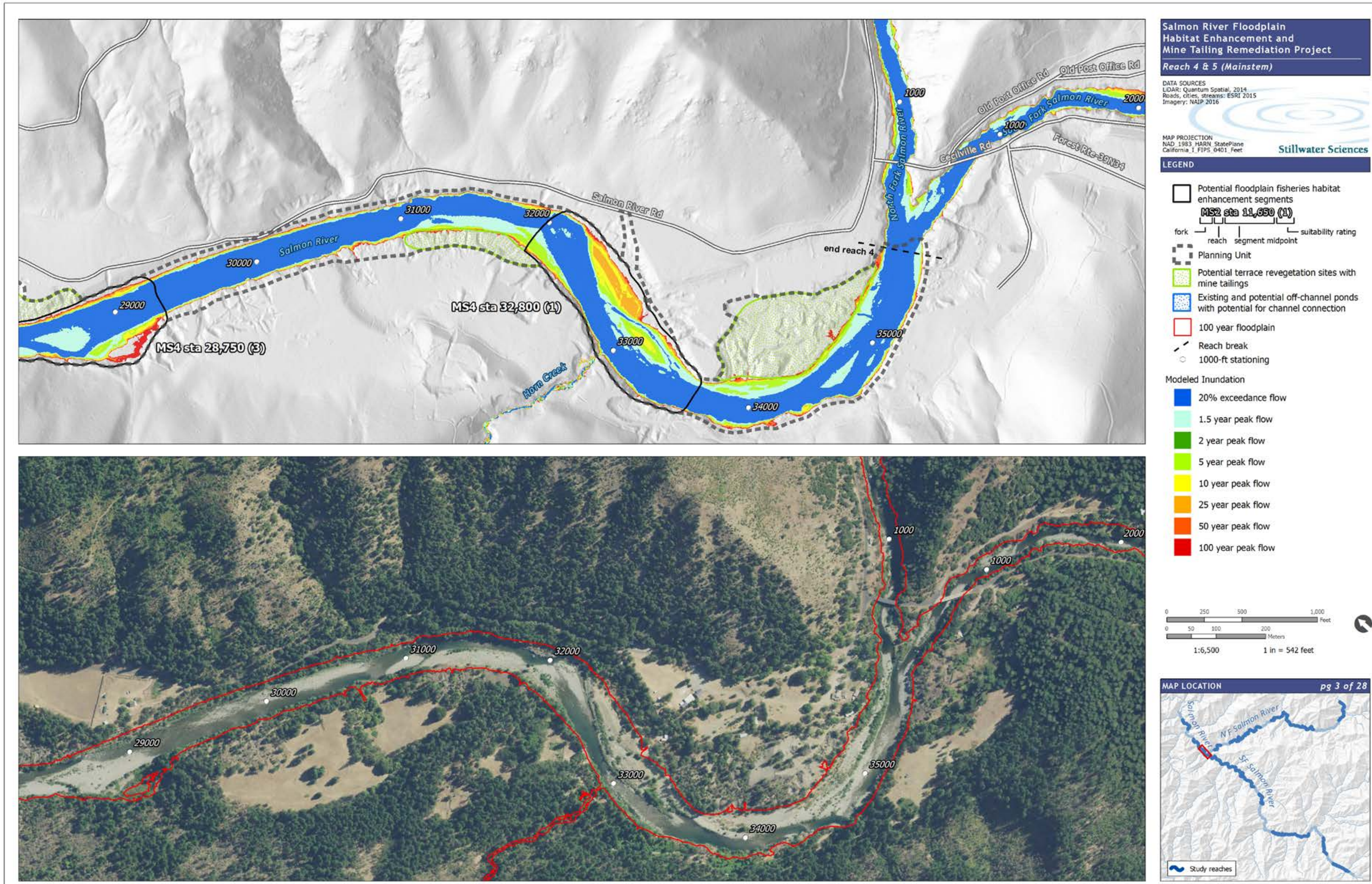


Figure A-6. Flow inundation in predominantly alluvial reaches within the Salmon River project area, Tile 3 of 28.

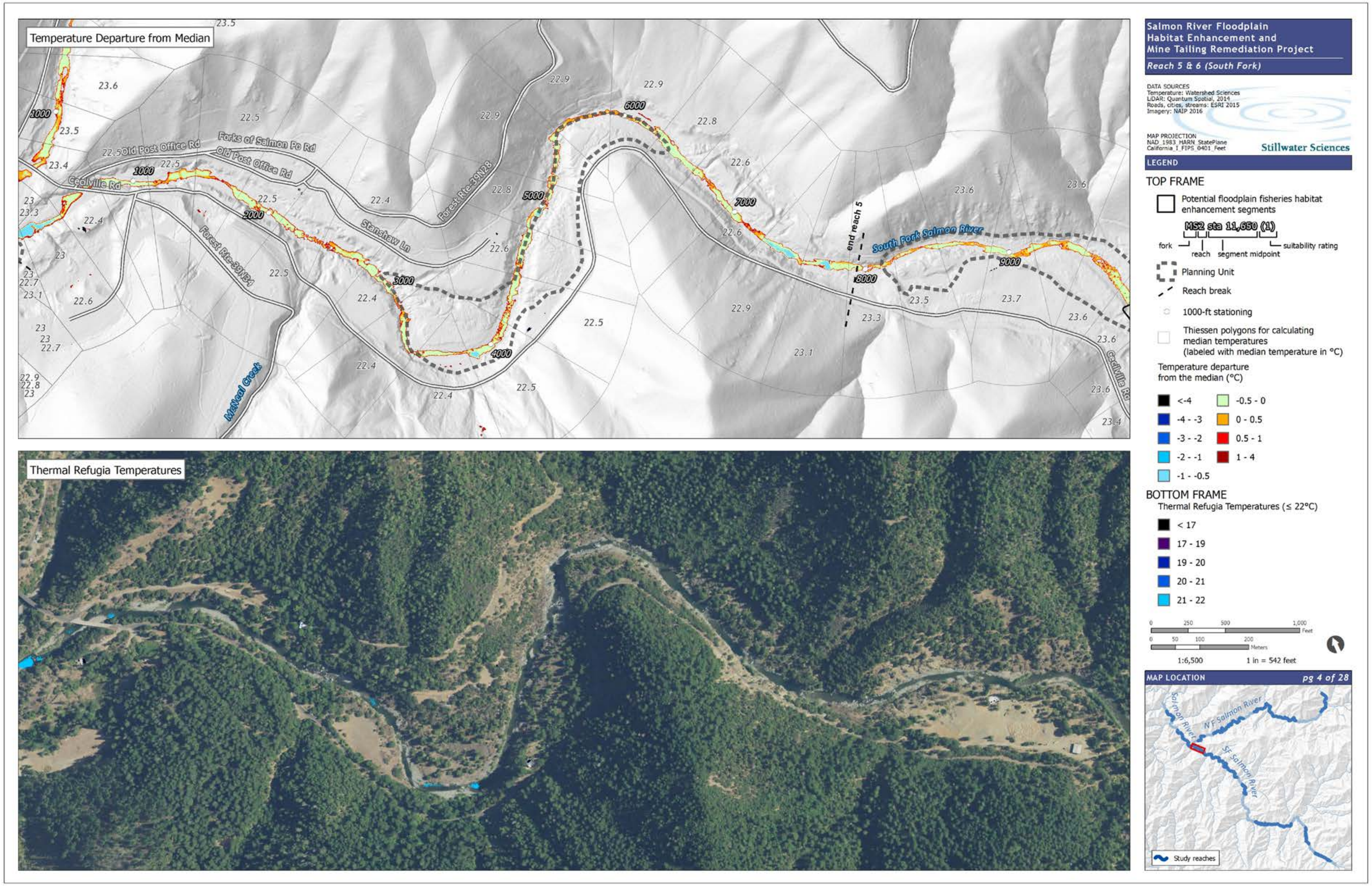


Figure A-7. Thermally suitable habitat and localized thermal refuges in predominantly alluvial reaches within the Salmon River project area based on 2009 TIR data, Tile 4 of 28.

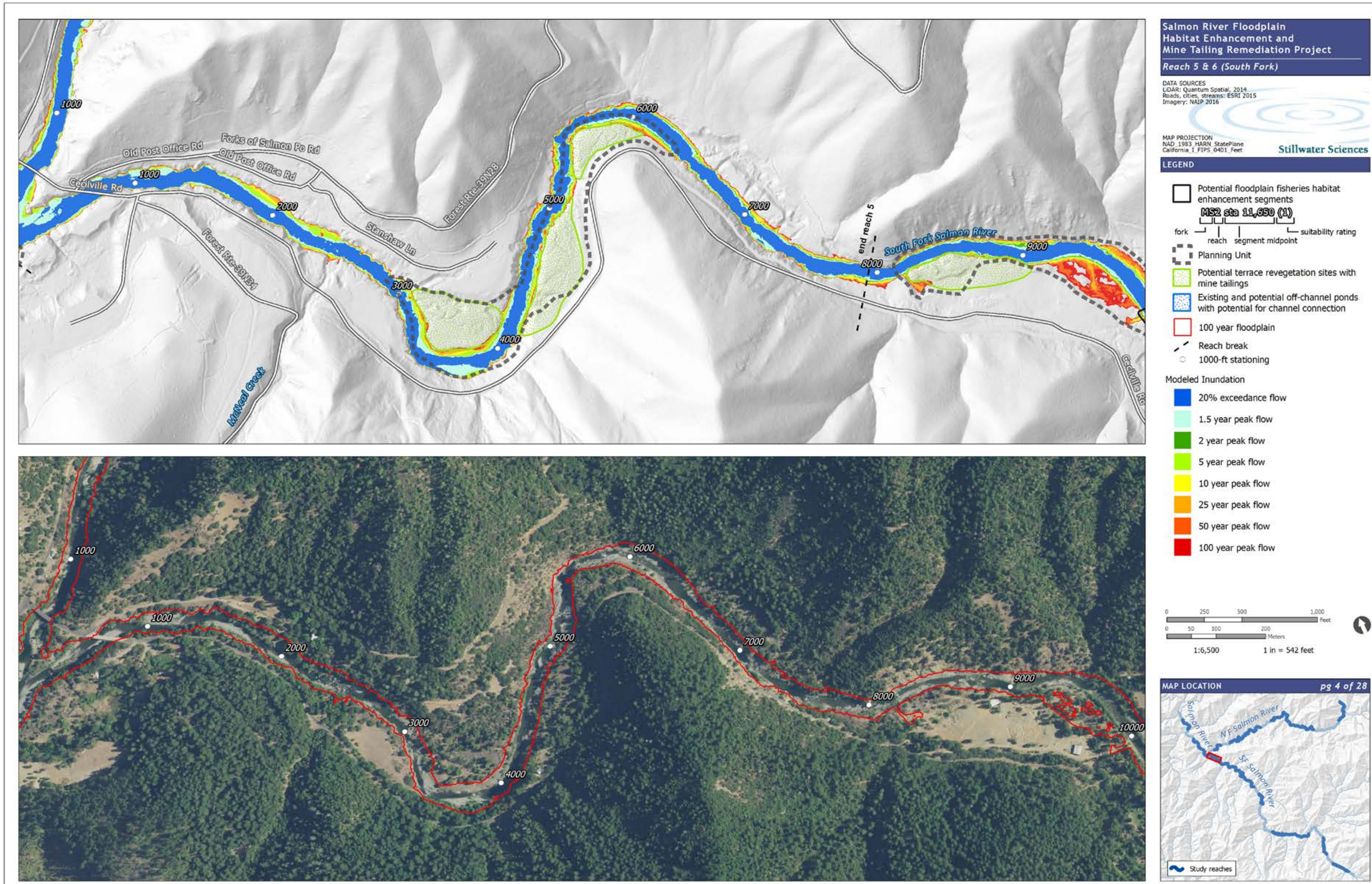
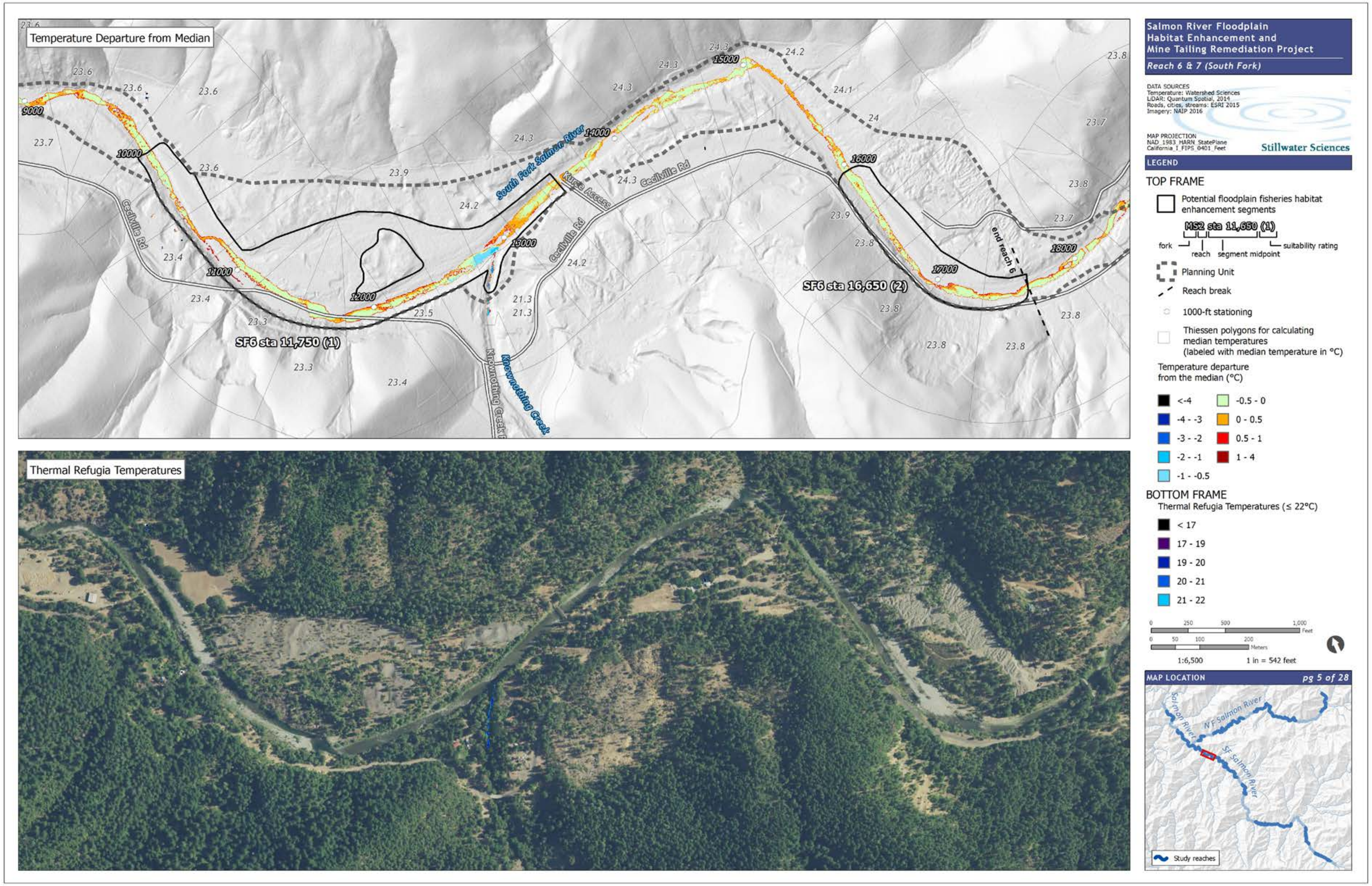


Figure A-8. Flow inundation in predominantly alluvial reaches within the Salmon River project area, Tile 4 of 28.



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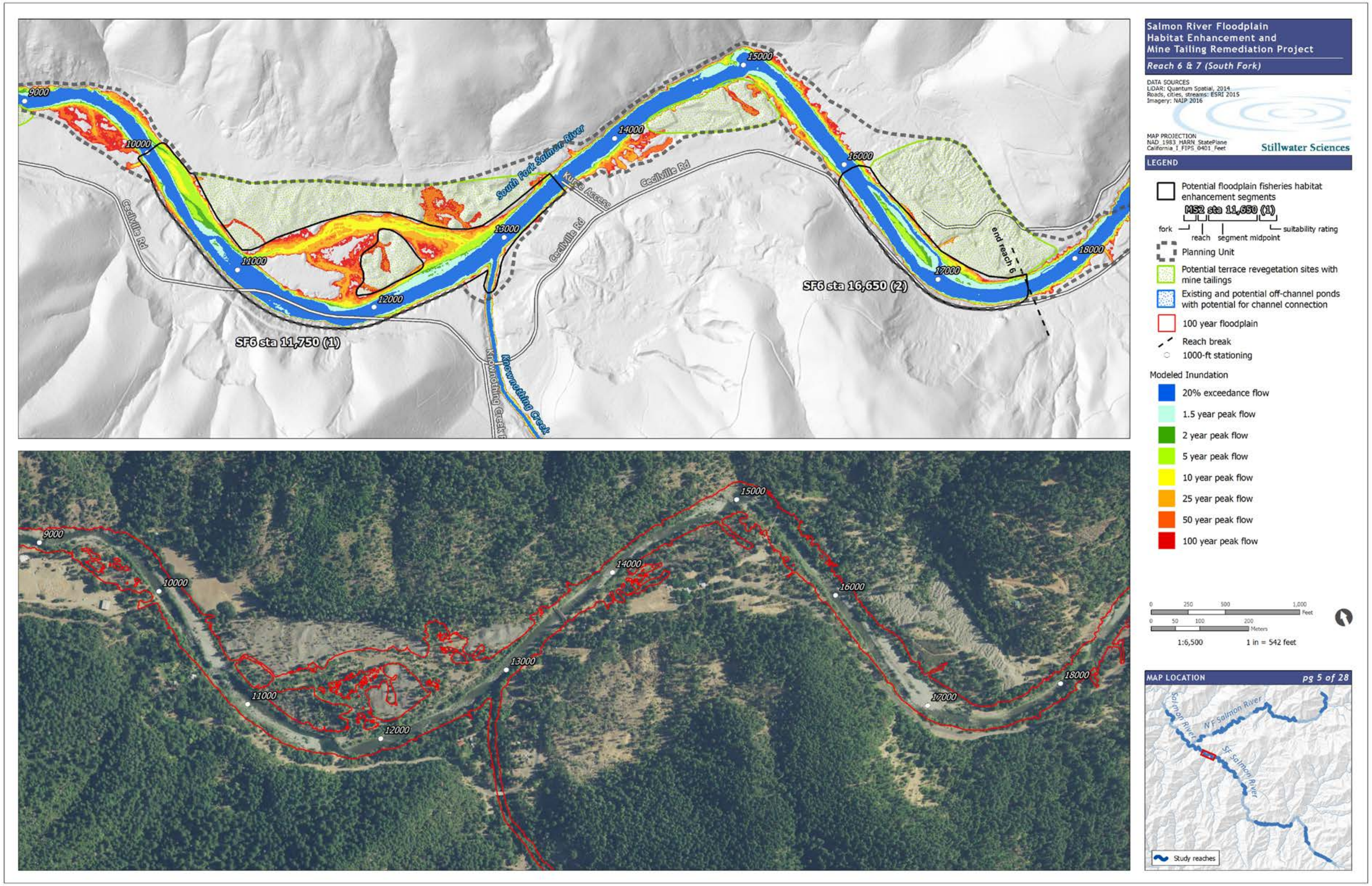


Figure A-10. Flow inundation in predominantly alluvial reaches within the Salmon River project area, Tile 5 of 28.

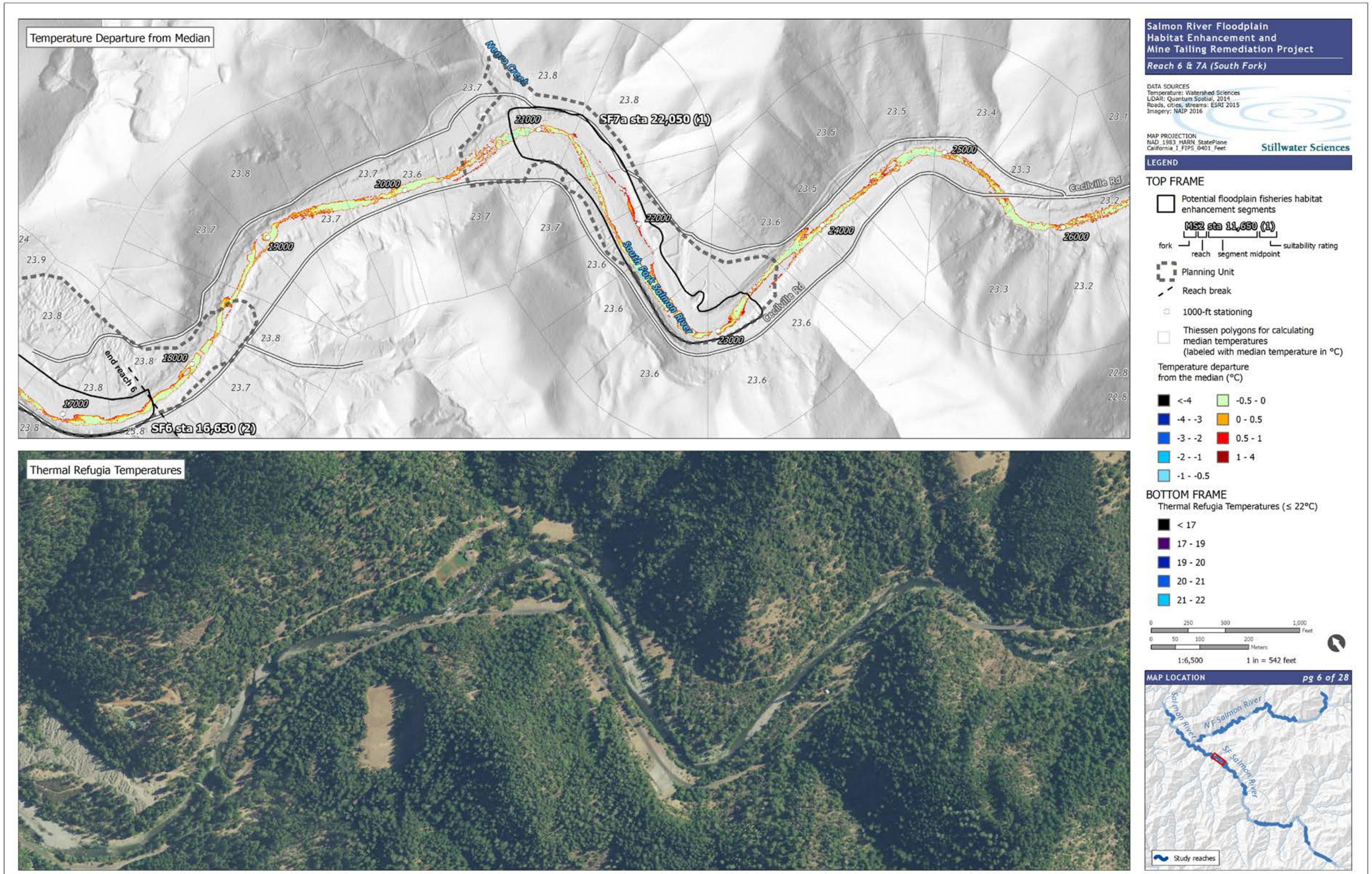


Figure A-11. Thermally suitable habitat and localized thermal refuges in predominantly alluvial reaches within the Salmon River project area based on 2009 TIR data, Tile 6 of 28.

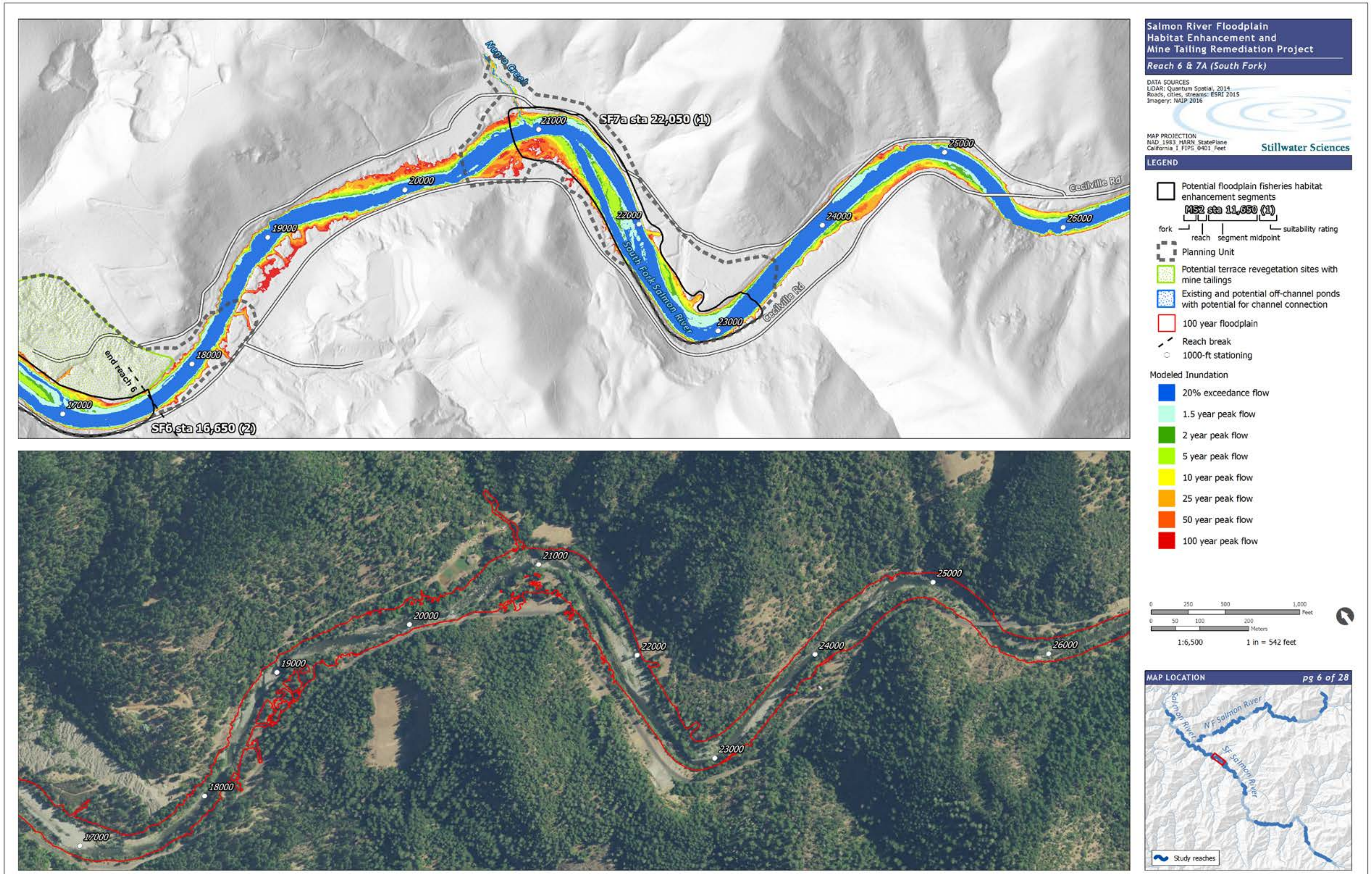


Figure A-12. Flow inundation in predominantly alluvial reaches within the Salmon River project area, Tile 6 of 28.

