VEGETATION AND WILDLIFE ASSESSMENT OF THE MINERAL CREEK STUDY AREA

RESOLUTION COPPER MINING

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September 2012
No. 807.60

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EXECUTIVE SUMMARY

Resolution Copper Mining LLC (RCM) is currently in the prefeasibility phase of development of a copper mining and processing project located near Superior, Pinal County, Arizona. In order to assist RCM in obtaining the necessary environmental permits, WestLand Resources, Inc. (WestLand) has been conducting various baseline biological surveys and studies in and around where project features will be located. WestLand was retained by RCM to conduct surveys of biological and natural resource features along a segment of Mineral Creek (the Study Area). The Study Area is about 3.7 mi (6.2 km) in length beginning at the boundary with ASARCO property (stream mile 9.0), and ending at the boundary with Government Springs Ranch (stream mile 12.7, traversing State Trust land).

The goal of this report is to present results of surveys in the Study Area for: 1) riparian tree species, 2) pools and runs in the streambed, 3) fish species, 4) amphibians species, and 5) aquatic snake species.

Fourteen species of trees, 12 other plant species, and a total of 1,950 individual trees were identified during vegetation surveys of the Mineral Creek Study Area. Surveys of pools and runs along the Mineral Creek Study Area located 142 pools and 96 runs, in which approximately 35,000 longfin dace (*Agosia chrysogaster*) were counted or estimated. No other fish species were seen during these visual surveys. A total of 61 pools were also surveyed for amphibians. These surveys found 16 adults and 4,399 tadpoles of lowland leopard frog (*Lithobates yavapaiensis*) and six adults and 139 tadpoles of canyon treefrog (*Hyla arenicolor*).

Northern Mexican garter snakes (*Thamnophis eques megalops*) were not captured during two trapping periods in Mineral Creek. A total of seven black-necked garter snakes (*Thamnophis cyrtopsis*) were captured in minnow traps distributed along the Study Area, six during June and one in September. Longfin dace, lowland leopard frog adults and metamorphs, and canyon treefrog adults and metamorphs were also captured in the minnow traps.

Incidental observations of other reptile species included: Sonoran whipsnake (*Masticophos bilineatus*), black-tailed rattlesnake (*Crotalus molossus*), Western diamondback rattlesnake (*Crotalus atrox*), and Sonoran mud turtle (*Kinosternon sonoriense*).

1. INTRODUCTION

Resolution Copper Mining LLC (RCM) is currently in the prefeasibility phase of development of a copper mining and processing project located near Superior, Pinal County, Arizona (***Figure 1***). In order to assist RCM in obtaining the necessary environmental permits, WestLand Resources, Inc. (WestLand) has been conducting various baseline biological surveys and studies in and around where project features may be located (***Figure 1***). The goal of these surveys is to provide information regarding the biological and natural resource features in the vicinity of potential project areas. WestLand was retained by RCM to conduct surveys along a segment of Mineral Creek (the Study Area) (***Figure 1***). The Study Area encompasses areas below the Apache Leap escarpment, Queen Creek Canyon, Oak Flat, Rancho Rio Creek, Devils Canyon, and Mineral Creek (***Figure 1***). This particular study reports on surveys of the trees and selected wildlife species along a portion of Mineral Creek. Two other studies present results of surveys for western yellow-billed cuckoo and raptors in Mineral Creek (WestLand 2011 and 2012).

Mineral Creek is a largely perennial creek that flows south from the Pinal Mountains, joins Devils Canyon at the Big Box Dam site, and empties into the Gila River approximately 9 miles farther south. The stretch of Mineral Creek included in these surveys extends from Government Spring near the junction of Lyons Fork Road to the southern edge of State Lands. The segment of Mineral Creek in our survey area (the Study Area) is about 3.7 mi (6.2 km) in length beginning at the boundary with ASARCO property (stream mile 9.0), and ending at the boundary with Government Springs Ranch (stream mile 12.7, traversing the State Trust land) (***Figure 2***). Elevations in the Mineral Creek site range from roughly 2,800 ft (853 m) at Government Springs Ranch to approximately 2,400 ft (732 m) at the lower boundary of the State land. Along Mineral Creek, Interior Riparian Deciduous Forest vegetation includes a diverse mixture of Bonpland willow (*Salix bonplandiana*), Goodding willow (*S. gooddingii*), velvet ash (*Fraxinus arizonica*), Fremont cottonwood (*Populus fremontii*), Arizona sycamore (*Platanus wrightii*), and Arizona walnut (*Juglans major*). Steeply sloping hillsides along the creek rise rapidly through velvet mesquite (*Prosopis velutina*) groves into Arizona Upland Subdivision of Sonoran Desertscrub vegetation (Brown 1994).

The goal of this report is to present results of surveys in the Study Area for: 1) riparian tree species, 2) pools and runs in the streambed, 3) fish species, 4) amphibians species, and 5) aquatic snake species.

2. METHODS

Access to Mineral Creek was from the northeastern end of the Study Area through Government Springs Ranch, with the owner kindly providing permission for WestLand to conduct the work. All surveys were conducted by walking down the creek to reach points where data were taken and returning upstream by the same route.

To create a distributional profile of survey results along the length of Mineral Creek, WestLand's GIS department divided the 3.7 mi (6.2 km) length of the creek into 220 yd (200 m) segments and all data were collected relative to these divisions. Field crews had aerial and topographic maps at 1:400 (in/ft) to be able to spatially reference all observations. GPS units were used to record all data points or specific sampling sites, and maps were updated with these locations when necessary.

2.1. Riparian Tree Survey

Two WestLand biologists walked the length of the Study Area and counted the number of riparian trees and shrubs in each 220 yd (200 m) segment. The bank-to-bank limit of these counts varied with the stream segment and was usually identified as the fairly discrete point where tall riparian trees gave way to mesquite and where short desertscrub vegetation began. In some cases steep canyon walls limited the interior riparian vegetation. Discrete canopies of riparian trees seen on aerial photographs were identified to species.

2.2. Streambed Survey

Two WestLand biologists visited and measured the dimensions of each pool and run or riffle (both referred to as runs hereafter) along the length of the Study Area and measured the length, width, and depth to the nearest 4 in (10 cm) for pools and for length of runs to the nearest 3.3 ft (1 m). Each pool and run was photographed with a GPS camera. Creek depth varies with time of year, so the data collected on these dates only permit comparison among pools and runs at the time of data collection and cannot be applied among dates and years. Furthermore, intense flooding occurring in the creek during winter run-off and summer monsoons, as evidenced by the smooth canyon walls, can scour the streambed and rearrange locations of pools and runs.

2.3. Fish Survey

At the time streambed data were being collected, WestLand biologists counted or estimated the number of longfin dace (*Agosia chrysogaster*) visible in each pool and run. The number of fish was counted when relatively small numbers of fish (50 or fewer) were in a feature. When more than 50 fish were present, the crew estimated the area that included 50 visible fish and extrapolated to estimate the total number of visible fish. Some fraction of fish was undetectable because they were hidden under overhanging vegetation or boulders or were hidden by other fish, so the undetectable fraction of fish likely make these estimates less than the numbers that were actually present. Furthermore, small individuals (especially fry) were not counted during these surveys since they are more difficult to see.

2.4. Amphibian Survey

Visual encounter surveys for frogs focused on 61 pools along the Study Area in June 2011. Pools were approached carefully to observe any adults or post-metamorphic individuals escaping into water from the pool perimeter. The entire pool perimeter was then thoroughly searched; probing and looking under potential cover structures such as bunch grasses, sedges, and debris piles. The water in pools was clear so numbers of tadpoles were estimated visually. A dip net was used to sweep overhanging vegetation and undercut banks to further search for tadpoles that escaped visual detection. The water column was also searched for egg masses. Tadpoles and post-metamorphic individuals were identified to species (canyon tree frog [*Hyla arenicolor*] or lowland leopard frog [*Lithobates yavapaiensis*]). To characterize pools, length, width, and depth were estimated and a visual estimate of the percentage of dominant substrates (bedrock/boulder, gravel/sand, and soil/root masses), and perimeter and canopy vegetation were made. Pools were photographed and their position was recorded using GPS units. In September 2011, 20 pools were visited, their location and dimensions were recorded, and the number and developmental stage of the amphibians present in each pool was counted.

2.5. AQUATIC SNAKE SURVEY

Reptile surveys were primarily focused on detecting northern Mexican garter snakes (*Thamnophis eques megalops*) and other riparian-associated snakes, such as the black-necked garter snake (*Thamnophis cyrtopsis*). Biologists set galvanized wire mesh minnow traps at stations along the length of the Study Area to trap these snakes. Longfin dace, lowland leopard frogs, and canyon tree frogs were also caught in the traps, and snakes enter the traps since fish and frogs are the prey of these snake species. Traps were set on one day and were visited the next morning to record captures. Snakes, fish, frogs, and other incidental captures were counted and recorded, and all animals were released unharmed. Snakes were measured to the nearest ½ in (about 1 cm), photographed, and released. Traps were reset for the next day for the duration of the trapping period. During this survey and others herein, incidental observations of other reptiles along the creek were recorded.

3. RESULTS AND DISCUSSION

3.1. RIPARIAN TREE SURVEY

Fourteen species of trees were identified and 12 other plant species were noted during the vegetation survey of Mineral Creek (***Table 1***). A total of 1,950 individual trees were counted. The six most abundant tree species in the survey were: Bonpland willow, velvet ash, Fremont cottonwood, Goodding willow, Arizona sycamore, and Arizona walnut, which together comprised 98.1 percent of all trees counted (***Table 2***). Bonpland willow alone accounted for 40.1 percent of all trees counted.

Trees were most abundant in the middle segment of Mineral Creek (***Table 2***). ***Figures 3a and 3b*** illustrate the frequency of the six most common tree species for each creek segment: Bonpland willow, velvet ash, and Fremont cottonwood (***Figure 3a***); and Goodding willow, Arizona sycamore, and Arizona walnut (***Figure 3b***). There were relatively low numbers of trees in the first 4,600 ft (1,400 m) of the Study Area, where narrow canyon walls limited available space for vegetation and water flow was intermittent (***Appendix A1-A3***). In the last 4,600 ft (1,400 m) of the Study Area, again water is intermittent, the creek channel is wider, and the substrate changes from bedrock with sediment deposits to predominantly sandy deposits (***Appendix A10-A12***). There are few trees in this segment as well.

The less common tree species were found in scattered locations and, with the exception of saltcedar (*Tamarix* sp.), the other plants species recorded during the tree survey are not obligate wetland species.

3.2. STREAMBED SURVEY

Along Mineral Creek there were 142 pools and 96 runs (***Table 3***). In numerous cases, there was a sequence of 2-3 adjacent pools, which explains why the number of runs does not equal the number of pools. Pools varied greatly in size, ranging in length from 1.8 to 262 ft (0.55 to 80 m), in width from 1 to

36.8 ft (0.3 to 11.2 m), and in depth from 1 to 1.8 ft (0.3 to 0.55 m). Runs also varied greatly in length, ranging from 1 to 1,788 ft (0.3 to 545 m).

The location of each pool along the Study Area is shown in ***Figure 4***. Between the 40th and 50th pool there are long stretches of runs with fewer pools, but between the 50th and 130th pool there are few long runs. Toward the southern extent of the Study Area there are a few pools at the end of the perennial reach, about 3,937 ft (1,200 m) from the boundary of State Land with ASARCO property.

3.3. FISH SURVEY

Approximately 35,000 longfin dace were counted or estimated in the Study Area (***Table 3***). No other fish species were seen during these visual surveys. Only 13 of the 238 pools or runs (5.5%) had no fish and 18 pools or runs (7.6%) had more than 400 fish each during the survey. Fish numbers, tallied for every 10 pools and intervening runs fluctuate along the length of our Study Area (***Figure 5***). The number of fish declined toward the south end of the Study Area where perennial water ends.

Arizona Game and Fish Department (AGFD) have conducted surveys for fish in the Mineral Creek for several years. Gila chub was listed as endangered with critical habitat, including portions of Mineral Creek, in November 2005 (US Fish and Wildlife Service [USFWS] 2005). In 2000, AGFD recorded Gila chub, longfin dace, and green sunfish in Mineral Creek (***Attachment 1***), but subsequent surveys in 2002, 2005, and 2006 did not document any fish in the creek, including Gila chub (***Attachments 1-3***). AGFD (***Attachment 4***) hypothesized that either some form of contamination or high water flows led to the extirpation of all fish from the creek. In August and October 2006, 149 and 140 longfin dace, respectively, captured in Aravaipa Creek were stocked downstream from Government Spring Ranch (***Attachment 4***). During surveys conducted along Mineral Creek in April 2008, AGFD noted only longfin dace above a small waterfall created by boulders at the southern extent of the Study Area (***Attachment 3***). These observations are consistent with surveys in 2011 where only longfin dace were found in the Study Area (***Attachment 5***).

3.4. AMPHIBIAN SURVEY

Sixty-one pools were surveyed for amphibians in July 2011 (***Figure 6***). There were 16 adults and 4,399 tadpoles of lowland leopard frog and six adults and 139 tadpoles of canyon treefrog counted during the survey (***Table 4***). There was large variation in the number of lowland leopard frog tadpoles in pools, ranging from 0 to about 500 per pool. Pool size does not appear to be associated with the number of lowland leopard frog tadpoles per pool (***Table 4***). Pools ranged widely in size with maximums of 52 ft (15.8 m) long, 36.8 ft (11.2 m) wide, and 4.6 ft (1.4 m) deep, and minimums of 4.9 ft (1.5 m) long, 4.9 ft (1.5 m) wide, and 1 ft (0.3 m) deep). Substrates for pools in order of abundance were bedrock and boulders, sand and gravel, and soil and roots (***Table 4***). Twenty-seven of the 61 pools (44.3%) had a portion of their perimeter with undercut banks, and most of the pools had some portion of their perimeter partially or completely covered with overhanging vegetation, which provides cover for amphibians and fish (***Table 4***).

A survey of 20 pools conducted in September 2011 found 127 adult lowland leopard frogs and 1 canyon treefrog (***Table 5***). Thus, by this time the frogs had metamorphosed to adults and had presumably dispersed into creek-side vegetation.

An incidental observation of red-spotted toads (*Anaxyrus punctatus* [formerly *Bufo punctatus*]) was made along Mineral Creek, but no red-spotted toad tadpoles were identified in the Study Area.

3.5. AQUATIC SNAKE SURVEY

Northern Mexican garter snakes were not captured or observed during two trapping periods in the Study Area. A total of seven black-necked garter snakes were captured in minnow traps in the Study Area (***Figure 7***); six during June and one in September (***Tables 6a-6c***). Longfin dace, lowland leopard frog adults and metamorphs, and canyon treefrog adults and metamorphs were also captured in the minnow traps (***Tables 6a-6c***).

Specific surveys were not conducted for other reptiles in the Study Area, but incidental observations of other reptile species included: Sonoran whipsnake (*Masticophos bilineatus*), black-tailed rattlesnake (*Crotalus molossus*), Western diamondback rattlesnake (*Crotalus atrox*), and Sonoran mud turtle (*Kinosternon sonoriense*).

4. REFERENCES

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TABLES

Table 1. List of the tree species and a list of other select plant species recorded in the Mineral Creek Study Area.

Trees in Mineral Creek		**Other Plant Species** [1]	
Common Name	**Scientific Name**	**Common Name**	**Scientific Name**
Arizona sycamore	*Platanus wrightii*	White sagebrush	*Artemisia ludoviciana*
Arizona walnut	*Juglans major*	Seep monkeyflower	*Mimulus guttatus*
Arizona white oak	*Quercus arizonica*	Seepwillow	*Baccharis salicifolia*
Bonpland willow	*Salix bonplandiana*	California buckthorn	*Frangula californica ursina*
Fremont cottonwood	*Populus fremontii*	Tree tobacco	*Nicotiana glauca*
Goodding's willow	*Salix gooddingii*	Broadleaf cattail	*Typha latifolia*
Netleaf hackberry	*Celtis reticulata*	Deergrass	*Muhlenbergia rigens*
Oneseed juniper	*Juniperus monosperma*	Canyon grape	*Vitis arizonica*
Saltcedar	*Tamarix* sp.	Southwestern mock vervain	*Glandularia gooddingii*
Spiny hackberry	*Celtis ehrenbergiana*	Singlewhorl burrobrush	*Hymenoclea monogyra*
Utah juniper	*Juniperus osteosperma*	Thurber's desert honeysuckle	*Anisacanthus thurberi*
Velvet ash	*Fraxinus velutina*	Desert false indigo	*Amorpha fruticosa*
Velvet mesquite	*Prosopis velutina*		
Wingleaf soapberry	*Sapindus saponaria*		

[1] These 12 species are not a complete list of the other plants present along the creek, but they are the most common species noted in this riparian area.

Table 2. Number of riparian trees (of each tree species) in order of total abundance counted in each 220-yd (200-m) segment in the Mineral Creek Study Area[1].

Tree Sampling	**Segment 1**	**Segment 2**	**Segment 3**	**Segment 4**	**Segment 5**	**Segment 6**	**Segment 7**	**Segment 8**	**Segment 9**	**Segment 10**	**Segment 11**	**Segment 12**	**Segment 13**	**Segment 14**	**Segment 15**	**Segment 16**
Start of Segment (yards)	**0**	**220**	**440**	**660**	**880**	**1100**	**1320**	**1540**	**1760**	**1980**	**2200**	**2420**	**26400**	**2860**	**3080**	**3300**
Bonpland willow *Salix bonplandiana*		3	6	4	24	10	5	41	56	42	51	84	72	44	34	47
Velvet ash *Fraxinus velutina*	1	7	14	20	23	25	23	7	15	24	32	20	14	16	19	4
Fremont cottonwood *Populus fremontii*		2	2		9	6	20	18	27	17	48	28	31	19	16	14
Goodding willow *Salix gooddingii*	1	3	24	11	6	1	9	1			1			2	4	
Arizona sycamore *Platanus wrightii*	4	5	3	9	5	1	1	1	1	2	4	4	2	1	3	1
Arizona walnut *Juglans major*	1	3		1	1		1	2	5	2	4					
Netleaf hackberry *Celtis reticulata*									3	2	3	2			1	1
Velvet mesquite *Prosopis velutina*	1	1	3		1											
Wingleaf soapberry *Sapindus saponaria*						2										
Saltcedar *Tamarix ramosissima*						2	1									
Spiny hackberry *Celtis ehrenbergiana*				1												
Oneseed juniper *Juniperus monosperma*			1													
Utah juniper *Juniperus osteosperma*									1							
Arizona white oak *Quercus arizonica*		1														

[1] Empty cells indicate that no trees of that species were observed.

Table 2 (continued). Number of riparian trees (of each tree species) in order of total abundance counted in each 220-yd (200-m) segment in the Mineral Creek Study Area[1].

Tree Sampling	**Segment 17**	**Segment 18**	**Segment 19**	**Segment 20**	**Segment 21**	**Segment 22**	**Segment 23**	**Segment 24**	**Segment 25**	**Segment 26**	**Segment 27**	**Segment 28**	**Segment 29**	**Segment 30**	**Segment 31**	**Total number of trees**	**Rank**
Start of Segment (yards)	**3520**	**3400**	**3740**	**3800**	**4180**	**4400**	**4620**	**5060**	**5280**	**5500**	**5720**	**5940**	**6160**	**6380**	**6600**		
Bonpland willow *Salix bonplandiana*	33	56	72	29	43	22	7	17	2							**804**	**1**
Velvet ash *Fraxinus velutina*	3	25	24	26	4	6	11	11	10	30	6	4		1		**425**	**2**
Fremont cottonwood *Populus fremontii*	16	17	16	16	15	21	18	9	12	2	4	3	3	1	11	**421**	**3**
Goodding willow *Salix gooddingii*		2		5	4	1	4	9	5	2	1	2	4	12	31	**145**	**4**
Arizona sycamore *Platanus wrightii*	3		1	5	12	1	6	5	5							**85**	**5**
Arizona walnut *Juglans major*		1	3	1	3				1	3	1					**33**	**6**
Netleaf hackberry *Celtis reticulata*																**12**	**7**
Velvet mesquite *Prosopis velutina*			1		1				1							**9**	**8**
Wingleaf soapberry *Sapindus saponaria*				3												**5**	**9**
Saltcedar *Tamarix ramosissima*											1	1				**5**	**10**
Spiny hackberry *Celtis ehrenbergiana*			2													**3**	**11**
Oneseed juniper *Juniperus monosperma*																**1**	**12**
Utah juniper *Juniperus osteosperma*																**1**	**13**
Arizona white oak *Quercus arizonica*																**1**	**14**
All species combined																**1950**	

[1] Empty cells indicate that no trees of that species were observed.

Table 3. Dimensions of pools and runs encountered and the estimated numbers of longfin dace seen in each pool or run during a north-south survey of the Mineral Creek Study Area[1].

Pool Number	Run Number	Length (ft)	Width (ft)	Depth (in)	Fish Count[2]	Comments
1		1.8	1.5	1.6	100+	Pool drying up
2		8.5	5.6	5.2	200+	Pool drying up
	1	13.1	1.6	1.2	0	Shallow run
3		5.6	8.9	6.8	150	Small pool
4		8.9	5.6	7.2	50	
5		19.7	1.5	8.0	40	Long, shallow pool
	2	74.5	3.3	9.6	150	Long, shallow run
6		28.5	4.3	24.0	500+	Deep pool
7		5.2	1.0	4.0	20	Small pool
	3	150.9	3.3	10.0	200+	Long run, many have riffles at top flow
8		9.8	3.3	12.0	55	Small pool
	4	13.1	3.6	1.2	80	Short run
9		4.9	1.0	4.8	30	Small pool
10		262.4	13.1	12.0	40	Long pool
	5	29.8	2.0	16.0	0	Long run
11		23.0	5.9	34.0	200+	Deep pool
	6	19.7	0.8	12.0	25	Narrow run
12		9.8	4.9	16.0	50	Pool
	7	11.5	9.8	1.2	10	Short run
13		16.4	4.9	16.0	150	Pool
14		11.5	6.6	20.0	50	Pool
	8	108.2	3.9	6.0	300	Long, complex run
15		49.2	5.2	22.0	180	
	9	298.5	3.3	10.0	750+	Long run
16		29.5	13.1	0.4	600	Deep pool
17		41.0	29.5	0.1	500+	
	10	29.5	16.4	4.8	25	
18		13.1	3.9	5.2	50	
19		6.6	4.9	12.0	400	
	11	32.8	1.6	1.2	0	
	12	54.1	1.3	2.0	5	
	13	9.8	1.6	1.2	0	
20		6.2	2.3	12.0	200	
	14	26.2	4.9	14.0	20	

Table 3 (continued). Dimensions of pools and runs encountered and the estimated numbers of longfin dace seen in each pool or run during a north-south survey of the Mineral Creek Study Area[1].

Pool Number	Run Number	Length (ft)	Width (ft)	Depth (in)	Fish Count[2]	Comments
21		3	2	50	40	
	15	0.3	0.5	1	0	Tiny run
22		12	1.5	50	106	Long, shallow pool
	16	3.5	1.1	30	0	
23		2	2	28	25	
	17	30	1	30	300	Flowing vegetation at downstream end
24		5	1	60	70	
	18	8.1	0.6	40	60	
25		7.9	1.5	60	90	
	19	24	1	50	210	
26		6.5	1.5	65	80	
	20	9	5	5	20	Cascading run
27		7.1	1	6	150	
	21	11.1	0.8	7	60	Cascading, boulder-strewn run
28		5	1.4	5	60	Small pool between two long, cascading runs
	22	2.6	1.2	6	40	Cascading, boulder-strewn run
29		5.9	1.3	85	80	
	23	28	1.2	5	250	Long, shallow, wide runs
30		6	4	6	200	Floating algal mat provides cover for longfin dace
	24	4	0.8	5	15	
31		1.1	0.9	6	60	
	25	17.5	1.3	4	125	
32		7.6	1.5	6	200+	
	26	14	1.3	6	180	
33		8.5	2.5	8	90	Unknown fish sighted
	27	12.5	0.8	5	12	
34		5	4	8	300	Lots of big tadpoles
	28	60	1.5	5	750+	
35		8	6	80	500+	
	29	31	1.2	15	300+	Complex, cascading run
36		17	2	65	500+	
	30	90	2	70	1000+	Long, complex, cascading run
37		8	0.8	65	150	
	31	1	0.6	3	10	Short run

Table 3 (continued). Dimensions of pools and runs encountered and the estimated numbers of longfin dace seen in each pool or run during a north-south survey of the Mineral Creek Study Area[1].