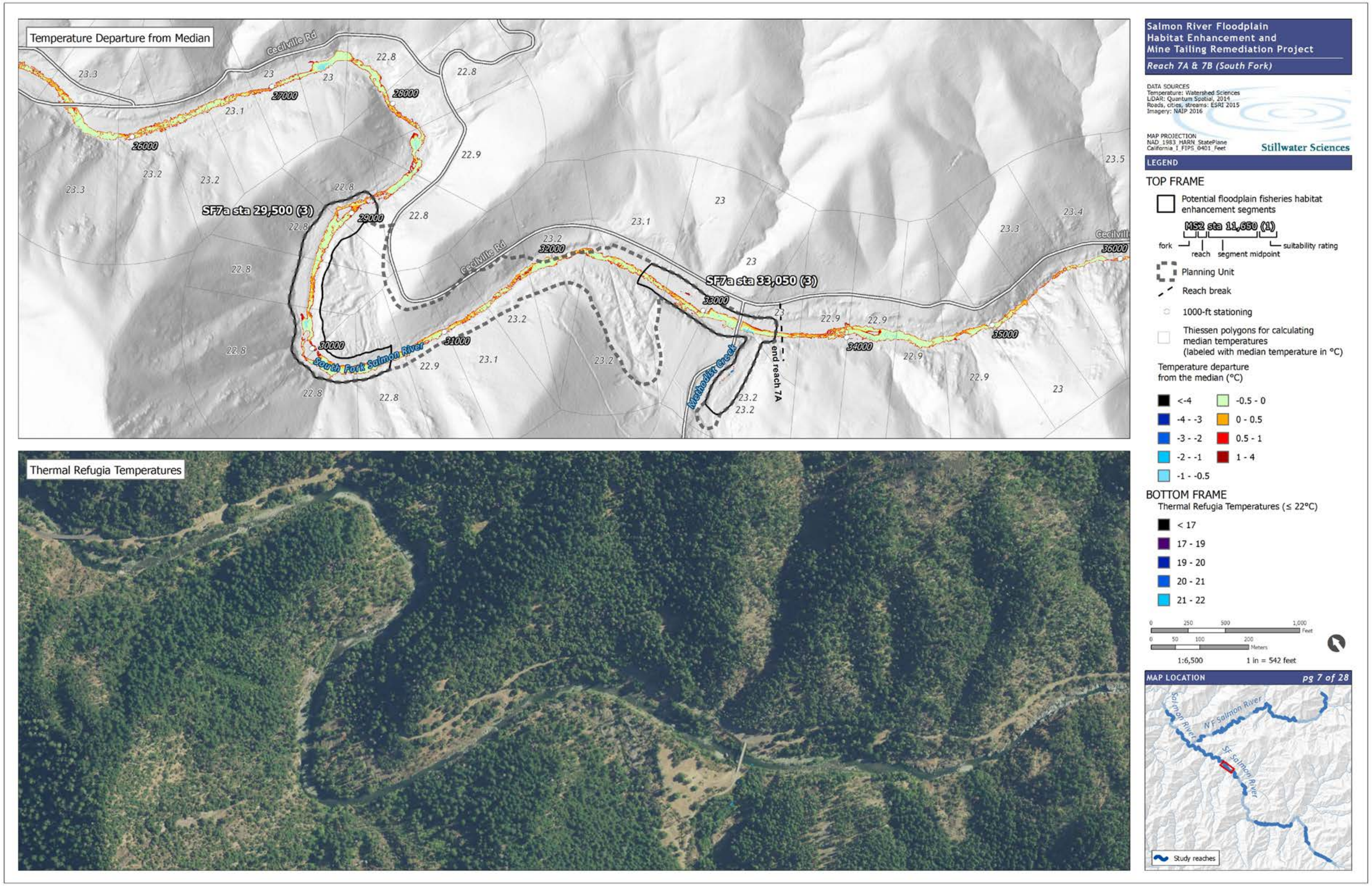
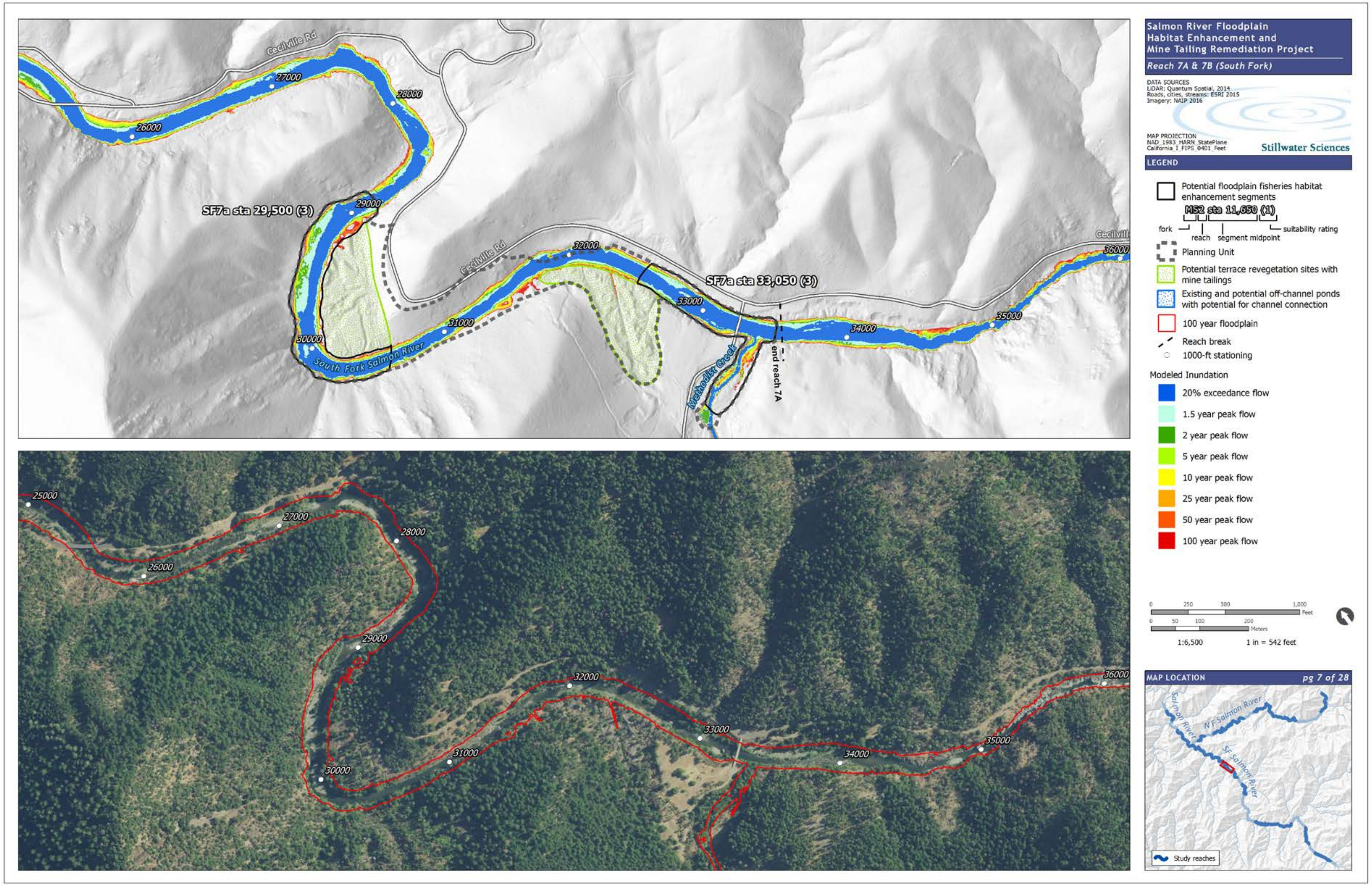


Figure A-13. Thermally suitable habitat and localized thermal refuges in predominantly alluvial reaches within the Salmon River project area based on 2009 TIR data, Tile 7 of 28.



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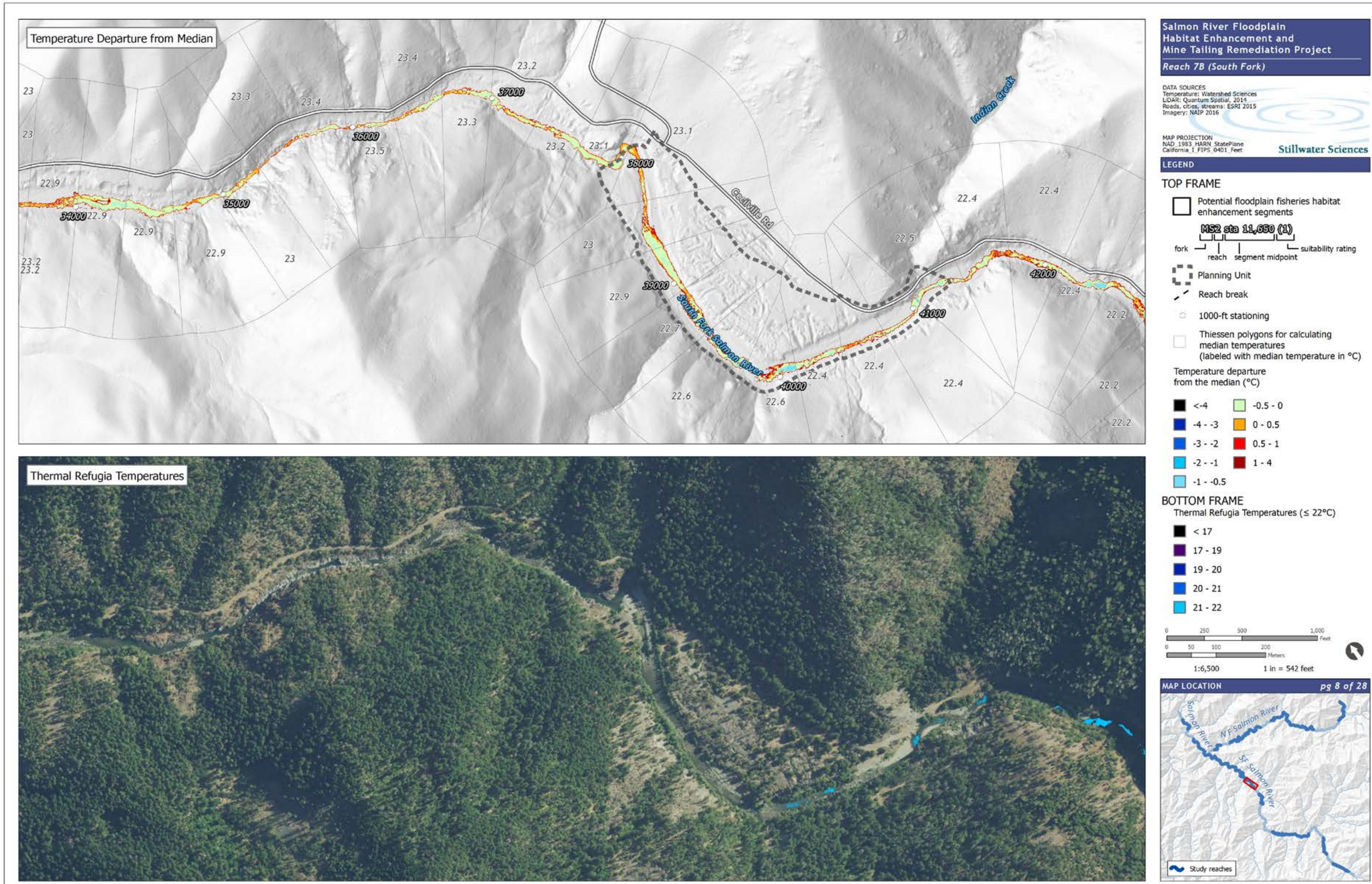

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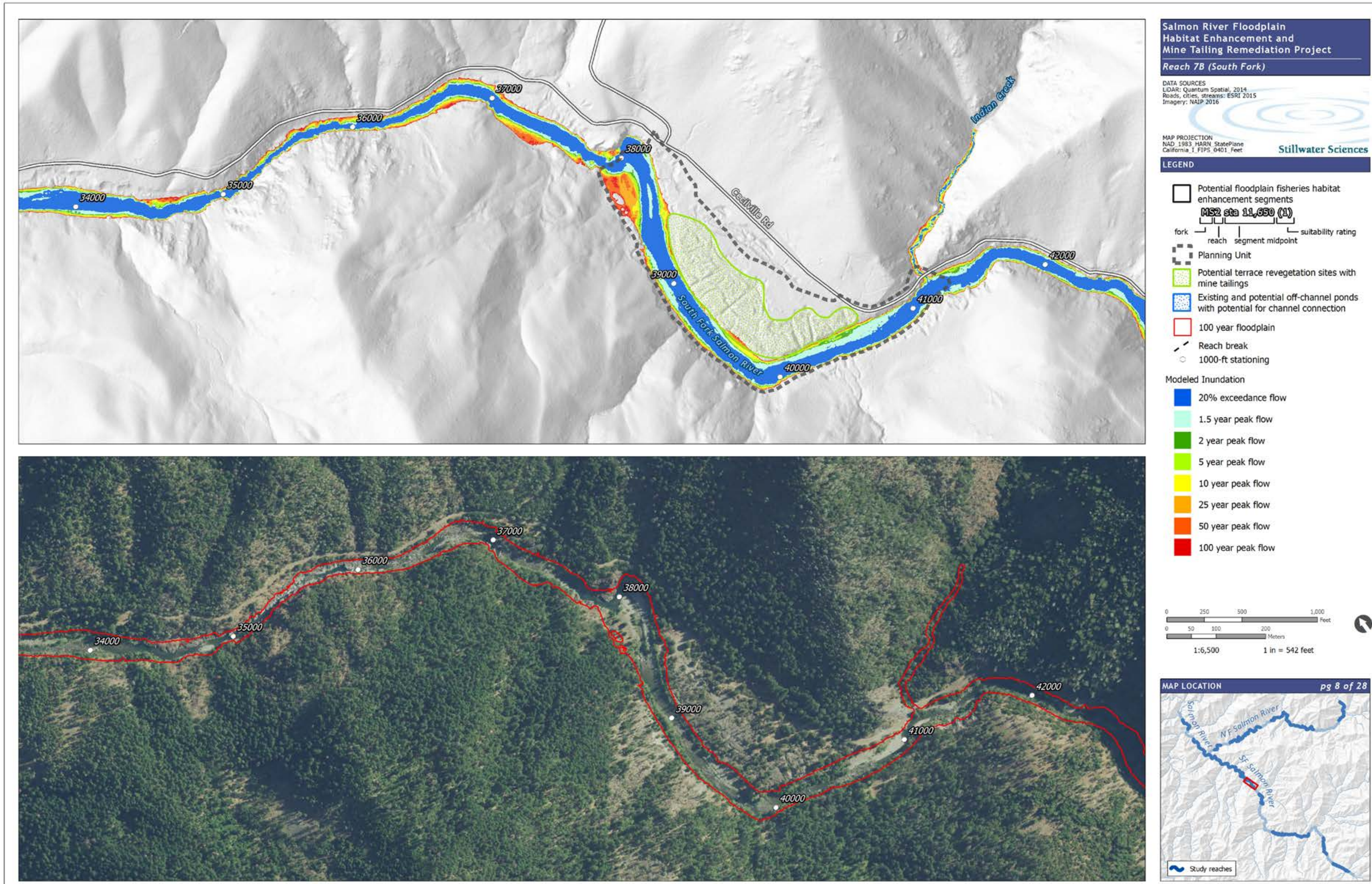

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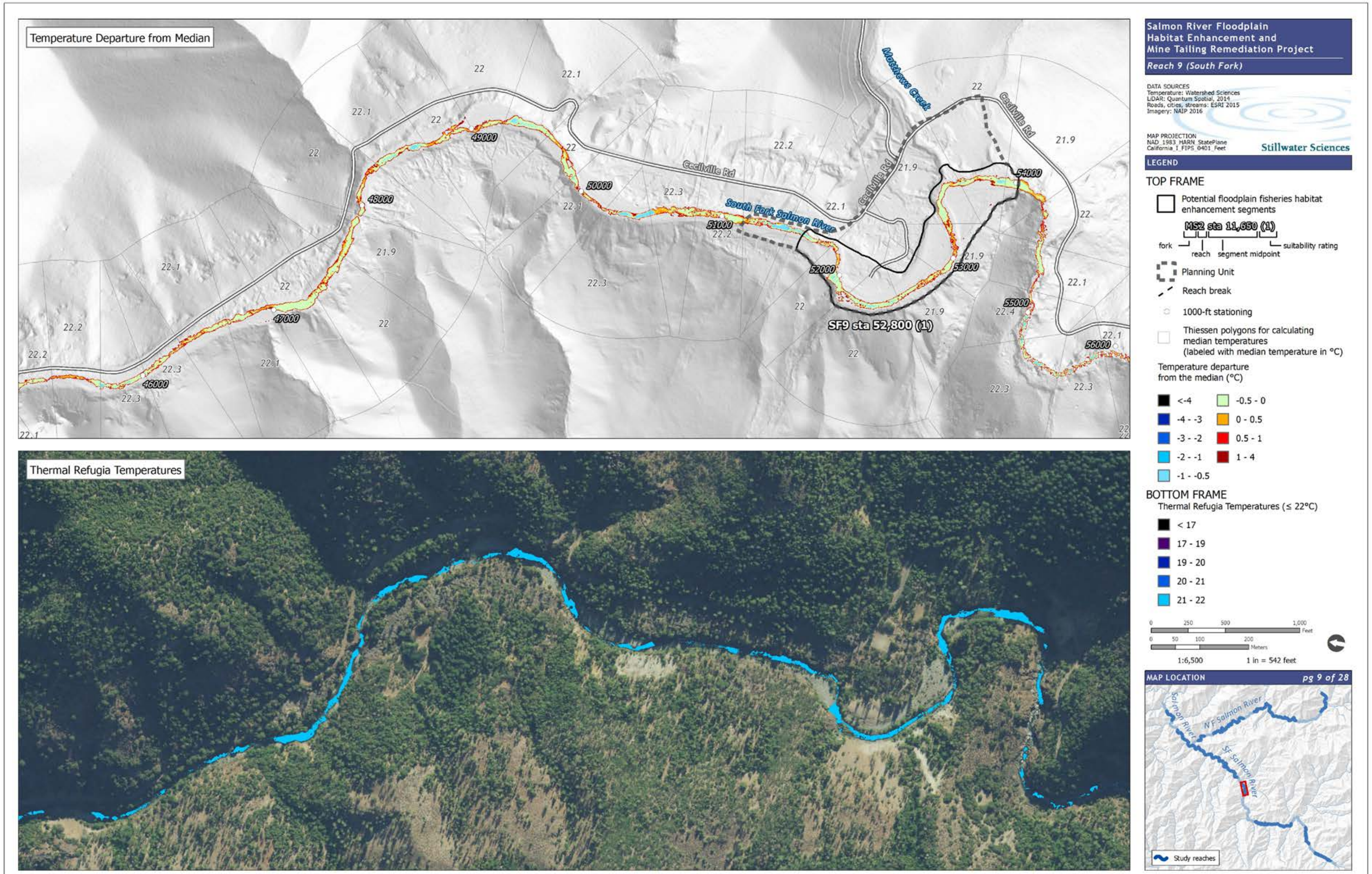

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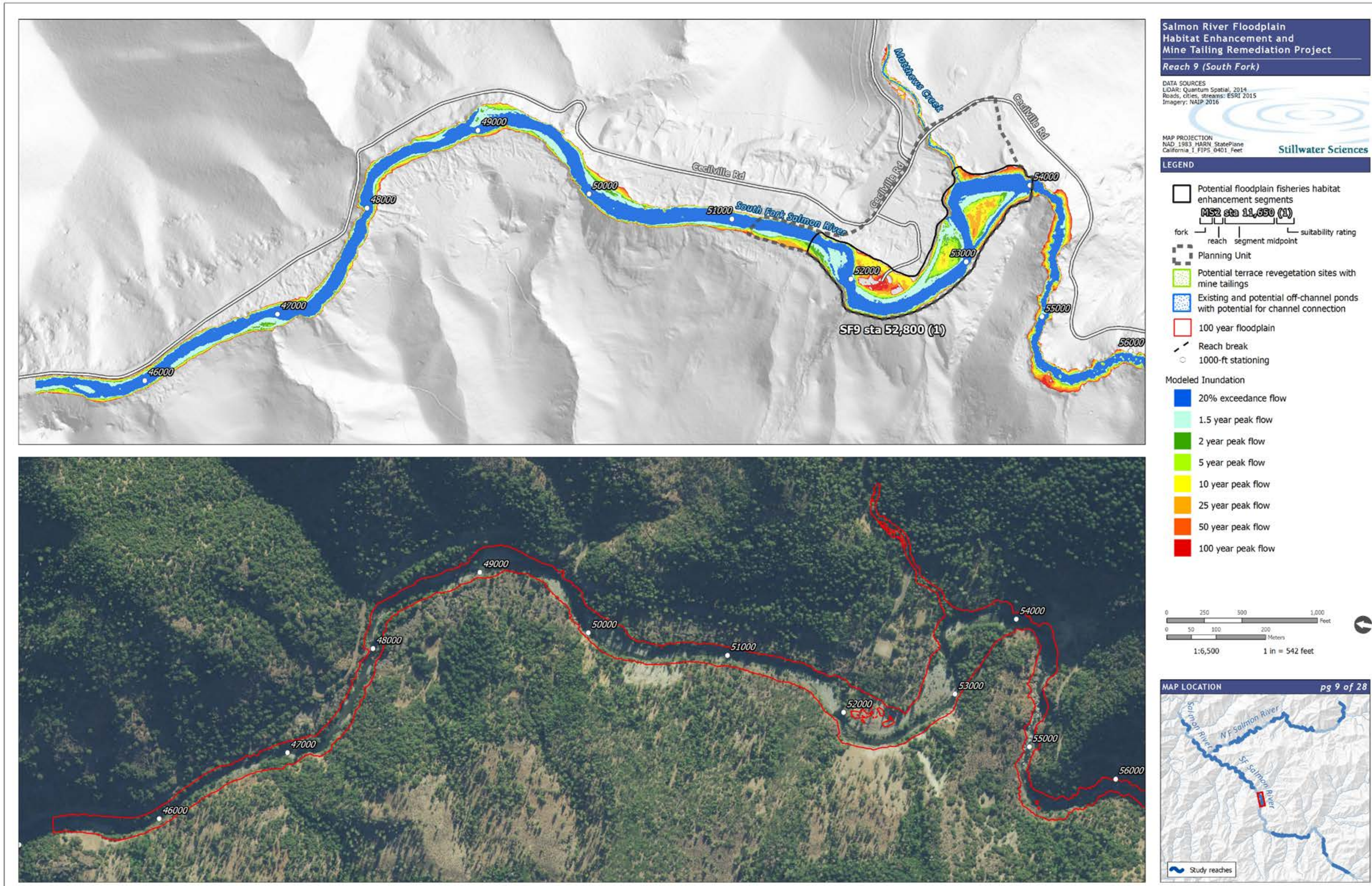

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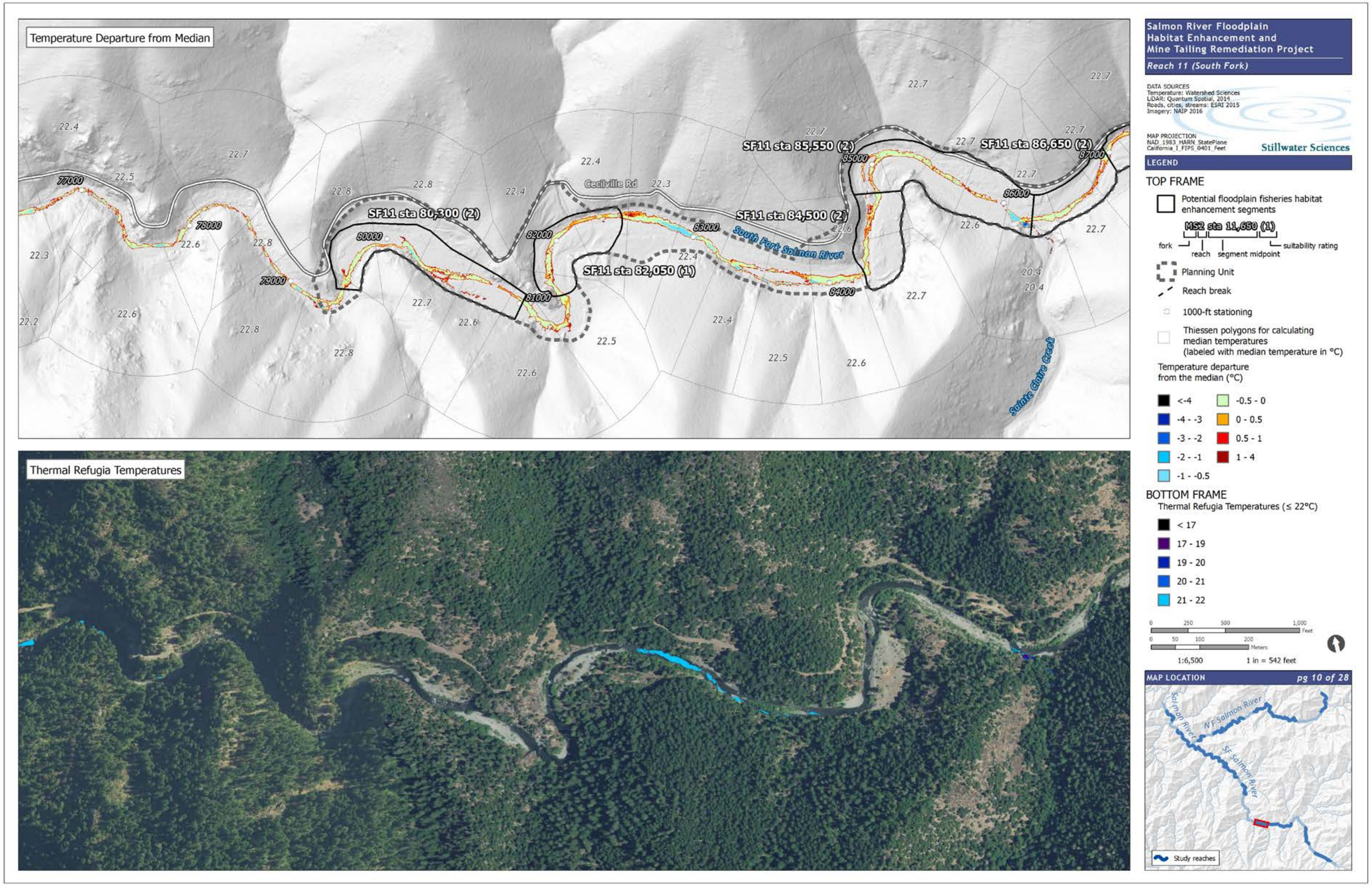

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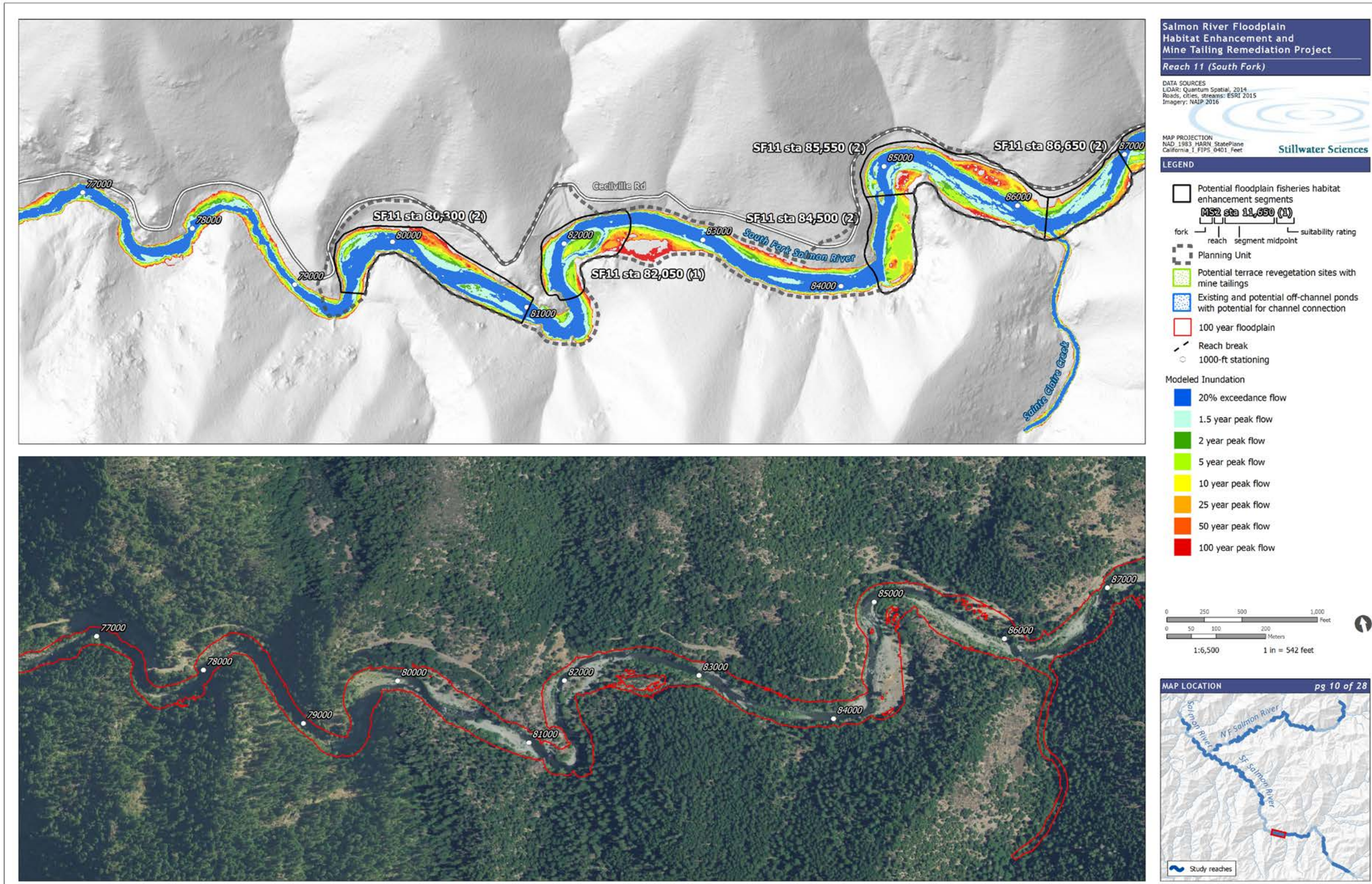

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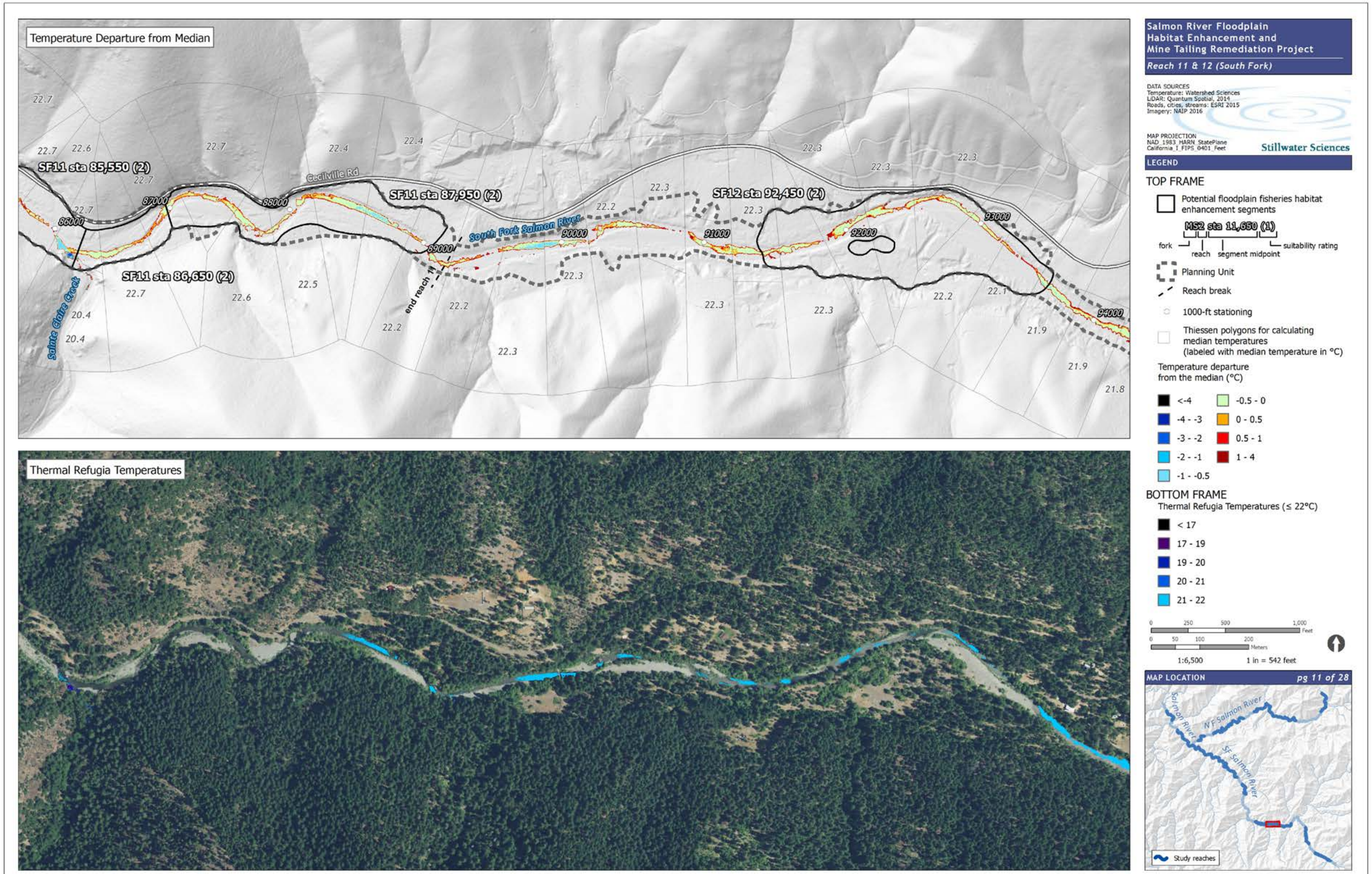