Pool Number	Run Number	Length (ft)	Width (ft)	Depth (in)	Fish Count[2]	Comments
38		9.8	6.6	20.0	400+	
	32	1.0	1.6	0.4	200+	
39		39.4	4.9	20.0	100+	
	33	11.5	3.6	12.0	25	
40		6.6	6.6	11.2	80	
	34	98.4	3.3	12.0	60	Complex, cascading, boulder-strewn run
41		16.4	3.3	24.0	200+	
	35	26.6	2.0	16.0	75	
42		25.9	4.9	24.0	600+	
	36	78.7	3.3	20.0	50	
43		21.3	4.9	26.0	45	
	37	29.5	16.4	2.0	350+	Complex, cascading run
44		23.3	3.3	2.4	300+	Algal mat covers about half of pool surface
	38	36.4	2.6	2.8	45	
45		16.4	4.6	2.0	500+	
	39	8.5	3.9	2.4	No Count	Long, complex run
46		19.4	4.3	34.0	200+	Small pool
	40	91.8	3.9	2.0	200+	
47		19.7	13.1	2.4	60	
	41	13.1	2.6	2.0	No Count	
48		3.6	3.0	2.4	50	
	42	57.4	4.3	1.6	75	
49		24.9	4.9	2.4	25	
	43	45.9	4.3	2.4	No Count	Long, complex run
50		27.9	8.2	3.2	200+	
	44	41.0	2.6	2.0	No Count	
51		16.4	13.1	3.2	200+	Cattails present
	45	196.8	4.9	2.0	50+	
52		26.2	19.7	32.0	75	
	46	101.7	3.9	6.0	250+	
53		55.8	6.6	26.0	300	
	47	295.2	6.6	28.0	75	
54		26.2	2.6	26.0	150	
	48	3.3	2.0	1.2	70	
55		6.6	9.8	10.0	90	

Table 3 (continued). Dimensions of pools and runs encountered and the estimated numbers of longfin dace seen in each pool or run during a north-south survey of the Mineral Creek Study Area[1].

Pool Number	Run Number	Length (ft)	Width (ft)	Depth (in)	Fish Count[2]	Comments
	49	82.0	26.2	4.0	200+	
56		19.7	3.9	16.0	300	
	50	347.7	2.6	4.0	100+	
57		23.0	3.3	16.0	250	
	51	150.9	6.6	12.0	150	
58		15.7	9.8	14.8	160	
	52	6.6	3.0	4.0	0	Cascading run
59		34.4	6.2	20.0	0	Low pool
	53	36.1	2.0	4.0	0	Low grade run flows out of Pool 59
	54	15.1	6.6	0.4	0	Cascading run
60		10.5	4.9	8.0	60	
	55	229.6	16.4	6.0	25	Cascading run
61		219.8	3.0	10.8	125	
62		52.5	3.0	15.2	0	Adjacent tinaja, stair-step
	56	88.6	13.1	4.0	25	
63		15.7	6.9	8.0	60	
	57	180.4	6.6	8.0	200+	
64		15.1	5.9	20.0	150+	Three pools separated by cascades
65		14.1	6.2	18.8	100+	Three pools separated by cascades
66		42.6	9.5	16.8	300+	Three pools separated by cascades
	58	45.9	6.6	8.0	100+	
67		26.2	9.8	26.4	500+	
	59	82.0	6.6	4.0	80+	
68		13.1	11.5	8.0	100	Shaded, 100% canopy closure
	60	26.2	16.4	8.0	50+	
	60.5	11.2	6.9	4.0	0	First Riffle
69		34.4	3.9	12.0	60	
	61	127.9	3.3	6.0	40	
70		11.8	4.6	17.2	75	
	62	14.8	1.3	6.0	25	Large, shallow pool
71		37.7	7.2	8.0	100	
	63	36.1	4.9	8.8	50	
72		19.7	6.2	19.6	120+	Two pools separated by cascade
73		6.6	9.8	10.0	200+	
	63.5	8.2	7.9	1.6	20	Second Riffle

Table 3 (continued). Dimensions of pools and runs encountered and the estimated numbers of longfin dace seen in each pool or run during a north-south survey of the Mineral Creek Study Area[1].

Pool Number	Run Number	Length (ft)	Width (ft)	Depth (in)	Fish Count[2]	Comments
74		19.0	17.1	15.6	275	
	64	23.9	26.2	8.0	40	
75		10.5	4.6	12.8	35	Two pools separated by cascade
76		8.2	6.2	18.0	45	
	65	15.4	1.0	2.0	12	Cascade slide run
77		14.8	2.0	3.6	25	Two pools separated by cascade
78		62.3	9.8	36.0	1500+	Snorkel survey
	66	72.2	6.6	4.0	300+	Long complex run, over bedrock
79		9.8	2.3	17.6	100	
	67	45.9	8.2	8.0	40	
80		50.8	3.9	36.4	300+	
	67.3	14.8	9.8	1.6	70	Riffle Three
	67.5	39.4	6.6	4.0	50	
	67.7	3.3	9.8	0.4	4	
81		26.2	8.2	12.0	200+	Over-grown with trees
	68	164.0	6.6	6.0	No Count	
82		10.5	9.2	28.0	175	
83		7.9	3.9	22.0	200+	Disjunctive pool off-channel, water warmer
	69	19.7	3.3	2.0	25	
84		34.4	4.6	15.2	200+	
	69.5	19.7	13.1	2.0	60	
	70	52.5	26.2	7.2	200+	
85		16.4	3.9	6.0	100+	
86		5.9	5.6	8.4	60	
	70.5	9.8	4.9	1.6	25	
87		34.4	3.9	14.4	130	
	71	39.4	6.9	4.0	100	
88		42.6	9.8	30.0	750	Data pod at head of pool
	72	13.1	1.3	4.0	20	
89		7.9	3.6	10.0	80	
	73	34.4	2.0	2.4	50	
90		26.2	5.9	1.6	125	
91		75.4	7.9	48.0	No Count	Disjunct pool off-channel in rock fissure; deep, dark, warm, turbid pool
	74	8.2	7.9	1.6	50	

Table 3 (continued). Dimensions of pools and runs encountered and the estimated numbers of longfin dace seen in each pool or run during a north-south survey of the Mineral Creek Study Area[1].

Pool Number	Run Number	Length (ft)	Width (ft)	Depth (in)	Fish Count[2]	Comments
92		19.0	17.1	15.6	120	
	75	23.9	26.2	8.0	45	
93		16.1	8.2	16.8	50	
	76	15.1	19.7	1.6	40	
94		31.2	5.9	11.2	300+	
	77	229.6	2.3	6.0	No Count	
95		9.8	3.0	5.6	25	
	78	29.5	4.3	10.0	60	
96		44.3	14.8	28.4	100	
	78.5	9.5	9.8	1.2	11	
97		3.3	7.9	8.4	25	Off-channel pool
	79	65.6	3.3	6.4	75	
98		13.8	6.6	8.0	50	Off-channel pool
99		17.4	4.9	14.0	200+	
100		11.5	8.2	10.4	50+	
	80	26.2	9.8	5.6	75	
101		23.6	10.5	220.0	400+	
	81	28.9	2.0	4.0	60	
102		29.2	9.8	6.0	250	
	82	6.6	13.1	2.0	150	
103		28.9	11.5	10.0	300+	Two pools separated by cascade
104		50.8	19.7	28.0	500+	Two pools separated by cascade
	83	108.2	6.6	4.0	No Count	Long, grained, complex run with large overstory obstruction
105		32.8	9.8	4.0	250	
	84	5.9	1.6	4.0	100	
106		3.3	3.0	12.8	125	
	85	1.6	1.6	2.0	20	
107		19.7	3.3	24.0	150	Pool at foot of large ash
	86	39.4	6.6	2.0	50	
108		23.0	11.5	8.0	75+	
	87	298.5	26.2	4.0	No Count	Large, complex, grained run
109		14.1	8.2	32.0	190	Two pools separated by cascade
110		14.1	3.3	11.6	150	Two pools separated by cascade
	88	26.2	4.3	4.8	50	
111		38.7	4.9	14.4	70	Poor light/conditions per count

Table 3 (continued). Dimensions of pools and runs encountered and the estimated numbers of longfin dace seen in each pool or run during a north-south survey of the Mineral Creek Study Area[1].

Pool Number	Run Number	Length (ft)	Width (ft)	Depth (in)	Fish Count[2]	Comments
112		85.3	19.0	36.0	150	Poor light/conditions per count
113		13.8	9.8	24.0	250	Bear! Approached within 33 feet
114		49.5	32.1	32.0	1000+	Complex, boulder-strewn pool
115		16.1	9.2	24.0	200	
116		26.9	11.5	10.4	100	
117		13.8	8.2	20.0	60	
118		17.4	4.9	8.0	40	
119		24.3	9.8	22.8	80	
120		16.4	13.1	24.0	120	
121		22.0	36.7	22.0	750+	
122		32.1	19.7	24.0	1000+	At old diversion structure
123		9.2	17.7	20.0	500+	
124		12.1	8.5	14.0	50	
125		12.1	6.6	24.0	100+	
126		14.1	14.8	27.2	250	
127		9.8	3.3	24.0	110	
128		14.8	4.9	18.0	100	
129		9.8	11.2	21.6	70	
130		12.8	6.6	12.0	60	
131		15.4	4.9	12.0	250	
132		17.4	9.8	22.4	75	
133		17.1	9.8	18.8	100	
134		21.3	8.2	20.0	90	
135		19.0	14.1	18.0	80	
136		14.1	1.0	10.0	60	
137		8.2	9.5	16.0	25	Male Sonoran mud turtle
138		12.8	9.8	16.0	60	
139		21.3	9.8	20.0	120	
140		21.6	13.1	28.0	50	
141		16.4	13.1	16.0	5	Surface flow becoming intermittent
142		26.2	8.2	10.0	0	No fish, this pool dries daily

Table 4. Pool characteristics and amphibian species encountered at selected pools along the Mineral Creek Study Area in June 2011[1].

Location	UTM Coordinates		Pool Dimensions			Lowland Leopard Frog		Canyon Tree Frog		Substrate			Bank Structure	Vegetation	
Pool Number	Easting	Northing	Length (ft)	Width (ft)	Depth (ft)	Tadpoles	Adults	Tadpoles	Adults	Bedrock/ Boulder (%)	Gravel/ Sand (%)	Root/Soil (%)	Undercut Bank (%)	Perimeter (%)	Canopy (%)
1	502110	3679408	9.8	23.0	2.6	0	0	2	0	85	15	0	0	0	15
2	501970	3679392	8.2	9.8	2.0	3	0	0	0	50	50	0	25	10	100
3	501961	3679358	9.2	14.8	2.3	0	0	0	0	50	50	0	5	5	60
4	501954	3679297	8.2	13.8	3.0	10	0	0	0	80	20	0	5	10	60
5	501942	3679261	17.1	9.2	1.1	100	0	0	0	80	20	0	0	5	0
6	501902	3679199	9.8	19.7	2.0	75	1	0	0	70	30	0	30	15	60
7	501891	3679185	12.5	14.8	3.0	100	0	0	6	75	25	0	10	0	60
8	501865	3679165	7.9	18.4	1.3	200	0	0	0	25	75	0	5	10	30
9	501837	3679147	13.8	18.4	3.0	250	0	0	0	80	20	0	5	0	30
10	501820	3679109	13.1	42.6	2.6	300	0	10	0	90	0	0	0	10	30
11	501681	3679076	9.2	13.8	1.3	75	0	10	0	85	15	0	0	10	0
12	501599	3679076	4.9	19.7	1.0	50	0	1	0	40	60	0	0	10	85
13	501579	3679079	4.9	36.7	1.3	120	0	0	0	60	40	0	0	5	75
14	501562	3679090	4.9	13.8	1.3	20	0	0	0	50	50	0	5	25	20
15	502222	3679529	10.8	6.9	1.3	0	0	0	0	10	0	90	0	0	100
16	501762	3679055	31.2	12.5	2.0	1	0	30	0	40	60	0	10	0	0
17	501700	3679060	13.8	7.9	1.6	0	0	0	0	40	0	60	10	10	100
18	501528	3679113	18.4	8.2	1.0	20	0	0	0	40	30	30	0	15	90
19	501075	3679074	18.4	4.9	1.5	10	2	0	0	0	0	100	40	5	100
20	500955	3678894	13.8	7.2	1.3	10	0	0	0	50	20	30	0	5	100
21	501085	3678706	23.0	7.9	1.6	100	3	0	0	85	0	15	0	25	60
22	501097	3678682	18.4	7.2	1.0	20	0	0	0	60	0	40	0	5	100
23	501119	3678643	27.9	9.2	1.6	100	0	1	0	60	0	40	0	20	50
24	501133	3678552	13.8	9.2	2.3	10	1	0	0	40	20	40	0	10	100
25	501173	3678455	23.0	8.2	1.8	100	1	0	0	5	10	85	0	50	100
26	501177	3678389	13.1	9.2	1.6	10	0	0	0	85	15	0	0	0	100
27	501174	3678353	23.0	9.2	1.3	20	0	0	0	40	0	60	0	5	85
28	501212	3678291	13.1	9.8	1.6	10	0	0	0	15	15	70	0	10	85
29	501214	3678254	27.6	7.9	2.3	50	1	0	0	60	5	35	0	5	80
30	501257	3678164	13.1	5.2	1.6	15	0	0	0	20	10	70	0	5	100
31	501254	3678150	18.0	12.5	1.6	30	1	5	0	15	35	50	5	5	70
32	501246	3678103	51.8	9.8	3.3	150	0	5	0	85	0	15	5	5	15
33	501231	3678054	50.8	7.2	2.3	150	0	10	0	85	10	5	0	10	0
34	501210	3677995	13.1	8.2	2.3	10	0	0	0	75	10	15	5	10	20

[1] Data were collected on June 9-10, 2011.

Table 4 (continued). Pool characteristics and amphibian species encountered at selected pools along the Mineral Creek Study Area in June 2011[1].

Location	UTM Coordinates		Pool Dimensions			Lowland Leopard Frog		Canyon Tree Frog		Substrate			Bank Structure	Vegetation	
Pool Number	Easting	Northing	Length (ft)	Width (ft)	Depth (ft)	Tadpoles	Adults	Tadpoles	Adults	Bedrock/ Boulder (%)	Gravel/ Sand (%)	Root/Soil (%)	Undercut Bank (%)	Perimeter (%)	Canopy (%)
35	501185	3677917	18.4	6.6	2.3	200	0	20	0	95	5	0	0	5	0
36	501196	3677901	14.8	7.5	1.3	10	1	0	0	85	15	0	10	0	85
37	501206	3677876	12.5	7.9	2.3	250	0	0	0	90	10	0	0	10	0
38	501206	3677878	18.4	7.9	2.6	500	0	0	0	90	10	0	0	10	0
39	501206	3677878	27.9	7.9	4.6	500	0	0	0	90	10	0	10	10	0
40	501210	3677848	24.6	7.2	1.6	50	0	10	0	30	50	20	0	0	50
41	501197	3677761	32.8	9.8	2.3	75	0	0	0	40	30	30	0	15	60
42	501165	3677736	19.7	9.8	2.0	30	0	0	0	40	20	40	5	5	90
43	501121	3677614	36.1	4.9	1.3	25	1	0	0	5	0	95	0	10	100
44	501104	3677498	16.4	7.9	2.3	25	1	0	0	25	75	0	0	10	100
45	501041	3677410	19.7	6.6	2.3	25	1	0	0	50	40	10	0	5	50
46	501023	3677296	18.4	13.8	2.0	25	0	0	0	60	20	20	0	0	90
47	500972	3677224	14.8	9.8	2.0	75	0	0	0	50	40	10	5	5	30
48	500958	3677171	9.8	8.2	1.6	50	0	0	0	50	50	0	5	0	80
49	500828	3677039	13.1	9.8	1.0	20	0	0	0	25	25	50	10	50	30
50	500768	3676909	17.7	9.2	1.3	75	0	0	0	10	70	20	0	20	25
51	500624	3676607	12.5	11.2	1.3	20	0	10	0	60	30	10	0	10	15
52	500615	3676554	13.8	8.2	1.6	50	0	5	0	80	20	0	5	5	45
53	500785	3676850	17.1	7.5	1.3	25	1	0	0	40	40	20	50	40	85
54	500968	3677210	12.5	5.9	1.6	30	0	5	0	50	50	0	5	5	50
55	500975	3677231	9.8	9.8	2.3	5	0	5	0	60	5	35	0	5	70
56	500987	3677247	21.3	9.5	1.6	75	0	0	0	75	20	15	0	25	70
57	500995	3677261	12.5	9.2	1.3	5	0	0	0	60	40	0	5	0	100
58	501039	3677310	13.1	8.2	2.0	5	0	10	0	85	10	5	5	5	25
59	501046	3677388	13.8	9.8	1.6	5	0	0	0	40	30	30	5	15	75
60	501048	3677409	18.4	9.8	2.3	50	1	0	0	50	45	50	0	0	5
61	501066	3677435	26.2	9.2	2.6	75	0	0	0	30	40	30	10	0	70
					TOTALS:	**4399**	**16**	**139**	**6**						

[1]Data were collected on June 9-10, 2011.

Table 5. Pool characteristics and amphibians encountered along the Mineral Creek Study Area in September 2011[1].

Date	Pool Number	UTM Easting	UTM Northing	Length (ft)	Width (ft)	Depth (ft)	Lowland Leopard Frog Adults[2]	Canyon Tree Frog Adults
9/21/11	1	500965	3677235	13.1	6.6	1.8	3	
	2	500923	3677116	16.4	4.9	0.7	3	
	3	500837	3677048	19.7	13.1	1.8	6	
	4	501014	3677286	23.0	13.1	2.4	6	
	5	501040	3677380	16.4	23.0	2.9	3	
	6	501084	3677473	19.7	9.8	1.7	14	
9/22/11	7	501211	3677837	82.0	9.8	3.3	20+	
	8	501327	3677807	26.2	13.1	2.0	13	1
	9	501255	3677952	13.1	6.6	2.0	6	
	10	501251	3678141	26.2	13.1	2.0	6	
	11	501233	3678266	19.7	6.6	1.0	3	
	12	501175	3678380	49.2	4.9	1.3	4	
	13	501131	3678554	13.1	6.6	1.3	2	
9/23/11	14	501592	3679074	23.0	4.9	1.0	0	
	15	501656	3679076	26.2	9.8	2.0	4	
	16	501762	3679054	23.0	6.6	2.3	1	
	17	501808	3679121	49.2	13.1	3.0	5	
	18	501881	3679177	26.2	13.1	3.1	9	
	19	501899	3679197	23.0	9.8	1.6	13	
	20	501938	3679285	16.4	6.6	2.0	6	
						Total	**127**	**1**

[1] Data were collected on September 21-23, 2011.

[2] A "+"indicates that the number of amphibians observed in the pool or run appeared to exceed the estimated number but could not be more accurately estimated due to vegetation or pool characteristics.

Table 6a. Location of traps and number of aquatic vertebrates captured at the Mineral Creek Study Area in June 2011.

			June 28, 2011			June 29, 2011					
Trap Number	**Easting**	**Northing**	**Black-necked garter snake**	**Longfin dace**	**Lowland leopard frog adult**	**Black-necked garter snake**	**Longfin dace**	**Lowland leopard frog adult**	**Lowland leopard frog metamorph**	**Canyon tree Frog metamorph**	**Canyon tree frog tadpole**
1	502285	3679451		32			67				
2	502184	3679206		34		1	19				
3	502047	3679198		1			7				
4	502020	3679113		1	1		2				
5	501762	3678851		5			2				
6	501607	3678921		3			2	1			
7	501127	3678859	1				1				
8	501104	3678568		2							
9	501189	3678407		1						2	2
10	501238	3678257		1			45		1	6	
11	501282	3677816						1	1	2	1
12	501261	3677743	1	5	1						
13	501172	3677383		1			1		3	2	2
14	501104	3677185		7			5		1	1	3
15	501035	3677018		1			5		1	1	3
16	500876	3676814		2			2		3	6	
17	500834	3676713		3			2		1	7	5
IC	501104	3677185	1								
IC	500843	3676631	1								
IC	501271	3677764	1								

Legend: black-necked garter snake *(Thamnophis cyrtopsis)*, longfin dace *(Agosia chrysogaster)*, lowland leopard frog *(Lithobates yavapaiensis)*, lowland leopard frog metamorph, canyon tree frog metamorph *(Hyla arenicolor)*, canyon tree frog tadpole, IC=Incidental Capture.

Table 6b. Location of traps and number of aquatic vertebrates captured at the Mineral Creek Study Area in September 2011.

			September 20, 2011			September 22, 2011			September 23, 2011		
Trap Number	**Easting**	**Northing**	**Black-necked garter snake**	**Longfin dace**	**Lowland leopard frog adult**	**Black-necked garter snake**	**Longfin dace**	**Lowland leopard frog adult**	**Black-necked garter snake**	**Longfin dace**	**Lowland leopard frog adult**
1	502019	3679378		2	13					1	2
2	501970	3679395			6						8
3	501967	3679330		5	7					1	5
4	501892	3679183		5						1	3
5	501832	3679150		18	3					2	2
6	501719	3679052			8						3
7	501552	3679093		36	4					2	3
8	501329	3679157		7	1					16	3
9	500961	3678893		8	4						
10	501038	3678775		7	3		1	1		2	4
11	501117	3678648			2		2	1			
12	501170	3678458		2	1						
13	501229	3678272		14	1		4				
14	501215	3678080		2	1			2			
15	501198	3677961			2						
16	501140	3677708		6			7				
17	501099	3677523		1	2						
18	501028	3677316		2	1			1			
19	500990	3677252		15	1		2	1			
IC	501991	3679387				1					

Legend: black-necked garter snake *(Thamnophis cyrtopsis)*, longfin dace *(Agosia chrysogaster)*, lowland leopard frog *(Lithobates yavapaiensis)*, lowland leopard frog metamorph, canyon tree frog metamorph *(Hyla arenicolor)*, canyon tree frog tadpole, IC=Incidental Capture.

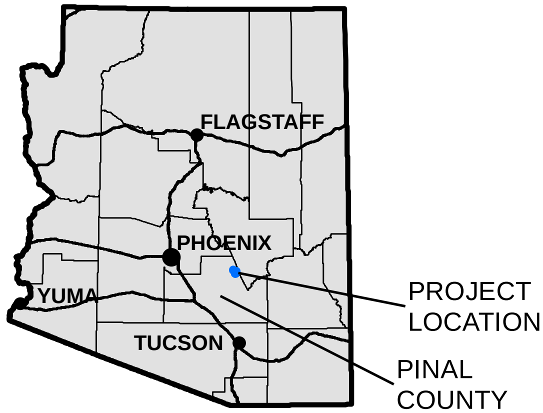
Table 6c. Total number of aquatic vertebrates captured at the Mineral Creek Study Area in June and September 2011.

	Black-necked garter snake	**Longfin dace**	**Lowland leopard frog adult**	**Lowland leopard frog metamorph**	**Canyon tree frog metamorph**	**Canyon tree frog tadpole**
June	6	259	4	11	27	16
September	1	171	99	-	-	-
Total	7	430	103	11	27	16

Legend: black-necked garter snake *(Thamnophis cyrtopsis)*, longfin dace *(Agosia chrysogaster)*, lowland leopard frog *(Lithobates yavapaiensis)*, lowland leopard frog metamorph, canyon tree frog metamorph *(Hyla arenicolor)*, canyon tree frog tadpole, IC=Incidental Capture.

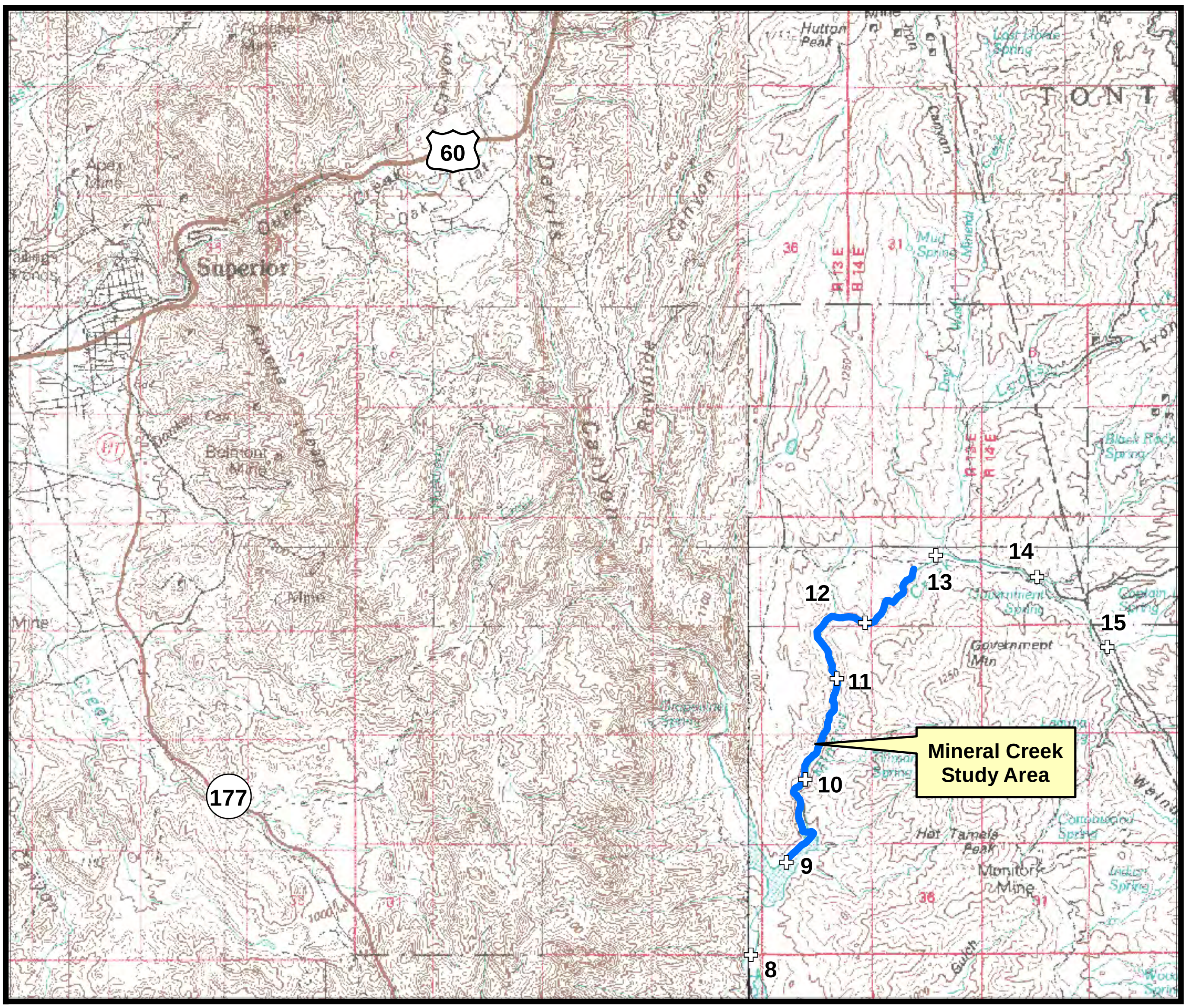
FIGURES

ARIZONA



Legend

✚ 10 Stream Miles Along Mineral Creek from Confluence With The Gila River



Pinal County, Arizona,
Superior, Pinal Ranch, Teapot Mntn,
& Hot Tomale Peak USGS 7.5' Quadrangles

N

0 8,000 16,000 Feet

WestLand Resources, Inc.
Engineering and Environmental Consultants

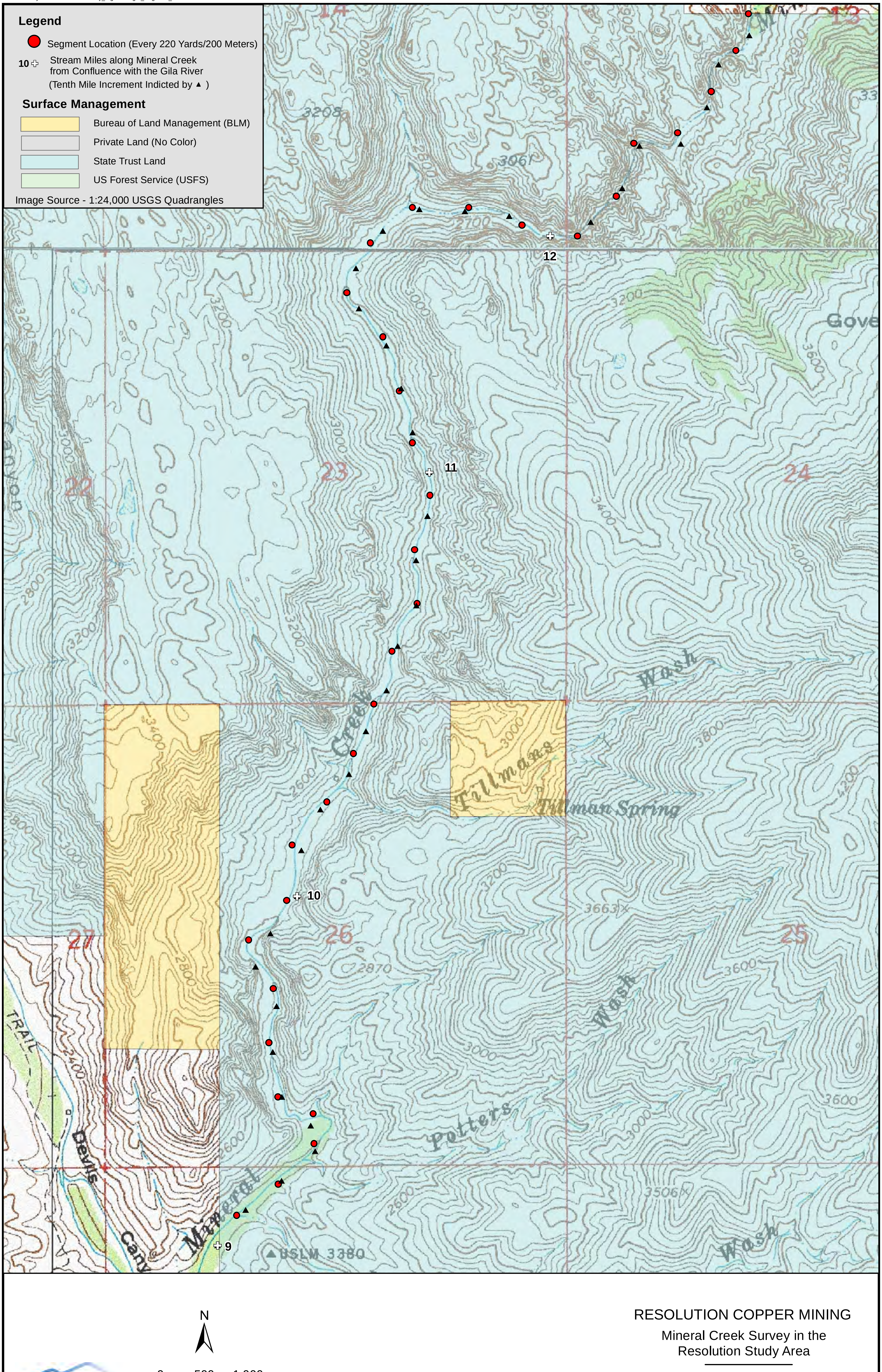
RESOLUTION COPPER MINING

Mineral Creek Survey in the Resolution Copper Study Area

VICINITY MAP AND STUDY AREA LOCATION

Figure 1

Path: M:\Projects\807.60\Preliminary_Figures\Fig 2_Segment_Locations.mxd



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RESOLUTION COPPER MINING

Mineral Creek Survey in the Resolution Study Area

Segment Locations

Figure 2

Path: M:\Projects\807.60\Preliminary_Figures\Fig 4_Location_of_Pools.mxd

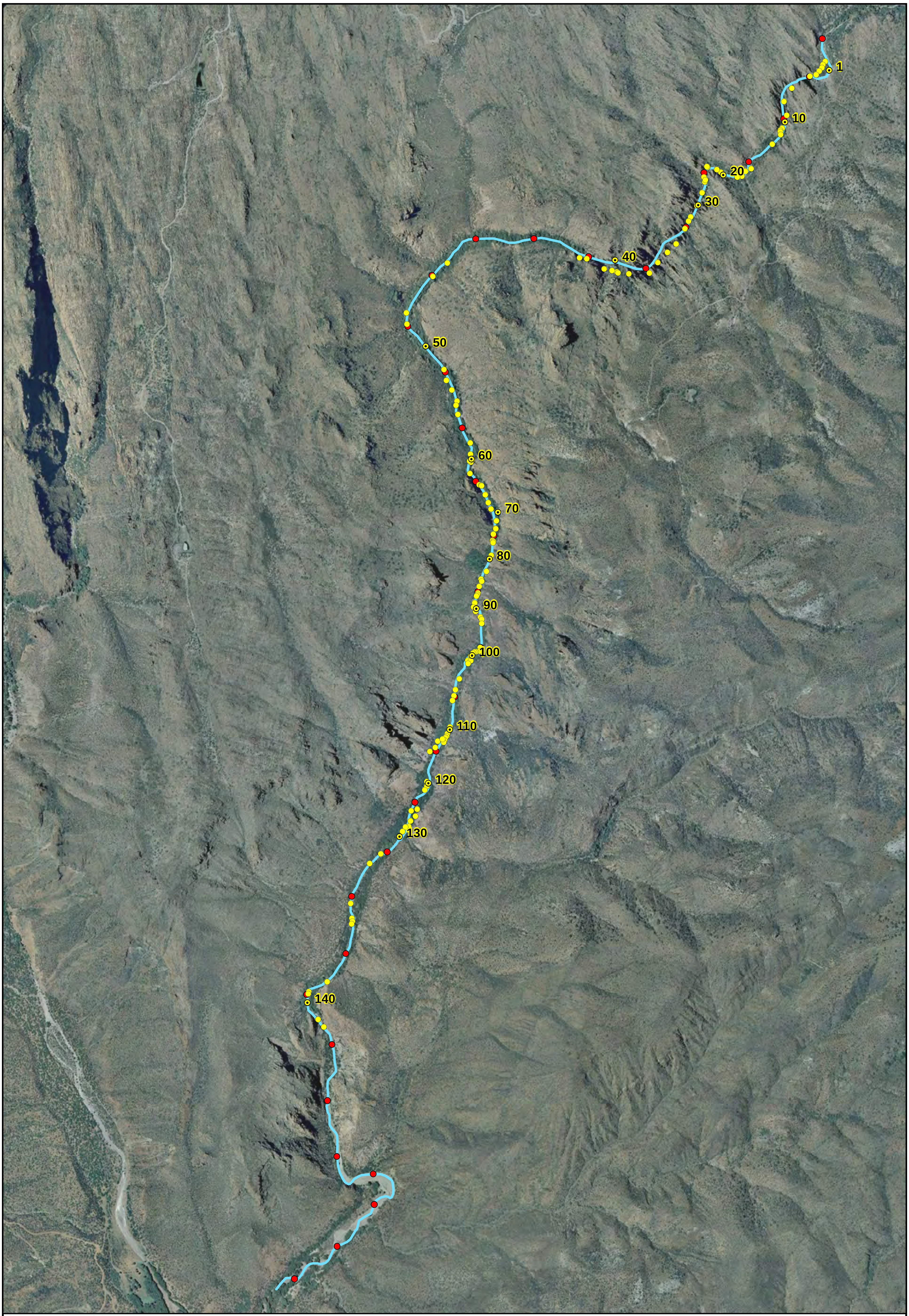

Photo Source - Aerials Express 2009

N

0 500 1,000
Feet

Legend

- 40 **Every 10th Pool**
- **Pools**
- **Segment Location (Every 220 Yards/200 Meters)**
- **Survey Area**

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Engineering and Environmental Consultants

RESOLUTION COPPER MINING

Mineral Creek Survey in the Resolution Study Area

Location of Pools Along the Mineral Creek Survey Area

Figure 4

Path: M:\Projects\807.60\Preliminary_Figures\Fig 5_Estimated_Abundance_of_Longfin_Dace.mxd

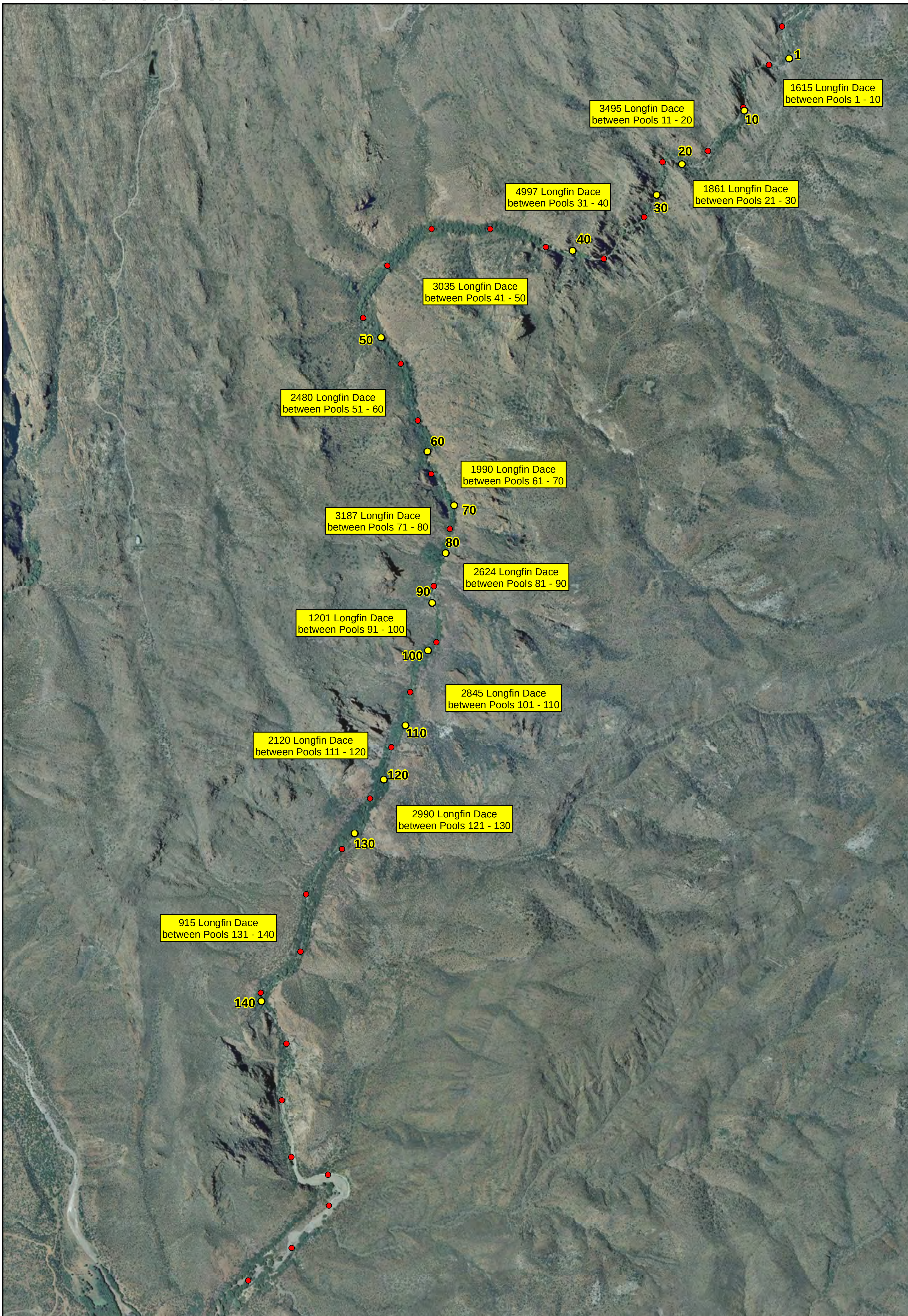

Photo Source - Aerials Express 2009

N

0 500 1,000 Feet

Legend

50 Pools (Every 10th)

Segment Location (Every 220 Yards/200 Meters)

WestLand Resources, Inc.
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RESOLUTION COPPER MINING

Mineral Creek Survey in the Resolution Study Area

Estimated Abundance of Longfin Dace

Figure 5

Path: M:\Projects\807.60\Preliminary_Figures\Fig 6_Location_of_Sample_of_Pools_for_Amphibians.mxd

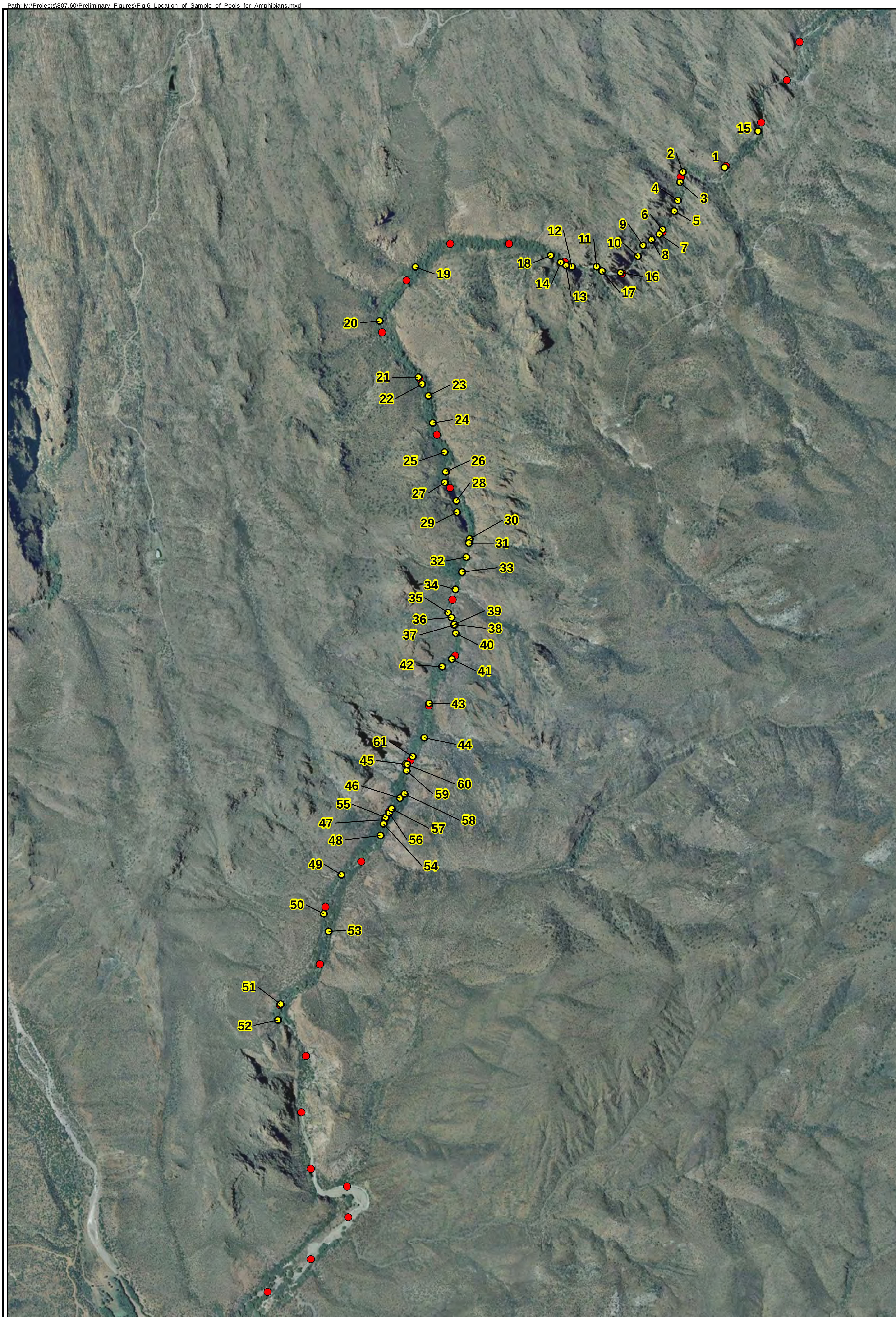

Photo Source - Aerials Express 2009

N

0 500 1,000 Feet

Legend

- Amphibian Sample Pool and Number
- Segment Location (Every 220 Yards/200 Meters)
- 23 Pool

WestLand Resources, Inc.
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RESOLUTION COPPER MINING

Mineral Creek Survey in the Resolution Study Area

Location of Sample of Pools for Amphibians

Figure 6

Path: M:\Projects\807.60\Preliminary_Figures\Fig 7_Location_of_Trapping_Site_for_Aquatic_Snakes.mxd

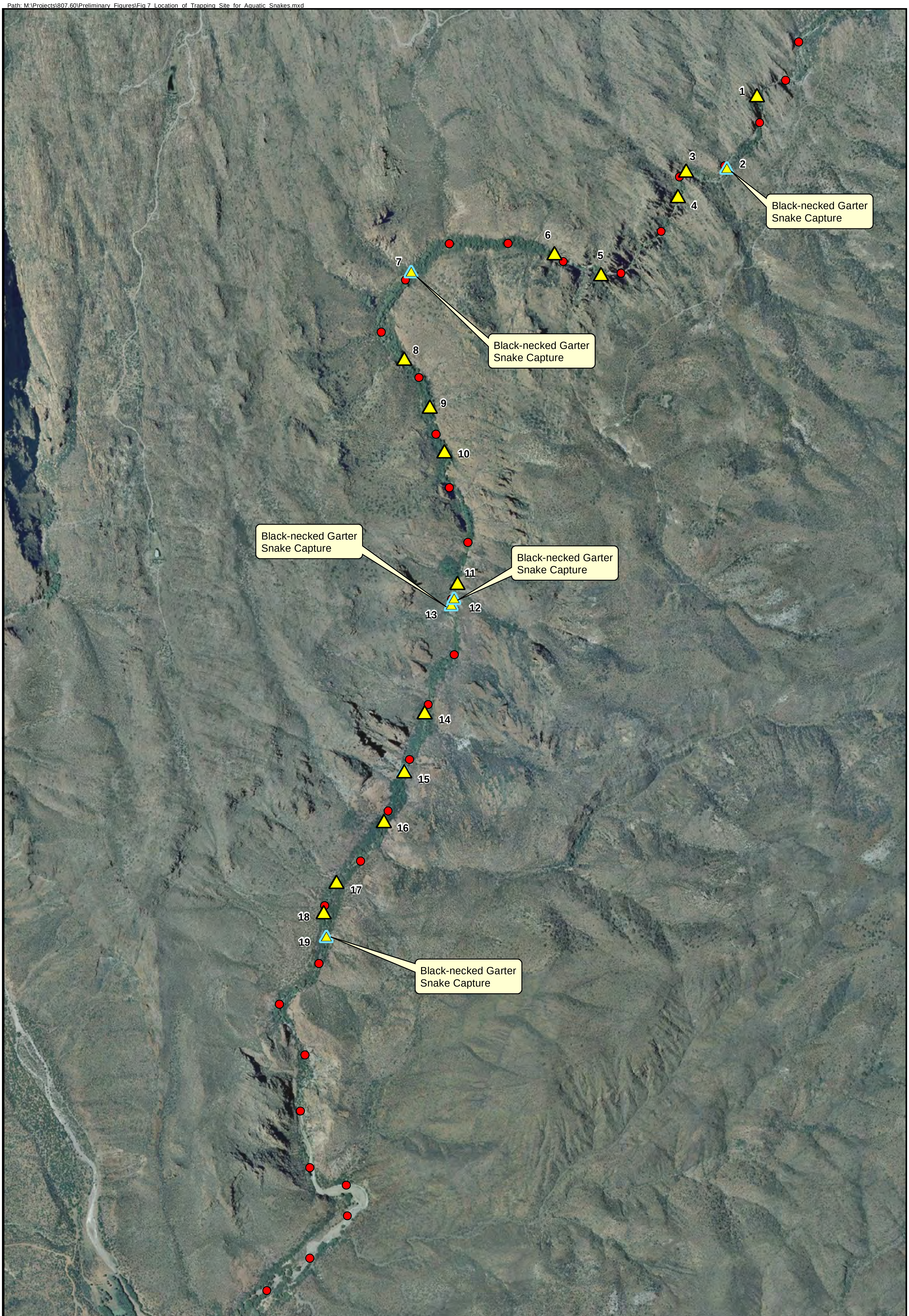

Photo Source - Aerials Express 2009

N

0 500 1,000 Feet

Legend

- Trap Location and Number
- Trap Location Where Black-necked Garter Snakes Were Captured
- Segment Location (Every 220 Yards/200 Meters)

WestLand Resources, Inc.
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RESOLUTION COPPER MINING