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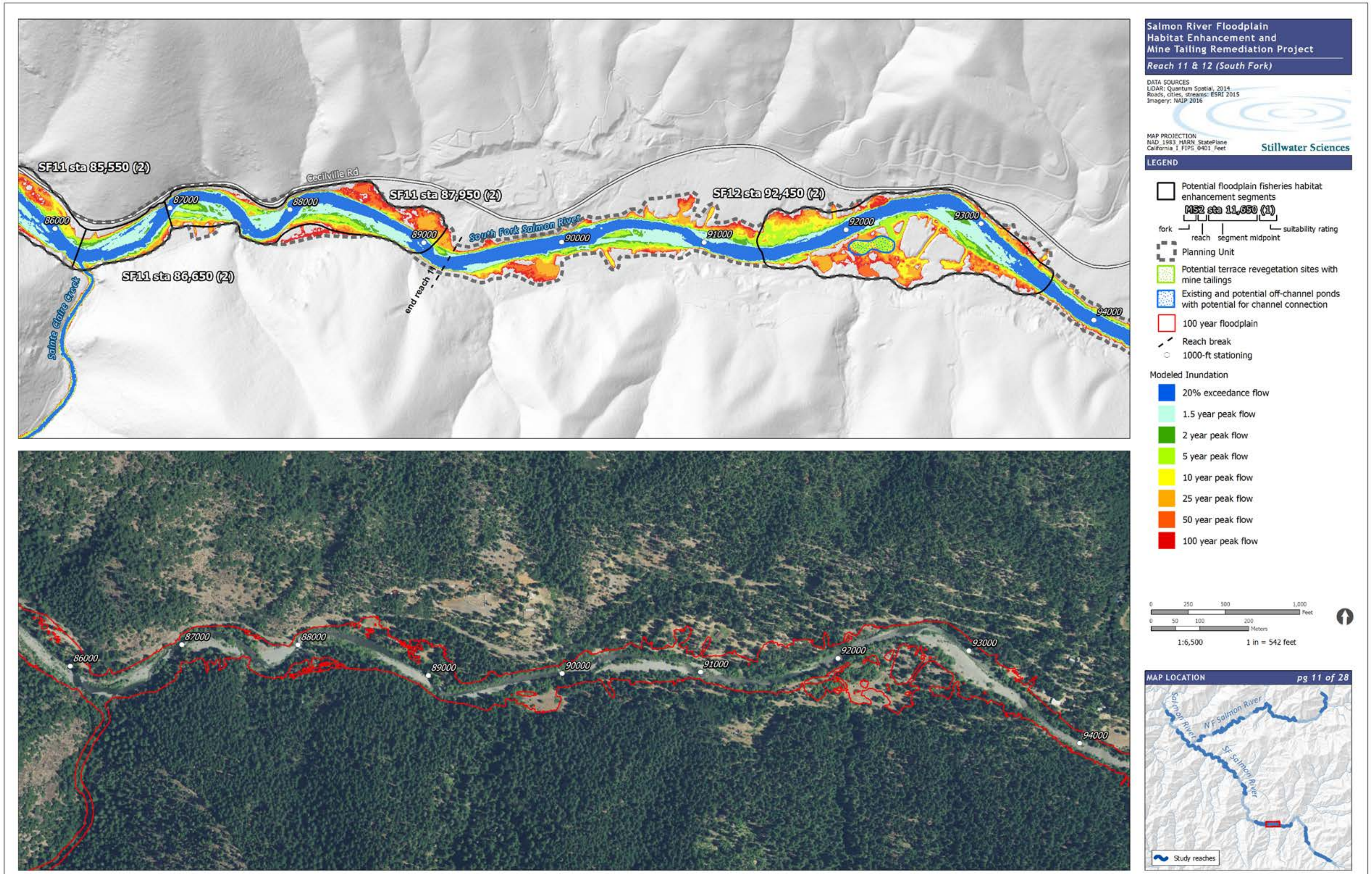

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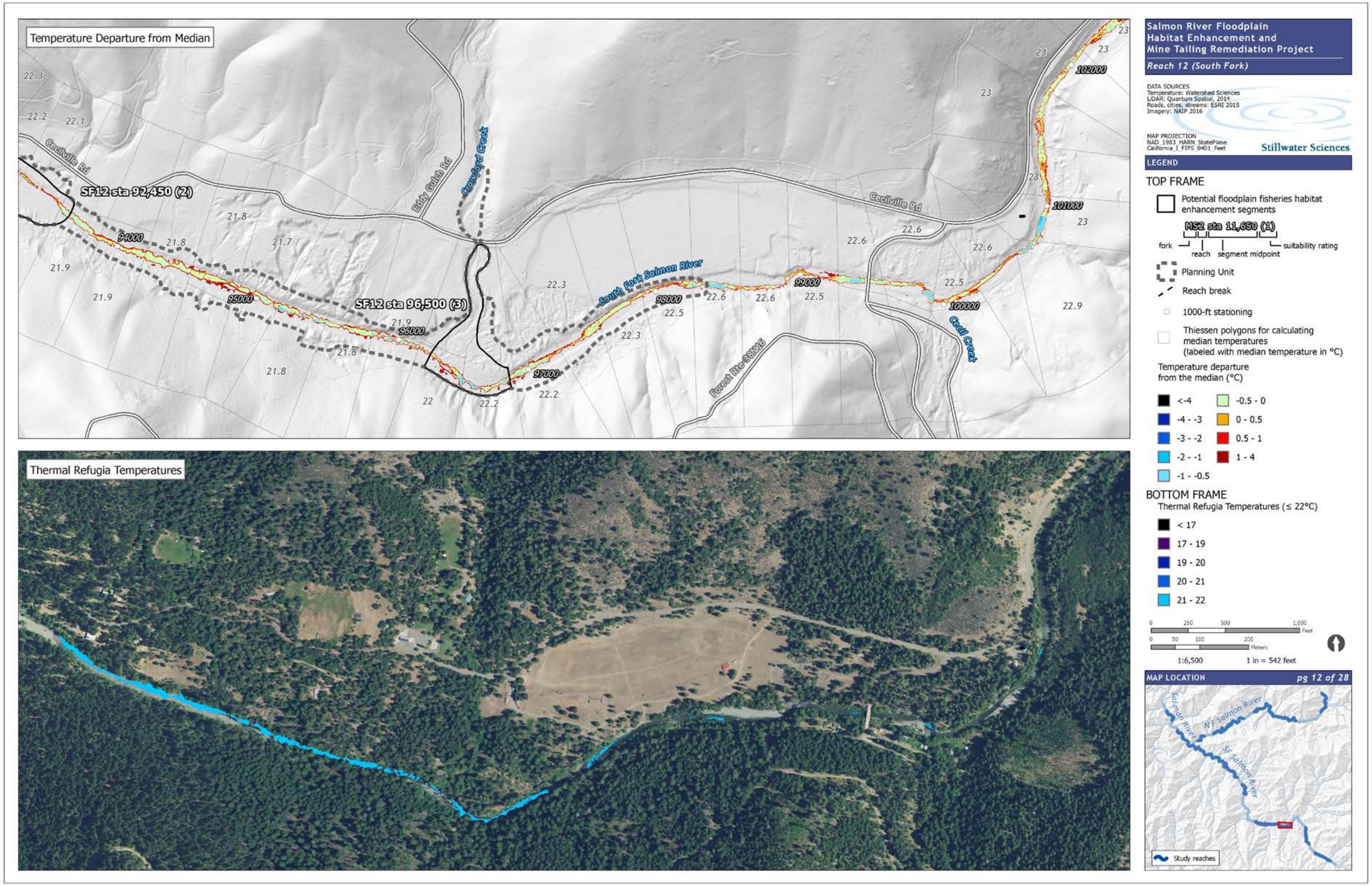

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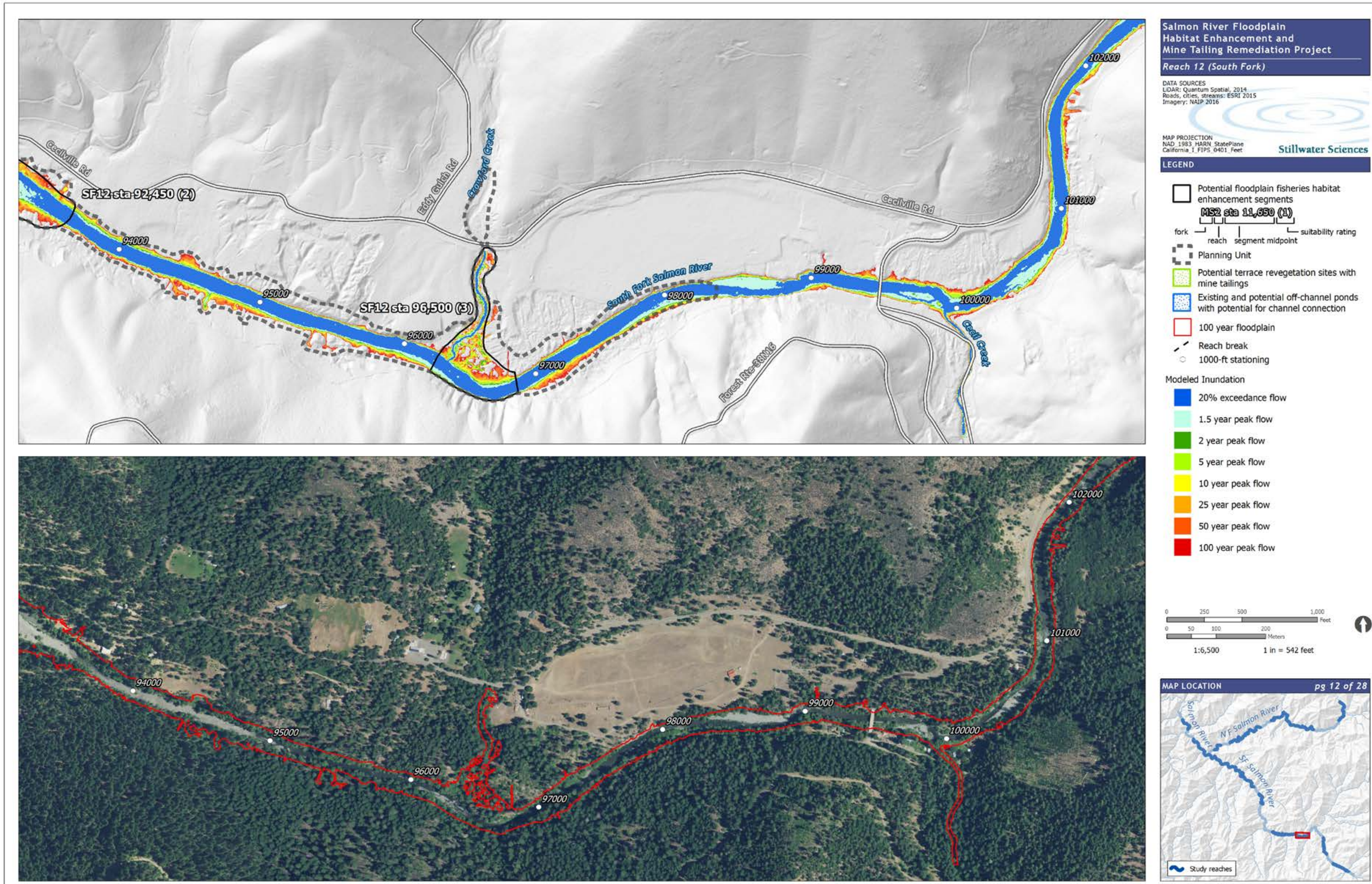

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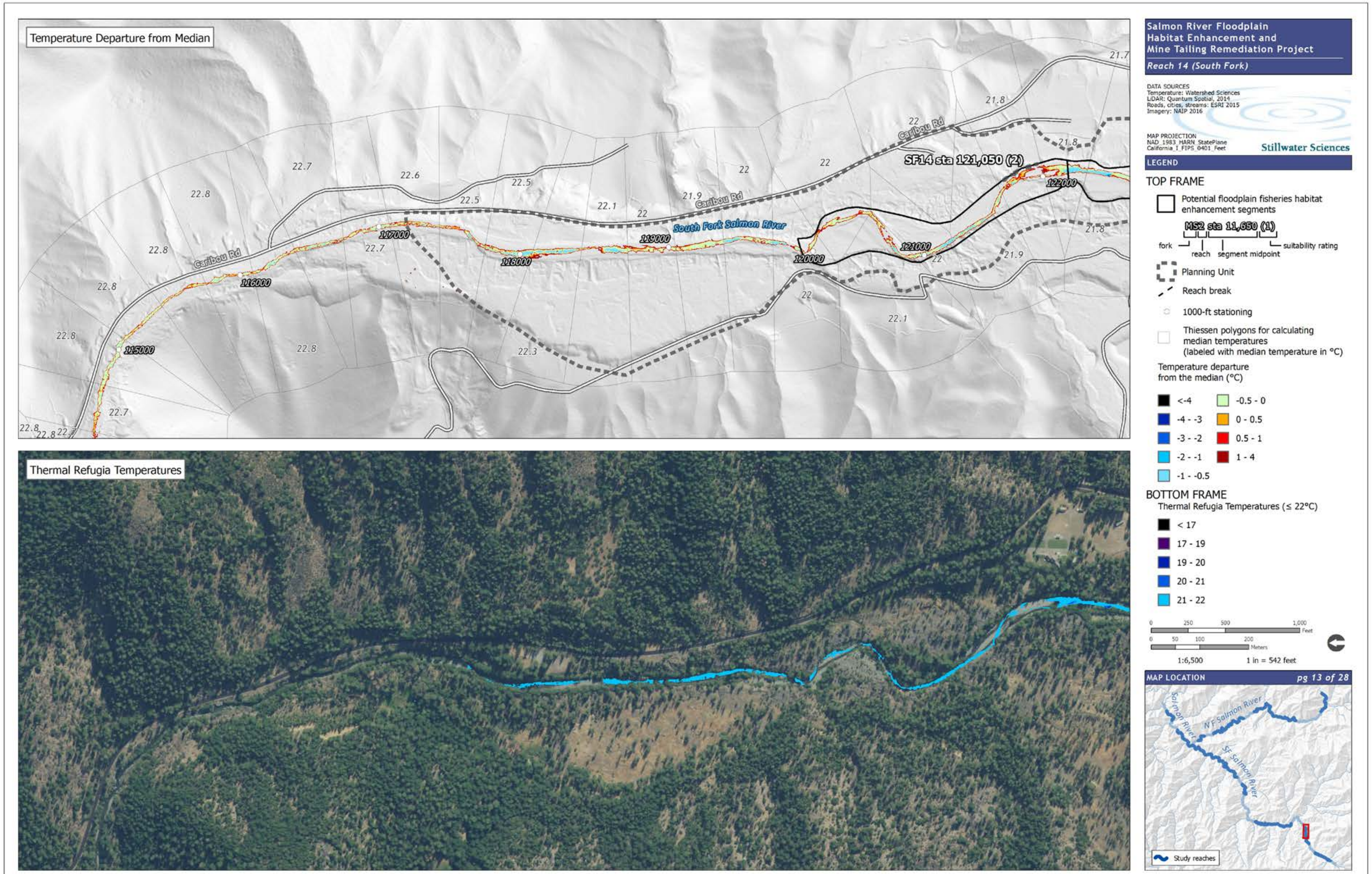

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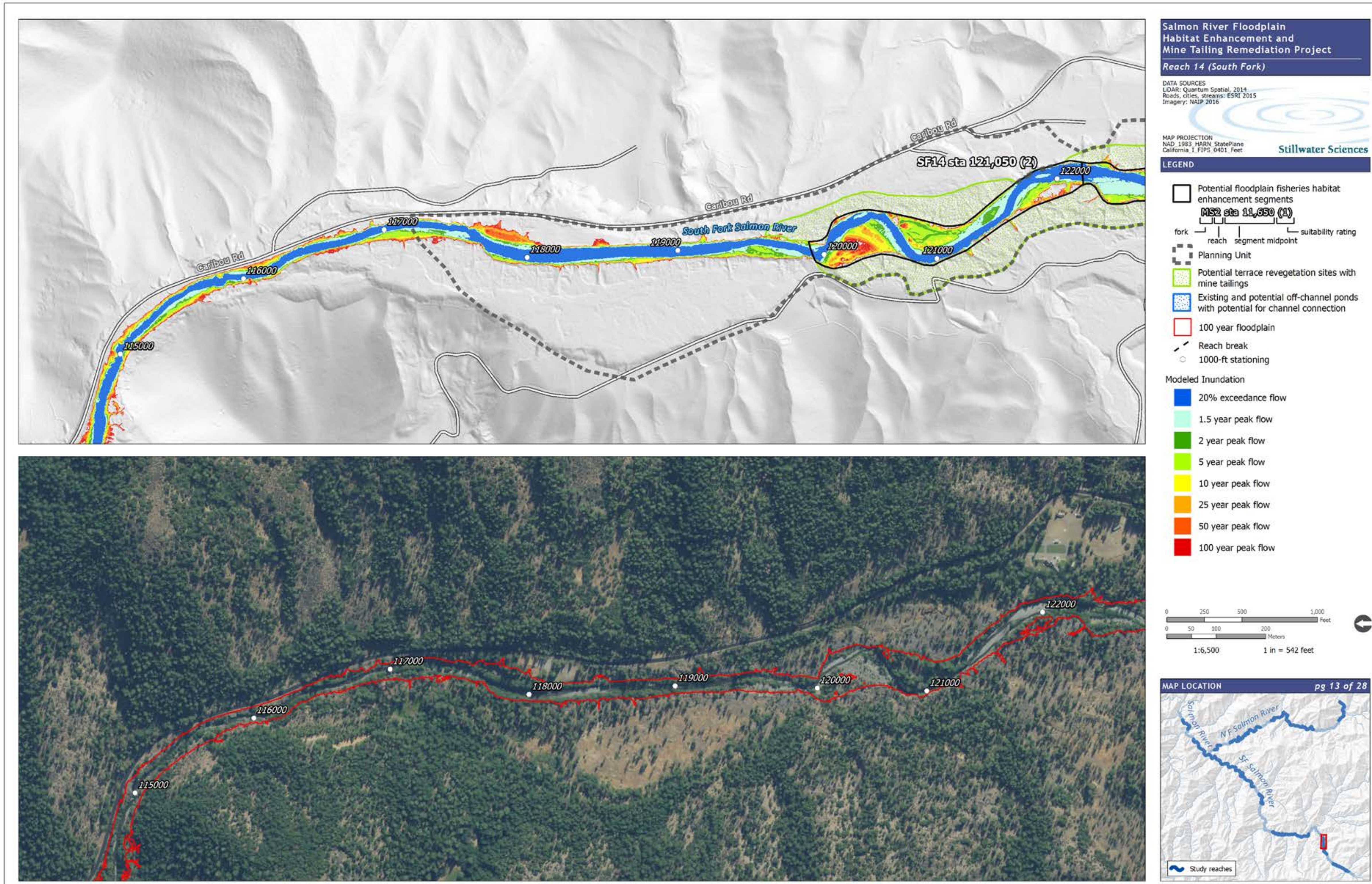

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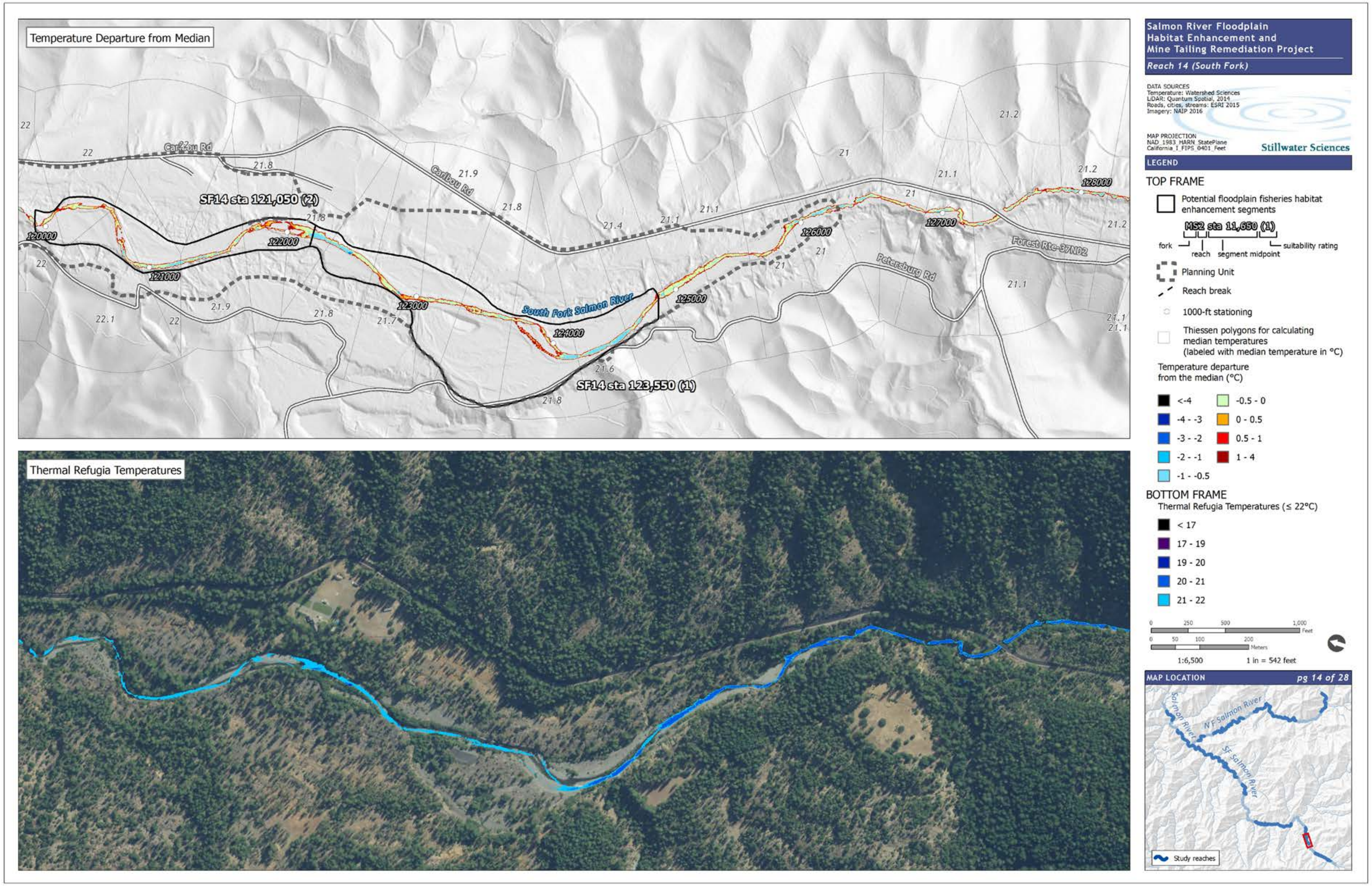

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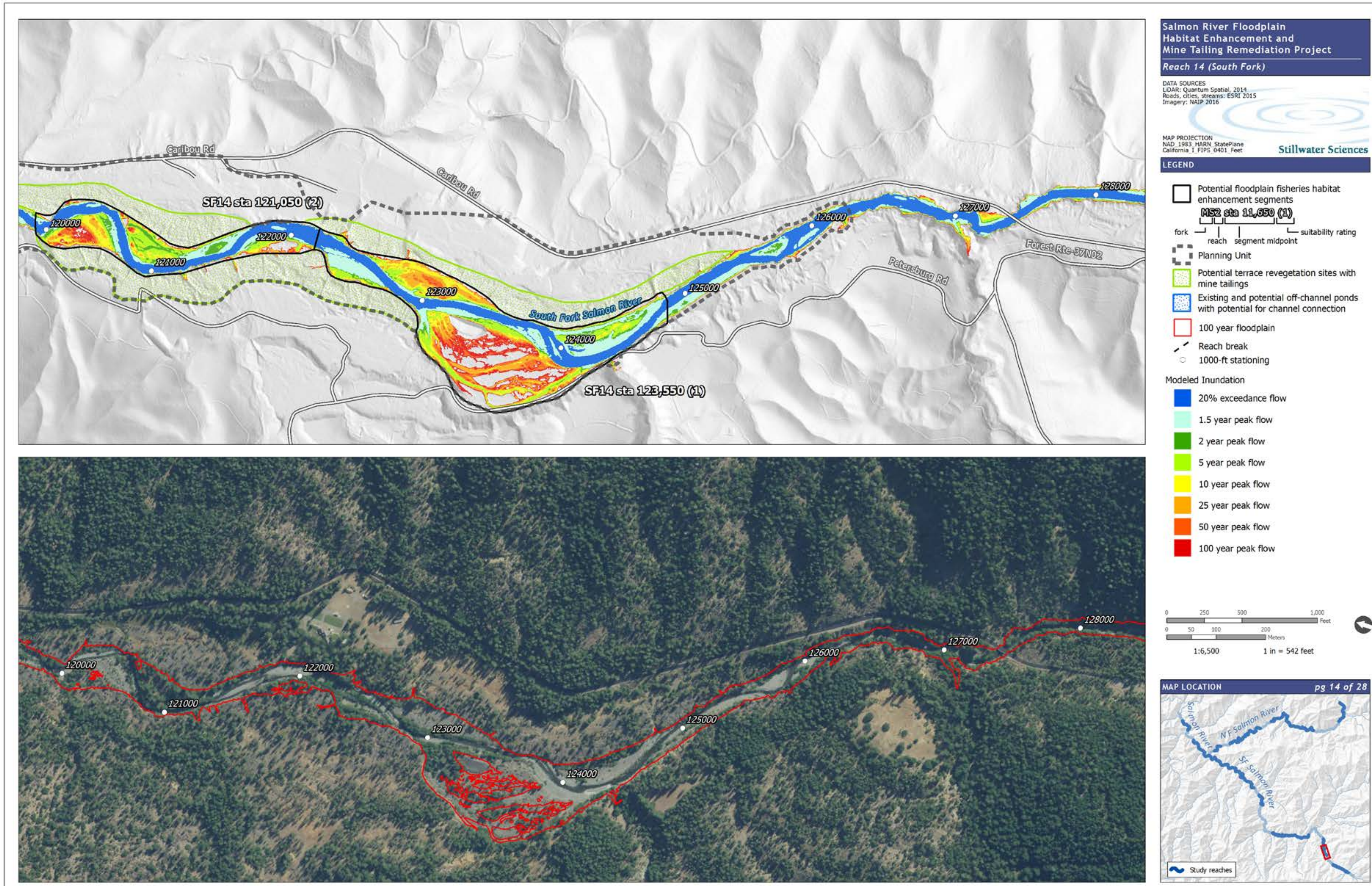
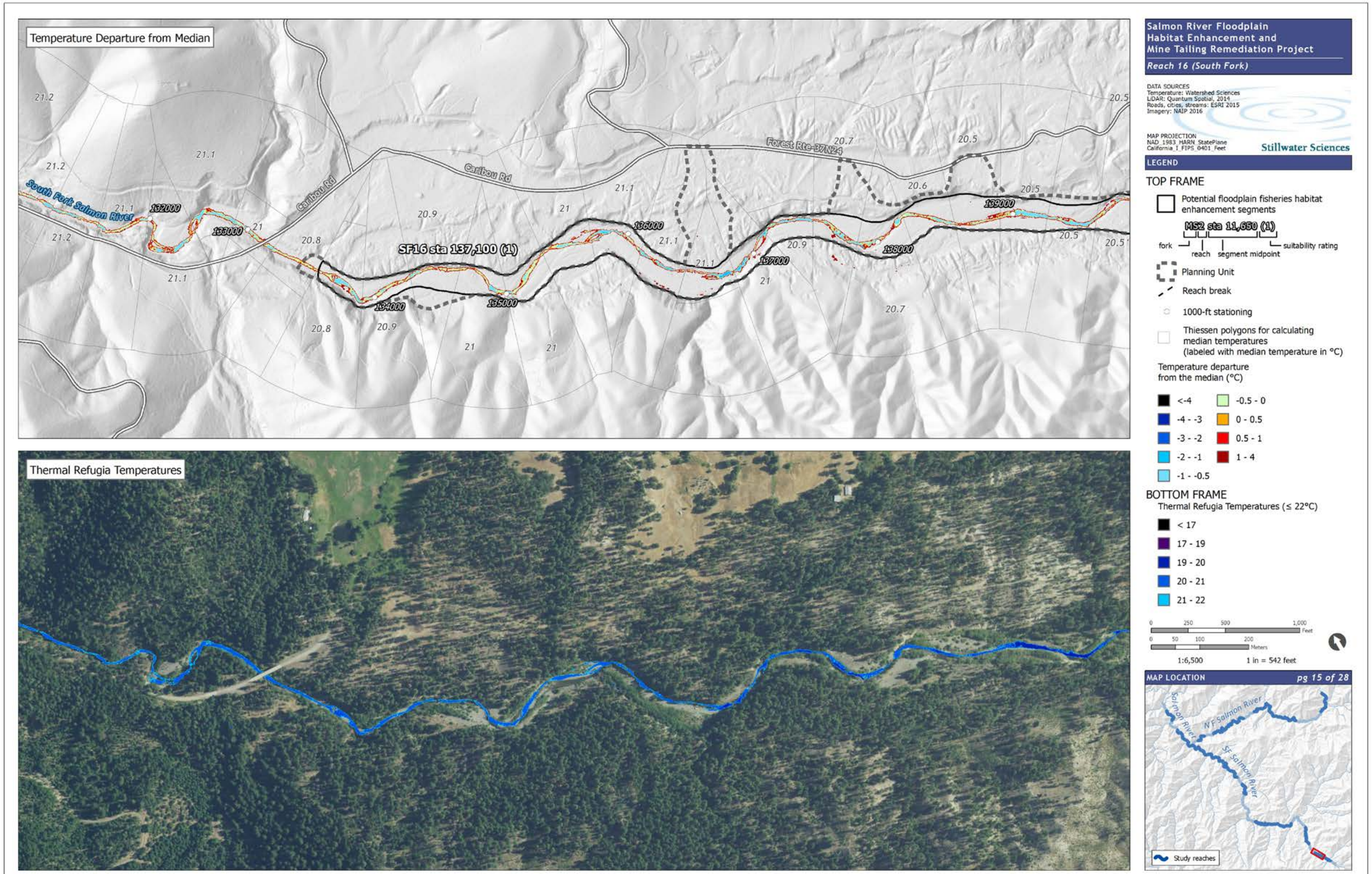


Figure A-28. Flow inundation in predominantly alluvial reaches within the Salmon River project area, Tile 14 of 28.