Mineral Creek Survey in the Resolution Study Area

Location of Trapping Sites for Riparian-associated Snakes

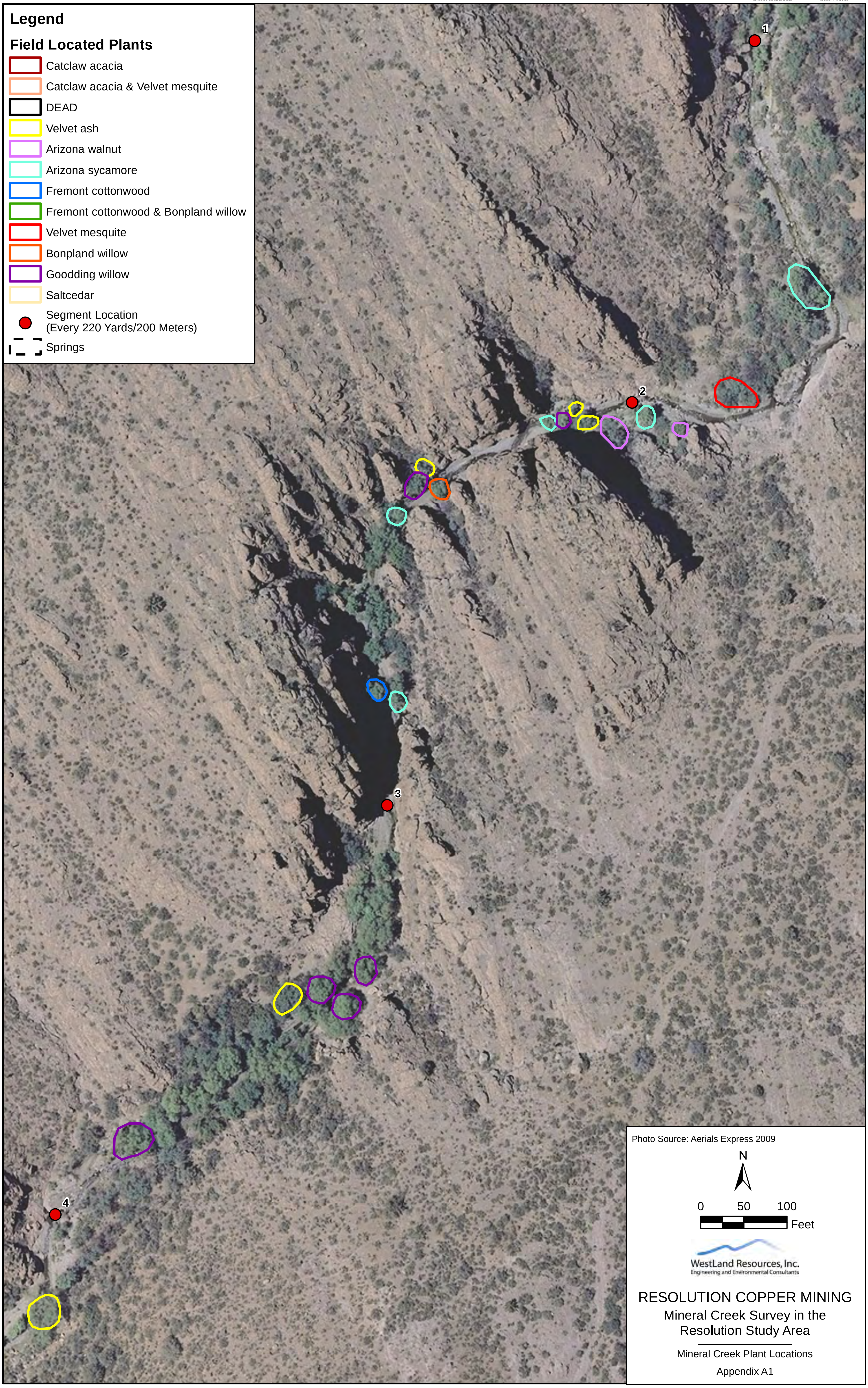
Figure 7

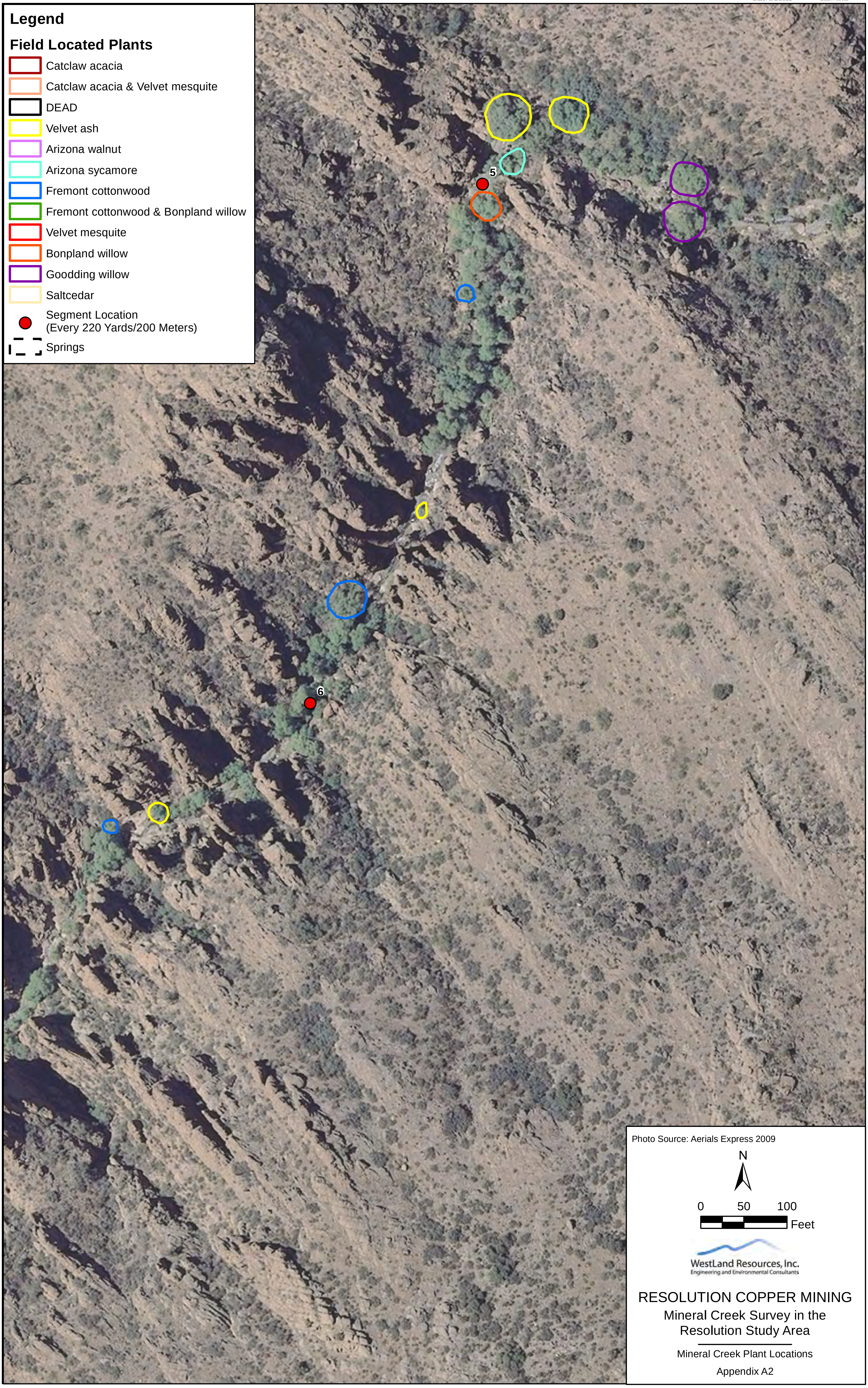
APPENDIX A

AERIAL PHOTOGRAPHS OF MINERAL CREEK (A1 - A12)

Path: M:\Projects\807.60\Figures_MC_Plant_Locations\Appendix_1.mxd

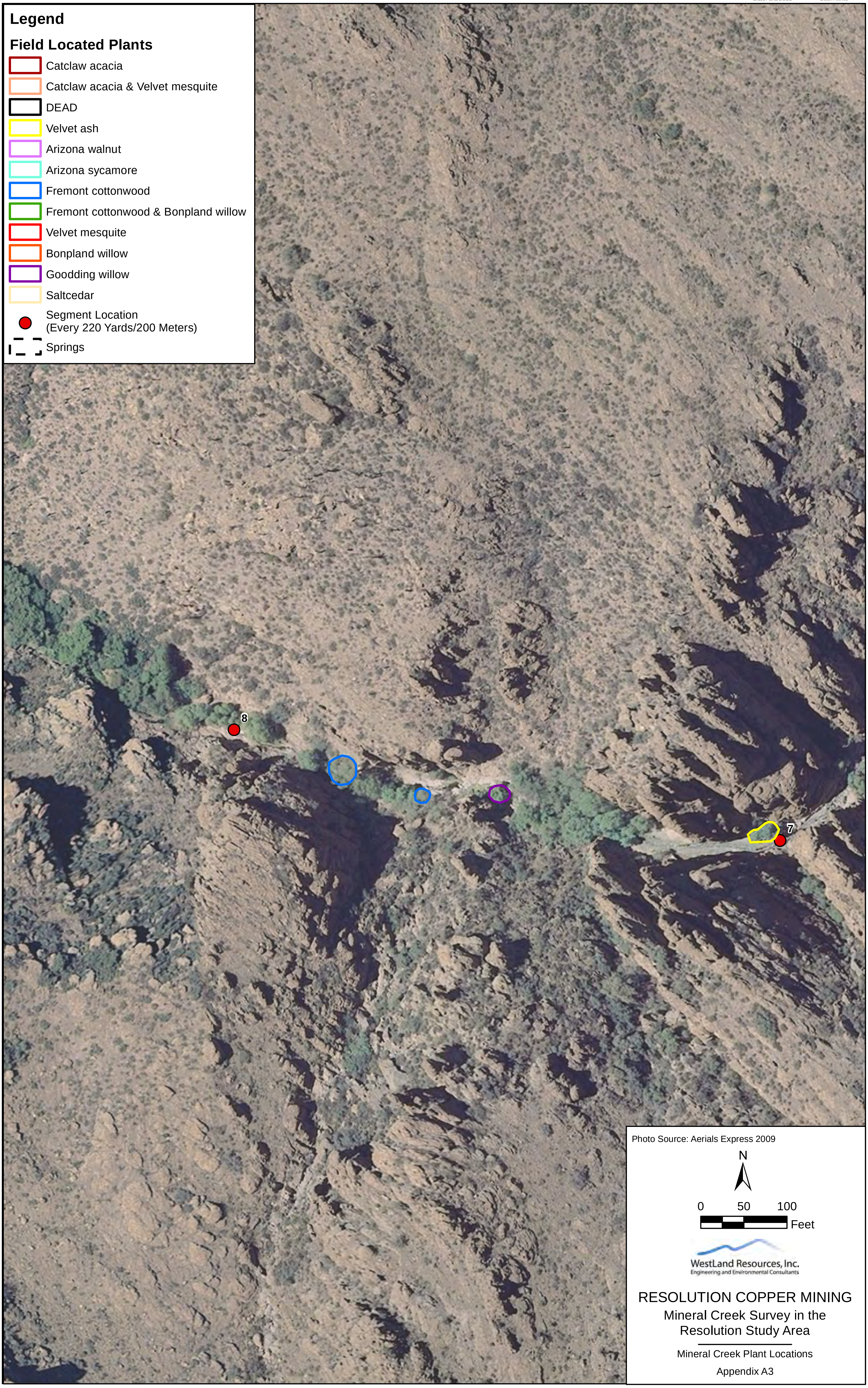
Date: 8/3/2012 User: kirks




Legend
Field Located Plants
Catclaw acacia
Catclaw acacia & Velvet mesquite
DEAD
Velvet ash
Arizona walnut
Arizona sycamore
Fremont cottonwood
Fremont cottonwood & Bonpland willow
Velvet mesquite
Bonpland willow
Goodding willow
Saltcedar
Segment Location
(Every 220 Yards/200 Meters)
Springs
5
6
Photo Source: Aerials Express 2009
N
0 50 100
Feet
WestLand Resources, Inc.
Engineering and Environmental Consultants
RESOLUTION COPPER MINING
Mineral Creek Survey in the
Resolution Study Area
Mineral Creek Plant Locations
Appendix A2

Path: M:\Projects\807.60\Figures_MC_Plant_Locations\Appendix_1.mxd

Date: 8/3/2012 User: kirks



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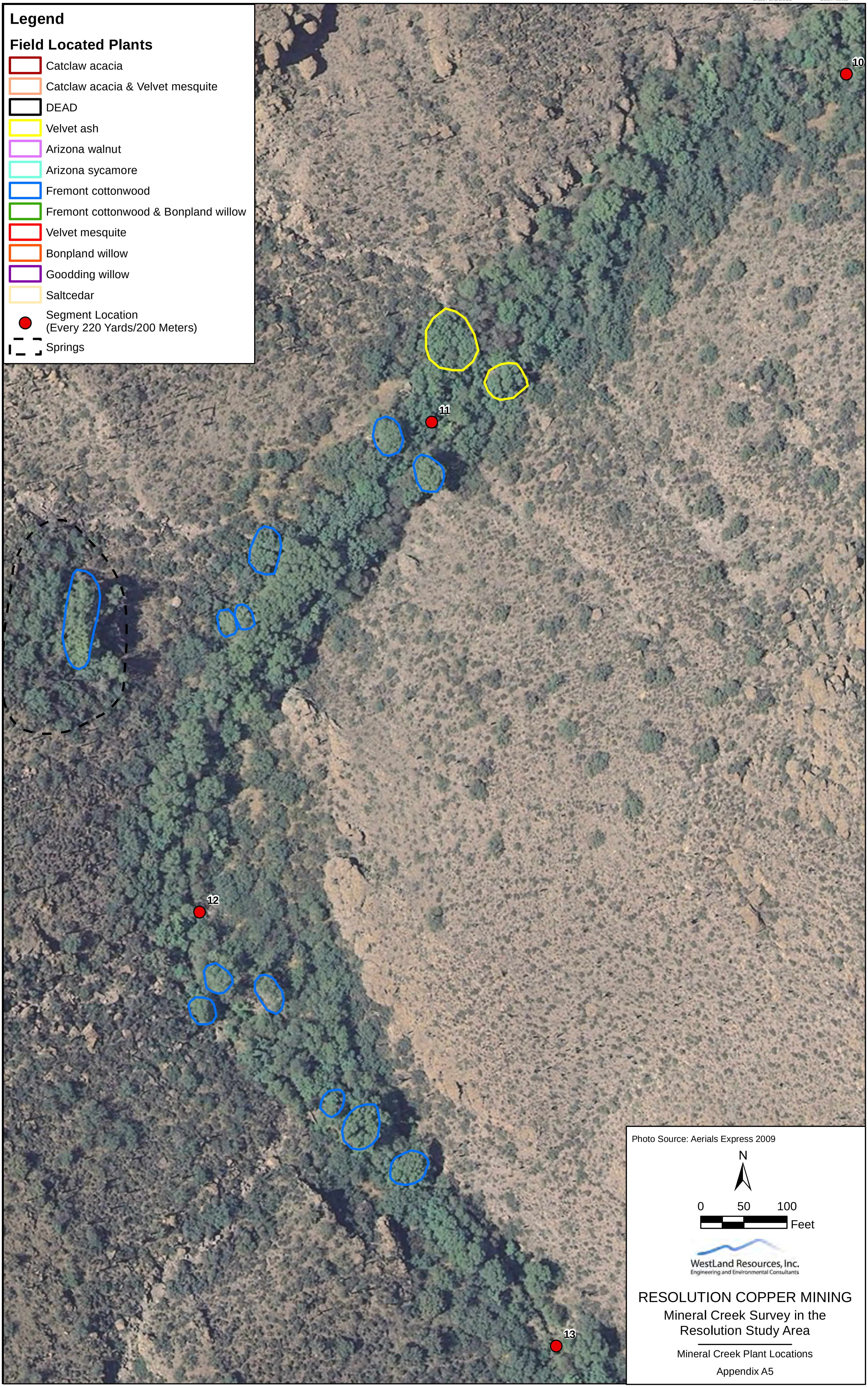
Date: 8/3/2012 User: kirks

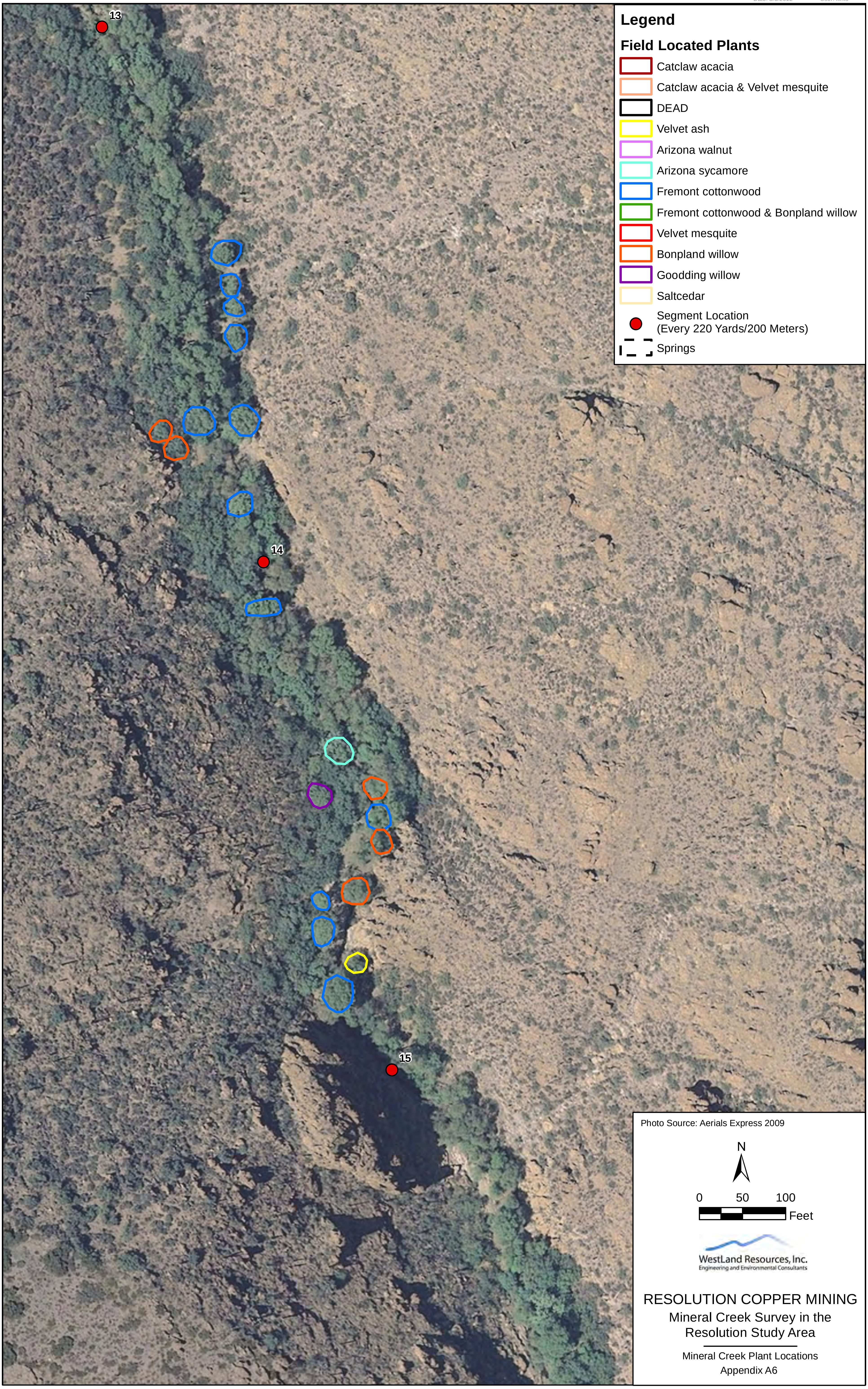


RESOLUTION COPPER MINING

Mineral Creek Survey in the Resolution Study Area

Mineral Creek Plant Locations

Appendix A5



RESOLUTION COPPER MINING

Mineral Creek Survey in the Resolution Study Area

Mineral Creek Plant Locations

Appendix A6

Path: M:\Projects\807.60\Figures_MC_Plant_Locations\Appendix_1.mxd

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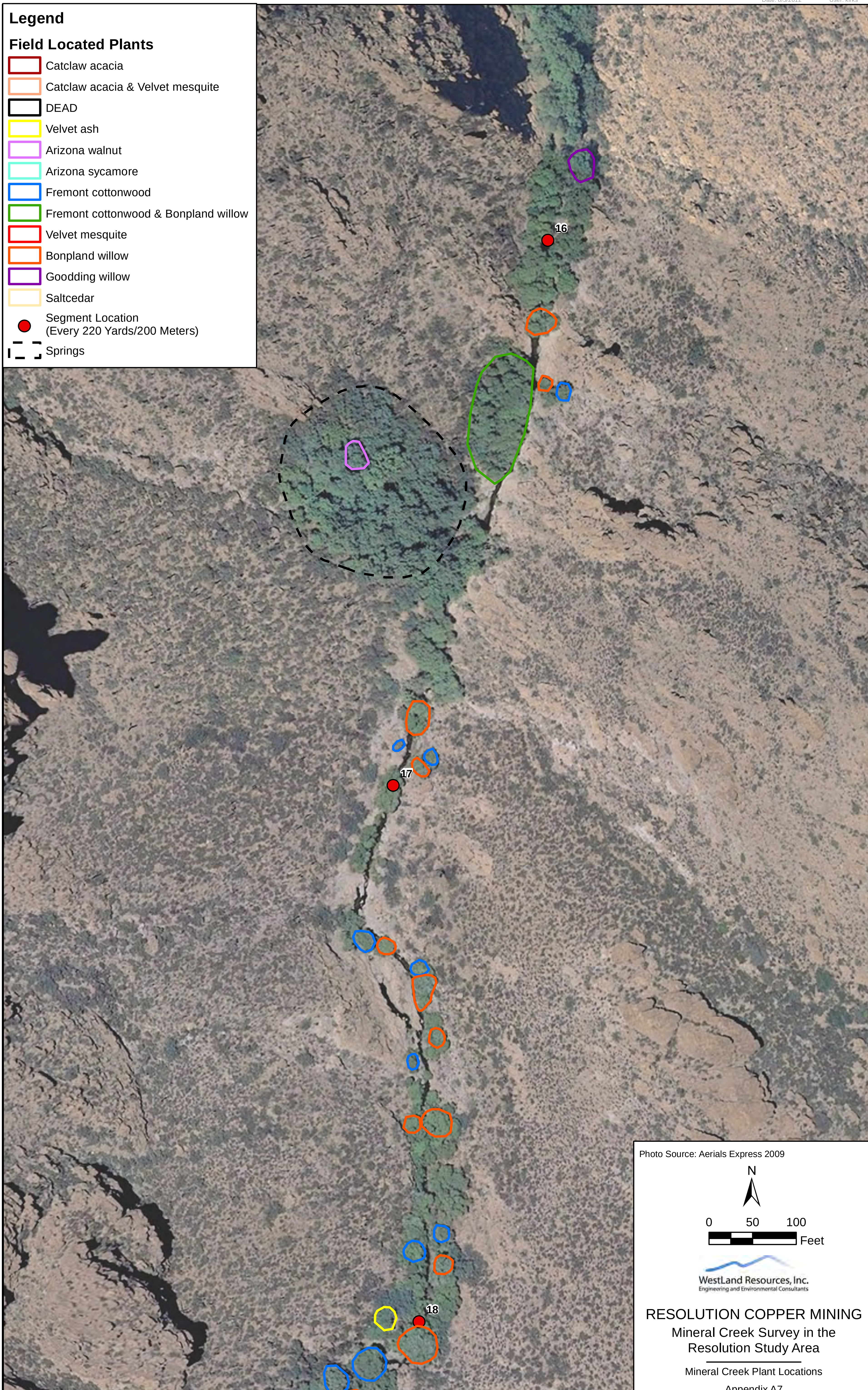

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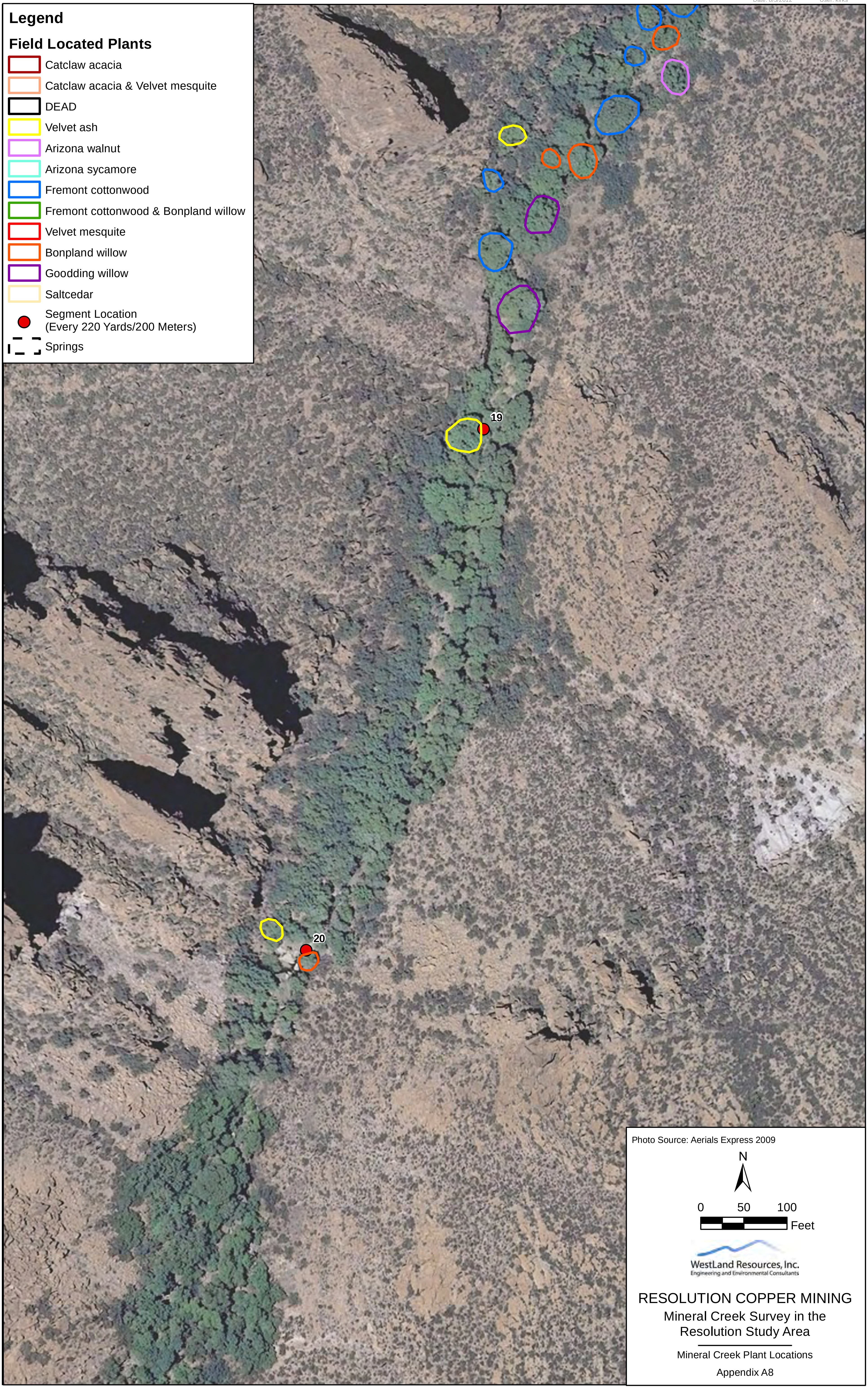

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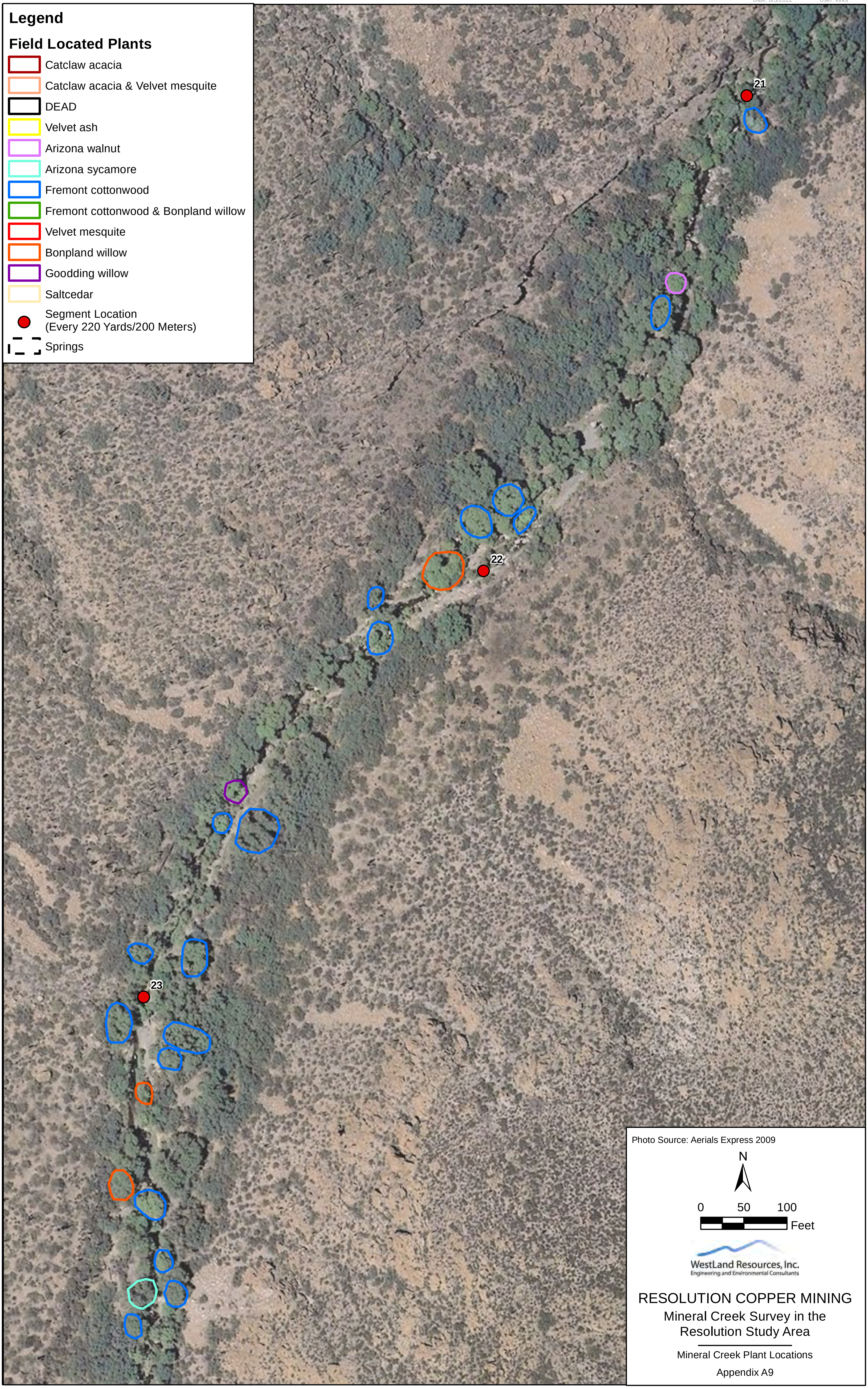

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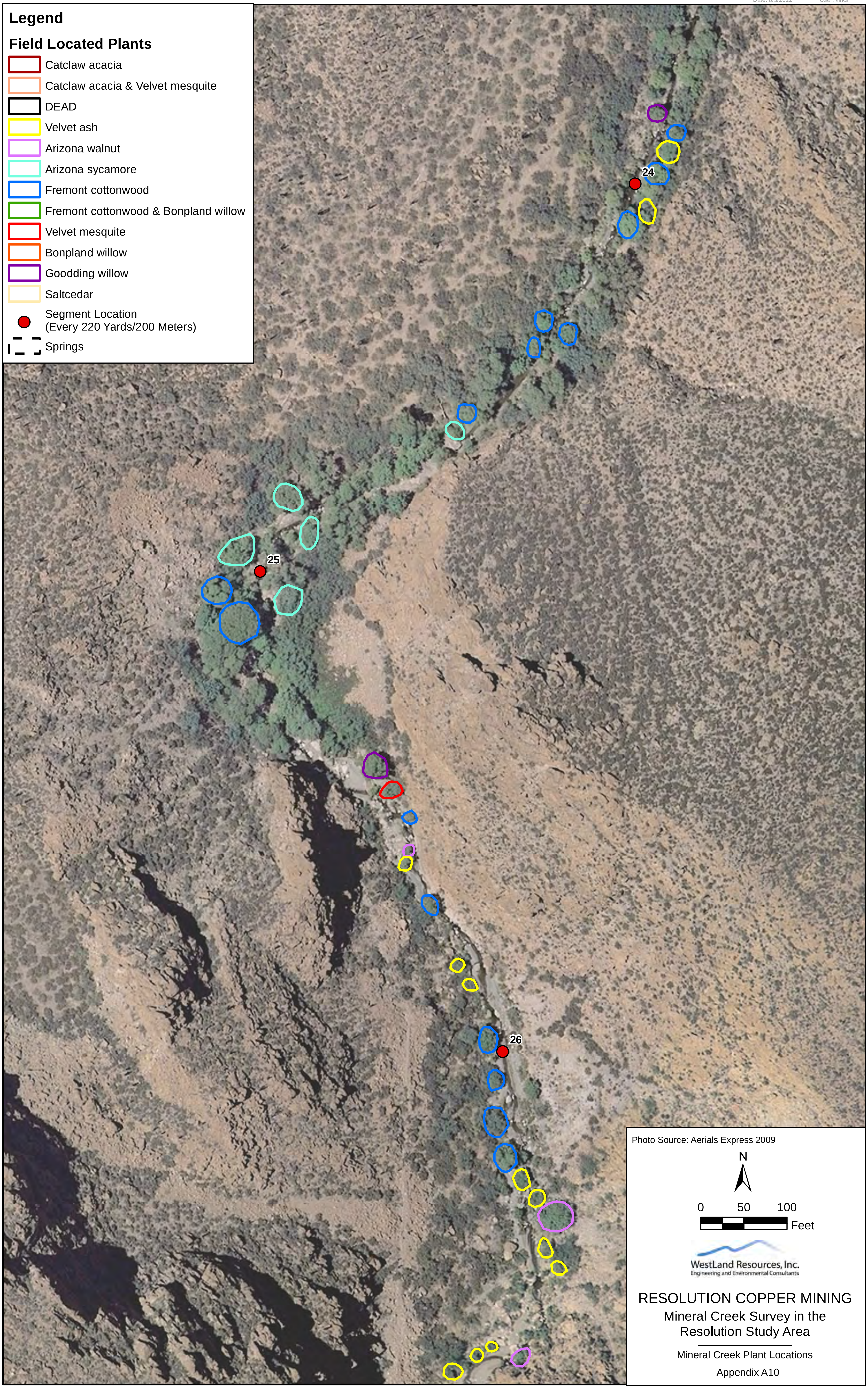
Date: 8/3/2012 User: kirks



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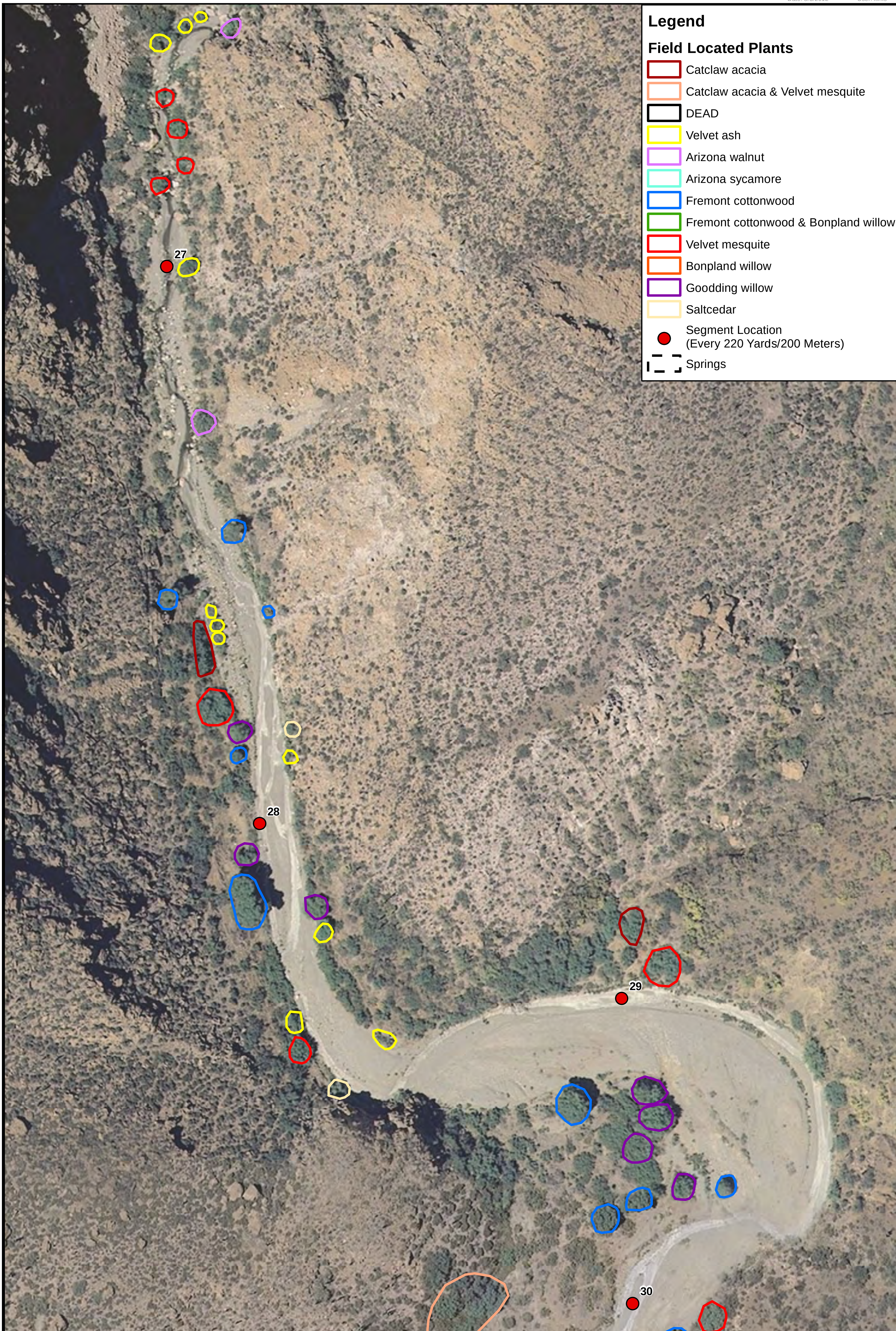


Photo Source: Aerials Express 2009

N

0 50 100 Feet

WestLand Resources, Inc.
Engineering and Environmental Consultants

RESOLUTION COPPER MINING

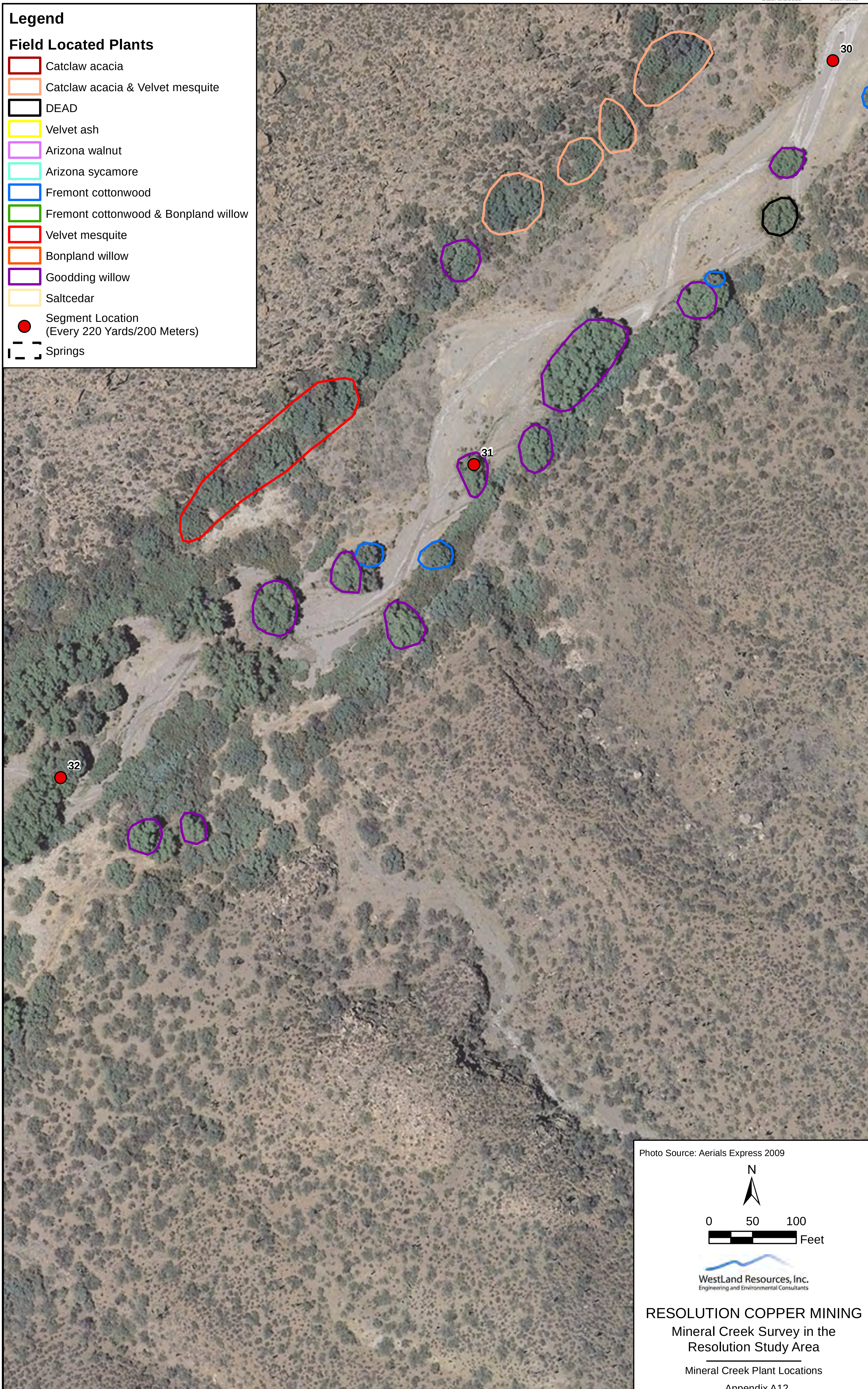
Mineral Creek Survey in the Resolution Study Area

Mineral Creek Plant Locations

Appendix A11

Path: M:\Projects\807.60\Figures_MC_Plant_Locations\Appendix_1.mxd

Date: 8/3/2012 User: kirks



APPENDIX B

SELECTED PHOTOGRAPHS

Photo 1.
View of the upland habitat on a hillside above Mineral Creek

Photo 2.
Cattails along Mineral Creek

Photo 3.
Morning glory flower in gravel of stream terrace

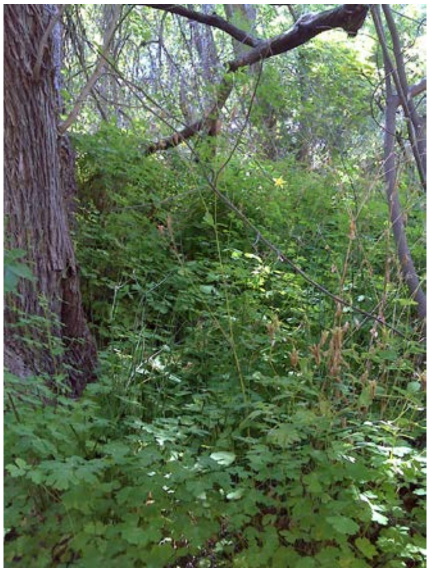


Photo 4.
Golden columbine patch along stream bank

Photo 5.
Velvet ash shading pool

Photo 6.
Bonpland willows and bullgrass along run

Photo 7.
View of a reach of Mineral Creek

Photo 8.
View of water flowing from shallow pool in Mineral Creek

Photo 9.
View of a series of pools along Mineral Creek

Photo 10.
View along a run in Mineral Creek

Photo 11.
View along a run in Mineral Creek

Photo 12.
View of a pool along Mineral Creek and the smoothed rock walls created by flood events

Photo 13.
View of Mineral Creek

Photo 14.
View of Mineral Creek

Photo 15.
View of a clear, shallow pool along Mineral Creek

Photo 16.
Lowland leopard frog egg mass

Photo 17.
Lowland leopard frog egg mass

Photo 18.
Lowland leopard frog tadpole

Photo 19.
Lowland leopard frog tadpole

Photo 20.
Lowland leopard frog adult

Photo 21.
Lowland leopard frog adult

Photo 22.
Canyon tree frog adult

Photo 23.
Canyon tree frog adult

Photo 24.
Sonoran mud turtle

Photo 25.
Sonoran mud turtle

Photo 26.
Black-necked garter snake

Photo 27.
Black-necked garter snake

ATTACHMENT 1

UPPER MINERAL CREEK SURVEY DURING 2000 AND 2002, ARIZONA GAME & FISH DEPARTMENT

Upper Mineral Creek

On March 15-16, 2006 Bill Burger, Curt Gill, Natalie Robb, Cori Carveth and Craig Woods surveyed the upper section of Mineral Creek from the ASARCO Dam to the headwaters at Government Springs Ranch. This section of Mineral Creek was surveyed in 2000 and 2002. Gila chub, longfin dace and green sunfish were reported in 2000 however since then no fish have been observed in the upper section of Mineral Creek. Suitable physical habitat currently exists for native fish species however it is unclear whether high flows or some form of contamination caused the extirpation of fishes from this section of stream. Lowland leopard frogs, Sonoran mud turtles and a mixture of invertebrates were observed on this survey. We would recommend re-introducing longfin dace to the upper section of Mineral Creek to determine its suitability as habitat for native fish species.

Survey Results

Mineral Creek is a tributary to the Gila River in Pinal County, Arizona. Mineral Creek is a highly disturbed system. The headwaters of Mineral Creek have been heavily grazed and destroyed by fire. The stream is dammed above the ASARCO Mine and downstream flows are diverted around the mine, by way of a tunnel, for 1700 feet.

Surveys were conducted in two areas, from the ASARCO mine upstream to Tillmans Wash (~2.5 km) and from Government Springs Ranch downstream to Tillmans Wash (~2 km)

Upstream: 12S 0502659E 3679736N (Government Springs Ranch)
Midway: 12S 501230E 3677527N (Upstream of Tillmans Wash)
Downstream: 12S 0500656E 3675446N (Above reservoir)

Note: All UTM's are in NAD27.

Access: Moderate

Note: The drive to both locations is fairly easy. Permission is required in advance by way of letter to enter the mine site. Mine personnel must accompany visitors through the mine. Permission is also required for Government Springs Ranch (see file).

Elevation: 2540 ft or 770 m at midpoint

Dates/Time: 03-15-06 and 02-16-05

Personnel: B. Burger, N. Robb, C. Gill, C. Carveth (AZGFD) and C. Woods (USFS)

Habitat: The stream channel is canyonized for the large part of the flowing stream. Substrate consists of sand, gravel, large boulders and bedrock outcroppings. Flows were moderate although multiple large pools were present and many backwater areas have been formed by large boulders. Riparian vegetation was lush and canopy was moderate throughout most of the surveyed area. Watercress, duckweed, algae and other aquatic vegetation were well represented and provided abundant habitat within the stream.

Methods: Electrofishing, fine mesh dip nets or visual observation.

Note: We electrofished the lower section of the stream on March 15th.

Fish: None

Riparian Herps:
Lowland leopard frogs, *Rana Yavapaiensis (*Both adult and tadpole life stages were observed)
Sonoran mud turtles, *Kinosternon sonoriense sonoriense*

Aquatic Invertebrates:
Hemipterans, notonectidae and corixidae
Larval caddis flies, mayflies, and Diptera
Adult Tycos (check with Curtis on all these)

Crayfish: No crayfish were observed during this or past surveys.

Barrier: Maybe

Note: Large boulders currently provide barriers for upstream movement in several locations but may not be barriers at all flows.

Water Quality: Good (taken at 11am on March 15, 2006)
Temp: 16^{0}C
pH: 8.85

Land Use: This portion of Mineral Creek experiences minimal recreational use because of restricted access at both its upstream and downstream ends. Cattle are permitted to graze the upstream portion of the stream, and we saw sign of cattle at both ends of the creek. Due to a change in ownership of the Government Springs Ranch, the upper portion of the stream is currently less grazed than it had been under the prior permittee. The new permittee is working to develop a management strategy that hopefully will reduce the impact of cattle on the stream.

Recommendations:
Mineral Creek has been designated as critical habitat for Gila Chub, however, since 2002 Mineral Creek has been devoid of fish. Prior to 2002 longfin dace, Gila chub and green

sunfish were collected from this creek. The habitat within the creek consisted of deep pools with runs and riffles in between indicating good structure. Fallen trees and a diverse mixture of riparian species provide stabilization for adjacent banks. Despite extreme flooding last winter (landowner), most vegetation seemed stable with the exception of some large broken trees. Large boulders and channel morphology should provide backwater habitat for native fishes. Aquatic invertebrates were abundant and should provide a forage base for native fishes. The presence of sensitive aquatic invertebrates and lowland leopard frogs indicates good water quality.

It has been speculated that flooding within the canyon led to the disappearance of fishes from the stretch of Mineral Creek. We recommend re-stocking this section of Mineral Creek with longfin dace. If this species is successful, after two years we propose re-stocking Gila chub.

Mineral Creek has been designated as critical habitat for Gila Chub since November 2005. Surveys in 2000 documented longfin dace, Gila chub and green sunfish; however subsequent surveys in 2002, 2005, and our current survey have failed to document any fish in this creek. During our survey habitat within the creek consisted of deep pools with runs and riffles in between indicating good structure. Fallen trees and a diverse mixture of riparian species provide stabilization for adjacent banks. Despite the landowners report of high flows in 2005 most vegetation seemed stable with the exception of some large broken trees. Large boulders and channel morphology should provide backwater habitat for native fishes. Aquatic invertebrates were abundant and should provide a forage base for native fishes. The presence of sensitive aquatic invertebrates and lowland leopard frogs indicate that good water quality currently exists in this portion of the stream.

It has been speculated that flooding within the canyon may have led to the disappearance of fishes from this stretch of Mineral Creek since 2000, but other than the apparent disappearance of the fish, there is little evidence to support this contention. Currently the reason for the disappearance of the fish is unclear.

We recommend re-stocking this section of Mineral Creek with longfin dace. Depending on the success of this species we recommend re-evaluating Mineral Creek as habitat for the endangered Gila chub.