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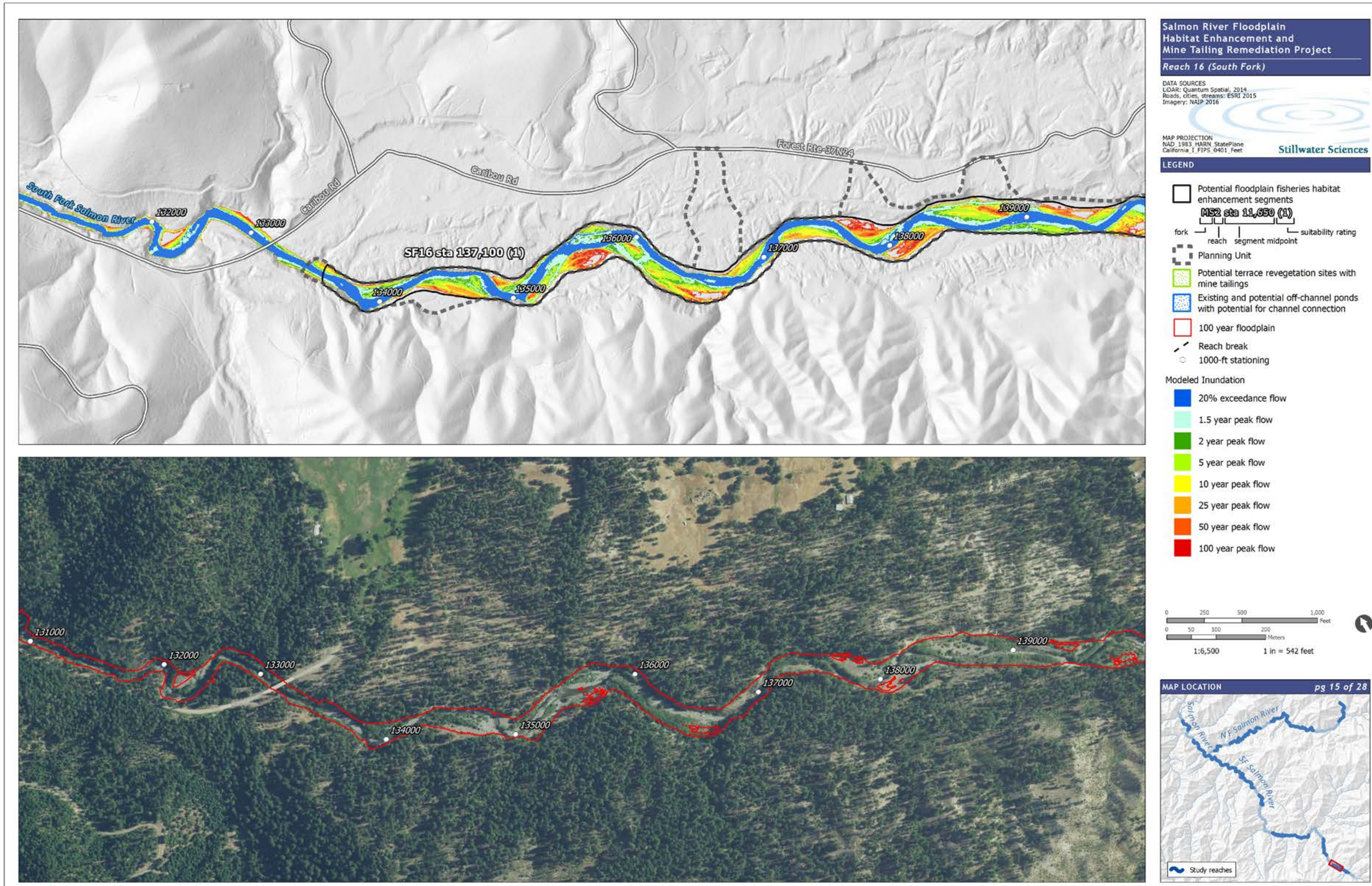
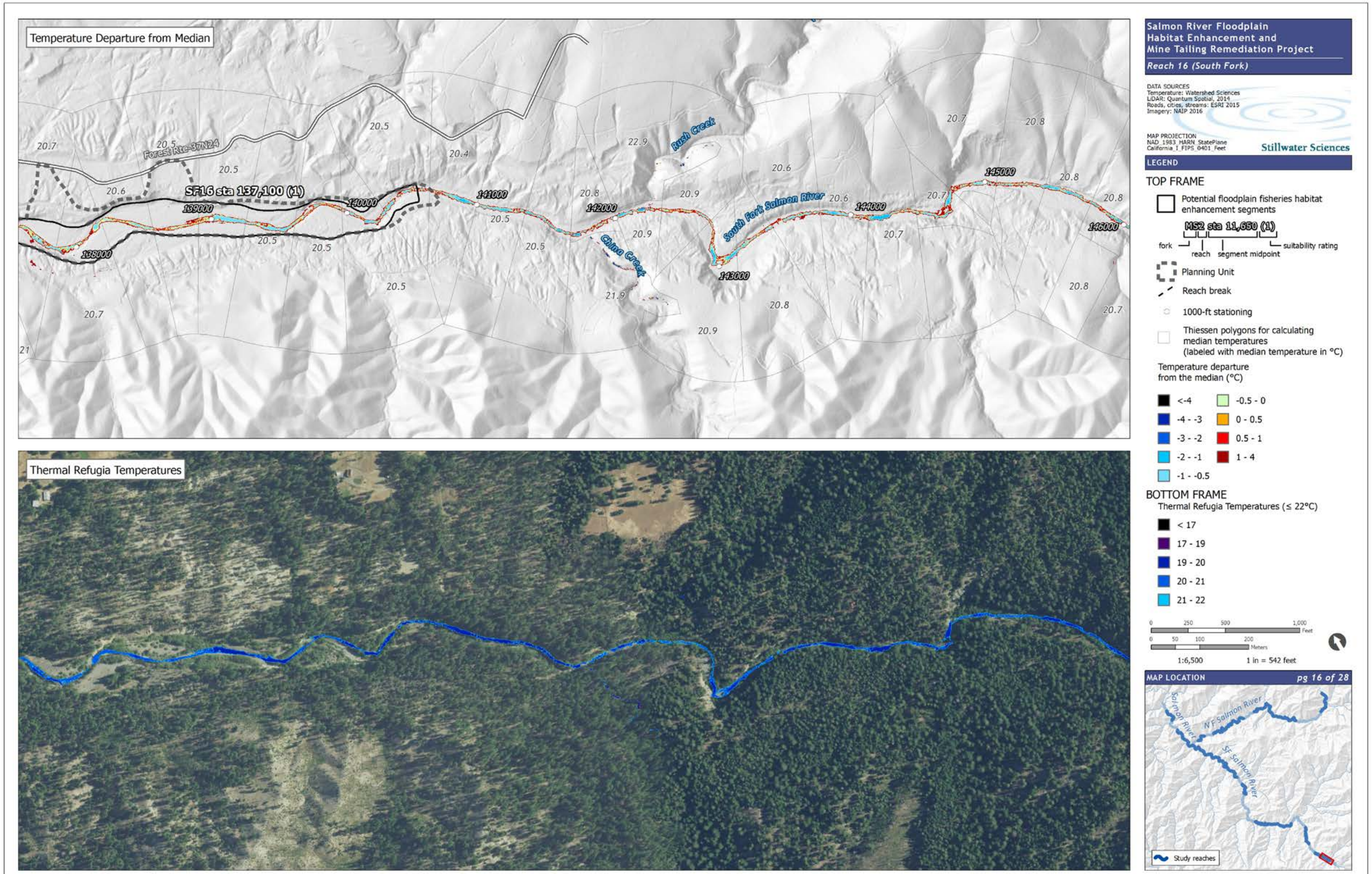


Figure A-30. Flow inundation in predominantly alluvial reaches within the Salmon River project area, Tile 15 of 28.



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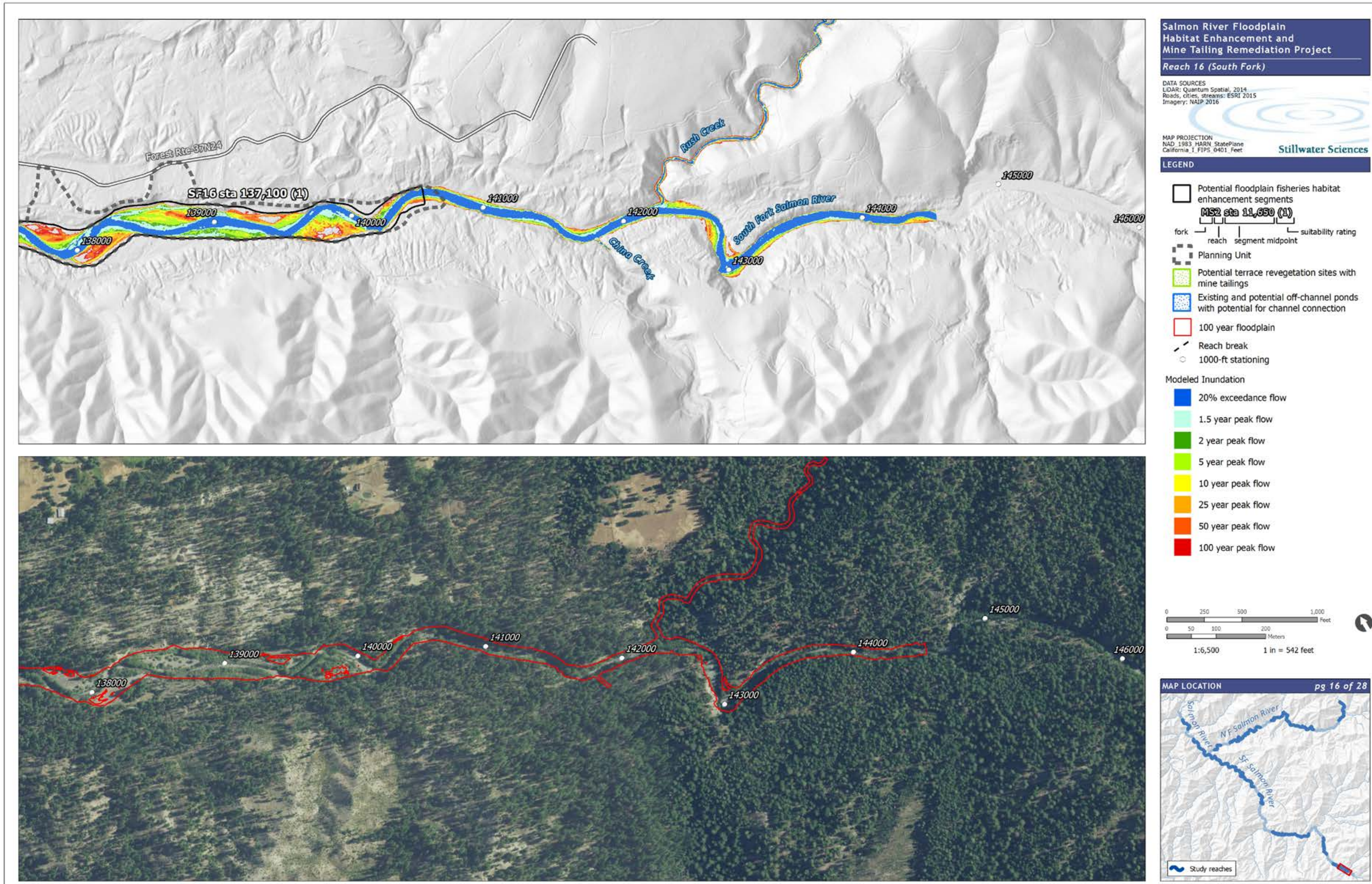
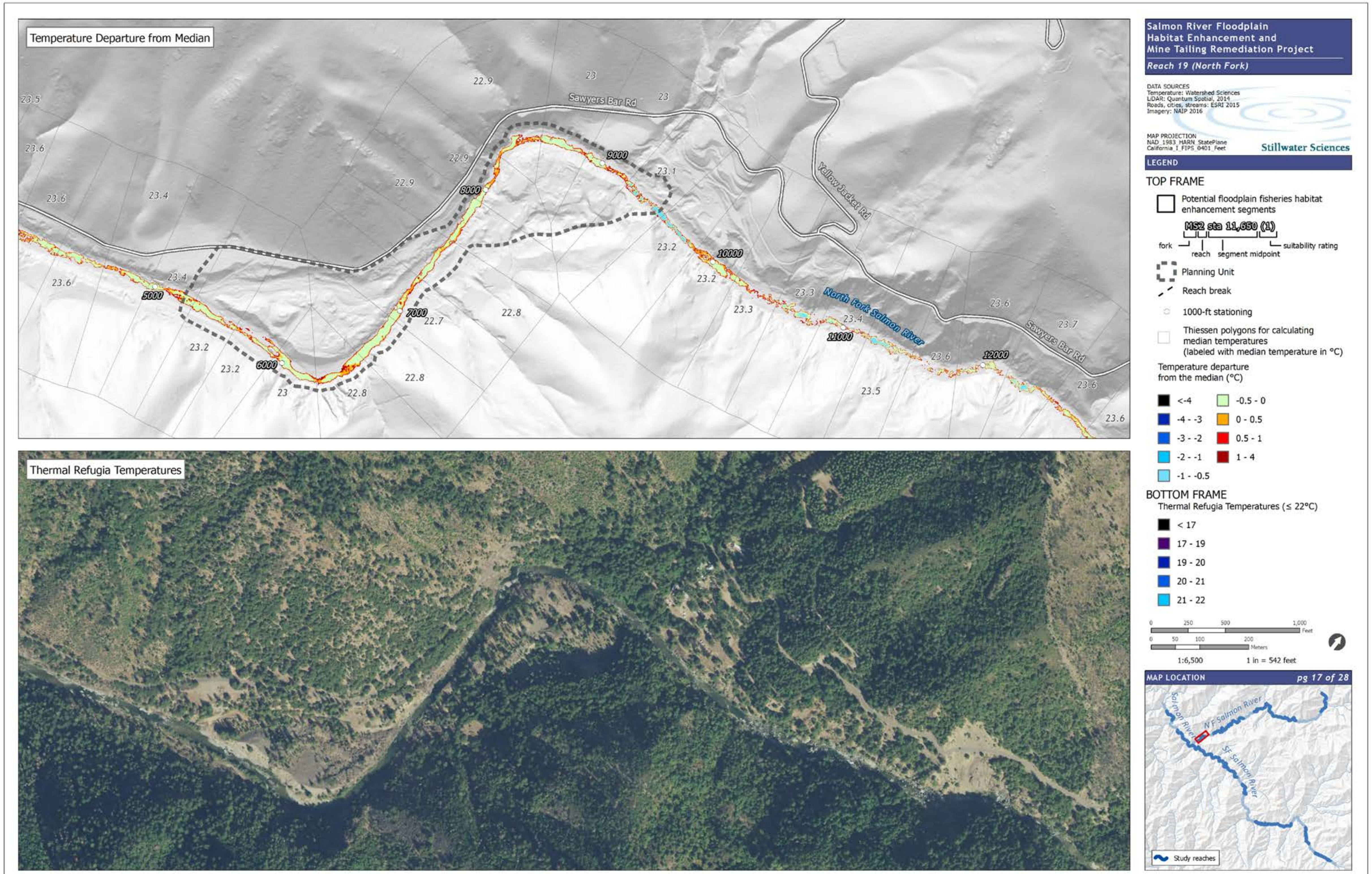


Figure A-32. Flow inundation in predominantly alluvial reaches within the Salmon River project area, Tile 16 of 28.



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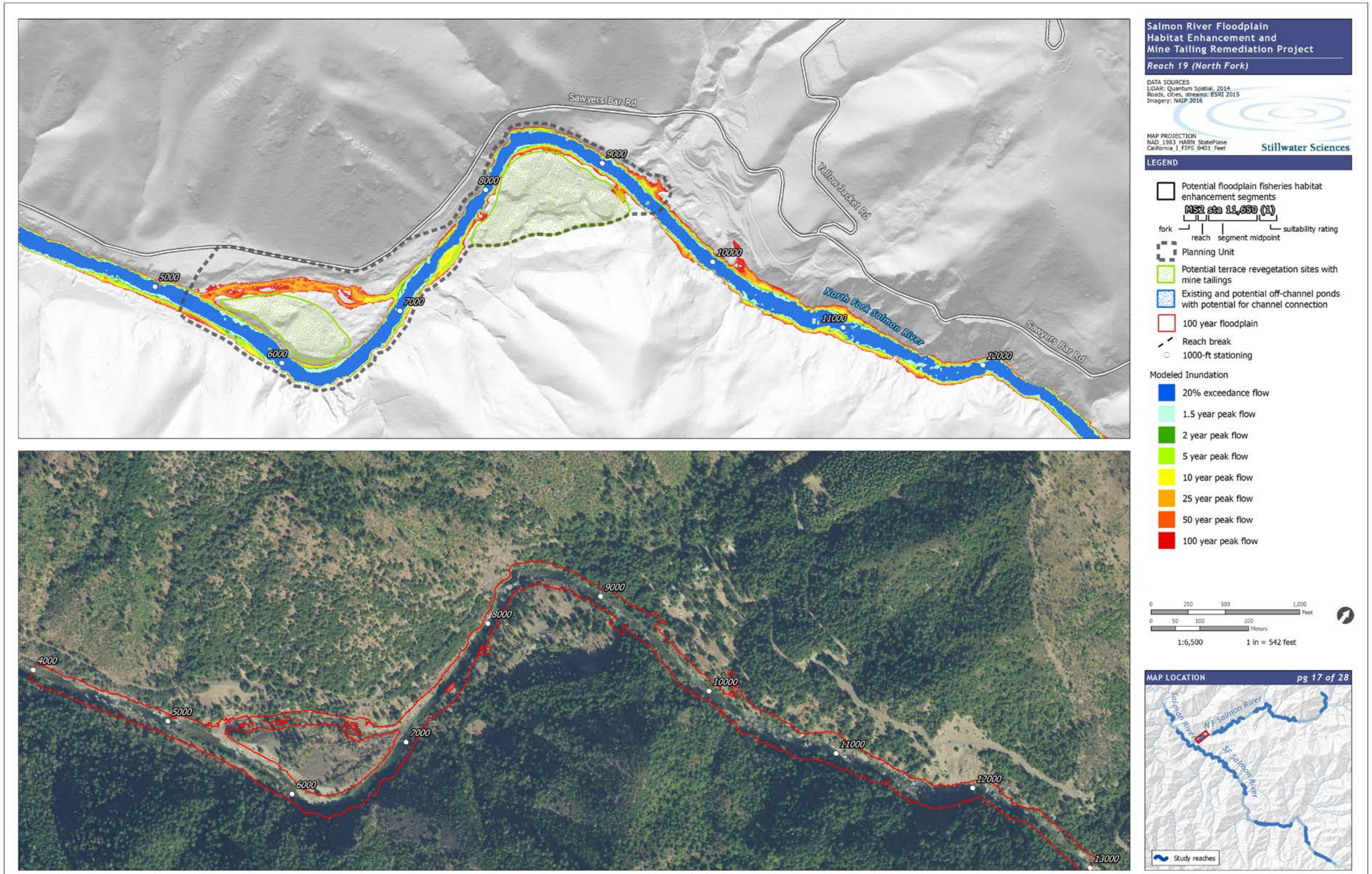


Figure A-34. Flow inundation in predominantly alluvial reaches within the Salmon River project area, Tile 17 of 28.

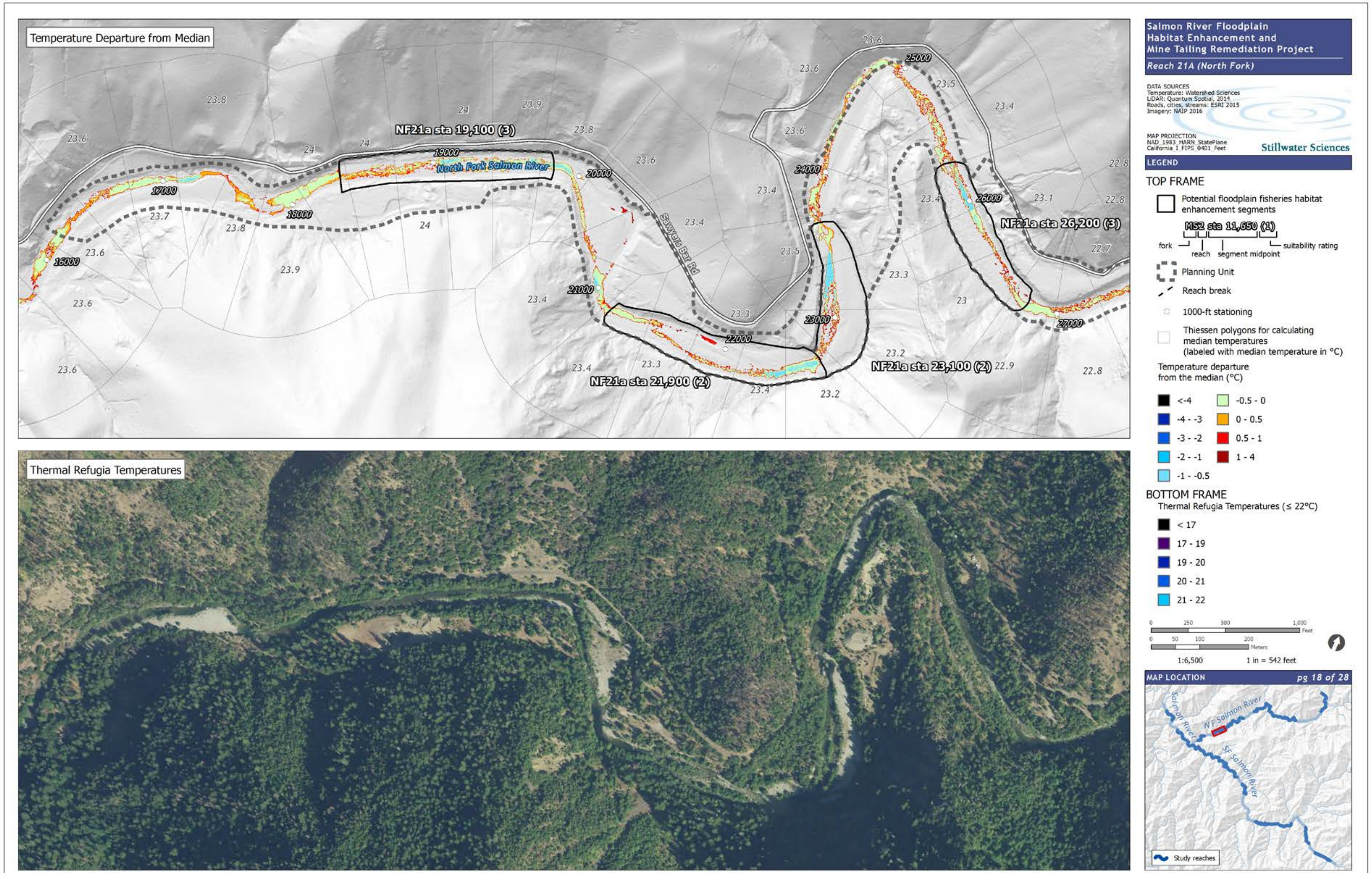
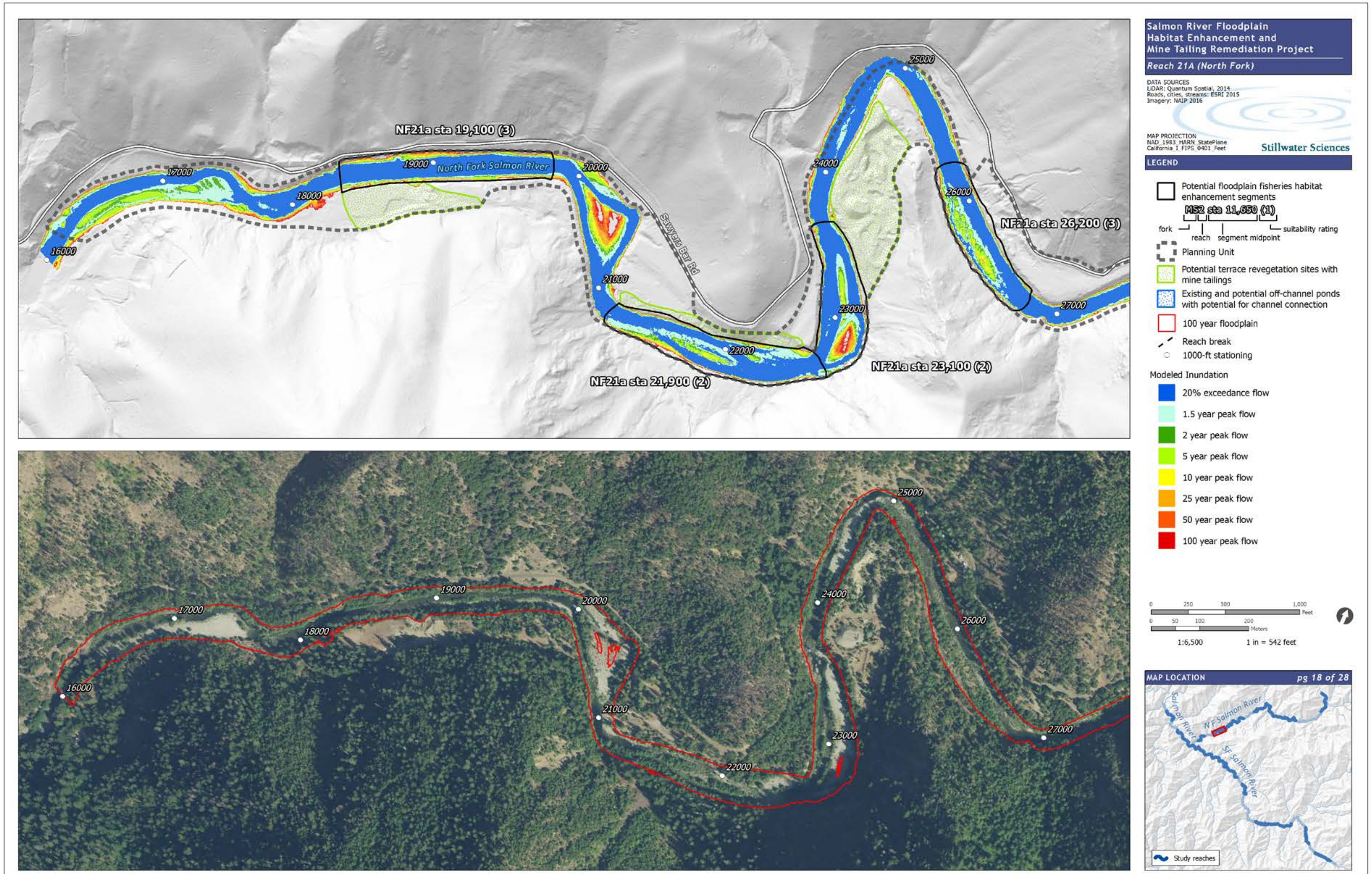


Figure A-35. Thermally suitable habitat and localized thermal refuges in predominantly alluvial reaches within the Salmon River project area based on 2009 TIR data, Tile 18 of 28.