ATTACHMENT 2

MINERAL CREEK – BIG BOX DAM RESERVOIR SURVEY, ARIZONA GAME & FISH DEPARTMENT

ARIZONA GAME AND FISH DEPARTMENT

Mineral Creek--Big Box Dam Reservoir Survey, April 11-12, 2007

Report prepared by Anthony Robinson, AZGFD, Research Branch

Introduction

Mineral Creek is a tributary to the Gila River in Pinal County Arizona. Mineral Creek is impounded by Big Box Dam just upstream of ASARCO Ray Mine (Figure 1). Immediately above the impoundment, the watershed divides into Devils Canyon to the west and Mineral Creek to the east (this portion of Mineral Creek is referred to as upper Mineral Creek). Upper Mineral Creek and its tributaries originate in Gila County on Tonto National Forest and drain the Pinal Mountains and the Dripping Springs Mountains. However perennial flow (approximately 8 km in length) within Mineral Creek begins on Government Springs Ranch. The portion of Mineral Creek from the impoundment upstream approximately 0.9 km is intermittent. Upper

Mineral Creek was designated as critical habitat for the Gila chub *Gila intermedia* when it was listed as endangered in 2005.

Five fish species have been documented in the streams above Big Box Dam. Fish species reported in Devils Canyon include green sunfish (2002 and 2006) and fathead minnow (2002). Fish species reported in upper Mineral Creek during 1993 include two natives (longfin dace *Agosia chrysogaster* and Gila chub), and three nonnatives (fathead minnow *Pimephales promelas*, green sunfish *Lepomis cyanellus*, and mosquitofish *Gambusia affinis* (Andrews and King 1997). Gila chub, longfin dace, and green sunfish were observed by Arizona Game and Fish Department biologists in Mineral Creek during 2000, but during May and September 2002 and March 2006 surveys no fish were found. The stream was assumed to be fishless, and longfin dace from Aravaipa Creek were stocked during August (149 fish) and October (140 fish) 2006. During the October 2006 stocking, numerous young-of-year longfin dace were observed, indicating that the fish stocked during August had reproduced. During a visual survey on February 26, 2007, green sunfish and longfin dace were observed in the lower portion of upper Mineral Creek. No fish were captured during a fish survey of the reservoir above Big Box Dam on February 26, 2007, but that was likely because of the short duration (2 h) of gill net and hoop net sets; a few dead fathead minnow were observed in the reservoir.

Methods

On Wednesday April 11-12, 2007 Arizona Game and Fish Department (AZGFD) biologists Codey Carter, Curtis Gill, Cori Carveth, and a representative from SWCA Inc., sampled the reservoir behind Big Box Dam on Mineral Creek, Pinal County. The AZGFD and SWCA biologists were escorted through the ASARCO Ray Mine Complex by a mine employee.

The reservoir was approximately 32 ft deep. The crew sampled the reservoir using six 150' x 6' experimental gill nets set at dispersed locations around the reservoir. Nets were set perpendicular to shore, with the small-mesh end attached to shore. The crew set nets at approximately 3:00pm on April 11, 2007, and pulled and checked the nets beginning at 9:00am on April 12, 2007. The crew also electroshocked the entire shoreline of the reservoir, in two 900 second efforts, using a canoe electrofisher. The canoe was outfitted with a Smith-Root 2.5 GPP electrofishing unit, a 30 cm diameter spherical cathode suspended from a bow-mounted boom, and 12 x 334 cm anodized aluminum strips that were permanently affixed to each side of the canoe such that they would be mostly submerged when the canoe was loaded. The electrofisher was operated continuously for each 900 second effort.

Results

Green sunfish and fathead minnow were the only species of fish captured. Sixty-four fathead minnow (mean catch-per-unit effort = 0.59 fish/hr, standard deviation = 1.37) and 243 green sunfish (mean catch-per-unit effort = 2.25±3.07 fish/hr) were captured in gill nets. Twelve fathead minnow (mean catch-per-unit effort = 24.0±23.94 fish/hr) and 86 green sunfish (mean catch-per-unit effort = 172.0±124.45 fish/hr) were captured by electrofishing.

Green sunfish were noted in Mineral Creek, just upstream of the reservoir during a February 26, 2007 survey; no fish were captured in the reservoir during that survey, likely because nets were set for too short of duration (2 hours), but a few dead fathead minnow were found. During the

February survey, Mineral Creek was dry for approximately 0.9 km of the stream immediately upstream from the reservoir, after which a perennial portion was encountered. It is likely that green sunfish migrated upstream from the reservoir into Mineral Creek during flooding events or spring runoff.

Recommendations

Green sunfish are reported to negatively impact Gila chub populations (Dudley and Matter 2000). Therefore, it is recommended that green sunfish and fathead minnow be removed from the system above Big Box Dam before any attempt to reintroduce Gila chub is made. The reservoir could be renovated using rotenone. It will also be necessary to renovate Devils Canyon, and the portion of Mineral Creek that has green sunfish; rotenone and/or antimycin should be used to renovate the streams. With regard to the later, it will be necessary to survey all perennial water within Mineral Creek prior to chemical renovation to determine the distribution of green sunfish in the stream. Communication with ASARCO Ray Mine, Tonto National Forest, U.S. Fish and Wildlife Service, Arizona State Land Department, SWCA Inc., and Government Springs Ranch should be initiated as soon as possible to discuss the reservoir and stream renovation and stocking of Gila chub into Mineral Creek. Consideration should also be given to stocking federally threatened loach minnow *Tiaroga cobitis* and spikedace *Meda fulgida* as habitat in Mineral Creek appears suitable for those species as well.

References

Andrews, B. J., and K. A. King. 1997. Environmental contaminants in sediment and fish of Mineral Creek and the middle Gila River, Arizona. U. S. Fish and Wildlife Service, Ecological Services Office, Phoenix.

Dudley, R. K., and W. J. Matter. 2000. Effects of small green sunfish (Lepomis cyanellus) on recruitment of Gila chub (Gila intermedia) in Sabino Creek, Arizona. The Southwestern Naturalist 45:24-29.

Photographs of upper Mineral Creek (left) and Big Box Dam impoundment (right).

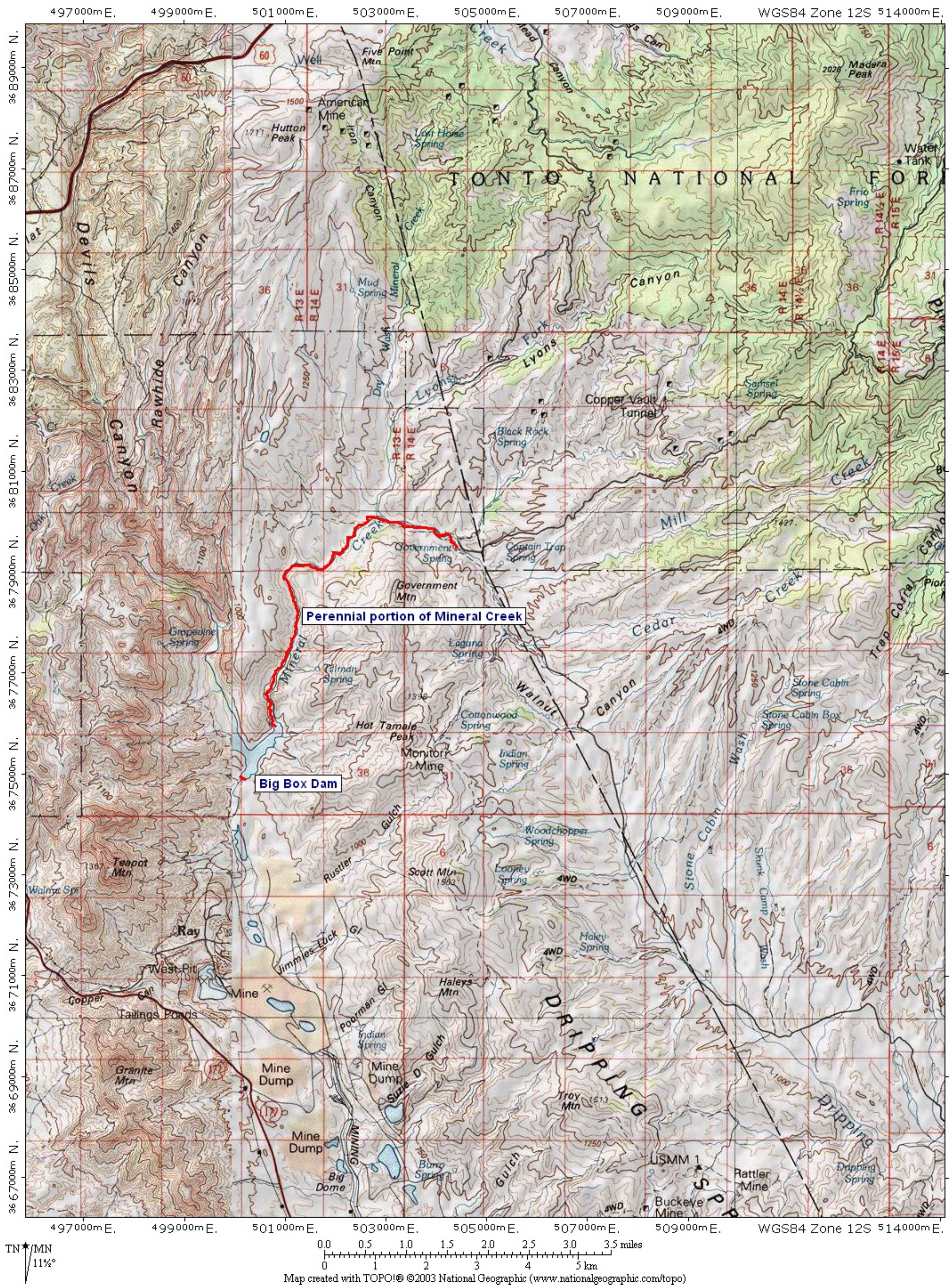


Figure 1. Map showing the impoundment above Big Box Dam and upper Mineral Creek, with the perennial portion in red.

ATTACHMENT 3

MINERAL CREEK FISH SURVEY, APRIL 21-22, 2008, ARIZONA GAME & FISH DEPARTMENT

Mineral Creek Fish Survey, April 21-22, 2008

Anthony Robinson,
Arizona Game and Fish Department
5000 W. Carefree Highway
Phoenix, AZ 85086

May 1, 2008

Background

Mineral Creek is a tributary to the Gila River in Pinal County Arizona. Mineral Creek is impounded by Big Box Dam (constructed in 1971) just upstream of ASARCO Ray Mine (Figure 1). Immediately above the dam, the watershed divides into Devils Canyon to the west and Mineral Creek to the east (this portion of Mineral Creek is referred to as upper Mineral Creek). Upper Mineral Creek and its tributaries originate in Gila County on Tonto National Forest and drain the Pinal Mountains and the Dripping Springs Mountains. However perennial flow (approximately 7 km in length) within upper Mineral Creek begins on Government Springs Ranch. The portion of upper Mineral Creek from the impoundment upstream approximately 0.9 km is intermittent. Upper Mineral Creek was designated as critical habitat for the Gila chub *Gila intermedia* when it was listed as endangered in 2005.

Seven fish species have been documented in Mineral Creek and its tributary Devils Canyon. Fish species reported in Devils Canyon include green sunfish *Lepomis cyanellus* (2002 and 2006) and fathead minnow *Pimephales promelas* (2002). Arizona State University and ASARCO Ray Mine employees surveyed Big Box Dam reservoir and upstream into Devils Canyon in July 2002, and captured fathead minnow and green sunfish in the reservoir, but only green sunfish upstream. Arizona Game and Fish Department (AZGFD) only captured or observed green sunfish during a May 2006 visual and dip net survey of Devils Canyon from the Big Box Dam impoundment upstream. In Mineral Creek, L.H. Carufel captured longfin dace *Agosia chrysogaster* in 1967. Arizona Game and Fish Department and U.S. Fish and Wildlife Service surveyed a portion of Mineral Creek between Big Box Dam and the Gila River confluence during 1993, and captured two natives, longfin dace and Gila chub *Gila intermedia*, and three nonnatives fathead minnow, green sunfish, and mosquitofish *Gambusia affinis* above the mine just downstream of the old reservoir in Lakel Flat (downstream of Big Box Dam; Andrews and King 1997). During a contaminants study (Andrews and King 1997) mosquitofish, green sunfish, black bullhead *Ictalurus melas*, and desert sucker *Catostomus clarki* were captured in one site in lower Mineral Creek downstream of Ray Mine. Gila chub, longfin dace, and green sunfish were captured by AZGFD biologists in upper Mineral Creek between the confluence with Devils Canyon and Tillman Wash during 2000. No fish were found during a survey of upper Mineral Creek from the reservoir up to the vicinity of Tillman Wash by AZGFD on May 30, 2002. No fish were found during a second survey of upper Mineral Creek during 2002 from approximately half a mile above Tillman Wash to Government Springs Ranch by AZGFD and ASU during September. No fish were captured during the next survey by AZGFD and U.S. Forest Service personnel from Big Box Dam reservoir upstream to Government Springs Ranch during March 2006. After the March 2006 survey, upper Mineral Creek was assumed to be fishless, and longfin dace from Aravaipa Creek were stocked during August (149 fish) and October (140 fish) 2006 just downstream of Government Springs Ranch. During the October 2006 stocking, numerous young-of-year longfin dace were observed, indicating that the fish stocked during August had reproduced. During a visual survey in the lower, approximately 2 km, portion of upper Mineral Creek upstream of Big Box Dam reservoir on February 26, 2007, green sunfish and longfin dace were observed. No fish were captured in hoop nets or gill nets set in Big Box Dam reservoir on February 26, 2007, but that was likely because of the short duration (2 h) of gill net and hoop net sets; a few dead fathead minnow were observed in the reservoir. Green sunfish and fathead minnow were the only species captured in Big Box Dam reservoir during a subsequent survey (electrofishing and gill nets) on April 11-12, 2007.

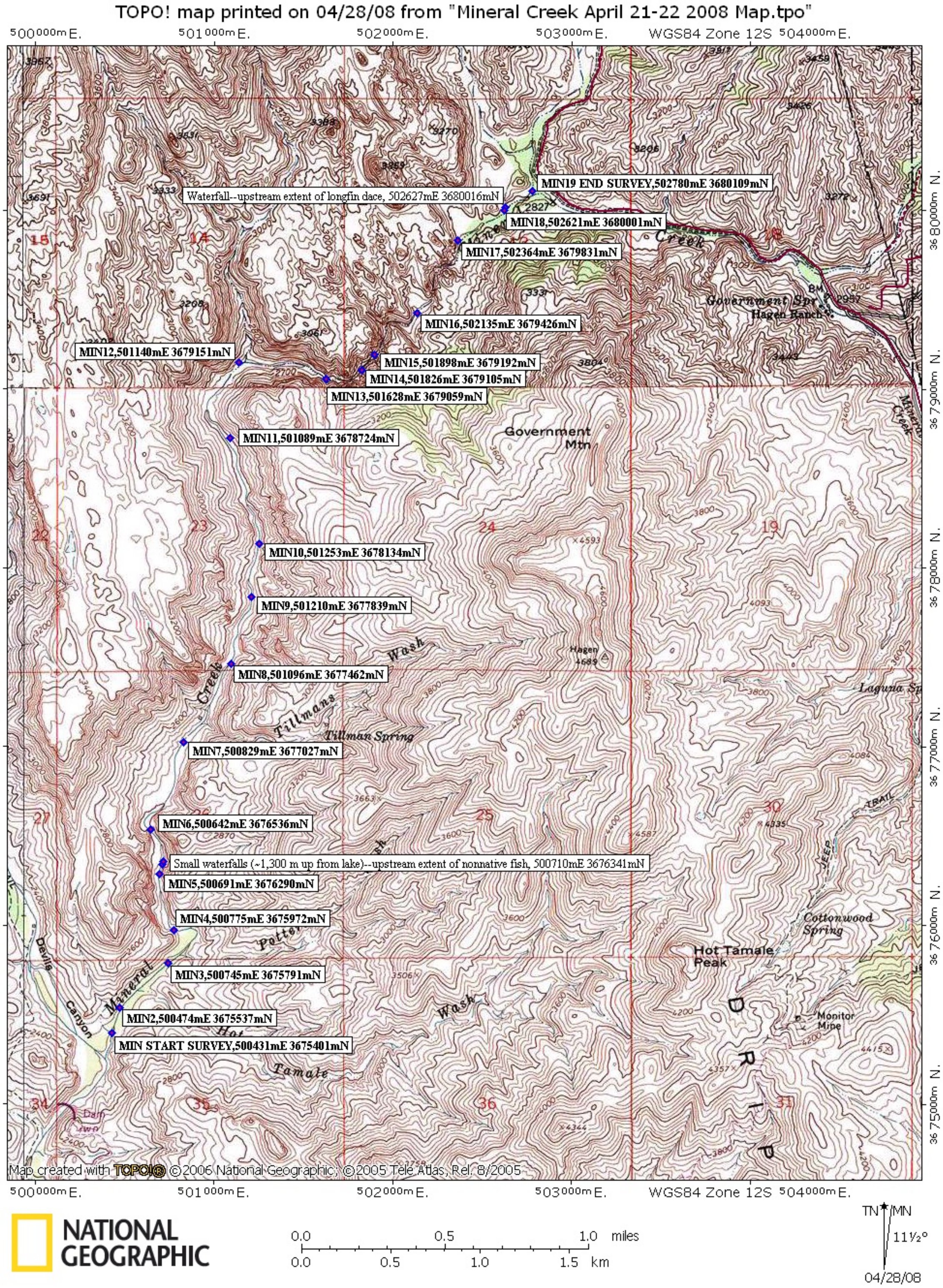


Figure 1. Map of Mineral Creek, showing end points of reaches sampled (e.g., reach 2 is from Min2 to Min3), and locations of waterfalls that limited distribution of fishes.

The objectives of the April 2008 survey of upper Mineral Creek reported herein were to 1) document the upstream distribution of nonnative fishes, 2) assess the abundance and distribution of the longfin dace population, and 3) to attempt to capture Gila chub.

Methods

Arizona Game and Fish Department personnel Tony Robinson, Codey Carter, and Jesse Bahm, accompanied by ASARCO Ray Mine employee Cindy Gutierrez, sampled Mineral Creek from Big Box Dam Reservoir upstream to approximately ½ mile past Tillman Wash during April 21 2008. We sampled from 10:11 am until approximately 2:30 pm, and then hiked out and arrived at our trucks at 4:00 pm. We were escorted out of the mine by Cindy, and then we drove around to the upstream end of perennial water at Government Springs Ranch, where we camped at the confluence of Mineral Creek and Lyons Canyon; the ranch manager, Mickey Byrne permitted us to camp on the ranch and access the creek. On April 22, 2008, Tony, Codey, Jesse, and AZFGD Region 6 personnel Natalie Robb and Danny Rodriguez hiked down from Government Springs Ranch (departed at 7:30 am) to the point where sampling had ended the day before, and sampled upstream to the confluence with Lyons Canyon (finished sampling at 5:00 pm).

We surveyed for fish using a backpack electrofisher and collapsible minnow traps. For electrofishing, we used a Smith Root model LR24 backpack electrofisher with one probe and rattail; we used the Quick-Setup feature, which set parameters as follows: 100-115 V, 30 Hz, 12% duty cycle, with a standard pulse type. We increased the voltage to 200, for the deeper pools. Stunned fish were captured with Duraframe dip nets. We shocked 6,536 m of the 6,918 m from Big Box Dam reservoir upstream to the confluence with Lyons Canyon. Reach length and duration shocked were variable, and were a result of where we stopped to process fish.

We set four Promar Collapsible Minnow traps (0.85 m long, 0.3 m diameter circular hoops, with 9 mm mesh), baited with gravy train dog food between 8:00 to 8:30 am on April 22, 2008. Nets were pulled between 2:25 and 3:15 pm. Nets were set in deep pools that looked like potential Gila chub habitat, within a canyon bound reaches 14 and 15 (Figure 1).

Captured fish were identified to species and counted, but only longfin dace were measured for length. We measured all longfin dace in each reach, until we surpassed 100 measured individuals, and thereafter did not measure lengths in the remaining reaches surveyed.

Location of reaches and waterfalls (barriers) were recorded onto a Garmin GPSmap 60Cx receiver. Distances (m) between reaches were determined with a hip chain, or when it malfunctioned, and after we ran out of string, by mapping out the distance on National Geographic TOPO! software. Water quality parameters ph, conductivity (µS), salinity (mg/L), total dissolved solids (mg/L), and water temperature (°C), were measured using an EXTECH Instruments Inc., ExStik EC500 meter. Dissolved oxygen (% saturation and mg/L) was measured using an YSI Inc., Model 55 dissolved oxygen meter.

Results

We shocked 17 reaches, encompassing 6,536 m of the 6,918 m from Big Box Dam reservoir upstream to the confluence with Lyons Canyon (Figure 1); only the 382 m long reach 3 was not shocked. No fish were captured in the first 148 m surveyed (Reach 1), but upstream of that, fish were captured in each reach. Three species of fish were captured: 1,412 longfin dace, 20 green sunfish, and 11 fathead minnow. There were three closely-spaced waterfalls, 0.7-1.5 m tall, in Reach 5 (Figure 2), and fathead minnow and green sunfish were limited to downstream of these. Longfin dace were captured both above and below the waterfalls in reach 5 and up to, but not above, a waterfall in reach 18. Mean, and standard deviation, catch-per unit effort (CPUE; number caught per minute shocked) of fish in reaches 1, 2, 4, and 5 was: 0.35±0.34 for green sunfish, 0.24±0.29 for fathead minnow, and 0.53±0.68 for longfin dace. Mean CPUE for longfin dace in the 13 reaches above reach 5 was 7.50±7.90. Catch rates of longfin dace generally increased upstream, and reached a peak in reach 13, after which they decreased until reaches 17 and 18 (Figure 3). For minnow traps, no fish were captured in the furthest upstream and furthest downstream traps (set for 7.03 and 6.13 hours respectively). One longfin dace was captured in the downstream-middle trap (0.16 fish/hour), and two longfin dace were captured in the upstream-middle trap (0.29 fish/hour).

Figure 2. Three waterfalls in reach 5; green sunfish and longfin dace were limited to downstream of these, whereas longfin dace were found above and below these waterfalls.

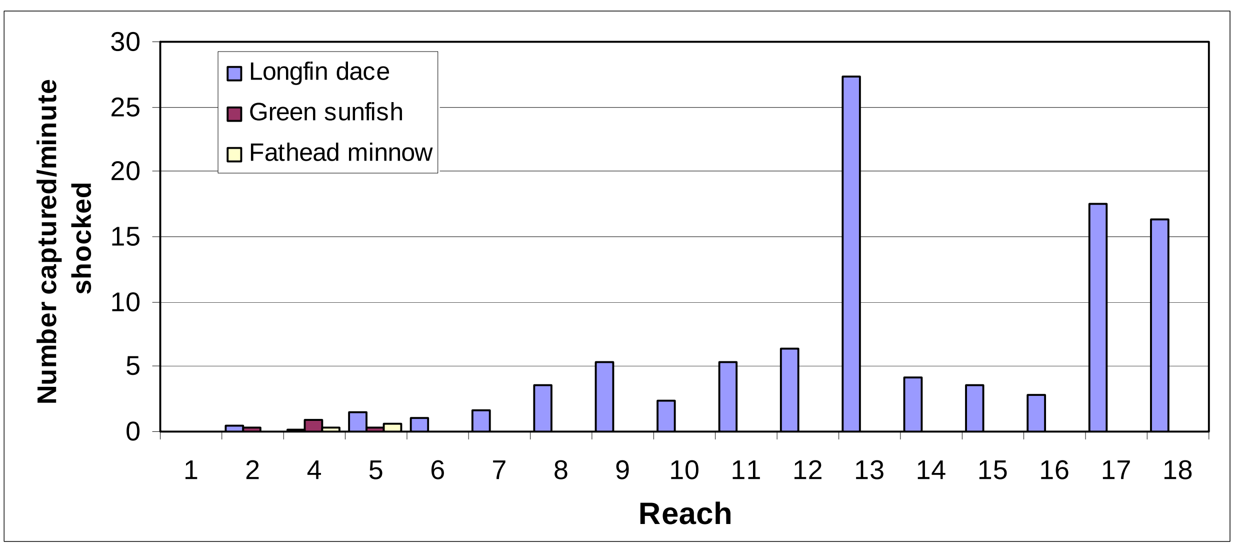


Figure 3. Electrofishing catch per unit effort (number captured divided by minutes shocked) for each of the three species in each reach sampled. Green sunfish and fathead minnow were limited to downstream of three small waterfalls in reach 5.

Thousands of young-of-year (10-20 mm total length) longfin dace were observed throughout the stream; they were observed in every reach except reach 1. We did not attempt to capture the YOY fish while electrofishing. Lengths of longfin dace captured during electrofishing are shown in Figure 4. The abundance of the two size classes (YOY not shown on the graph) indicates a well established longfin dace population in Mineral Creek.

No Gila chub were captured or observed during the survey. The water was clear during the surveys, stream width was typically 2 m and depth <30 cm, and the deepest pools were approximately 1.5 m deep, so fish were easily observed. No fish larger than longfin dace were observed above the waterfalls in reach 5, nor were any fish larger than green sunfish observed below the waterfalls in reach 5.