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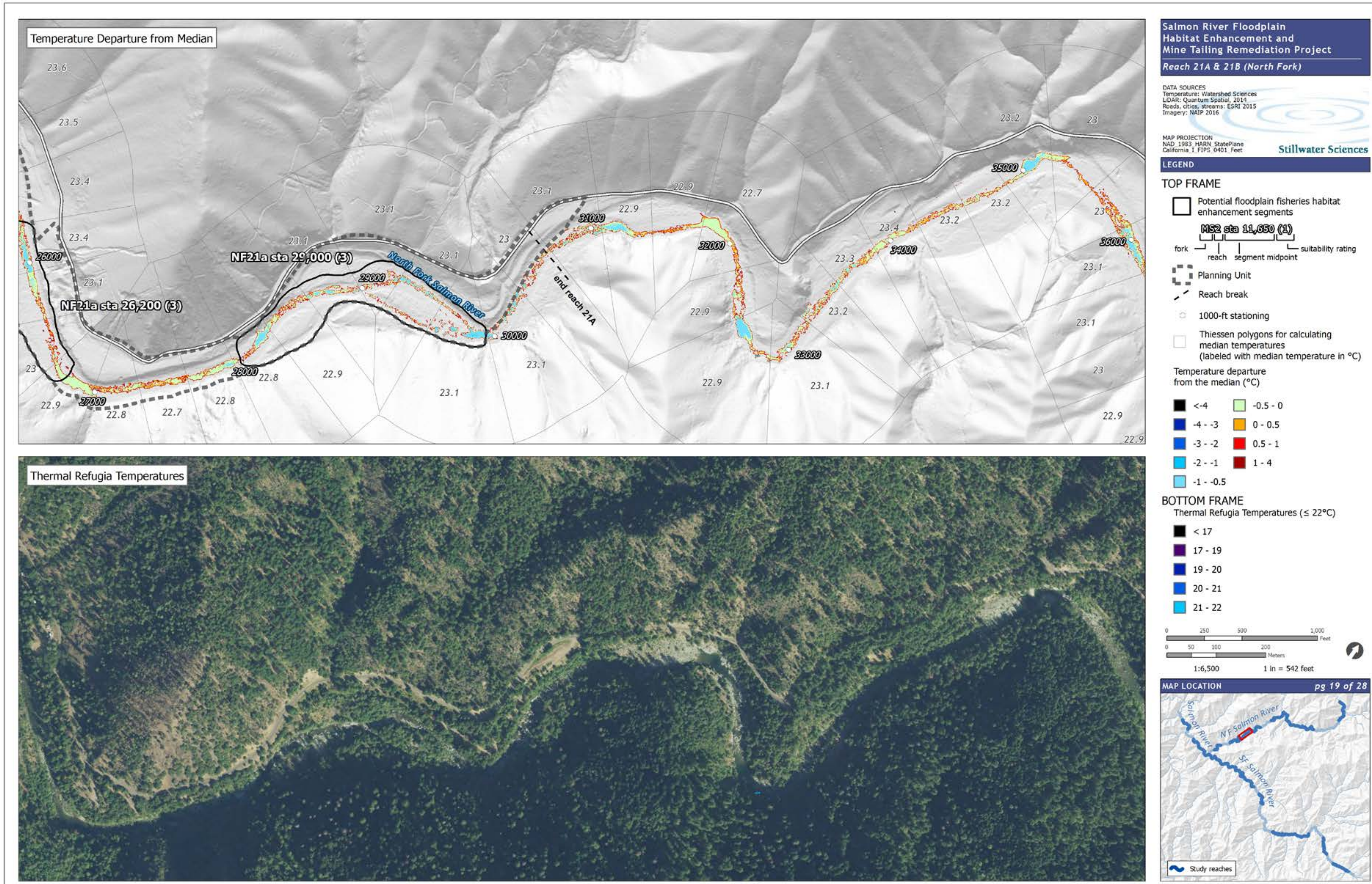
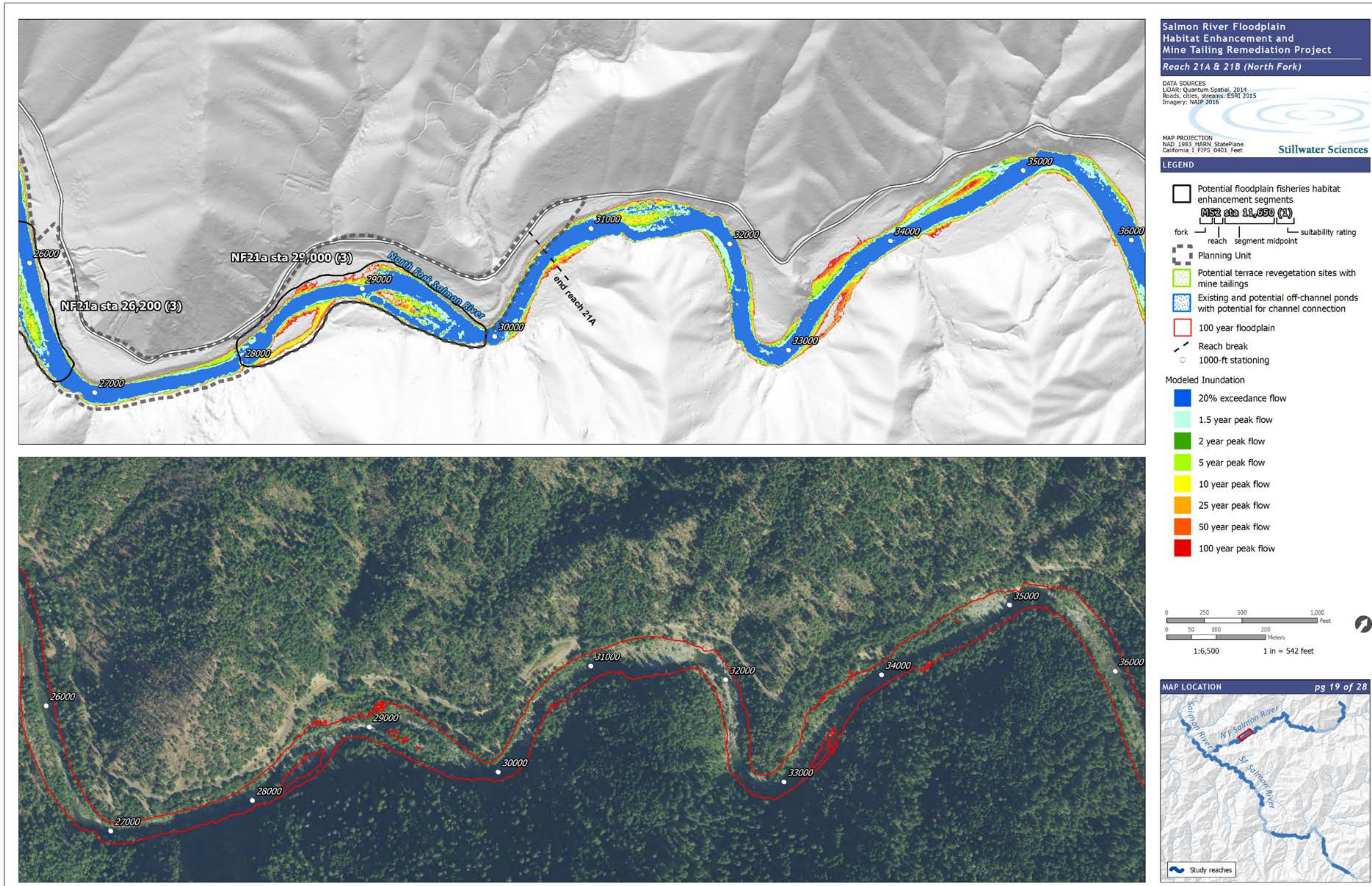


Figure A-37. Thermally suitable habitat and localized thermal refuges in predominantly alluvial reaches within the Salmon River project area based on 2009 TIR data, Tile 19 of 28.



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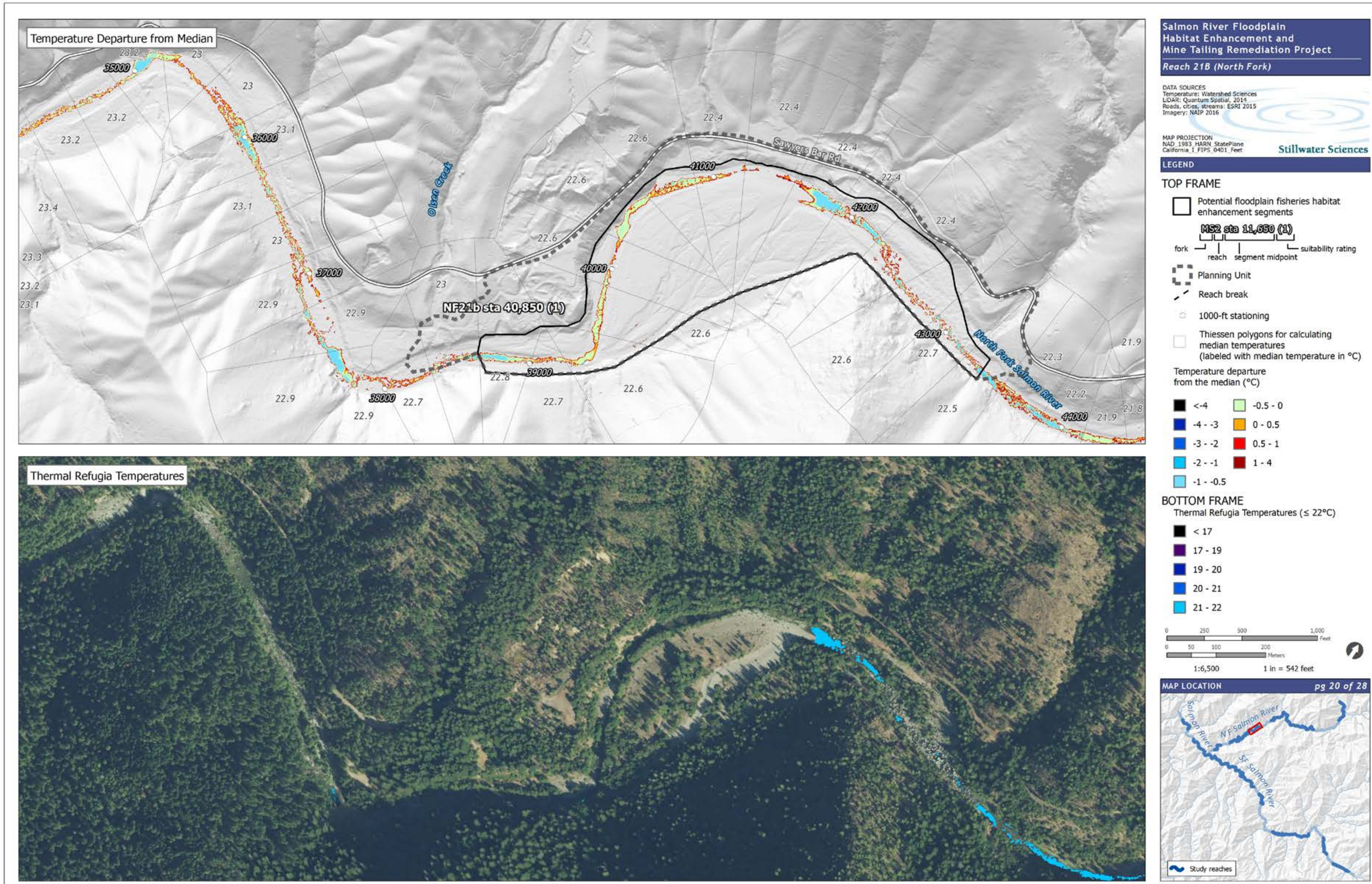

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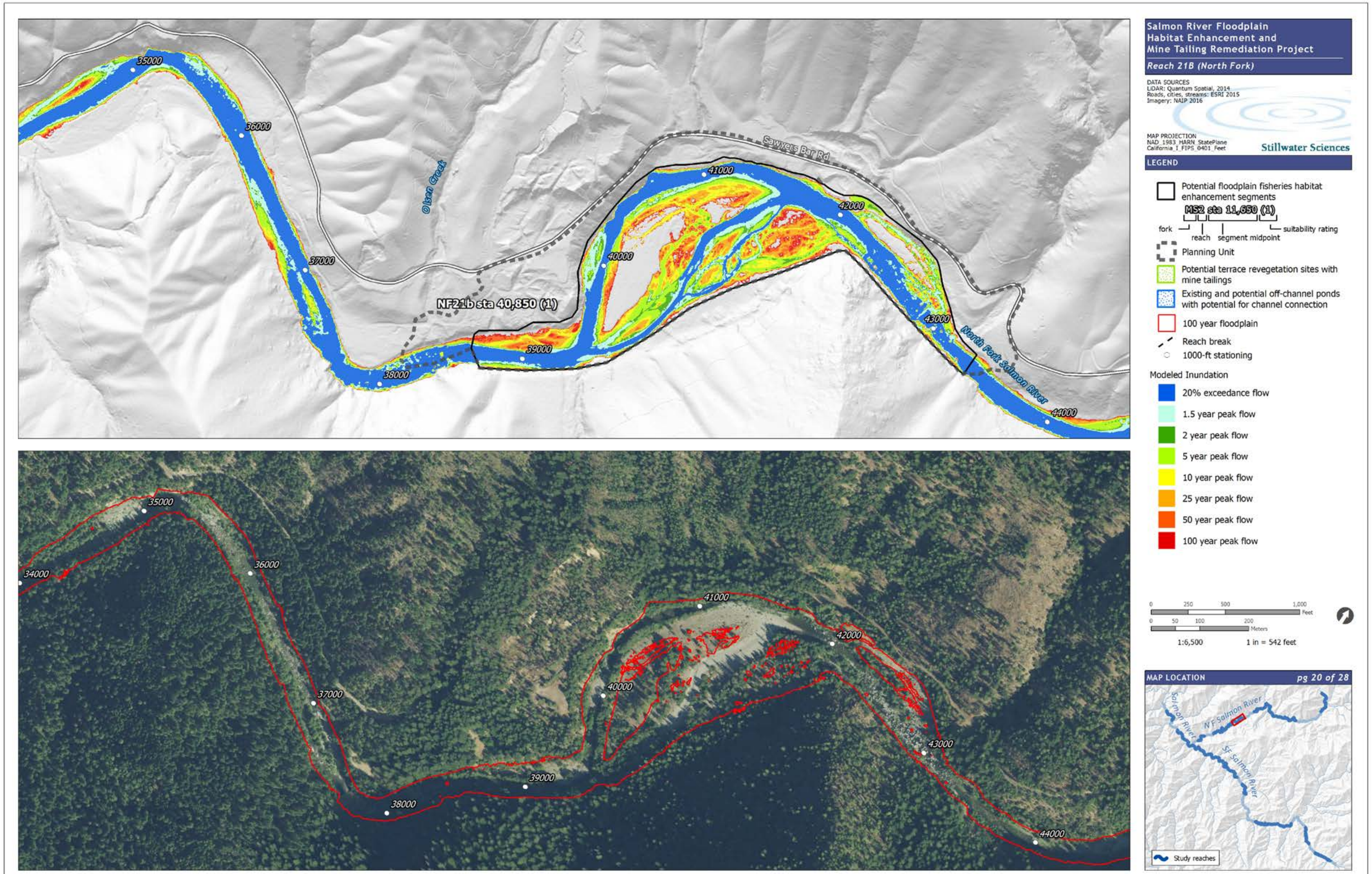


Figure A-40. Flow inundation in predominantly alluvial reaches within the Salmon River project area, Tile 20 of 28.

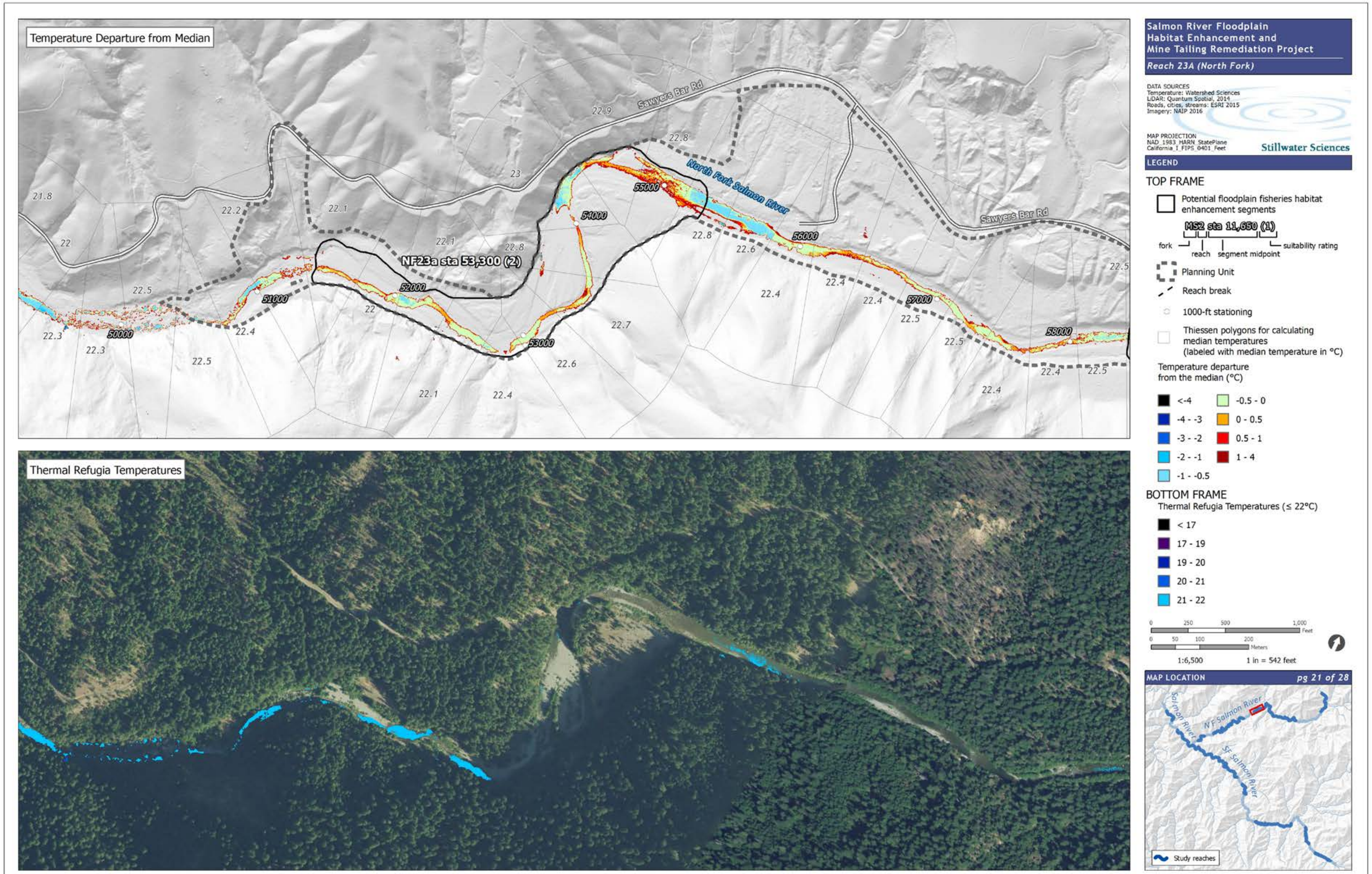


Figure A-41. Thermally suitable habitat and localized thermal refuges in predominantly alluvial reaches within the Salmon River project area based on 2009 TIR data, Tile 21 of 28.

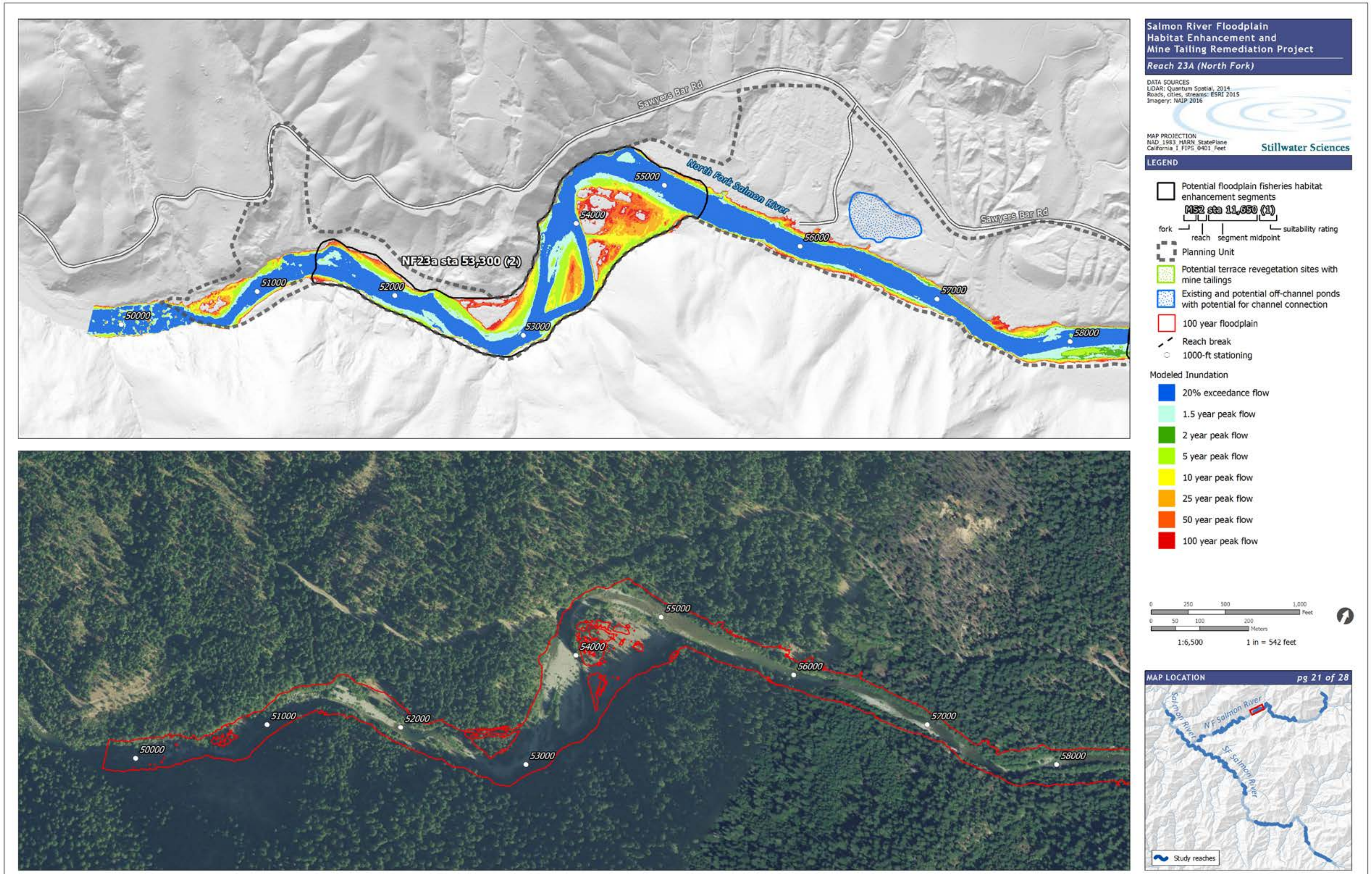


Figure A-42. Flow inundation in predominantly alluvial reaches within the Salmon River project area, Tile 21 of 28.

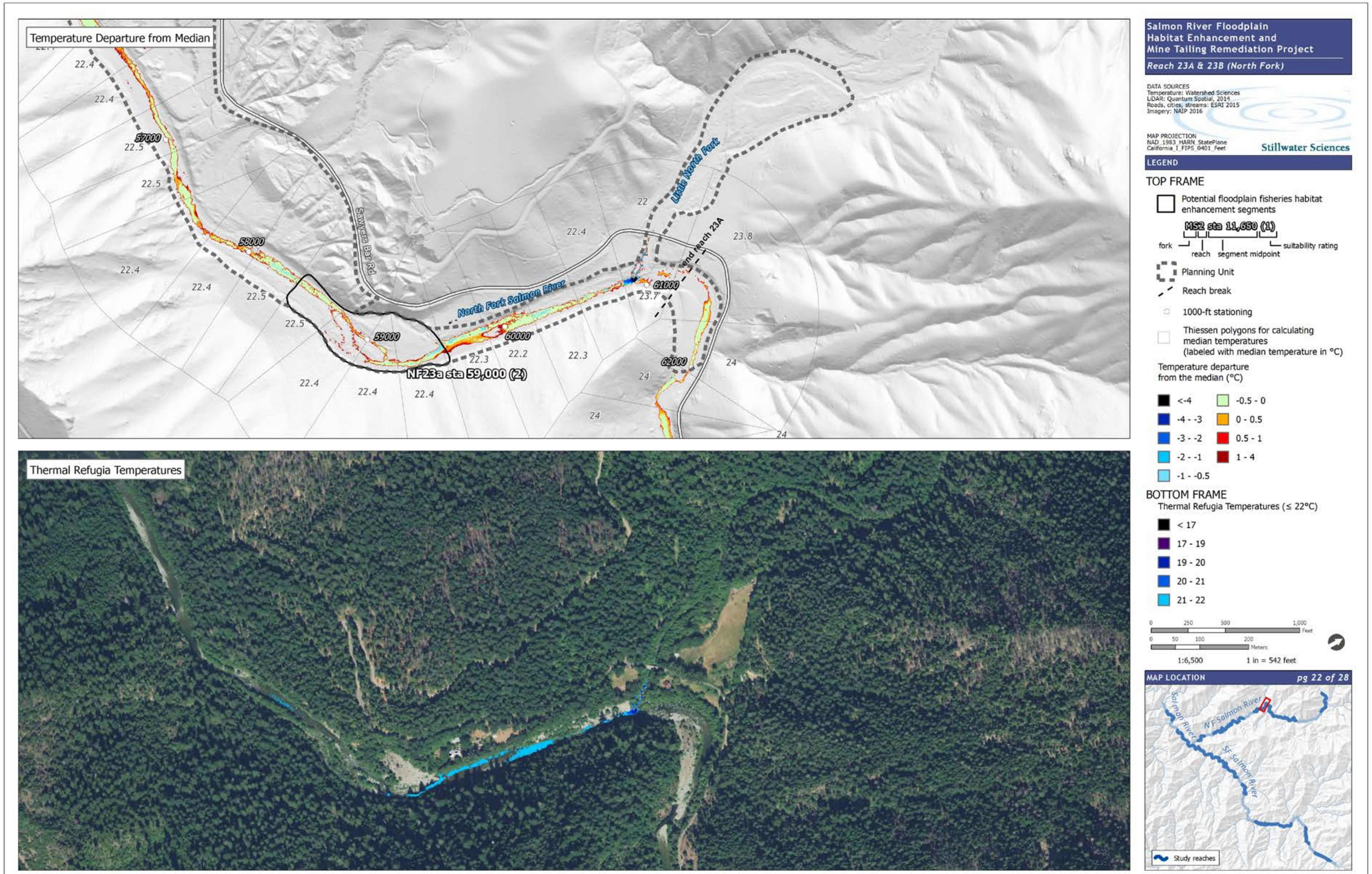


Figure A-43. Thermally suitable habitat and localized thermal refuges in predominantly alluvial reaches within the Salmon River project area based on 2009 TIR data, Tile 22 of 28.

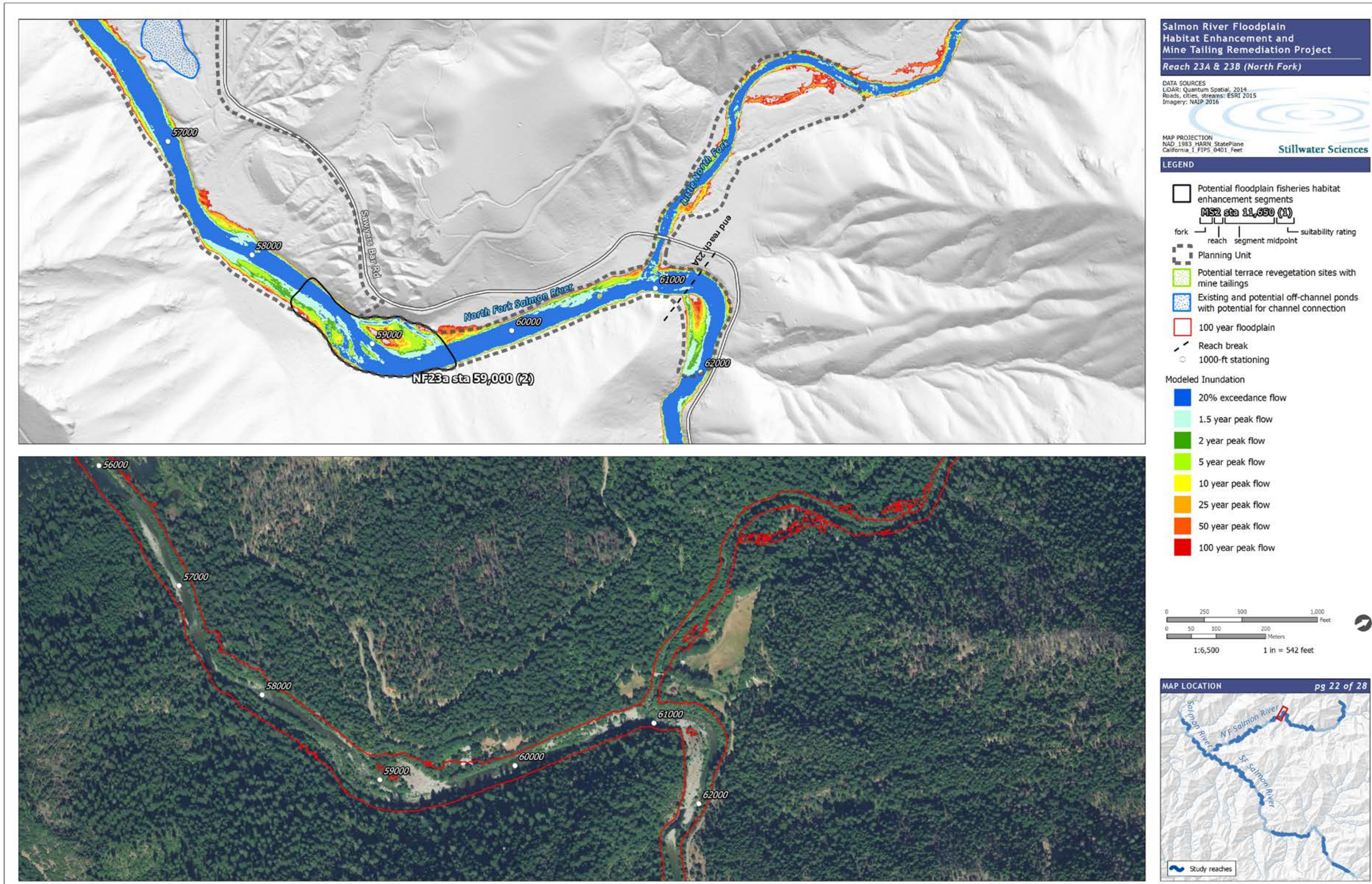


Figure A-44. Flow inundation in predominantly alluvial reaches within the Salmon River project area, Tile 22 of 28.

Figure A-45. Thermally suitable habitat and localized thermal refuges in predominantly alluvial reaches within the Salmon River project area based on 2009 TIR data, Tile 23 of 28.

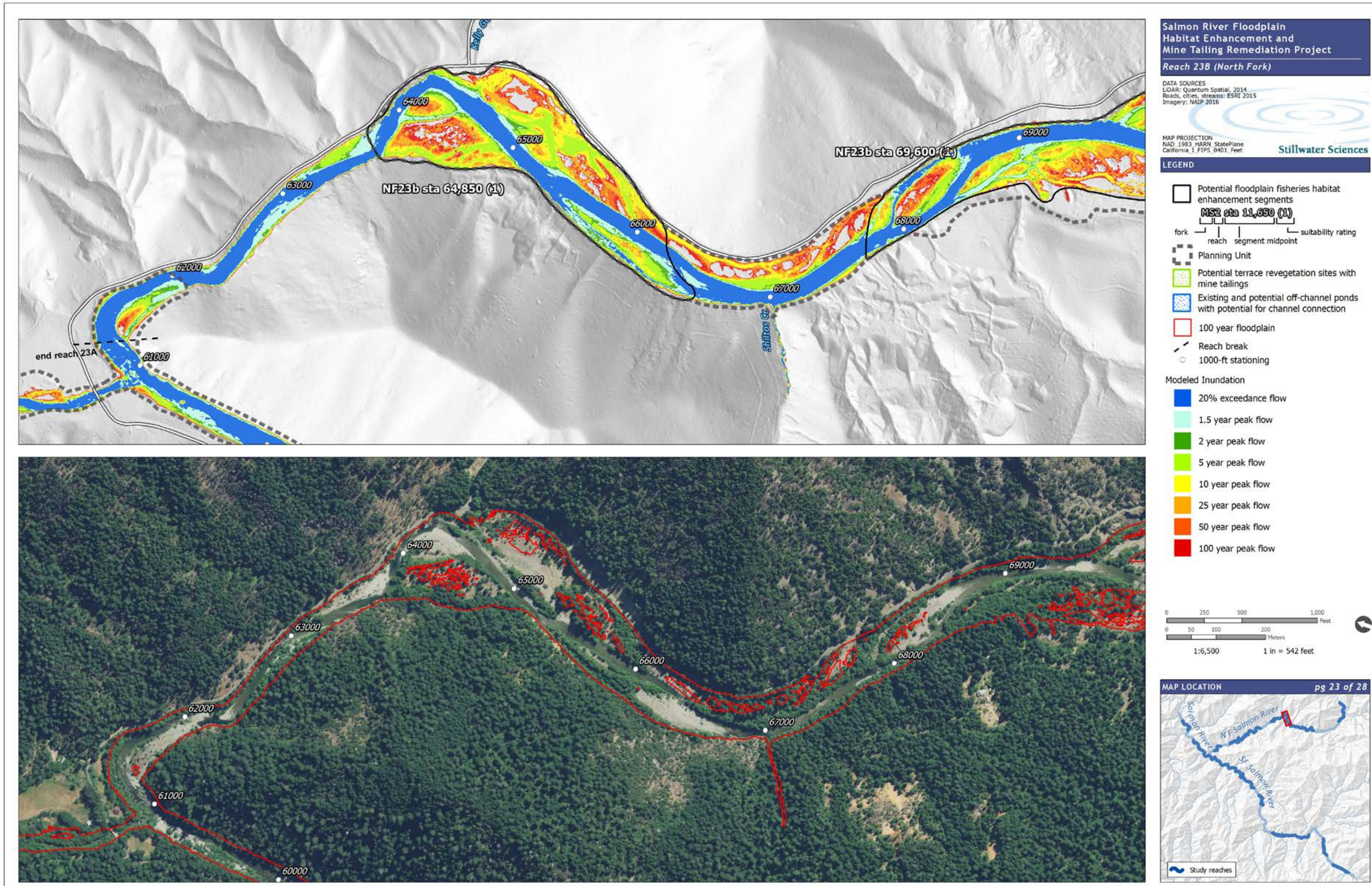


Figure A-46. Flow inundation in predominantly alluvial reaches within the Salmon River project area, Tile 23 of 28.

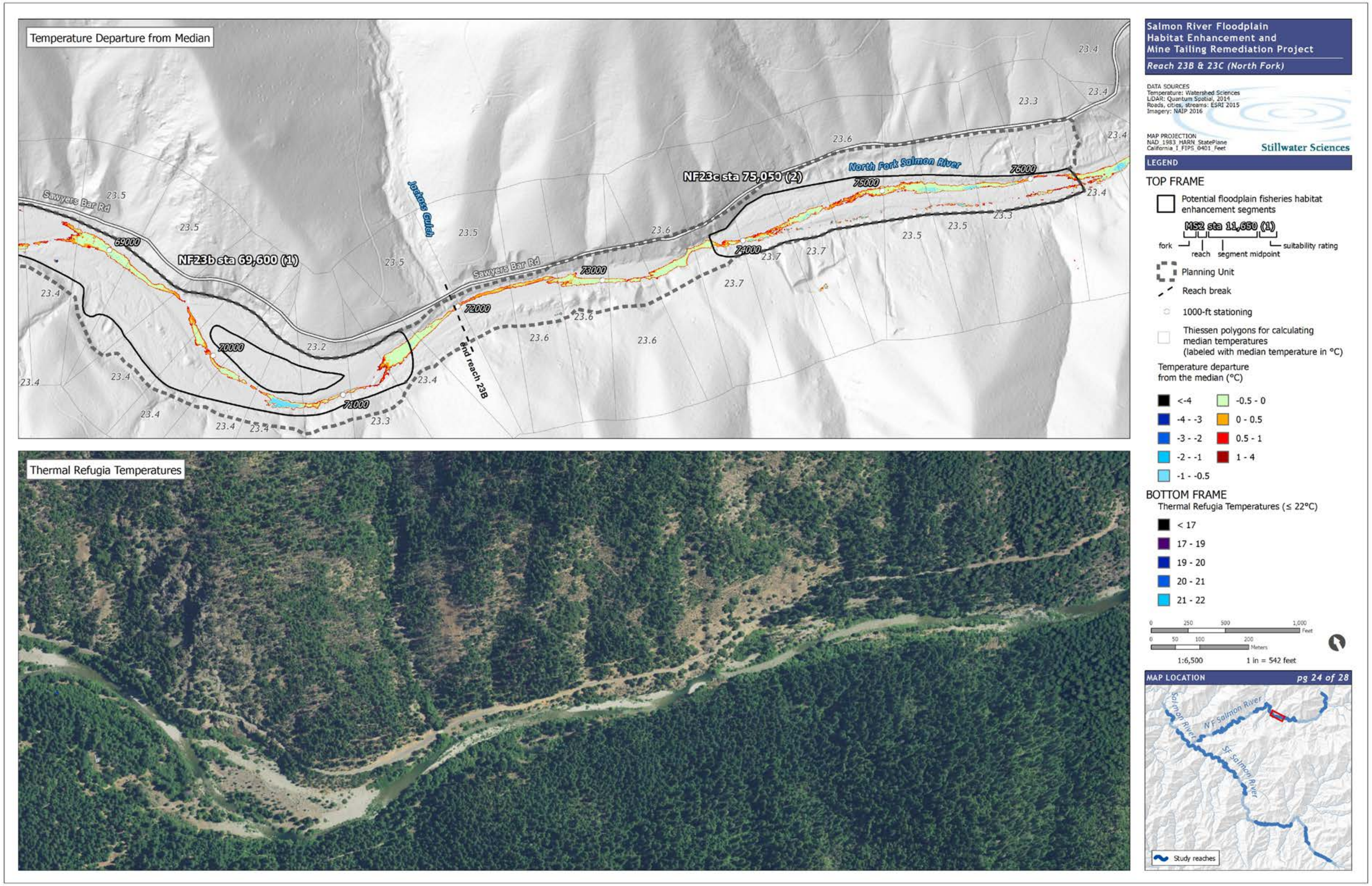
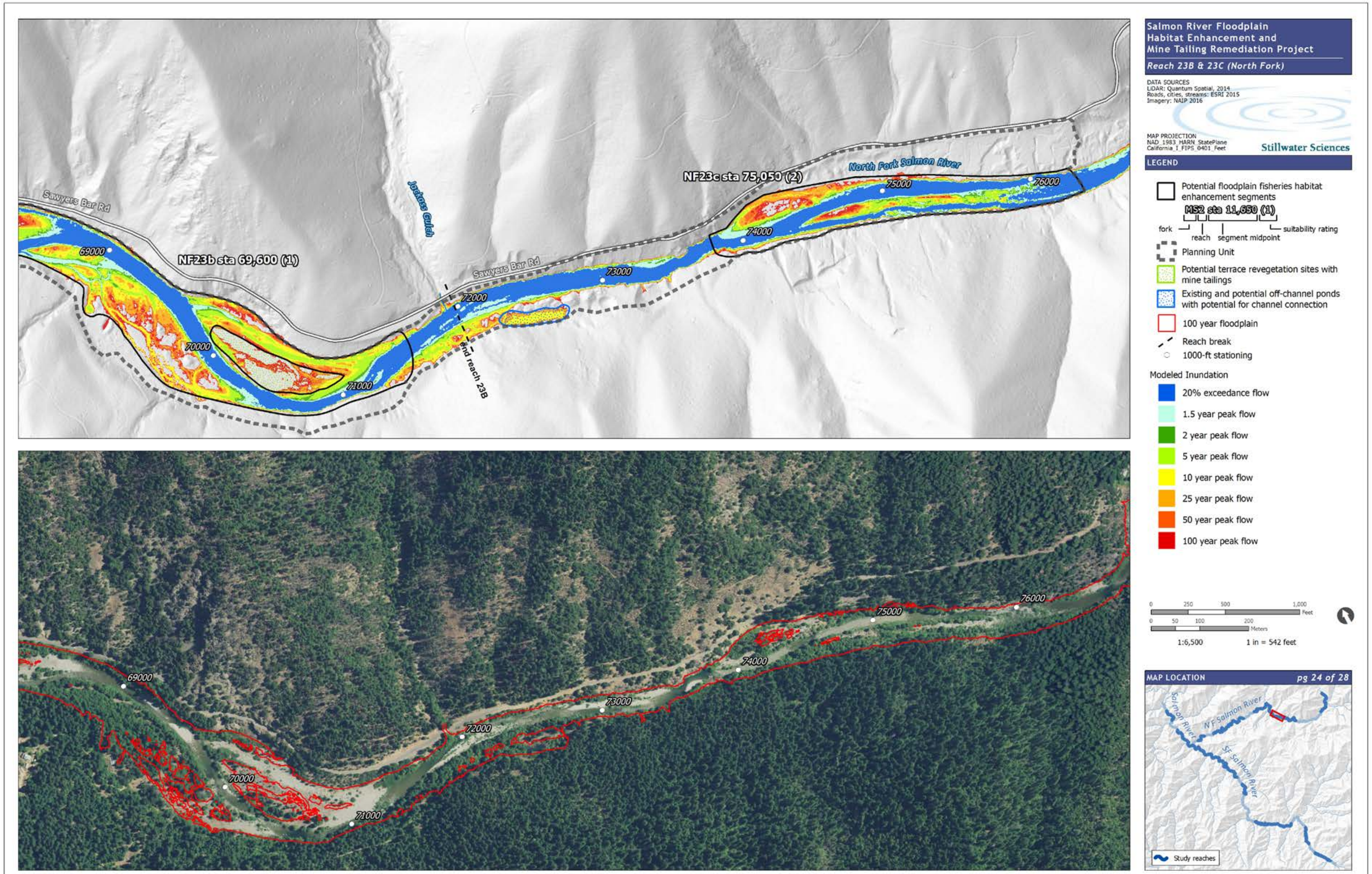


Figure A-47. Thermally suitable habitat and localized thermal refuges in predominantly alluvial reaches within the Salmon River project area based on 2009 TIR data, Tile 24 of 28.



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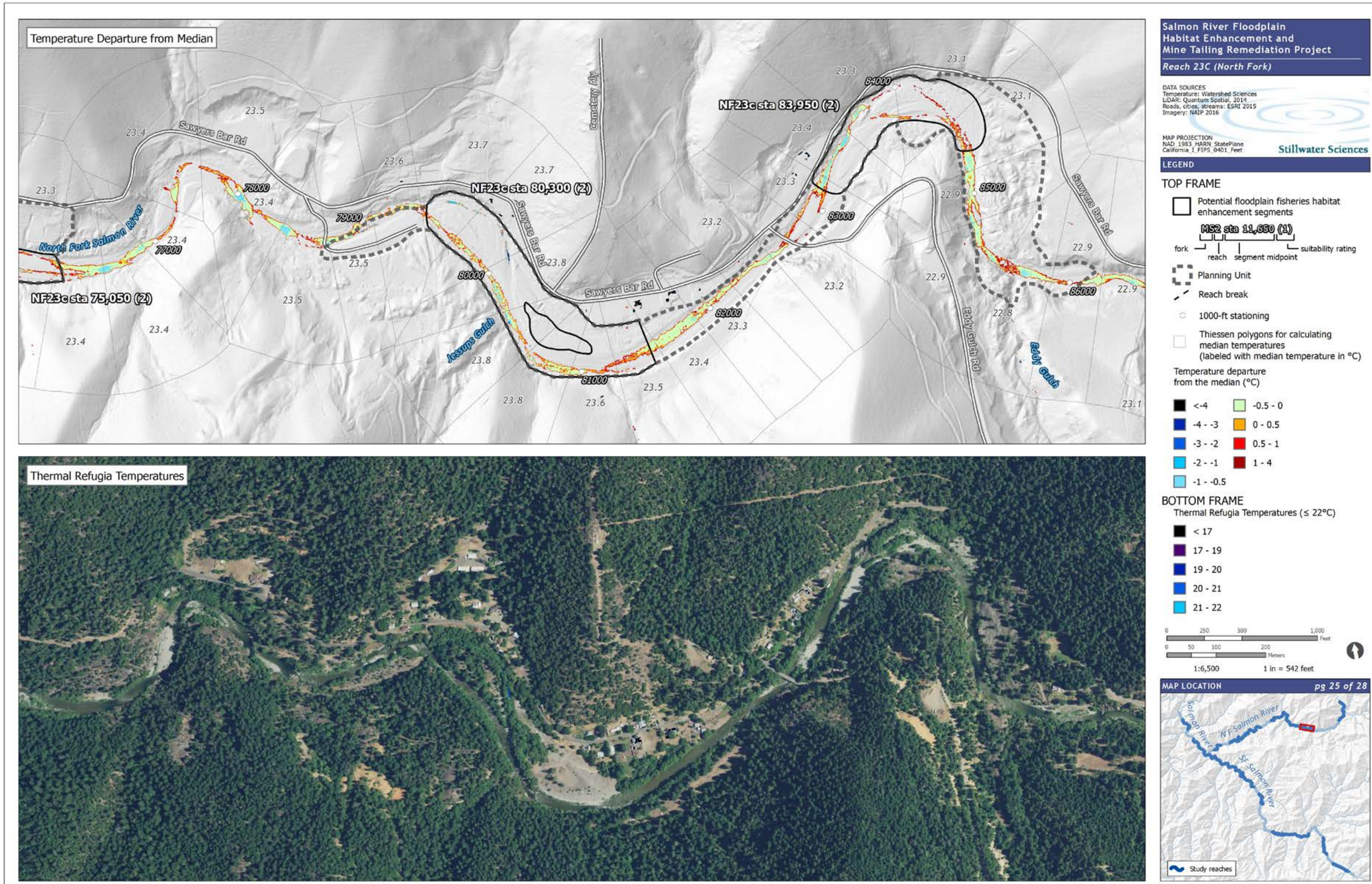

Figure A-49. Thermally suitable habitat and localized thermal refuges in predominantly alluvial reaches within the Salmon River project area based on 2009 TIR data, Tile 25 of 28.

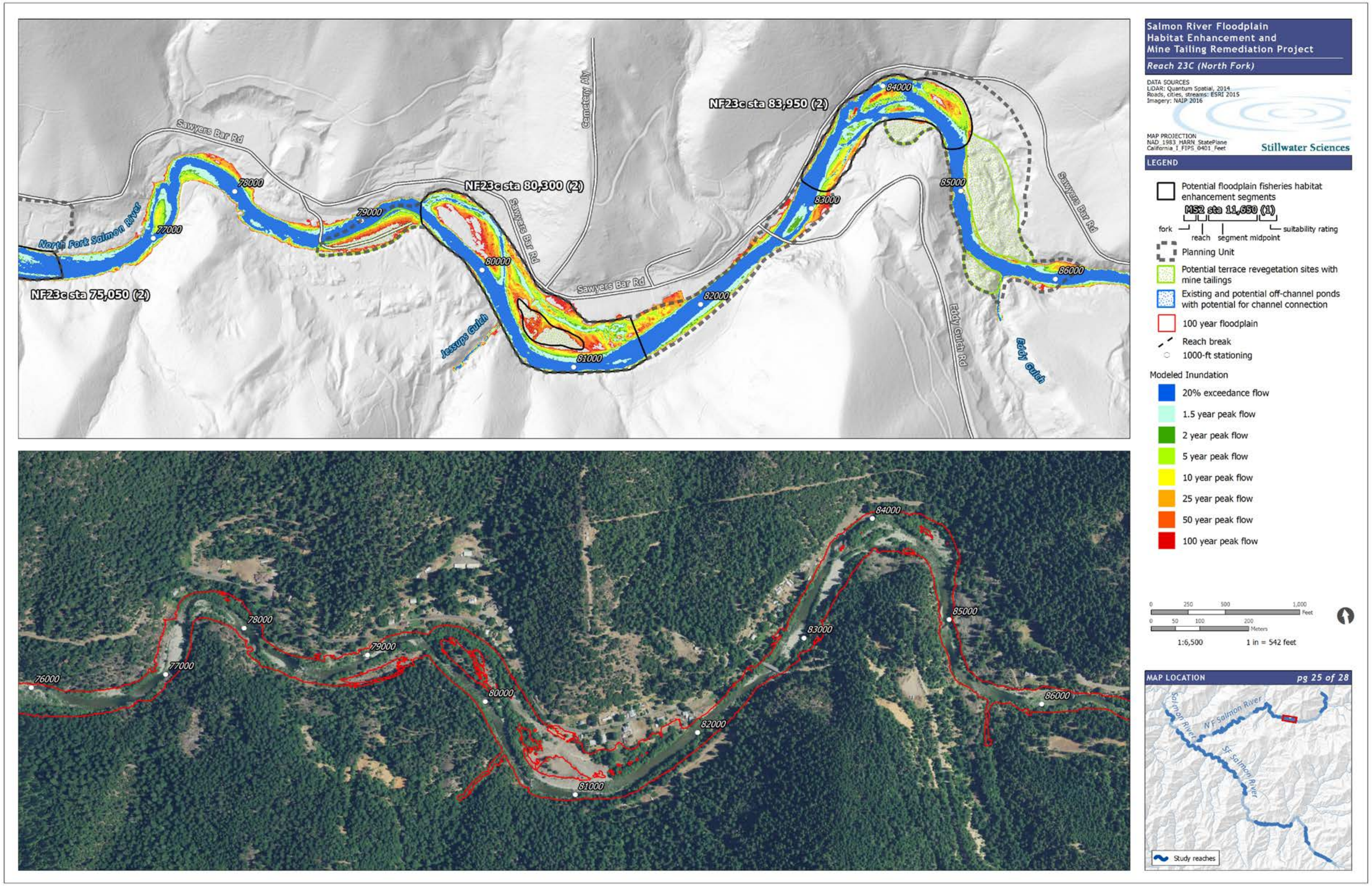

Figure A-50. Flow inundation in predominantly alluvial reaches within the Salmon River project area, Tile 25 of 28.

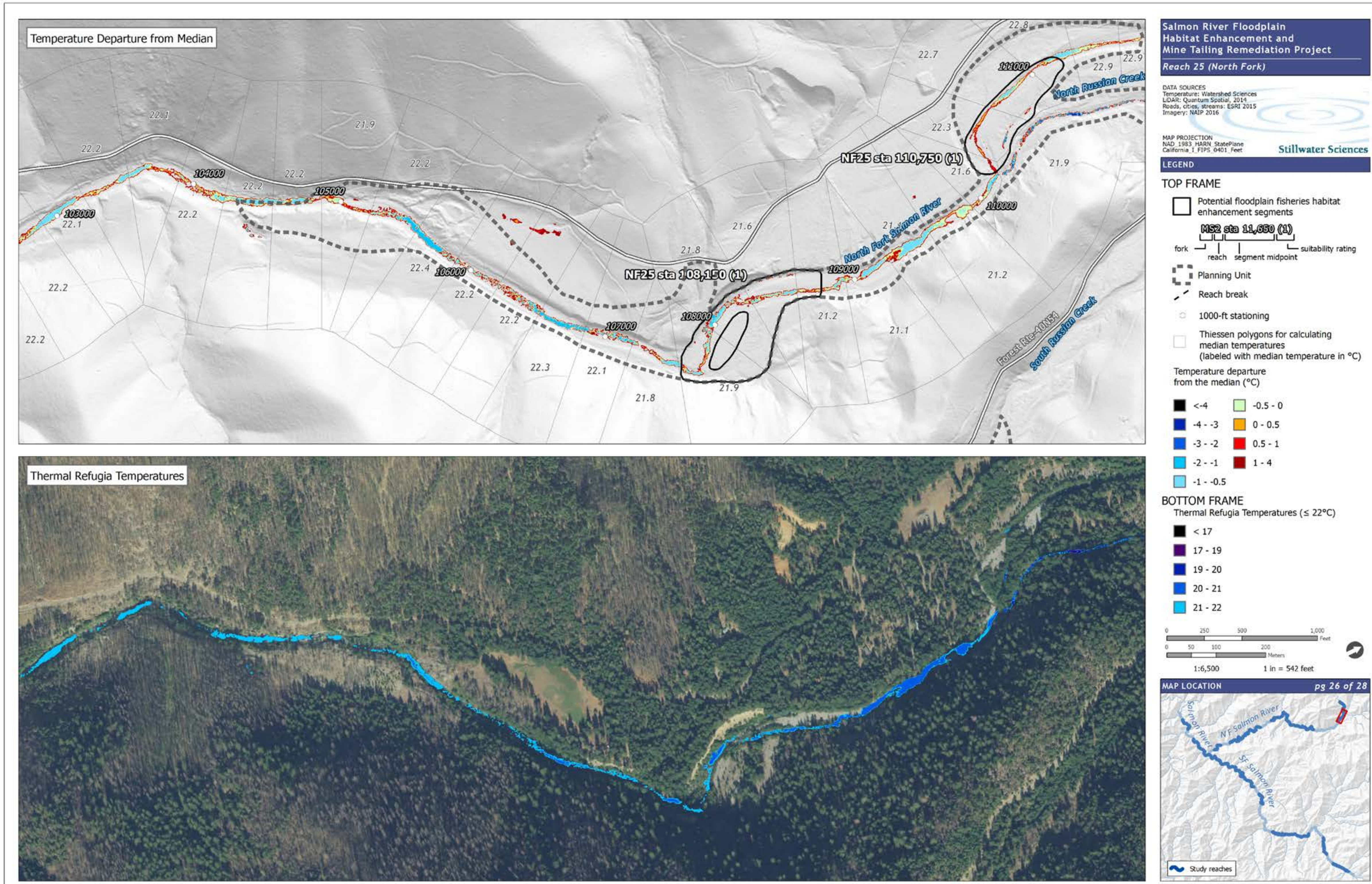

Figure A-51. Thermally suitable habitat and localized thermal refuges in predominantly alluvial reaches within the Salmon River project area based on 2009 TIR data, Tile 26 of 28.

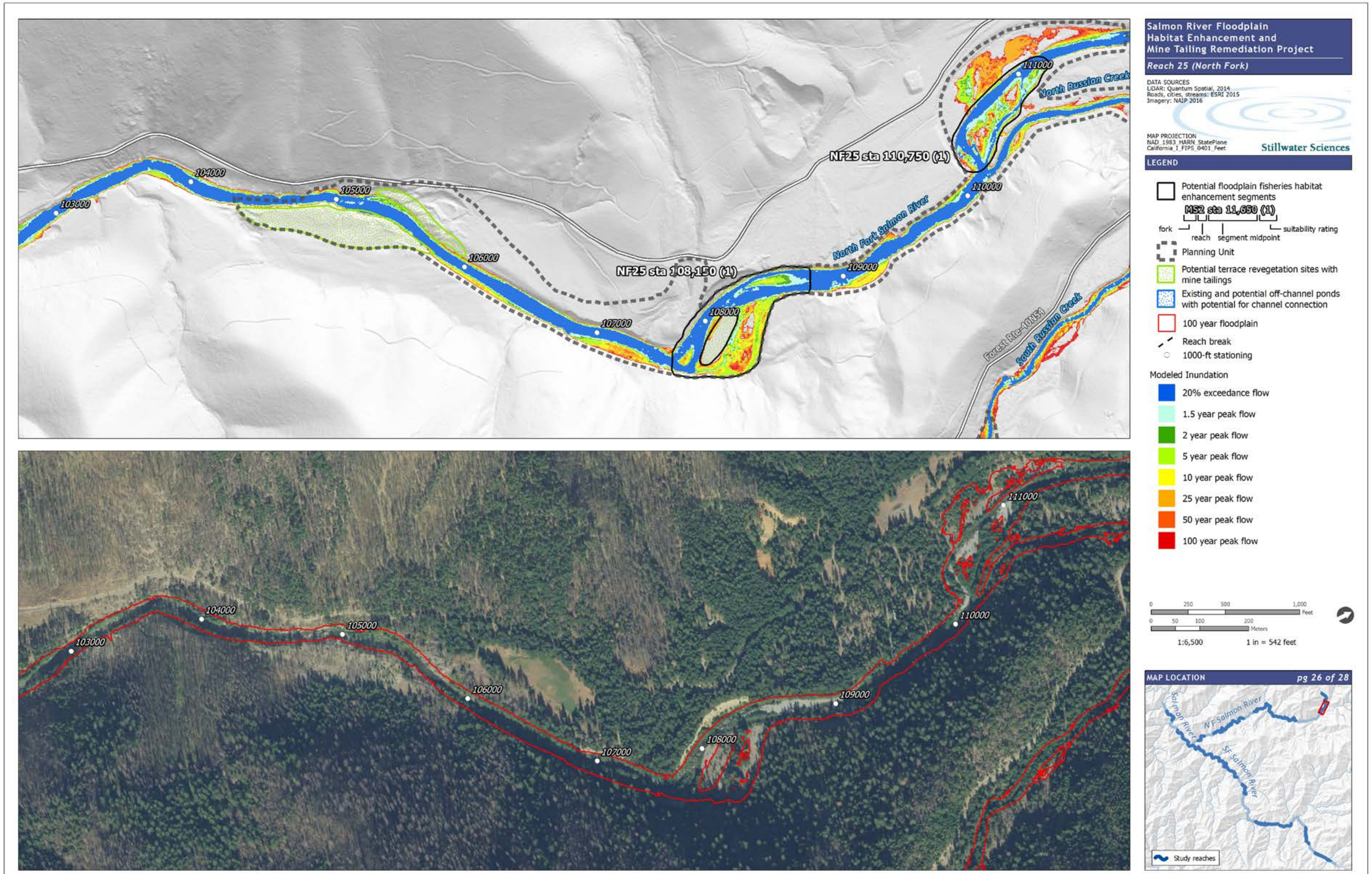

Figure A-52. Flow inundation in predominantly alluvial reaches within the Salmon River project area, Tile 26 of 28.