Gradient varied throughout the perennial portion of Mineral Creek surveyed, thus affecting the types of fish habitat (e.g., pools, runs, riffles, cascades, and waterfalls) and substrates (e.g., silt, sand, gravel, cobble, boulder, etc.). Reach 1 and 2 were within the lake bed and were mostly runs and riffles with a few pools, and were dominated by silt and sand substrates. Reach 3 was just upstream of the lake bed, substrates were mostly sand, and was dominated by runs and riffles. Reach 4 began at the first cliff on the left (facing upstream), and had mostly cobble strewn riffles interspersed with pools. Reach 5 had a few falls, cascades and associated plunge pools with intervening riffles; substrates were dominated by cobble and sand. Reaches 6-8 had mostly riffles with some cascades and plunge pools, and were dominated by cobble substrates. Reaches 9-12 had more cascades and plunge pools than the lower reaches, but was still dominated by riffles with cobble substrates. Reaches 13-16 were canyon bound, and the amount of cascades and plunge pools increased and riffles decreased; boulders and cobbles dominated but pools were full of sand. The amount of cascades and plunge pools decreased and riffles increased in reach 17, along with an accompanying increase in cobbles and gravels. The gradient lessened and riffles became the dominant habitat type in reach 18; cobble and sand substrates were dominant.

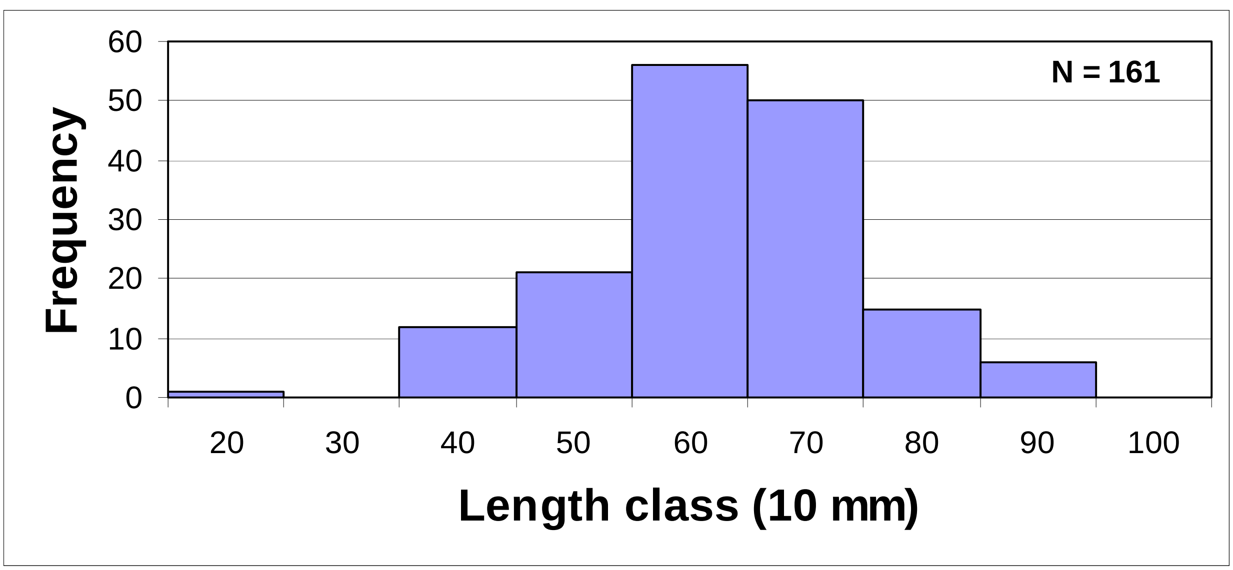


Figure 4. Length frequencies of longfin dace captured during electrofishing Mineral Creek, April 21-22, 2008.

Pysicochemical properties of the water were measured on April 22, 2008 at 11:15 am, at the end of reach 9 (Min10 in Figure 1). Water temperature was 17.6°C, pH = 8.59, salinity = 288 ppm, total dissolved solids = 406 mg/L, conductivity = 578 µS, and dissolved oxygen = 8.65 mg/L and 91.0% saturation. Water was clear enough to see the bottom of even the deepest pools. Filamentous algae (probably *Spyrogyra*) was found throughout the stream, but became especially abundant in the upstream two reaches, where the canyon opened up and riparian vegetation thinned.

Discussion

Nonnative fishes, although present in upper Mineral Creek, were found only within the 1.3 km immediately above Big Box Dam reservoir. A series of waterfalls approximately 1.3 km upstream from the reservoir appeared to limit the distribution of green sunfish and fathead minnow, as neither of these species were present above these waterfalls. Longfin dace were present above these waterfalls because they were stocked upstream near the confluence with Lyons Canyon in 2006 and have since reproduced.

It has been hypothesized that the portions of upper Mineral Creek surveyed in 2002 and 2006 were fishless because the stream went dry; which would also explain why Gila chub disappeared. Indeed, 2002 was the driest year in the last century in Superior and Globe, Arizona (Figure 5), so stream-drying seems like a plausible hypothesis. However, Mineral Creek had water during both the May and September 2002 surveys. It may be that the stream had flows during the May 30, 2002 survey because it was soon enough after rains in April. No rain was recorded in February, May or June 2002, and very little in January, March and April (Figure 6). But it rained during July, August and September, so it is not surprising that there were flows during September 2002.

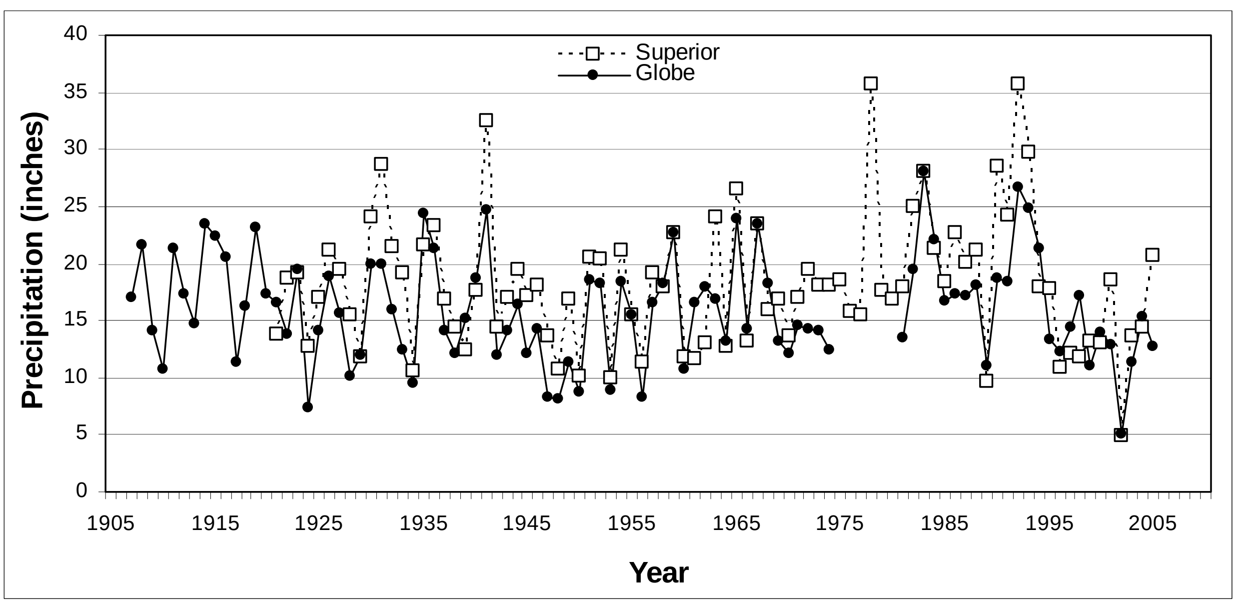


Figure 5. Annual precipitation in Globe and Superior, Arizona from 1907 through 2005. Data were obtained from the Arizona Climate Summaries web page (http://www.wrcc.dri.edu/summary/climsmaz.html).

We did not capture any Gila chub in upper Mineral Creek. This marks the fourth survey that Gila chub have not been captured or observed; they were last captured in 2000. It can probably be assumed, with a high degree of confidence, that Gila chub have been extirpated from upper Mineral Creek. They were not found during historical surveys of Devils Canyon, and therefore may not be present in Devils Canyon, although survey data are sparse. They may be extirpated through all of the Mineral Creek drainage, however they were captured above the mine but below Big Box Dam in 1993, so they may yet persist in this short portion of Mineral Creek. A thorough survey of Devils Canyon, and Mineral Creek below Big Box Dam should be conducted in an attempt to find Gila chub.

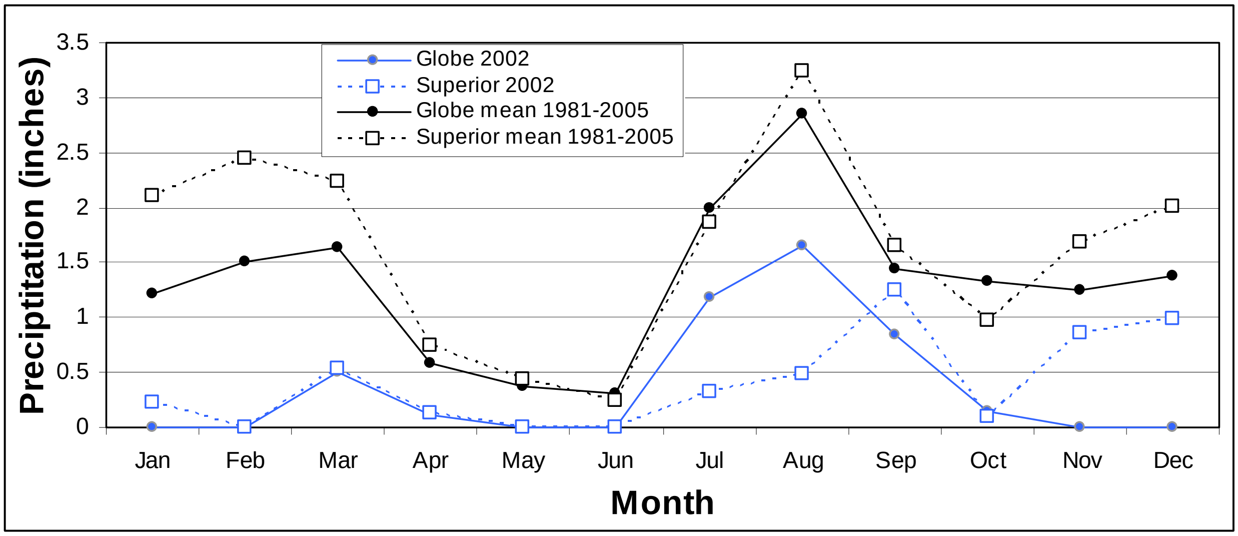


Figure 6. Monthly precipitation during 2002 and average precipitation during 1981-2005 at Globe and Superior, Arizona. Data were obtained from the Arizona Climate Summaries web page (http://www.wrcc.dri.edu/summary/climsmaz.html).

Recommendations

If upper Mineral Creek is to be managed as a native fishery, then consideration should be given to repatriating Gila chub, and stocking other native fishes into this section of stream. One concern with stocking another lineage of Gila chub into upper Mineral Creek is that there may yet be a few Gila chub in Devils Canyon or in Mineral Creek below Big Box Dam, and the two lineages could then mix. It would be best to conduct a thorough survey of Devils Canyon and Mineral Creek below Big Box Dam, to be more confident that Gila chub are extirpated from these reaches as well. If no Gila chub are found, then consideration could be given to stocking another lineage of Gila chub (probably either Redfield Canyon or Bonita Creek) into upper Mineral Creek.

Habitat in upper Mineral Creek is suitable for Gila chub and other native fishes. Reaches 5 through 18, but especially the canyon-bound reaches 13-16 were assessed to be suitable for Gila chub; many plunge pools were found throughout these reaches. In addition, reaches 5-13 also had habitat suitable for loach minnow; primarily low-gradient riffles with cobble substrates. Habitat throughout reaches 5 through 18 looked suitable for desert sucker, which although have not been found in this portion of Mineral Creek, have been captured downstream of the mine. Flows are likely to decrease until the summer monsoon season, but even so, the gradient and pools present indicate that these species could establish.

All of the Mineral Creek drainage above Big Box Dam could be managed as a native fishery. Big Box Dam is an effective barrier to upstream movements of fishes, so nonnative fishes could be limited to below the Dam. In order to achieve a native fishery in the entire drainage above Big Box Dam, it would be necessary to chemically treat (with Rotenone) the reservoir, Devils Canyon, and the lower 1.3 km of upper Mineral Creek in order to remove all fishes. After successfully removing all fishes from these areas, native fishes present in upper Mineral Creek would likely colonize the fishless areas. Plus, the treated areas could be stocked with native fishes to speed their establishment. Consideration could also be given to stocking Gila topminnow and desert pupfish into the reservoir. Renovation of the proposed areas could be done after Gila chub and other species are repatriated to upper Mineral Creek.

References

Andrews, B. J., and K. A. King. 1997. Environmental contaminants in sediment and fish of Mineral Creek and the middle Gila River, Arizona. U. S. Fish and Wildlife Service, Ecological Services Office, Phoenix.

ATTACHMENT 4

Devils Canyon and Mineral Creek Fish Survey during 2009, Arizona Game & Fish Department

Devils Canyon and Mineral Creek Fish Surveys During 2009

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February 2010

Introduction

Gila chub *Gila intermedia* was listed as federally endangered with critical habitat in 2005 (Federal Register 2005). At the time of listing 29 populations in seven watersheds in the Gila River basin were considered extant. One of the extant populations was in Mineral Creek, tributary to the Gila River in Pinal County, Arizona. The Mineral Creek population was first documented in 1993 (Andrews and King 1997), but was last documented during 2000 (Robinson 2008a) even though four surveys in upper Mineral Creek (upstream of Big Box Dam) were completed between 2002 and 2008: two during 2002, one in 2006, and one in 2008. Gila chub are likely extirpated from upper Mineral Creek (Robinson 2008a). Robinson (2008a) recommended repatriating Gila chub to upper Mineral Creek, however expressed concern about stocking another lineage of Gila chub into the system if the species still occurred elsewhere in the watershed (e.g., Devils Canyon and the portion of Mineral Creek between Big Box Dam and the ASARCO Ray Mine tunnel). Mineral Creek watershed Gila chub, if they still exist, would be the preferred lineage to repatriate into upper Mineral Creek. Robinson (2008a) recommended surveying Devils Canyon and the portion of Mineral Creek between Big Box Dam and the tunnel to be more confident that Gila chub are extirpated from the Mineral Creek watershed. Gila chub have never been documented in Devils Canyon, a tributary to Mineral Creek, but only two fish surveys are known to have been done, both restricted to the lowest reach immediately above Big Box Dam Reservoir (Robinson 2008a). Gila chub were recorded from the portion of Mineral Creek between Big Box Dam and the ASARCO Ray Mine tunnel in a 1993 survey (Andrews and King 1997).

The objective of the surveys within the Mineral Creek watershed during 2009 were to document occurrence of Gila chub and other fish species within perennial waters in Devils Canyon and the portion of Mineral Creek between Big Box Dam and the ASARCO Ray Mine tunnel.

Study Site

Mineral Creek is a tributary to the Gila River in Pinal County Arizona. Mineral Creek is impounded by Big Box Dam (constructed in 1971) just upstream of ASARCO Ray Mine. An approximately 650-m long reach of Mineral Creek exists from Big Box Dam to the tunnel entrance, after which the stream flows through the tunnel under the ASARCO Ray Mine (Figure 1). Immediately above Big Box Dam, the watershed divides into Devils Canyon to the west and Mineral Creek to the east (this portion of Mineral Creek is referred to as upper Mineral Creek). Devils Canyon is a mostly north-to-south oriented drainage and the northern upstream end crosses US Highway 60. Rawhide Canyon, a north-to-south oriented tributary, meets Devils Canyon approximately 3.1 km upstream from the confluence with Mineral Creek. Robinson (2008b) identified two perennial reaches in Devils Canyon during an aerial survey; the upper reach extended from the U.S. Highway 60 bridge downstream for approximately 2 km, and the lower reach extended from the Rancho Rio Creek confluence downstream for approximately 4 km, ending about 750 m downstream of an area known to canyoneering enthusiasts as Five Pools (five waterfalls with associated plunge pools). Robinson (2008b) also observed some water and riparian vegetation in a short portion of Rawhide Canyon from its mouth upstream approximately 500 m. We surveyed five reaches during 2009 (Figure 1): 1) Devils Canyon from the U.S. Highway 60 bridge to 2,350 m downstream on July 14, 2) Devils Canyon from Rancho Rio Creek to approximately 2,440 m downstream on April 15-16, 3) the plunge pools

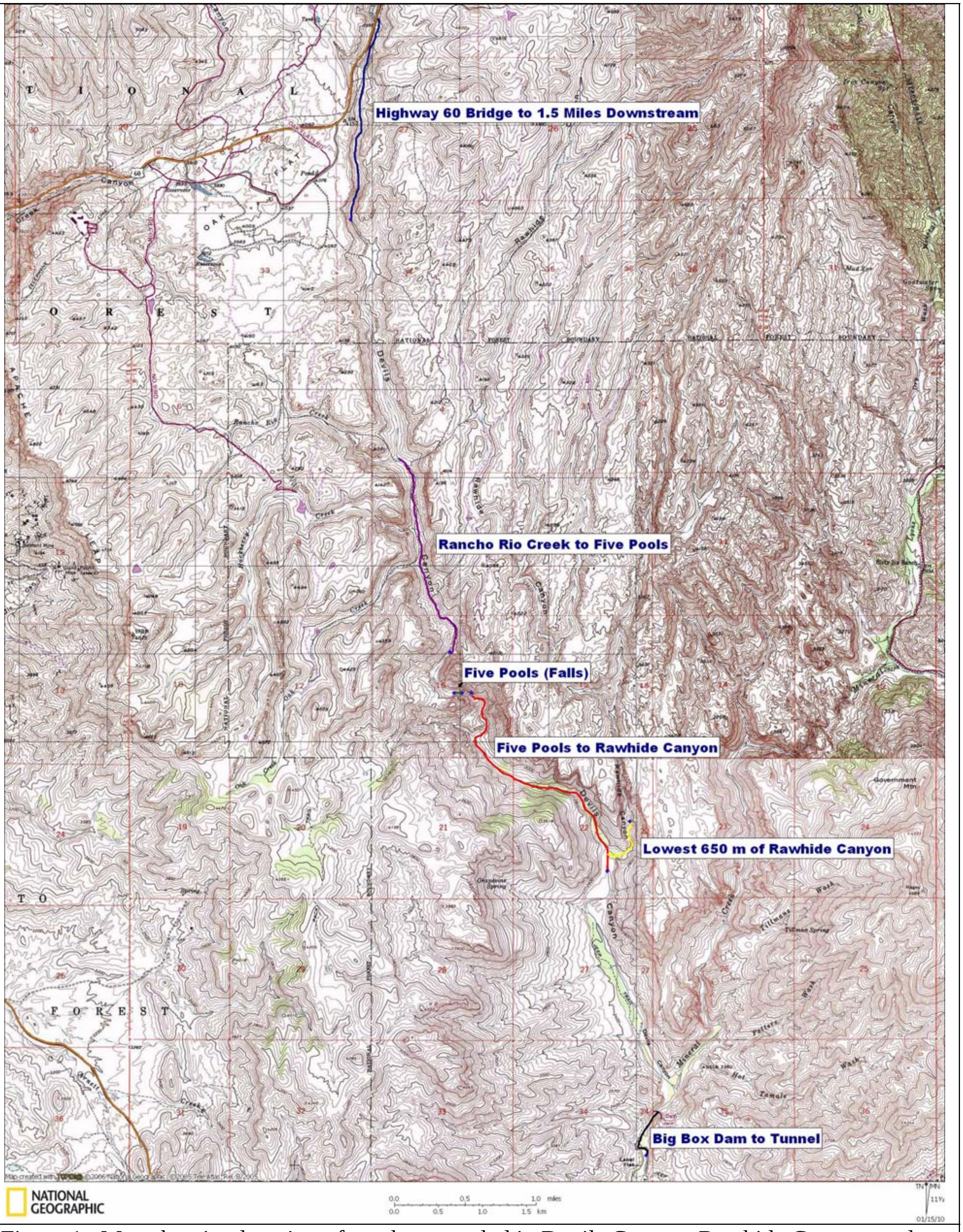

Figure 1. Map showing location of reaches sampled in Devils Canyon, Rawhide Canyon, and Mineral Creek during 2009 fish surveys.

below each of the five falls on April 16, 4) from approximately 50 m downstream of the lowest of the five falls downstream 3,070 m to about 175m past the confluence of Rawhide Canyon on August 3-4, and 5) Rawhide Canyon from its mouth upstream 650 m to a dry waterfall on August 3.

Seven fish species have been documented in Mineral Creek and its tributary Devils Canyon. Fish species reported in Devils Canyon include green sunfish *Lepomis cyanellus* and fathead minnow *Pimephales promelas* (Schwemm 2002; AGFD unpublished data). Fish species reported in Mineral Creek include native longfin dace *Agosia chrysogaster*, Gila chub *Gila intermedia*, and desert sucker *Catostomus clarki* and nonnatives fathead minnow, green sunfish, mosquitofish *Gambusia affinis*, and black bullhead *Ictalurus melas* (Andrews and King 1997).

Methods

Wadeable water within each reach was surveyed using a Smith-Root model LR24 backpack electrofisher with one probe and rattail. Stream sections were shocked during daylight hours moving in an upstream direction, and stunned fish were captured with dip nets (Duraframe Dipnet® electro intermediate hex trap net with 3 mm mesh and 5 ft long pole). Section length and duration shocked were variable, and were a result of where we stopped to process fish. Data recorded for each section included: date, GPS location, species captured and numbers, seconds electrofished, and length of section electrofished.

Deeper pools were surveyed with Promar collapsible mini-hoop nets (0.85 m long, 0.3 m diameter circular hoops, with 9 mm mesh) or Promar collapsible minnow traps (0.43 m long, 0.25 m wide, with 2 or 5 mm mesh) baited with Gravy Train® dog food. Nets were set in the afternoon and pulled the next morning when possible, or for a minimum of 2 hours during daylight. Dip nets (Duraframe Dipnet® electro intermediate hex trap net with 3 mm mesh and 5 ft long pole) were also used to survey deeper pools or areas where electrofishing or traps could not easily be used. Data recorded for each trap or dip net sweep included: date and time net was set and pulled, GPS location, species captured and numbers of individuals.

Four of the Five Pools were sampled after rappelling down to each; the second uppermost pool is small and was not sampled. In the first and third pools, an experimental monofilament gill net (green meanie 15.2 m long x 1.5 m wide, with 6 different mesh panes ranging from 19 to 46 mm) was set in the morning and pulled several hours later in the afternoon. Two mini hoop nets (Promar® collapsible 0.85 m long, 0.3 m diameter circular hoops, with 9 mm mesh) baited with Gravy Train® dog food were also set in the morning in the third pool and pulled several hours later in the afternoon. The fourth and fifth pools were surveyed by snorkeling; two people snorkeled through each for approximately 10 minutes.

Results

No Gila chub were captured in any of the five reaches surveyed. Three fish species, all of which are nonnative, were captured during the surveys: green sunfish, fathead minnow, and mosquitofish. In the section of Mineral Creek below Big Box Dam, green sunfish were by far the most abundant species, and the only other species captured was fathead minnow (Table 1). Green sunfish appeared to be more abundant in this section of Mineral Creek than in any of the Devils Canyon reaches surveyed (Tables 1 and 2). In Devils Canyon both green sunfish and mosquitofish were captured, but mosquitofish were only captured in the upstream-most reach (Highway 60), whereas green sunfish were captured in all four reaches surveyed (Table 2). No fish were captured or observed in Rawhide Canyon. Crayfish were also captured in the Highway 60 and Rancho Rio to Five Pools reaches and two dead ones were observed in the reach between Five Pools and Rawhide Canyon (Table 2). Sonoran mud turtles *Kinosternon sornoriense* were observed all reaches except the Five Pools. A black-necked garter snake *Thamnophis cyrtopsis* was observed and captured in the Highway 60 reach of Devils Canyon.

Discussion

No Gila chub were captured or observed during our surveys, which lends evidence that they are not present in Devils Canyon and are no longer present in the section of Mineral Creek between Big Box Dam and the ASARCO Ray Mine tunnel. They were last captured in the section of Mineral Creek between Big Box Dam and the mine during 1993, but were captured just downstream of the old reservoir in Lakel Flat, which is now covered by the mine. Our survey in Mineral Creek was intensive, but within the uppermost portion immediately below Big Box Dam there was a large deep pool which could not be effectively sampled with the gear we had, so it is possible that Gila chub are present, but if so they are likely very rare, as there were many suitable looking pools downstream that were sampled but no chub were captured.