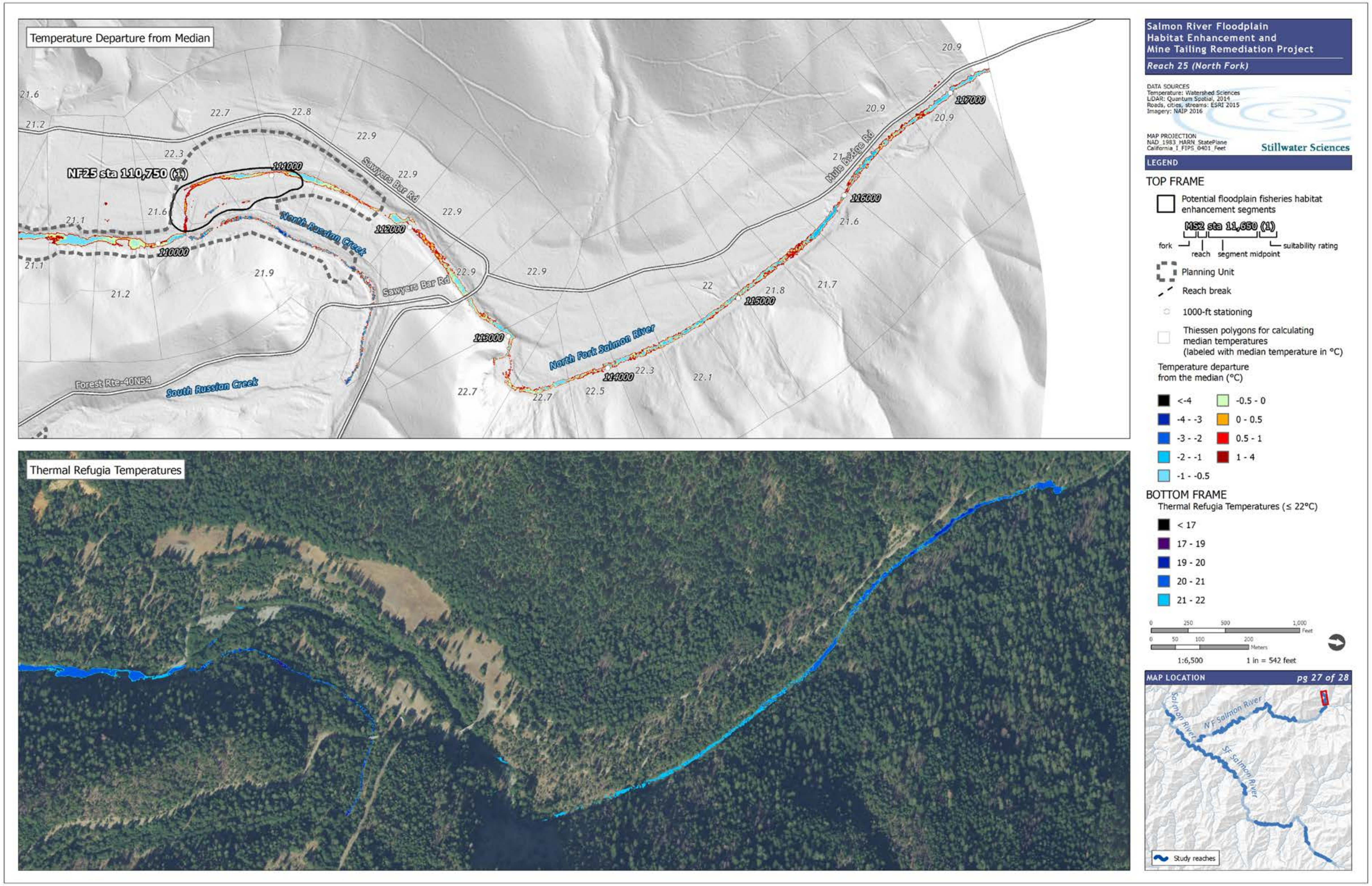

Figure A-53. Thermally suitable habitat and localized thermal refuges in predominantly alluvial reaches within the Salmon River project area based on 2009 TIR data, Tile 27 of 28

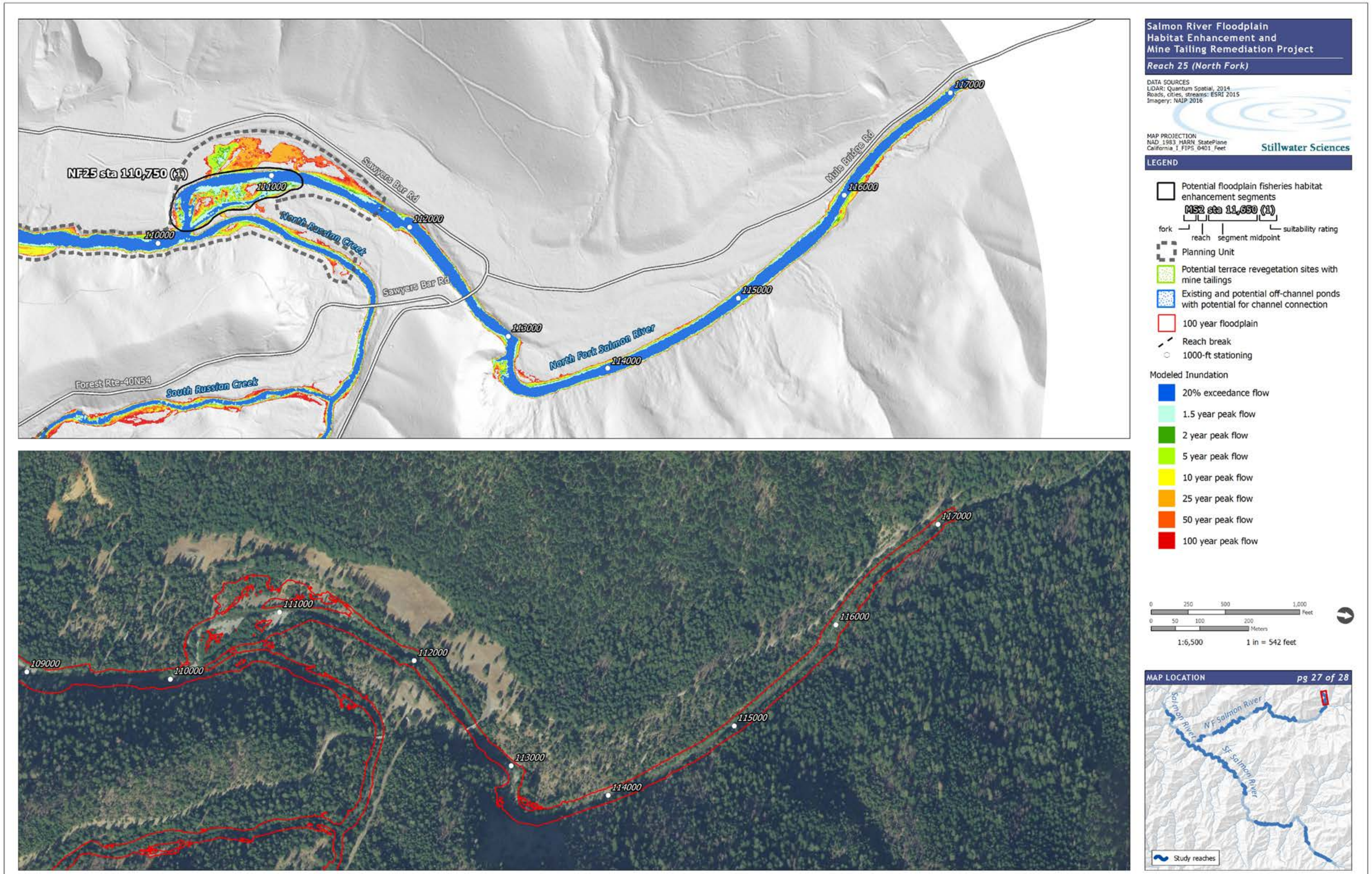

Figure A-54. Flow inundation in predominantly alluvial reaches within the Salmon River project area, Tile 27 of 28

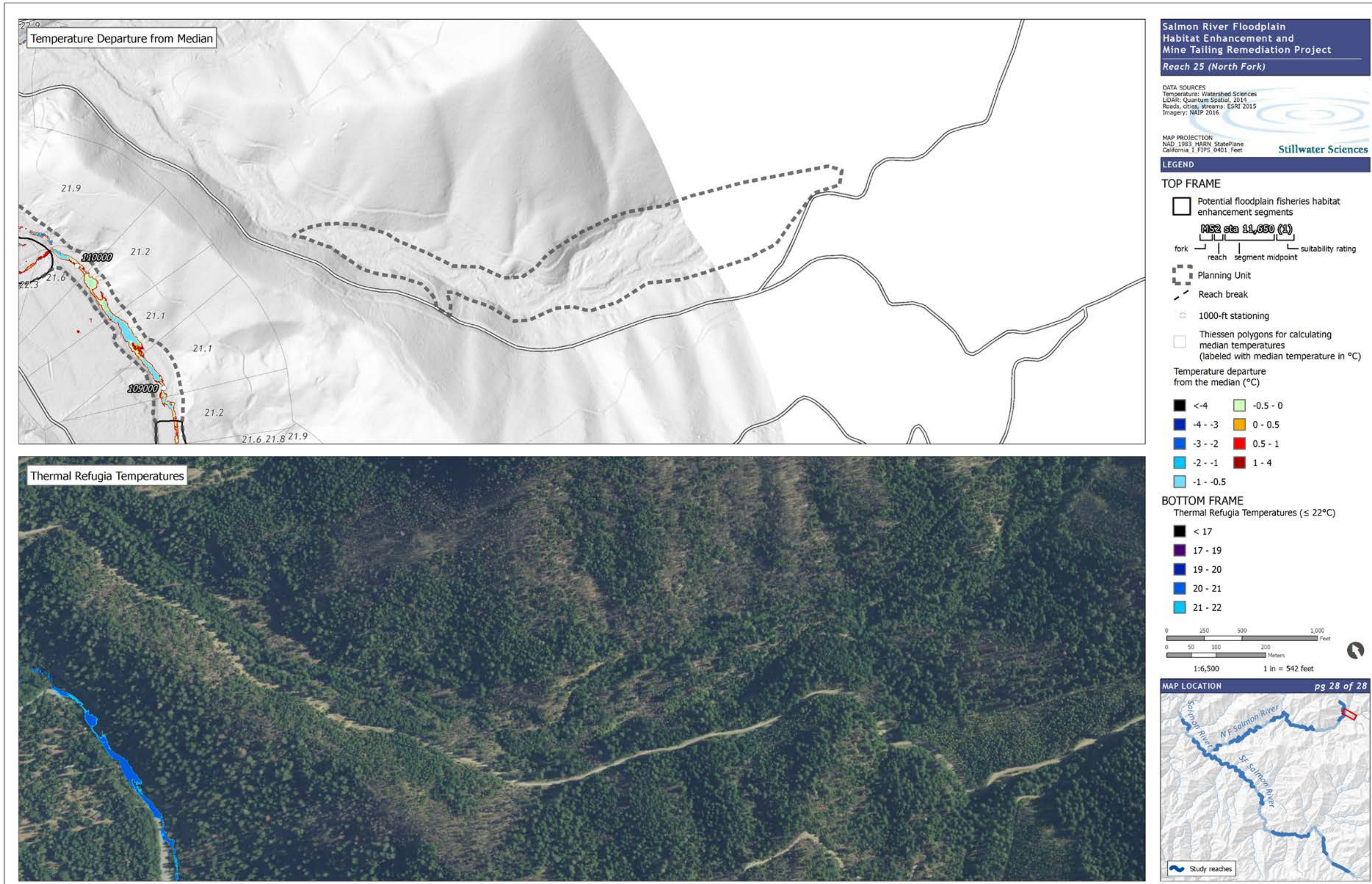

Figure A-55. Thermally suitable habitat and localized thermal refuges in predominantly alluvial reaches within the Salmon River project area based on 2009 TIR data, Tile 28 of 28

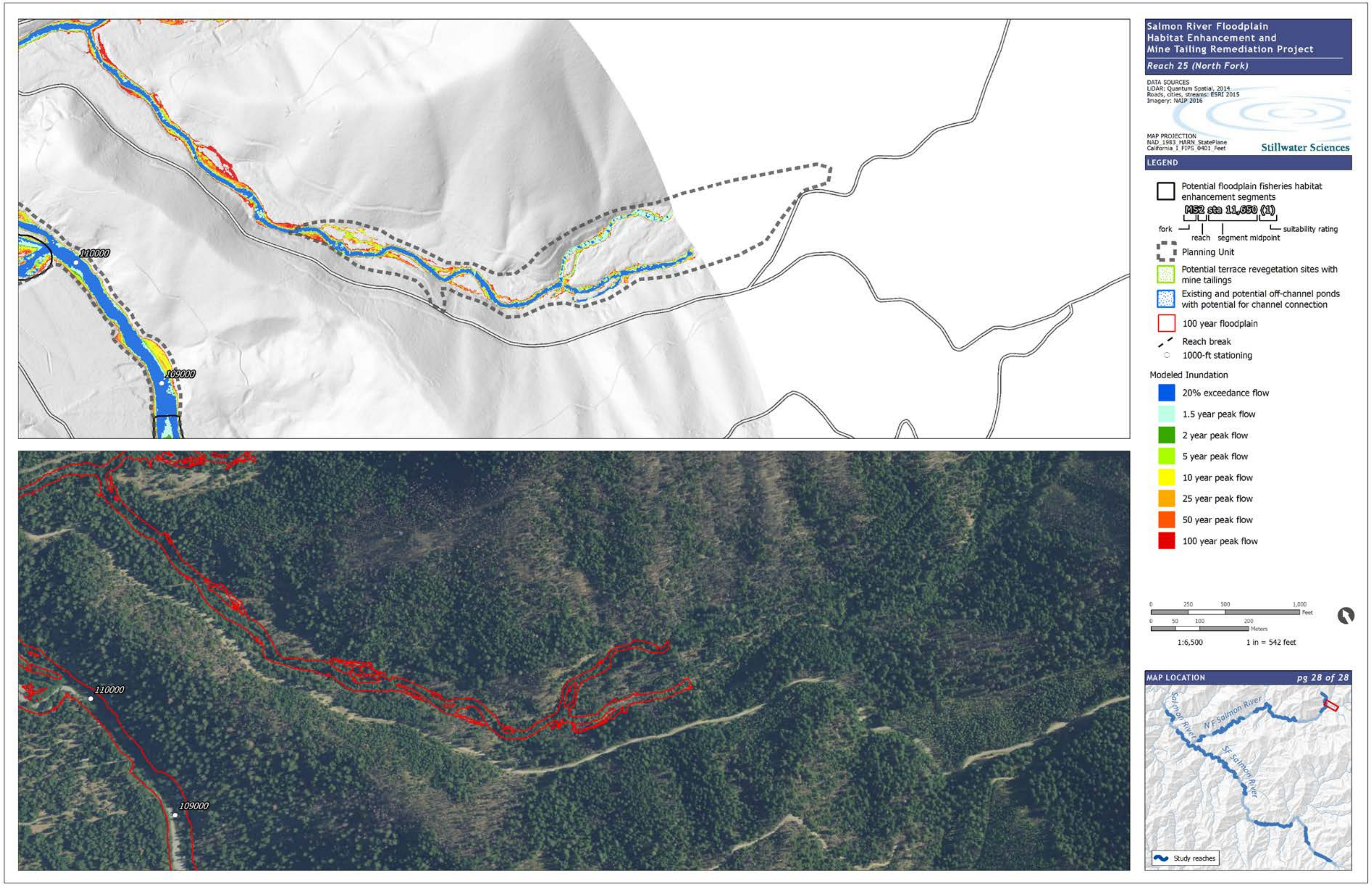

Figure A-56. Flow inundation in predominantly alluvial reaches within the Salmon River project area, Tile 28 of 28

Appendix B

Opportunities and Constraints in Potential Floodplain Habitat Enhancement Segments

Table B-1. Opportunities and constraints in potential floodplain habitat enhancement segments.[1]

Project reach	Geom reach	Segment[2]	Station[3]		Length, ft.	Channel gradient	Flow inundation	Thermal conditions	Geomorphology	Disturbance and infrastructure	Riparian vegetation and aquatic habitat	Habitat enhancement opportunities	Suitability rating
			Down	Up									
Mainstem	2	Overall MS2	5,400	12,800	7,400	0.55%	Very limited ≤5-year inundation areas: (1) Nordheimer Ck entering LB at sta 11,500 and (2) large LB bar at sta 8,500-9,500. Large, linear pond on LB with outlet near 7,800.	Generally unsuitable temperatures (max >22 C). Significant reach-scale cooling due to cool inputs from Crapo and Nordheimer creeks. The Crapo Creek confluence area provides one of the most important refugia for adult spring-run Chinook in the Salmon River.	Sediment storage in alternating bars through central portion of reach related to downstream bedrock channel constriction at Nordheimer rapid. Little change in bars since 1993, except at ~sta 6,500–7,000, where channel shifted from RB to LB.	Extensive hydraulic mining excavation of LB terrace from sta 7,800-11,000. No infrastructure. Nordheimer camp on high terrace.	Little change. 1997 event substantially cleared bars of vegetation. Minor colonization of bar flanks by woody veg since 2005.	Connect pond to base flow channel at 7,800 to provide winter off-channel habitat. Field observations needed to verify feasibility of connecting based on bedrock control and elevation change in connecting channel. Other mine tailing excavations are too high above the river to function as connected ponds. Very little opportunity to lower floodplain/ terrace surfaces due to shallow bedrock. Little opportunity to influence habitat associated with large alternating bars. Consider increasing complexity and steering flow across poorly vegetated bars through live willow planting. Small, dense patches of revegetation could serve as seed sources.	na
		MS2 sta 11,650 (1)	11,200	12,100	900	0.50%		Nordheimer Creek is key cold-water refuge for juveniles, one of better tributaries for salmonids.	Nordheimer delta is dynamic. No evidence of scour on LB terrace ds of confluence. Extensive bedrock outcrop in this area.			The primary restoration opportunity in this reach is lower Nordheimer Creek and its confluence. The confluence of Nordheimer Creek has good potential for enhancement of thermal refugia, including along the river bar. LWD structures in the lower reaches of the creek would enhance summer and winter rearing and spawning habitat. Treatments could include wood jams, brush bundles, and seasonal dam pools.	1

Project reach	Geom reach	Segment[2]	Station[3]		Length, ft.	Channel gradient	Flow inundation	Thermal conditions	Geomorphology	Disturbance and infrastructure	Riparian vegetation and aquatic habitat	Habitat enhancement opportunities	Suitability rating
			Down	Up									
Mainstem	4	Overall MS4	22,000	35,600	13,600	0.54%		Generally unsuitable (max >22 C). Notable warming from Forks confluence to Brazille Flat.	Hydraulically simple straight reaches with large alternating bars connecting more geomorphically and hydraulically complex bends with point bars and high flow side channels.	Extensive hydraulic mining excavation and tailings at upstream end of reach near Forks and at downstream end of the reach.	Little change. 1997 event and aquatic habitat. substantially cleared bars of vegetation. Minor colonization of bar flanks by woody veg since 2005. Reach provides spawning habitat, primarily for Fall Run Chinook.	Reach contains lowest gradient in mainstem. Could provide better coho spawning habitat but lacks structure and gravel sorting to be functional. Consider approaches to sorting substrate to increase spawning gravel quantity and quality. Limited opportunity for floodplain enhancement outside of the segments described below due to high stream power and lack of inundation area.	na
		MS4 sta 23,700 (3)	23,100	24,200	1,000	0.68%	Inundation of RB side channel at 20% exceedance with summer ponding over multiple years since 1993.		Larger side channel is stable feature since 1993, smaller side channel is more dynamic and not always present (present after 1997 event, gone after 2005 event, reformed recently). Side channel features probably related to local channel expansion onto LB floodplain terrace at ~sta 23700-24100. Shallow depth to bedrock on floodplain terrace. Bedrock controls channel along terrace riser.			Potential for enhancing RB side channel (e.g., LWD structure). High stream power in this reach makes suitability uncertain.	3
		MS4 sta 28,750 (3)	28,200	29,300	1,100	0.82%	20% exceedance to 5-yr inundation of LB side channel, 5–10 yr inundation of small adjacent LB floodplain.		Side channel formed after 1997. Adjacent floodplain terrace has been in same configuration since 1993.	Extensive mine tailings on right bank at ~sta 27,300–28,400		Investigate depth to bedrock in LB high flow channel with 100 yr inundation area. Potential for enhancing side channel and alcove at downstream end. Potential for riparian restoration on RB terrace with extensive tailings (sta 28,700–27,000). This is easily accessible area on private and County property.	3
		MS4 sta 32,800 (1)	32,000	33,600	1,600	0.81%	5- to 10-yr inundation of RB bar dissected by 20% exceedance–1.5 yr high-flow channel along back edge. Second, less-frequently inundated (10 yr) RB high flow channel at downstream end of bar. Horn Creek enters LB at sta 33,000.			Excavation and tailings throughout outer half of RB point bar terrace. Structures on high interior part of RB terrace. Vehicle access to RB bar and side channel.		Some potential for large ELJ bar apex jam designed to route more flow into lowered RB high flow channels. Some limited opportunities along inset floodplain areas on both banks. Recent tailing excavation may provide useful information regarding substrate composition and stratigraphy at depth with deposits to help assess restoration/revegetation suitability.	1

Project reach	Geom reach	Segment[2]	Station[3]		Length, ft.	Channel gradient	Flow inundation	Thermal conditions	Geomorphology	Disturbance and infrastructure	Riparian vegetation and aquatic habitat	Habitat enhancement opportunities	Suitability rating
			Down	Up									
South Fork	5	Overall SF5	400	7,900	7,500	0.95%	Very little 5 yr inundation area	Reach-scale cooling to marginal temperatures (20–22C). Cooler temperatures may correspond with cooler tributary input (e.g., Knownothing Creek) and steeper channel gradient with more deep bedrock pools and fewer long shallow riffles and runs. May also relate to cool groundwater inputs.	Steep and coarse grained. Predominantly bedrock controlled. Only alternating bar sequences occur from sta 900–1,700 related to supply from McNeil Creek and sta 3,200–3,900 related to channel width expansion and curvature. Little past or potential for future geomorphic change. Paired strath terraces in the middle part of the reach are high and have bedrock at shallow depth.	Extensive excavation at upstream and downstream ends, tailing piles of strath cover sediments.	Little change. 1997 event substantially cleared bars of vegetation. Minor colonization of bar flanks by woody vegetation since 2005.	Little restoration and enhancement opportunities. Limited opportunities for terrace revegetation in vicinity of mine tailing piles and increasing riparian shading along bar flanks sta 3,200–3,800.	na
South Fork	6	Overall SF 6	7,900	17,600	9,700	0.72%	Minimal 25–50 yr inundation in excavated areas of LB in vicinity of sta 13,800–14,300	Warm reach with median temperatures typically ≥22C. Warmest temperatures in the SF occur in this reach upstream of Knownothing. Notable warming (2–4 C) from Indian Creek (sta 41,000) to Knownothing Creek (sta 13,000) corresponding with lower gradient, large armored gravel bars, and increased mining impacts and tailings.			Juvenile coho observations only above warming reach. Few observations of spring-run Chinook juveniles. Juvenile coho observed in Knownothing Creek.	Mining excavations along LB may have potential for enhancing off-channel ponds. Excavated areas may be too high with bedrock at shallow depth. Potential for off-channel pond in old mine-tailing depression at lower end of Missouri Bar depending on gradient, depth to bedrock, and landowners located at sta 8,100.	na
		SF6 sta 11,750 (1)	10,000	13,500	3,500	0.73%	Knownothing Creek enters LB at sta 12,800. Large RB high flow channel with 5–10 yr inundation. At downstream end, RB bar has 2–5 yr inundation.	Median temperatures typically ≥22C but notable cooling at Knownothing Creek (20–22 C).	Sandy inlet to RB side channel. Field observations of scour along high flow channel. Fine sediment deposits observed at the downstream end substantiate more frequent inundation of last ~200 feet. No evidence of bedrock control along high-flow channel alignment, but bedrock exposure occurs in intervening upland areas.	Extensively disturbed by mining. Large mine tailings confine floodplain extent and contribute to heating.		Important area for protecting and enhancing thermal refuge. Potential for increasing inundation frequency in RB side channel and revegetating surrounding tailings. Potential to create alcove at downstream end of side channel. Knownothing Creek confluence also has opportunity for enhancing thermal refuge and winter refuge.	1
		SF6 sta 16,650 (2)	16,100	17,200	1,100	0.86%	Local expansion of ≤5 yr flow inundation. RB bar with 2–5 yr inundation of surface and 20%–1.5 yr concentrated flow along back edge.	Little variation in median temperatures but small disconnected pockets of cold water (19C) observed in RB winter base flow side channel.	RB lateral bar.	Extensive mine tailing field on high RB river terrace.	Little riparian vegetation cover. Poor structure and cover in RB winter baseflow side channel.	Potential for bar apex structure to sort gravel at pool tail and enhance RB side channel flow, RB side channel enhancement, and revegetation of lateral bar flanks and adjacent mine tailings.	2

Project reach	Geom reach	Segment[2]	Station[3]		Length, ft.	Channel gradient	Flow inundation	Thermal conditions	Geomorphology	Disturbance and infrastructure	Riparian vegetation and aquatic habitat	Habitat enhancement opportunities	Suitability rating
			Down	Up									
South Fork	7a	Overall SF7a	18,000	35,600	17,600	0.87%		Warming reach with median temperatures ≥22 C. Highly localized cooling to 21-22 C at confluence of Methodist Creek and in some large, deep pools.	Reach is generally bedrock controlled with little sediment storage, all associated with planform curvature and in pools associated with large bedrock obstructions (e.g., 18800 and 19000). Long Bo plane bed reaches between bends.		Little change	Little floodplain inundation and little opportunity for floodplain habitat restoration. Some opportunity to revegetate mine tailings on terraces.	na
		SF7a sta 22,050 (1)	20,900	23,200	2,300	0.96%	Summer baseflow channel split upstream of Negro Ck (enters RB at ~sta 20,900). Relatively more extensive 1.5–5 yr inundation of midchannel bar and upstream/downstream point bars.	Median temperature typically >23 C, with up to 1C cooling in deeper runs and pools (especially at Negro Creek confluence).	Split flow channel. Little change in midchannel bar. Some bedrock/large boulder control at head and tail. Flow vectors move left to right approaching bend. Extensive right bank erosion. Bedrock control along both valley margins.	Unimproved road along RB undermined by bank erosion.	Poorly vegetated midchannel bar.	Potential for bar apex structure to sort gravel at pool tail and enhance RB side channel flow, RB side channel enhancement, and revegetation of lateral bar flanks. Potential for alcoves at ST 22,100 and sta 22,700. Potential opportunity to enhance summer refugia in lower Negro Creek.	1
		SF7a sta 29,500 (3)	28,900	30,100	1,200	0.98%	Left bank bar has 1.5 to 5-year inundation		Large wood jams on left bank Bo bar/low floodplain racked in front of riparian forest established after 1997 event. Little organized flow path/channelization across surface. Coarse and progressively more bedrock control in downstream direction. Little to no opportunity to influence channel morphology.	Extensive excavation and reorganization of strath cover sediments into piles on high RB terrace		Potential enhancement of low bar on LB and revegetation of tailings on RB terrace.	3
		SF7a sta 33,050 (3)	32,600	33,500	900	0.82%	RB side channel inundated at 20% exceedance, pool in side channel persists during most years. Methodist Creek enters LB at sta 33,400.	Highly localized cooling to 21-22 C at confluence of Methodist Creek.	Little to no change over time	Adjacent road	Little change	Opportunities to enhance mainstem RB side channel with pool, revegetate LB mine tailings on terrace, and enhance lower Methodist Creek.	3

Project reach	Geom reach	Segment[2]	Station[3]		Length, ft.	Channel gradient	Flow inundation	Thermal conditions	Geomorphology	Disturbance and infrastructure	Riparian vegetation and aquatic habitat	Habitat enhancement opportunities	Suitability rating
			Down	Up									
South Fork	9	Overall SF9	46,700	54,000	7,300	0.92%	Typically confined with little floodplain inundation, except in vicinity of Mathews Creek.	Reach-wide median temperatures typically 21- 22C. Moving in upstream direction, SF9 is generally where temperatures first reach this marginally suitable range.	Typically narrow, bedrock confined channel with shallow depth to bedrock, some large Bo riffle controls. Large LB landslide at ST 50,000–50,700. Landslide sediment input creates alternating bars upstream and downstream. Very dynamic channel at toe of landslide.	Cover sediments mined and piled on high strath terraces	Little riparian vegetation. Alcove around sta 48,900	Some potential for revegetation of tailings on terraces. Potential to enhance RB side channel and vegetate intervening bar and adjacent high terrace immediately downstream of Matthews Creek.	na
		SF9 sta 52,800 (1)	51,600	54,000	2,400	1.02%	5-10 yr inundation cutting back edge of highly disturbed RB point bar terrace at downstream end. Extensive 1.5-5 yr inundation of alternating point bars at upstream end, each with channel cutting their back edge (1.5 yr inundation in the downstream side channel and 20% exceedance inundation in the upstream side channel.	Median temperatures typically 21- 22C, ~20 C in the deeper pools at upstream and downstream ends and at Matthews Creek confluence.	RB terrace from sta 52,000–52,500 has high flow path across back edge. Coarse sediment deposited along this path. Two alternating point bars have side channels cutting back edge. Upstream-most side channel passes through higher, heavily vegetated area. May cut bedrock, requires field investigation. Little geomorphic change over time. Active streamside landslide across from lower point bar at sta 52,800–53,000.	RB terrace highly disturbed with little to no existing habitat value.	High quality habitat in LB summer baseflow/winter baseflow side channel at upstream end of reach. Good analogue. Poor habitat in RB winter base/bankfull side channel in middle of reach. This side channel and intervening bar devoid of riparian vegetation.	Potential for bar apex structures to sort gravel at pool tails and enhance side channel flow, RB side channel enhancement, and revegetation of midchannel bar. Need to better understand potential limitations on excavation imposed by shallow bedrock. Good river access at downstream end.	1

Project reach	Geom reach	Segment[2]	Station[3]		Length, ft.	Channel gradient	Flow inundation	Thermal conditions	Geomorphology	Disturbance and infrastructure	Riparian vegetation and aquatic habitat	Habitat enhancement opportunities	Suitability rating
			Down	Up									
South Fork	11	Overall SF11	71,000	89,200	18,200	1.16%	Typically confined floodplain with little inundation extent outside of the segments identified below.	Median temperatures are warm relative to upstream and downstream reaches, typically 22-23 C. Significant cooling at and for short distance downstream of Saint Claire Creek (key thermal refuge).		Little evidence of large-scale hydraulic mining in this reach.	Start of potential spring Chinook spawning. Quantity and quality of spawning habitat becomes important.	Some opportunities for LWD on functioning inset floodplains from sta 79,500–81,500, other potential opportunities for locally lowering floodplain surfaces. A lot of private property in reach.	na
		SF11 sta 80,300 (2)	79,600	81,000	1,400	1.01%	RB side channel with 20%–1.5 yr inundation at outside of bend at sta 79,600–79,900; alcove at downstream end. LB side channel that inundates at 20% exceedance at back edge of large lateral bar at sta 80,500–81,100.	Median temperatures typically > 22 C, locally cools to 19 in pools.	Bar/RB side channel at sta 79,800: bedrock control with thin, discontinuous alluvial cover. Lack of LWD across crest of downstream bar indicative of high energy environment at outside of bend. Bar/LB side channel at sta 80,500–81,100: LB lateral bar controlled by large LB bedrock outcrop, channel width expansion, and abrupt reduction in planform curvature. Dynamic.	None	Little veg cover across bar flanks. Little change. Existing high value left bank alcove.	May be potential to add structure to LB side channel. Bedrock may limit opportunities to create deeper, more persistent holding habitat. Difficult access.	2
		SF11 sta 82,050 (1)	81,700	82,400	700	0.78%	Inundation of LB side channel at 20% exceedance at sta 81,800–82,400; no summer inundation or ponding.	Median temperatures > 22 C.	Bar/side channel at sta 81,800–82,400: locally wider reach with tight downstream curvature and large bedrock outcrops creating hydraulic control/backwater. High LB terrace immediately upstream. Little change since 1993. Extensive bedrock control along channel margins.			Potential site for large ELJ/bar apex jam in vicinity of sta 82,250 to build head and route water into LB side channel. Large bedrock outcrops in this vicinity already provided similar functions. LB side channel enhancement.	1
		SF11 sta 84,500 (2)	84,200	84,800	600	0.82%	Broad LB floodplain with 5 yr inundation sta 84,200–84,800.	Median temperatures > 22 C with no thermal refuge.	Bedrock extensively exposed in banks at shallow depth but none at surface across LB floodplain. Little organized flow path or channeling across floodplain surface. Wood transported into center of floodplain and rafted up along downstream edge.	Tailing piles across LB floodplain. Likely old mine site.	Little to no riparian vegetation across LB floodplain.	Potential LB floodplain enhancement, including side channel excavation, increased veg cover. Potential limitations imposed by shallow bedrock. Equipment access difficult.	2

Project reach	Geom reach	Segment[2]	Station[3]		Length, ft.	Channel gradient	Flow inundation	Thermal conditions	Geomorphology	Disturbance and infrastructure	Riparian vegetation and aquatic habitat	Habitat enhancement opportunities	Suitability rating
			Down	Up									
South Fork	11 (cont.)	SF11 sta 85,550 (2)	84,800	86,300	1,500	0.92%	LB side channel with inundation at 20% exceedance at inside of bend sta 84,800–Low-relief LB lateral bar with 1.5 yr inundation, flow converges in side channel at downstream end with inundation at 20% exceedance. Saint Clair Creek enters LB at sta 85,300.	Median temperatures typically 22-23 C. Significant cooling at and for short distance downstream of Saint Claire Creek enters (key thermal refuge) at upstream end.	LB point bar at downstream end of segment has complex flow across. LB lateral bar cut by incipient high flow side channels. Lots of wood accumulated in jams on the upstream end of the bar. Dynamic.	Secondary road accesses RB floodplain area across from Saint Claire Creek.	Good cover on point bar at the downstream end of segment. Little cover on LB lateral bar further upstream.	Potential for bar apex structure to sort gravel at pool tail and enhance LB side channel flow, RB side channel enhancement, and revegetation of midchannel bar downstream of Saint Clair Creek at sta 85,300–85,900. Saint Claire Creek is key thermal refuge, enhance confluence vicinity (e.g., LWD, brush bundles). Equipment access may be possible via road across from St. Clair Creek.	2
		SF11 sta 86,650 (2)	86,300	87,000	700	0.76%	Low-relief LB bar with 1.5 yr inundation; side channel cutting back edge with inundation at 20% exceedance.	Median temperatures typically 22-23 C. Saint Claire Creek enters (key thermal refuge) at downstream end.	Large LB bar cut by incipient high flow side channels. Saint Claire Creek enters at downstream end.	none		Potential for bar apex structure to sort gravel at pool tail and enhance RB side channel flow, RB side channel enhancement and revegetation.	2
		SF11 sta 87,950 (2)	86,900	89,000	2,100	0.77%	Broad areas of 1.5 to 2 yr inundation across alternating point bars.	Median temperatures typically 22-23 C. Pool in middle of segment has good shading, cools to 16 C.	A series of three alternating point bars. Downstream most point bar has evidence of complex flow paths/side channel development along back edge.	none	little change	Potential for bar apex structure to sort gravel at pool tail and enhance LB side channel flow, LB side channel enhancement and revegetation at downstream point bar.	2

Project reach	Geom reach	Segment[2]	Station[3] Down	Station[3] Up	Length, ft.	Channel gradient	Flow inundation	Thermal conditions	Geomorphology	Disturbance and infrastructure	Riparian vegetation and aquatic habitat	Habitat enhancement opportunities	Suitability rating
South Fork	12	Overall SF12	89,200	101,500	12,300	0.76%		Cooler and more wide-ranging median temperatures compared to reaches upstream and downstream. Coolest temperatures in reach (<20 C) occur in confined areas downstream of Crawford Creek.	Mostly very confined BoCb plane bed with alternating lateral bars.	More extensive hydraulic mining impacts in this segment compared to SF11. A lot of infrastructure at upstream end of near Cecil Creek confluence ~sta 100,000.	Little riparian vegetation on large bars in reach.	Potential to load wood along gravel bars and long, straight runs to enhance rearing habitat and potentially sort substrate into better spawning habitat. Potential small alcove at sta 90,500, potential off-channel site at sta 92,000.	na
		SF12 sta 92,450 (2)	91,500	93,400	1,900	0.67%	1.5 yr inundation of large LB bar at upstream end of segment from sta 92,600–93,300. Areas of 5 yr inundation on disturbed LB terrace, including two small ponds at ~sta 92,000. Areas of 5 yr inundation on inset RB floodplain at downstream end of segment.	Median temperatures typically 22-23 C.	Large LB lateral bar with incipient high flow channel along back edge. There was a much better-defined side channel in this location prior to 1997 event, which shifted channel toward RB and filled side channel. Alcove on RB at ds end.	Extensive excavation and piling of strath cover sediments on high LB terrace. Houses on RB at upstream and downstream end.		Potential for bar apex structure to sort gravel at pool tail and enhance LB side channel flow at upstream end of segment. Potential for enlarging and connecting existing ponds on LB terrace in middle of segment. Shallow bedrock may limit excavation.	2
		SF12 sta 96,500 (3)	96,200	96,800	600	0.98%	Complex pattern of infrequent inundation at confluence of Crawford Creek. Little geomorphic evidence of active floodplain inundation or channeling in this area.		Large Bo controls near confluence.	Larger right bank area upstream of Crawford Creek extensively excavated		Unclear what opportunities may exist near Crawford Creek confluence. Lower gradient reach of creek could be good coho habitat and has potential for instream habitat enhancement. Low lying area adjacent to RB of Crawford Creek confluence could have opportunities for enhancing off-channel winter and summer refuge. Need to know more about flow characteristics of Crawford Creek (e.g., persistence of spring/summer flow and consumptive water use). A lot of private land in this area.	3

Project reach	Geom reach	Segment[2]	Station[3]		Length, ft.	Channel gradient	Flow inundation	Thermal conditions	Geomorphology	Disturbance and infrastructure	Riparian vegetation and aquatic habitat	Habitat enhancement opportunities	Suitability rating
			Down	Up									
South Fork	14	Overall SF14	116,400	126,200	9,800	1.22%		Median temperatures typically 21–22 C but notable warming from upstream reaches down to this point. Significant heating in this reach due to wide floodplain, mine tailings, and shallow channel with large unvegetated CoBo bars. Some cold pools and refugia related to hyporheic flow through transverse bars.	Very simple, confined Bo plane bed in lower third of reach up to sta 120,000.	Large, broad, very extensively mined high terraces throughout reach. Most out of inundation zone.	This segment has the good combination of cold water and relatively low channel gradient.	Needs treatments to improve thermal refugia and protect/enhance overall temperature conditions to avoid warming. Some potential for off-channel ponds and wetlands. Connectivity for fish may be difficult due to gradient.	na
		SF14 sta 121,050 (2)	120,000	122,100	2,100	1.35%	Gradational (1.5–10 yr) inundation of large, coarse-grained LB point bar sta 120,000–120,700. 2–5 yr inundation of RB terrace sta 120,600–121,200. Ponds exist on back edge of disturbed RB terrace.	Several good examples of small refugia created by emerging hyporheic flow at the downstream end of transverse bars.	Alternating RB and LB point bar terraces. Downstream end has dynamic LB bar that has changed a lot since 1993. Upstream end of segment has a wide and dynamic plane bed channel. Coarse grained.	Upper RB terrace looks like it may be undisturbed. Rest of area has reworked strath cover sediments in tailings piles.		Potential for bar apex structure at upstream end to sort gravel at pool tail and enhance flow into split channels. Second bar apex jam at head of bar near sta 121,600 to split flow. Potential for connecting ponds to mainstem looks challenging. Depth to bedrock may be an impediment. Grade and revegetate tailings on terraces.	2
		SF14 sta 123,550 (1)	122,200	124,900	2,700	1.25%	LB bar at downstream end with 1.5 yr inundation; veg suggests concentrated flow along back edge but unsupported by hydraulic modeling. Middle of segment has RB and LB terraces with 10–25 yr inundation. Large, low LB terrace is dissected by complex flow paths, high flow path at back edge is more frequently occupied (5 yr). More active RB bar at upstream end of segment has 2–5 yr inundation with a 1.5-yr high-flow channel at the back edge.	Median temperatures 21-22 C.	Broad RB and LB floodplain areas with complex flow patterns. Main channel has been dynamic through this area since 1993, shifting/increasing sinuosity after the 1997 event and bifurcating after the 2005 event. Channel at upstream end of reach migrated toward RB and away from LB floodplain in 2017. No obvious signs of bedrock control within the inundated areas.	Very extensively disturbed by hydraulic mining. Largest excavated area in South Fork.	Little change. 1997 event substantially cleared bars of vegetation. Minor colonization of bar flanks by woody veg since 2005.	Major floodplain restoration potential for rearing and spawning for coho and spring Chinook. Riparian revegetation will be key component. Needs considerable evaluation and potential phased approach to ensure desired response given extreme armoring, high floodplain surfaces, and magnitude of high flow events. Site of USFS project to enhance instream habitat in the 1990's.	1

Project reach	Geom reach	Segment[2]	Station[3]		Length, ft.	Channel gradient	Flow inundation	Thermal conditions	Geomorphology	Disturbance and infrastructure	Riparian vegetation and aquatic habitat	Habitat enhancement opportunities	Suitability rating
			Down	Up									
South Fork	16	Overall SF16	133,700	144,200	10,500	1.44%	Significant 20% to 5 yr inundation of alternating point bars, floodplains, and high flow side channels from sta 133,700–140,500. Little floodplain inundation upstream of sta 140,500.	Cold water reach. Median temperatures typically 19-21 C.	Channel in this reach is smaller and dynamic. Lots of high flow channels cutting across large alternate bars and low floodplain terraces. Several locations where secondary channels at the back edge of the bar inundate at 1.5–2 yr. Large wood plays key role in channel and floodplain morphology. A lot of large wood rafted onto bar apex and crest locations. Above sta 140,500, channel is relatively straight and confined with plane bed morphology. Bo Bdrx controls. Rush Creek enters at sta 142,300. Upstream of confluence, the canyon narrows significantly and the channel is steeper, coarser grained, and more bedrock controlled.	Pervasively mined/stripped terraces and valley side slopes exposing bedrock in many locations. Dense network of secondary/tertiary roads and trails.	Key reach for spawning.		na
		SF16 sta 137,100 (1)	133,700	140,500	6,800	1.41%	Significant 20% to 5 yr inundation of alternating point bars, floodplains, and high flow side channels up.	Cold water reach. Median temperatures typically 19-21 C.	Uniform plane bed and riffle pool morphology with BoCb channel bed and relatively little bedrock control except at outer meander bends and forming control at some riffle crossovers. Regular meander pattern and slope. Coarse sediment storage in alternating point bars and lateral bars. Large wood jams at bar heads (e.g., 136,100 and 139,900). 1997 event had a large effect in this reach, mobilizing most bars within the flood prone area. 2005 event had little effect.		1997 event removed most of the riparian forest from the flood prone area. 2005 event had little effect, steady increase in riparian veg cover since 1997.	Lots of functioning inset floodplains on alternating bars. Channel size, alluvial character, and existing bar/floodplain inundation create numerous opportunities for habitat enhancement with bar apex wood jams to enhance flow into cutoff channels and side channel construction/ enhancement. Potential for more significant side channel/ backwater at sta 138,000.	1

Project reach	Geom reach	Segment[2]	Station[3]		Length, ft.	Channel gradient	Flow inundation	Thermal conditions	Geomorphology	Disturbance and infrastructure	Riparian vegetation and aquatic habitat	Habitat enhancement opportunities	Suitability rating
			Down	Up									
North Fork	19	Overall NF19	5,100	10,200	5,100	0.76%	25–50 yr inundation of RB high flow channel cutting across inside of high strath terrace.	Median temperatures are typically 22-24 C. This reach is slightly cooler than upstream and downstream reaches.	Bedrock channel and bedrock exposed or at very shallow depth across alternating point bar strath terraces.	Extensive excavation and tailing piles, exposing bedrock over much of terrace areas.		Little opportunity for floodplain habitat enhancement in this reach. Focus on revegetating tailings and creating more thermal refugia, but overall temperatures of incoming flow is a challenge.	na
North Fork	21a	Overall NF21a	16,500	30,600	14,100	1.32%		Median temperatures are typically 23-24 C. Notable warming throughout the reach, related to alluvial channel with large cobble-gravel bars and more denuded areas from mining.	Pool riffle with long stretches of intervening plane bed. Larger pools at bends. Predominantly very coarse bed (Bo and BoCb). Large, very coarse midchannel storage features split flow. Upstream of 28,000, very coarse with cascade/step pool morphology.	Less overall terrace excavation by hydraulic mining, but all strath terrace cover sediments have been reworked, large tailing piles are common, some current aggregate extraction/mining of tailings.	Juveniles are observed in summer upstream of reach only.	Not many good opportunities for floodplain restoration but potential for instream enhancements for spawning habitat. Higher gradient then most other alluvial reaches.	na
		NF21a sta 19,100 (3)	18,400	19,800	1,400	0.75%	20% inundation of midchannel bar.	Median temperatures are typically 24 C with little deviation.	Long BoCo plane bed segment with little complexity. Large wood rafted onto midchannel bar crest. Persistent features with little change since 1993.		Little vegetation change. Spawning gravel could be important here.	May be suitable reach for enhancing spawning habitat by using ELJ structures to sort bed material.	3
		NF21a sta 21,900 (2)	21,200	22,600	1,400	1.18%	20%–1.5 yr inundation of split flow channels around midchannel bars with predominantly 2–5 yr inundation.	Median temperatures are typically 23 C with cooling in large pool at head of segment.	Flow splits around large, very coarse midchannel bar. Bo plane bed channel morphology.		Little vegetation change. Spawning gravel could be important here.	Potential for bar apex structure at upstream end to sort gravel at pool tail and enhance flow into split channels.	2
		NF21a sta 23,100 (2)	22,600	23,600	1,000	1.19%	20% inundation of LB side channel and 1.5–2 yr inundation of midchannel bar flanks.	Median temperatures are typically 23 C with cooling in large pools at upstream and downstream ends.	Flow splits around large, coarse midchannel bar. Significant flow separation and sorting at head by large bedrock outcrop. LB channel inlet controlled by dynamic GrCo pool tail deposit. Downstream channel is Bo plane bed.		Spawning gravel could be important here. Good holding pools at upstream and downstream ends	Potential for large bar apex structure at upstream end to sort gravel at pool tail and enhance flow split into LB side channel and maintain inlet.	2

Project reach	Geom reach	Segment[2]	Station[3]		Length, ft.	Channel gradient	Flow inundation	Thermal conditions	Geomorphology	Disturbance and infrastructure	Riparian vegetation and aquatic habitat	Habitat enhancement opportunities	Suitability rating
			Down	Up									
North Fork	21a (cont.)	NF21a sta 26,200 (3)	25,700	26,700	1,000	1.21%	20% exceedance –1.5 yr inundation of LB side channel around highly vegetated midchannel Bo bar with predominantly 2–5 yr inundation.	Median temperatures are typically 23 C.	Coarse sediment storage feature with split flow. High flow side channel not well defined from inlet to outlet and conveys less flow than others in reach. Large wood jams at bar head, in side channel, and across bar. 1997 event scoured the side channel but left riparian veg on downstream half of bar crest. Limited opportunity for side channel enhancement due to steep, coarse bed. Bedrock exposure may limit excavation potential.		Spawning gravel could be important here. Good holding pool at upstream end.		3
		NF21a sta 29,000 (3)	28,100	29,900	1,800	2.48%	LB side channel with 20% inundation at upstream end of bend, 2-5yr inundation at downstream end of bend.	Median temperatures are typically 23 C with cooling in large pools at upstream and downstream ends.	Coarse sediment storage features with split flow. Very steep and very coarse bedded (large Bo) main channel and side channel. At upstream end of bend, LB high flow side channel is well defined. At downstream end, side channel cutting LB terrace is less defined with less frequent inundation.		Spawning gravel could be important here	Little opportunity for side channel enhancement due to very steep, coarse bed. May be limited opportunity to improve LB side channel at downstream end of bend if shallow depth to bedrock.	3
North Fork	21b	Overall NF21b	30,600	43,200	12,600	1.61%		Median temperatures are typically 22-23 C.	Steep Bo bed with localized bedrock controls. Predominantly plane bed with bedrock controlled pools formed at bends.			Bedrock control with little feasible restoration potential with exception of Red Bank (design by MLA in progress).	na
		NF21b sta 40,850 (1)	38,500	43,200	4,700	1.41%	Complex 20% to 5 yr inundation patterns across inside of large point bar terrace	Median temperatures are typically 22-23 C.	Much wider valley bottom with much lower slope, finer grain size. Olsen Creek enters at downstream end. Not much geomorphic change since 1993.		Little riparian veg change since 1993. Past revegetation project beginning ~ 2004.	Red Bank, one of the best sites on the NF for side channel enhancement, potential off-channel features, and riparian enhancement. Refer to MLA design report.	1

Project reach	Geom reach	Segment[2]	Station[3]		Length, ft.	Channel gradient	Flow inundation	Thermal conditions	Geomorphology	Disturbance and infrastructure	Riparian vegetation and aquatic habitat	Habitat enhancement opportunities	Suitability rating
			Down	Up									
North Fork	23a	Overall NF 23a	51,400	61,200	9,800	0.77%	Little floodplain inundation except in locally wider sections at ~59,000 and ~54,000.	This reach is warmer than NF 22 located downstream but cooler than NF 21b upstream due to the influence of the Little North Fork (key thermal refugia). Median temperatures are typically 22-23 C.	Reach predominantly confined BoCb plane bed with locally wide valley bottom at ~59,000 and ~54,000.	Two very large hydraulic mine sites north of river likely have contributed large quantities of sediment to lower 2/3 of the reach and contribute to heating.	One potential significant restorable floodplain, existing off-channel pond, and some long plane bed runs.	Potential for connecting large year-round pond (Galia Pond) at ~sta 56,430. The pond currently connects during ≥10 yr event. May be potential for creating a longer connecting channel extending further downriver that would be connected more frequently. This pond is one of the best opportunities for connecting existing pond for winter refuge habitat in the Project area. May also be potential for instream and off-channel enhancement in lower Little North Fork.	na
		NF23a sta 53,300 (2)	51,400	55,200	3,800	0.80%	At downstream end of segment, 20% exceedance inundation in side channel at back edge of RB bar at sta 51,400–52,000 and in high flow channel at back edge of LB bar at sta 52,200–52,400. Split flow channels (20% exceedance) around mid-channel island bar (2-5 yr). At upstream end of segment, high flow channel with 5 yr exceedance cuts across large point bar terrace.	Median temperatures are typically 22-23 C.	Locally much wider and less steep valley. BoCb bed. No obvious signs of bedrock across LB point bar. No well-defined high-flow channels or erosion/deposition. Split flow channel around large midchannel bar on downstream end of bend.	Extensive hydraulic mine excavation located on north side of river immediately upstream. Likely large amount of sediment delivery to and aggradation in this reach due to these mines.	1997 event largely cleared the large point bar of riparian vegetation, except for a stand in the interior area near apex where more mature trees currently are.	Potential for large bar apex structures at upstream end to sort gravel at pool tail and enhance flow split into constructed LB. Second bar apex structure near sta 54,000. Their near 52,000. Extensive riparian revegetation component to increase shading and maintain cool hyporheic flow under bar. Depth to bedrock could limit opportunities.	2
		NF23a sta 59,000 (2)	58,400	59,600	1,200	1.06%	RB side channel with well-defined 20% inundation. Several channels with 20% inundation cut left to right across very coarse transverse Bo bar.	Median temperatures are typically 22-23 C.	Relatively short side channel cuts around back edge of RB BoCb bar. Inlet controlled by large boulder/ bedrock outcrop. Large wood accumulated on bar head/crest. Complex flow patterns across coarse transverse bar.	Compound with multiple structures near side channel inlet at upstream end of the reach.	Side channel heavily forested throughout imagery.	Potential for large bar apex jam or ELJ at upstream end of site to sort gravel and separate flow into RB side channel. Large bed boulder bedrock outcrop already provides these functions. Enhance RB side channel and revegetate upstream length.	2

Project reach	Geom reach	Segment[2]	Station[3]		Length, ft.	Channel gradient	Flow inundation	Thermal conditions	Geomorphology	Disturbance and infrastructure	Riparian vegetation and aquatic habitat	Habitat enhancement opportunities	Suitability rating
			Down	Up									
North Fork	23b	Overall NF23b	61,200	72,000	10,800	0.80%	Extensive and complex ≤5yr inundation patterns in locally wider segments. Complex flow patterns around mid-channel large mid-channel bars.	Significantly warmer median temperatures than downstream in 23b. Median temperatures typically 23 to >24 C.	Lower gradient reach with BoCo and CbGr bed. Riffle pool morphology with long intervening plane bed segments. A lot of sediment storage in midchannel bars within the reach. Sediment potentially sourced from Shitos Creek and/or mined LB slopes just upstream.			Significant floodplain areas with existing habitat and floodplain habitat enhancement potential.	na
		NF23b sta 64,850 (1)	63,700	66,000	2,300	0.84%	Complex high flow paths with 5 yr inundation across RB floodplain. Two high flow channels cut LB point bar/point bar terrace, one with 1.5 yr inundation at the back edge of the more active point bar and the other with 5 yr inundation at the back edge of the higher terrace.	Median temperatures typically 23-24 C.	Appears that LB streamside landslide at upstream end of segment resulted in downstream LB bar with side channel along back edge.			Kelly Bar enhancement site. Refer to MLA design report. In addition to the existing MLA Kelly Bar project design, there is potential opportunity to enhance a long RB side channel from 65,300 to 67,200 (high quality existing riparian floodplain).	1
		NF23b sta 69,600 (1)	67,700	71,500	3,800	0.87%	Numerous secondary flow paths inundate at 20% to 5-year flow. Inlets to these channels are typically less frequently inundated and may not activate until 5 yr.	Median temperatures typically 23-23.5 C	Anabranching channel pattern. CoBo and CoGr bed material. Bar flanks and side channels scoured in 2005.	Small bridge crosses channel at 68200	Not much significant change in riparian vegetation in reach since 1993	Potential for large bar apex jam or ELJ at upstream end of site to sort gravel and separate flow into constructed/enhanced RB side channel. Second opportunity for large bar apex jam or ELJ at upstream end of bar near sta 68,700 to sort gravel and separate flow into RB side channel. Good existing riparian vegetation in places, but good opportunities for increasing riparian cover in other areas.	1

Project reach	Geom reach	Segment[2]	Station[3] Down	Station[3] Up	Length, ft.	Channel gradient	Flow inundation	Thermal conditions	Geomorphology	Disturbance and infrastructure	Riparian vegetation and aquatic habitat	Habitat enhancement opportunities	Suitability rating
North Fork	23c	Overall NF23c	72,000	86,200	14,200	1.05%		Median temperatures typically 23-24 C. Notable warming starting about 1.5 miles below Whites Gulch and extending downstream to the Little NF. NF 23b and NF2c are major warming reaches overall and would benefit from treatments that improve temperature conditions (e.g., riparian shading, tailing revegetation, and increased hyporheic exchange/floodplain restoration).		Extensive tailings on terraces around 84,800 to 86,000.		Several notable and large inset floodplain areas in this reach that may benefit from enhancement. Some surfaces are too high. Assess spawnable substrate in long runs in this reach. Priority reach given significant warming and more extensive floodplain restoration opportunities then in upstream reaches. Existing mining pit/excavation on left bank at sta 72,500 may be one of the better opportunities for enhancing off-channel pond and connecting to main channel.	na
		NF23c sta 75,050 (2)	73,800	76,300	2,500	0.94%	Long LB side channel with 20% inundation. RB high flow side channel with infrequent inundation (10–25 yr) at the downstream end.	Median temperatures typically 23-23.5, with locally much cooler mainstem and side channel pools.	Straight reach with shallow pools and long riffles approaching plane bed. BoCb substrate. Long LB side channel separated from main channel by long linear bar. Large wood jams on bar crest and in side channel. RB high flow channel at ds end is in bedrock with no opportunity for lowering. 1997 event scoured the long midchannel bar and removed a lot of riparian vegetation but did not alter overall flow paths.	Some hydraulic mine excavation on high terraces and distal margin of steep fans.	Significant riparian revegetation since 1997 event. High existing aquatic and riparian habitat values.	High existing habitat value. Otherwise steep, coarse, and bedrock controlled. Little opportunity for habitat enhancement.	2

Project reach	Geom reach	Segment[2]	Station[3]		Length, ft.	Channel gradient	Flow inundation	Thermal conditions	Geomorphology	Disturbance and infrastructure	Riparian vegetation and aquatic habitat	Habitat enhancement opportunities	Suitability rating
			Down	Up									
North Fork	23c (cont.)	NF23c sta 80,400 (1)	79,300	81,500	2,200	1.33%	Long RB side channel with 20% inundation in the downstream half of the segment. High flow RB side channel with 1.5-yr inundation in the upper half.	Median temperatures typically 23.5-24 C, with locally much cooler (16-18 C) mainstem and side channel pools.	Side channel at downstream end densely vegetated. Inlet does not look open at 20% exceedance but open water areas apparent along its course. RB floodplain at us end has obvious high flow scour but is highly disturbed. Main channel is Bo plane bed with bedrock controls. 1997 event extensively scoured riparian veg and mobilized bed in downstream areas. Little change in upstream areas. Jessups Gulch enters on LB in middle of reach.	Community of Sawyers Bar lies just above RB in reach. Unimproved road traverses RB floodplain at us end.	Highly disturbed aquatic and riparian habitat conditions.	Excellent opportunities for enhancement based on existing features and extent of disturbance. Potential for large bar apex jam at bar head near sta 80,150 to sort gravel and separate flow into enhanced RB side channel. Potential for second large bar apex jam near sta 81,250 to increase inundation of RB constructed/enhanced side channel. Floodplain in upstream portion of segment is mostly unvegetated. Lots of private land in this vicinity.	1
		NF23c sta 83,950 (2)	83,200	84,700	1,500	1.35%	Multiple flow paths with inundation at 20% exceedance dissect the point bar.	Median temperatures typically 23-23.5 C, with locally much cooler (16-18 C) mainstem and side channel pools	Extensive bedrock control at outside and downstream end of bend, with large outcrops forcing pools. Point bar predominantly alluvial (BoCb and CbBo). Flow shifted to outside of bend following 1997 event then reestablished split flow across point bar following 2005 event. Steep, coarse, high stream power, dynamic.	Large tailing piles at back edge of point bar and along RB upstream of site. Road along RB. Community of Sawyers Bar immediately ds.	1997 event scoured riparian veg, significant regrowth since then.	Limited opportunity to create more habitat in secondary channel crossing. Potential for sequential large bar apex jams/ELJs sta 84,200 and sta 84,400 to sort gravel and separate flow. Potential to create summer refuge by routing summer flow from gulches entering RB at sta 84,500 into a backwater or old mining excavation at sta 84,800.	2

Project reach	Geom reach	Segment[2]	Station[3]		Length, ft.	Channel gradient	Flow inundation	Thermal conditions	Geomorphology	Disturbance and infrastructure	Riparian vegetation and aquatic habitat	Habitat enhancement opportunities	Suitability rating
			Down	Up									
North Fork	25	Overall NF25	104,000	117,000	13,000	1.29%	Highly confined with little floodplain inundation or secondary flow paths except in three segments with locally wider valley bottom.	Generally, the coolest of any North Fork reaches in the Project Area. Median temperatures typically 21-23. Rapid warming downstream of Russian Creek.	Much of reach is confined, relatively straight, Bo plane bed. Plane bed runs continue up to Mule Bridge at Wilderness Boundary. Three segments with locally wider valley bottom.	Mining disturbances not as extensive as in other reaches.	Geographically important reach for spawning.	Assess quality of spawning habitat and consider potential for ELJs to improve sorting.	na
North Fork	25	NF25 sta 108,150 (1)	107,500	108,800	1,300	1.75%	Two high flow channels dissect LB floodplain, one with discontinuous 1.5-yr inundation and the other with less frequent 5-yr inundation. Intervening island bar probably flooded during 1964 event. RB side channel with 20% inundation at back edge of bar at upstream end of the reach.	Median temperatures typically 21-22.	Large LB bar dissected by channels and dispersed flood flow. Extensively scoured during 1997 event except upland of intervening island bar crest and two stands of riparian forest. Lesser scour in 2005, but still apparent in side channels and bar flanks. Large wood dispersed across head of bar where flow separates.	Valley bottom mining disturbance not as apparent but upland on bar crest may be capped by remnant mine tailings dispersed by 1964 event.	1997 event scoured riparian veg, some regrowth since then but slow.	Potential for sequential large bar apex jams/ELJs at sta 108,250 and sta 108,450 to sort gravel and separate flow. Excavate side channel inlets and potentially lower RB floodplain to create more channel width expansion. Revegetate side channel margins.	1
North Fork	25	NF25 sta 110,750 (1)	110,200	111,300	1,100	1.37%	Flow splits across point/transverse bar. Main channel is at outside of bend, significant side channel with inundation at 20% exceedance cuts across back edge of bar. pond in side channel apparent during summer. Numerous secondary channels dissect bar, routing flow from main channel to side channel.	Median temperatures typically 22-23.	2012 and older air photos show second channel at outside of bend with surface flow in July, so channel is very active here. Significant scour during 1997 event but little to no change in 2005.	RB floodplain looks like it has been scraped/excavated. Currently road access to this area.	1997 event scoured riparian veg, significant regrowth since then.	Potential for sequential large bar apex jams/ELJs at sta 111,050 and sta 110,650 to sort gravel and separate flow. Excavate inlet and enhance LB side channel. Potential for off-channel pond in RB floodplain area. Good access.	1

[1] Abbreviations in the text include the following: left bank (LB), right bank (RB), large woody debris (LWD), engineered log jam (ELJ), boulder (Bo), cobble (Co), gravel (Gr), and sand (Sa).
[2] River station (sta) begins at the Morehouse Creek confluence on the mainstem Salmon River (sta 0) and extends upstream.
[3] Floodplain habitat enhancement segments are identified based on the Project reach and geomorphic reach in which they occur, the river station at the segment midpoint, and their suitability rating (e.g., SF16 sta 137000 (1) occurs in South Fork Salmon River in geomorphic reach 16 with a midpoint of station 137,000 and suitability rating of 1). Project reaches are abbreviated as follows: mainstem (MS), South Fork (SF), and North Fork (NF).