Gila chub have never been reported from Devils Canyon, but it seems likely that they could have occupied the lower reach from just downstream of Five Pools to the confluence with Mineral Creek as there are no natural waterfalls in this reach to prevent upstream movement during high flow periods, and the portion just downstream of Five Pools appears to be perennial. However, the section between Rawhide Canyon and the confluence with Mineral Creek appears to be ephemeral (Schwemm 2002, Cori Carveth, Arizona Game and Fish Department, personal communication), which may function as a fish barrier to some species. It also seems likely that Gila chub could have occupied the lowest reach of Rawhide Canyon for the same reasons. The five waterfalls that create the Five Pools however, are postulated to have been fish barriers for over ten thousand years, as we think they are basalt, and two of the falls are 15.2 vertical meters and two others 3.7 m, and one 3.0 m (Figure 2). If these five falls were fish barriers, then there should never have been any native fish captured upstream; results of our survey support this hypothesis and we only found records of one survey upstream (a vegetation survey; Jacobs and Flesch 2007) where only nonnative fish were observed. However, it seems likely that the upper portion of the stream was surveyed more times in the past given it's proximity to U.S. Highway 60 and the fact that it occurs on Forest Service and State Lands; records of any past surveys would help determine if the hypothesis is true or false. The dry waterfall in Rawhide Canyon about 650 m upstream of the confluence with Mineral Creek had a vertical drop of approximately 5-6 m and has thus also a likely been a fish barrier in at least the last few thousand or so years.

Only nonnative fishes were found during our survey of Devils Canyon and one section of Mineral Creek. Nonnative fish in the portion of Mineral Creek surveyed may have originated from the Gila River and migrated into Mineral Creek before the mine was developed, may have been purposely stocked, or may have migrated downstream from upstream stock tanks. Nonnative fish in the portion of Devils Canyon upstream of Five Pools likely originated from one of the many stock tanks in the upper portion of the Devils Canyon watershed (Robinson

2009b). Native fish were found in the 1990s within the portion of Mineral Creek that we surveyed, but are either now extirpated or are very rare.

Recommendations

Data from past surveys indicate that Gila chub are extirpated from upper Mineral Creek (upstream of Big Box Dam; Robinson 2009a), and data in this report and previous surveys indicates that they are not present in Devils Canyon. Therefore, we contend that Gila chub are extirpated from the Mineral Creek watershed upstream of Big Box Dam. They may also be extirpated from the portion of Mineral Creek downstream of Big Box Dam, as we did not capture any in the section between the dam and the ASARCO Ray Mine tunnel. It is possible, but seemingly unlikely, that they still exist, but are rare in this section of Mineral Creek, and we could conduct another survey in this section to be even more confident. Regardless, it is desirable to re-introduce Gila chub to upper Mineral Creek. Assuming they are extirpated from the entire Mineral Creek drainage, the preferable lineage to use for reintroduction would be one that is geographically close, as it would be assumed to be the most genetically similar. Based on an examination of Dowling et al. (2008), and considering genetics and geographic proximity we suggest that the three best choices of lineages to use are Redfield Canyon, Hot Springs Canyon, or Bonita Creek.

The portion of Devils Canyon from about 600 m upstream of Five Pools to the confluence of Rancho Rio Creek appears to be perennial, given the presence of mature riparian forest and presence of green sunfish. This reach had many deep pools (Figure 2) and abundant aquatic invertebrates which indicated that it would be suitable for Gila chub. Consideration should be given to renovating Devils Canyon upstream of Five Pools (including stock tanks) and repatriating native fishes including longfin dace, Gila chub, and desert sucker. Another approach that is more logistically complex and extensive would be to renovate the entire Mineral Creek watershed upstream of Big Box Dam, including Devils Canyon, Big Box Dam Lake and the lowest 1 km of upper Mineral Creek, and then stocking and managing for only native fish species upstream of the dam. Upper Mineral Creek upstream of the series of small waterfalls approximately 1450 m upstream of Big Box Dam Reservoir is free of nonnative fishes so would not need to be renovated.

Acknowledgements

These surveys were funded through and agreement with U.S. Fish and Wildlife Service as part of the Central Arizona Project (CAP) Gila River Basin Native Fishes Conservation Program. Various Arizona Game and Fish Department personnel people assisted with the fish surveys. Natalie Robb, Jeff Sorensen, Tony Robinson, Clay Crowder, and David Orabutt conducted the surveys in Devils Canyon between Rio Rancho Creek downstream to the bottom of Five Pools. Rawhide Canyon and the section of Devils Canyon between Rawhide Canyon and the Five Pools were surveyed by Clay Crowder, Antonio Lopez, Cassandra Smith, and Danny Rodriguez. The section of Devils Canyon near U.S. Highway 60 was surveyed by David Orabutt, Amberle Vasey, and Danny Rodriguez. The section of Mineral Creek between Big Box Dam and the ASARCO Ray Mine tunnel was surveyed by Tony Robinson, David Orabutt, and Clay Crowder; we were escorted by Keith Warren of ASARCO Ray Mine.

Table 1. Summary of results of the April 22, 2009 fish survey in Mineral Creek, ASARCO Ray Mine, Arizona, showing for each gear type total number of fish captured, the number of sampling efforts, mean catch-per-unit-effort and standard error of the mean catch rate. Catch rates for electrofishing are the number of individuals (Ind) captured per minute electrofished, and for minnow trapping are number of individuals captured per hour.

Gear type	Statistic	Green sunfish	Fathead minnow	Total
Electrofishing	# Individuals	596	4	600
	# Efforts	6	6	6
	Mean #Ind/min	16.88	0.15	17.03
	SE	(3.03)	(0.15)	(3.14)
Minnow Trapping	# Individuals	759	1	760
	# Efforts	21	21	21
	Mean #Ind/h	13.40	0.02	13.42
	SE	(4.17)	(0.02)	(4.17)
Table Total	# Individuals	1355	5	1360

Table 2. Summary of results of the 2009 fish survey of four reaches of Devils Canyon from the U.S. Highway 60 bridge downstream to Big Box Dam Reservoir. No fish were captured in the one reach of Rawhide Canyon (from mouth upstream 650 m) sampled.

Reach	Gear type	Statistic	Green Sunfish	Mosquitofish	Total Fish	Crayfish
Highway 60 to 1.5 miles downstream						
	Electrofisher	#Individuals	22	361	383	161
		#Efforts	8	8	8	8
		Mean #Ind/min	1.38	18.8	20.18	11.14
		SE	(1.37)	(12.71)	(12.49)	(4.52)
	Dip net	#Individuals	0	0	0	27
Rancho Rio Creek to Five Pools						
	Electrofisher	#Individuals	411		411	9
		#Efforts	9		9	9
		Mean #Ind/min	4.17		4.17	0.09
		SE	(0.67)		(0.67)	(0.05)
	Mini Hoop	#Individuals	215		215	7
		#Efforts	20		20	20
		Mean #Ind/h	0.55		0.55	0.02
		SE	(0.09)		(0.09)	(0.01)
Five Pools (falls)						
	Gill net	#Individuals	8		8	
		#Efforts	2		2	
		Mean	1.18		1.18	
		SE	(0.92)		(0.92)	
	Snorkel	#Individuals	11		11	
		#Efforts	4		4	
		Mean #Ind/min	16.18		16.18	
		SE	(16.18)		(16.18)	
	Mini hoop	#Individuals	10		10	
		#Efforts	2		2	
		Mean #Ind/h	1.52		1.52	
		SE	(1.52)		(1.52)	
Five Pools to Rawhide Canyon						
	Electrofisher	#Individuals	55		55	
		#Efforts	8		8	
		Mean #Ind/min	7.31		7.31	
		SE	(4.51)		(4.51)	

Reach	Gear type	Statistic	Green Sunfish	Mosquitofish	Total Fish	Crayfish
	Dip net	#Individuals	22		22	
		#Efforts	20		20	
		Mean #Ind/m^2	7.03		7.03	
		SE	(2.88)		(2.88)	
	Mini hoop net	#Individuals	110		110	2
		#Efforts	12		12	
		Mean #Ind/h	1.34		1.34	
		SE	(0.58)		(0.58)	

Figure 2. Photographs of Devils Canyon on April 17, 2008: *top left* shows Devils Canyon Creek near the confluence with Rio Rancho Creek. The rest of the photographs are of each of the Five Pools: *middle left* shows pool 1 (the uppermost pool), *bottom left* shows pool 2, *top right* shows pool 3, *middle right* shows pool 4, and *bottom right* shows pool 5 (lower most pool).

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ATTACHMENT 5

DEVILS CANYON DRAINAGES STOCK TANK SURVEYS DURING 2010 AND 2011, ARIZONA GAME & FISH DEPARTMENT

Devils Canyon Drainage Stock Tank Surveys During 2010 and 2011

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December 20, 2011

Arizona Game and Fish Department Mission

To conserve, enhance, and restore Arizona's diverse wildlife resources and habitats through aggressive protection and management programs, and to provide wildlife resources and safe watercraft and off-highway vehicle recreation for the enjoyment, appreciation, and use by present and future generations.

ACKNOWLEDGMENTS

The surveys conducted in the Devils Canyon and Mineral Creek drainages in 2010 and 2011 occurred with the assistance of multiple agency personnel and private citizens. These surveys were funded through an agreement with U.S. Fish and Wildlife Service as part of the Central Arizona Project (CAP) Gila River Basin Native Fishes Conservation Program. Involved in the 2010 surveys were individuals from Arizona Game and Fish Department (Tony Robinson, Clay Crowder, Natalie Robb, Danny Rodriguez, Steve Prager, Abi Medina and Kent Mosher). Additionally, the 2011 surveys included personnel from Arizona Game and Fish Department (Clay Crowder, Tony Robinson, Kent Mosher, Andrea Steffen and Kyle Yarush). Access to lower Devils Canyon was granted by ASARCO Ray Mine and escort provided by Ray Mine personnel (Keith Warren and Brian Munson), likewise access through Resolution Copper's JI Ranch was provided by the property caretakers.

Recommended Citation:

> Crowder, C.D. and A.T. Robinson. 2011. Devils Canyon drainage stock tank surveys during 2010 and 2011. Arizona Game and Fish Department, Phoenix. 9pp.

INTRODUCTION

Gila chub *Gila intermedia* was federally listed as endangered with critical habitat in 2005 (Federal Register 2005). Upper Mineral Creek, the watershed immediately upstream of the ASARCO Ray Mine Big Box Dam, was designated as critical habitat for Gila chub at the time of listing. According to Robinson (2008a), Gila chub were last documented in upper Mineral Creek in 2000. Subsequent surveys completed in 2002, 2006 and 2008 were not able to document the presence of Gila chub, and the species is considered extirpated from upper Mineral Creek (Robinson 2008a).

Robinson (2008a) recommended repatriation of Gila chub in upper Mineral Creek, as well as additional surveys of the drainage; namely the ~650 meter reach of Mineral Creek below Big Box Dam and the ASARCO Ray Mine tunnel, and the Devils Canyon drainage, to ascertain the possibility of Gila chub existing outside the upper Mineral Creek reach (Robinson 2008a). Mineral Creek lineage chub would be the preferred lineage for repatriation of chub into upper Mineral Creek (Robinson 2008a). In 2008, Robinson (2008b) performed aerial helicopter surveys to identify perennial reaches and stock tanks within the Devils Canyon drainage.

In 2009, Arizona Game and Fish Department (AGFD) conducted fish surveys in Mineral Creek from Big Box Dam to ASARCO Ray Mine tunnel, in Devils Canyon and in Rawhide Canyon, a sub-drainage of Devils Canyon located approx. 2.65 km upstream of Devils Canyon and Mineral Creek confluence (Robinson et al. 2010). No Gila chub or other native fish were observed or captured during the surveys. However, nonnative Green sunfish *Lepomis cyanellus,* fathead minnow *Pimephales promelas* and mosquitofish *Gambusia affinis* were detected. These nonnative species were previously detected in Devils Canyon (Schwemm 2002; AGFD unpublished data) and Mineral Creek, below Big Box Dam (Andrews and King 1997). Robinson et al. (2010) suggested that nonnative fish species within Devils Canyon and lower Mineral Creek could have originated from: 1) upstream migration from the Gila River to Mineral Creek prior to the construction of the ASARCO Big Box Dam, 2) illegally stockings or 3) downstream migration into Devils Canyon from stock tanks within the watershed. Robinson (2008b) recommended that all tanks in the Devils Canyon drainage be surveyed prior to any renovation effort to restore Gila chub to the Devils Canyon, Big Box Dam reservoir and lower Mineral Creek.

The objective of the surveys conducted in 2010 and 2011 was to complete the inventory of perennial waters (streams reaches and tanks) in the Devils Canyon drainage to document the presence and distribution of Gila chub and other fish and aquatic vertebrate species within the drainage. The inventory was also done to identify source populations of nonnative fish (i.e. stock ponds). Fish distribution information is needed if Gila chub are repatriated to upper Mineral Creek and if the watershed above Big Box Dam is renovated and managed for native fishes (Robinson 2008a).

STUDY SITE

Devils Canyon is a tributary to Mineral Creek, which is a tributary to the Gila River in Pinal County Arizona. Devils Canyon joins Mineral Creek approximately 14 km upstream of the Mineral Creek and Gila River confluence, on the southwestern edge of the Pinal Mountains (Figure 1). Devils Canyon begins at an elevation of approximately 685 m and runs in a north-to-south direction, bisecting U.S. Highway 60 in the uppermost 5.6 km of the canyon. Devils

Canyon has five main sub-tributaries; the three minor tributaries entering Devils Canyon from the west are Rancho Rio Creek, Hackberry Creek and Oak Creek. The largest tributary, Rawhide Canyon, runs in a northeast-to-south direction. Rawhide Canyon's confluence with Devils Canyon lies approximately 10.8 km downstream of Devils Canyon and US Highway junction. Another tributary is Iron Canyon, which drains the Top of the World area and then parallels U.S. Highway 60 before meeting Devils Canyon. The Devils Canyon drainage covers an area of about 92.35 km^2. More than 20 tanks are known to occur throughout the drainage (Robinson 2008b).

METHODS

Stock Tank Surveys

Using a combination of data collected from Robinson's (2008b) aerial survey of Devils Canyon drainage (Figure 3), TOPO! 4® software and aerial images from Google Earth®, 29 stock tanks within Devils Canyon drainage were identified. An additional three tanks were discovered during the surveys. Personnel from AGFD surveyed the stock tanks on July 6-8, 2010 and May 3, 4 and 16, 2011. Three stock tanks were not visited, two of which (Iron Flat tank and an unnamed tank identified as Tank 32 within Table 1) were reported (Robert Johnston, local landowner, personal communication, May 17, 2011) to go dry during the year and have limited access because roads were behind deeded or locked gates. The third unvisited tank (Tank 23) had incorrect GPS coordinates so was not found, but was later determined to exist based on examination of satellite photographs.

Stock tanks were surveyed using bag seines (9 m wide, 1.2 m high with 6 mm mesh), and dip nets (Duraframe Dipnet® electro intermediate hex trap net, 37 cm wide at the base, 12 cm wide at the apex and 41 cm long with 3mm mesh and 1.5 m pole). Ropes (~approximately 45 m long each) were attached to the seine brails to facilitate pulling the seine across the tanks. The bag seine was pulled through each tank three times, each time through a different portion of the tank, unless the tank was 1) dry, 2) small enough to be surveyed by one or two seine hauls, or 3) too shallow or small in which case dip nets were used. Data recorded for each sampling effort included: site name, site location (GPS coordinates), date, time, participants, effort (length and width of area surveyed via bag seine or dip net sweep), area of tank (length and width of wetted area), species captured and number of individuals.

Stream Surveys

A 1 km reach of upper Rawhide Canyon was visually surveyed on May 3, 2011 because bedrock tinajas were observed in that reach by Robinson (2008b). Wetted reaches, which were pools, were visually inspected and seined or dip netted if enough water was present. In addition, a 1-km portion of Devils Canyon was surveyed on June 2, 2011. This reach was previously surveyed (Robinson et al. 2010), however an Audubon Arizona employee reported a 'chub-like' fish in the reach and verification of the report was needed. The one reach of Devils Canyon targeted was surveyed using Smith-Root model LR24 backpack electrofisher with one probe and rattail. Sections were shocked in an upstream direction and fish were captured using dip nets. Survey length and duration shocked was variable. Data recorded for each effort included: site name, site location, species captured, number of fish of each species captured and seconds electrofished.

Deeper pools were sampled with Promar® collapsible mini-hoop nets (0.85 m long, 0.3 m diameter circular hoops, with 9 mm mesh) baited with Gravy Train® dog food. Nets were set for a minimum of 2 hours during daylight. Data recorded for each trap included: date and time net was set and pulled, GPS location, species captured and numbers of individuals captured.

Physical Environment
Water quality parameters; pH, conductivity (µS), salinity (ppm), total dissolved solutes (mg/L) and water temperature (˚C), were measured using an EXTECH Instruments Inc. ExStik EC500 meter. Dissolved oxygen (mg/L) was measured using an EXTECH Instruments Inc. ExStik DO600 meter.

RESULTS

Stock Tank Surveys
Of the 31 stock tanks that were surveyed; only two (Headquarter tank and East Fork tank) had fish (Table 2). Mosquitofish were the only fish species captured in East Fork tank. Mosquitofish and bluegill *Lepomis macrochirus* were captured in Headquarter tank, with bluegill being more abundant; this is the first time that bluegill has been documented in Devils Canyon drainage. A slider, likely a red-eared slider *Trachemys scripta* and a large female spiny soft-shell turtle *Apalone spinifera* were also observed at Headquarter tank. Eleven of the stock tanks had tiger salamander *Ambystoma tigrinum* in varying stages of development (ie. egg, brachial larvae, adult). Two tanks had northern crayfish *Orconectes virilis*, three had lowland leopard frog *Rana yavapaiensis*, and one had black-necked gartersnake *Thamnophis cyrtopsis* (Table 1).

Stream Sampling
No Gila chub were in Devils Canyon. Green sunfish and northern crayfish were captured during electrofishing. Only Green sunfish were captured in the mini-hoop nets (Table 2). Both adult and juvenile Green sunfish were captured in the traps.

Very little water was found in Rawhide Canyon. Most water was in three relatively small (about 2, 4, and 6 m^2) tinaja pools; the larger tinajas observed by Robinson (2008b) were dry. No fish were observed (the water was clear in all pools found) or captured in dip net sweeps (the number of dip net sweeps was not recorded).

DISCUSSION

Only nonnative fishes were found during our survey of stock tanks and two stream segments in the Devils Canyon drainage. We did not capture green sunfish in any of the stock tanks, so cannot conclude that the stock tanks were sources of dispersal of the species into Devils Canyon and upper Mineral Creek. However as Robinson et al. (2010) discussed, perhaps these fish were illegally stocked in the stream system in the past or moved downstream from a stock tank where they were previously stocked but no longer persist. The three stock tanks that were not surveyed are not likely a source of nonnatives fishes because two of them (Iron Flat tank and Tank 32) are reported (Robert Johnston, personal communication, May 17, 2011) to annually go dry, and the third, Tank 23, is upstream of Tank 22 and Tank 22 was fishless. Arizona Game and Fish Department Region VI office did not have stocking records or copies of a Wildlife Holding Permit for Headquarter tank (Chris Cantrell, AGFD Region VI Fish Program Manager, personal communication, December 05, 2011). Likewise, AGFD could not locate any stocking records or Wildlife Holding Permits for tiger salamanders, which were found in nine stock tanks in the

Devils Canyon drainage, indicating that there has been illegal movement of aquatic species within the drainage.
Gila chub have not been found in any surveys in any Mineral Creek or Devils Canyon since 2000 (Robinson 2007; Robinson 2008a; Robinson et al. 2010). Some of the perennial stream sections in Devils Canyon (e.g., from Rio Rancho Creek down to Five Pools) have only been surveyed once, but in multiple surveys of the lowest section of Devils Canyon, Gila chub have never been captured. Therefore, Gila chub can probably be considered extirpated from the Mineral Creek drainage.

RECOMMENDATIONS

Efforts to reestablish Gila chub into upper Mineral Creek and in suitable portions of Devils Canyon should be continued. Following recommendations from Robinson et al. (2010), the three best choices of lineages to use would be Redfield Canyon, Hot Springs Canyon or Bonita Creek. If the entire Mineral Creek and Devils Canyon drainage above Big Box dam is to be managed for Gila chub and other native fish, then the stock tanks in the drainage containing nonnative fishes as well as the perennial portions of Devils Canyon and upper Mineral Creek (Big Box Dam to series of small natural water falls) and Big Box Dam reservoir should be renovated to prevent the reinvasion of nonnatives into the system.

Prior to the completion of the renovation, stock tanks within the Mineral Creek drainage should be surveyed and assessed for nonnative fish presence. Likewise, the three remaining stock tanks in Devils Canyon drainage should be surveyed to completely rule them out as potential sources of nonnative fishes. Headquarter tank could be further evaluated to determine if other nonnative fish (i.e., bullhead or catfish) are also present.

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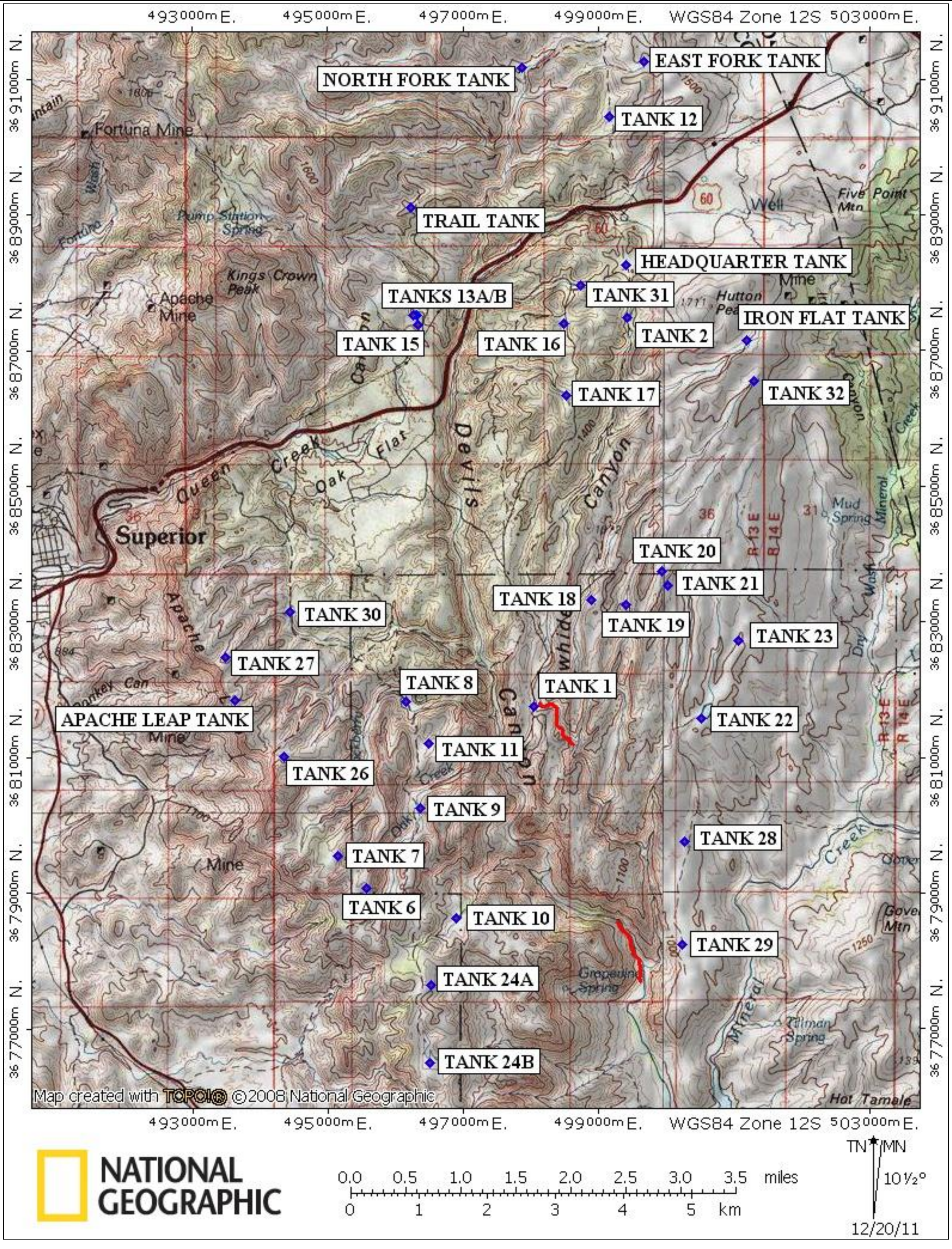

Figure 1. Map showing locations of stock tanks (blue triangles) in Devils Canyon drainage. The tanks were surveyed in 2010 and 2011. The red line located below Tank 1 in the central portion of the map is the 1 km portion of Rawhide Canyon that was surveyed on May 3, 2011. The red line in the lower right-hand portion of the map is the 1 km portion of Devils Canyon that was surveyed on June 2, 2011.

Figure 2. Photographs taken during Devils Canyon drainage stock tank surveys, 2010 and 2011. Top left: a large brachial larvae of tiger salamander. Top right: photo of Apache Trail tank, a typical stock tank. Bottom left: survey crew beginning a seine haul. Bottom right: bluegill, mosquitofish, and crayfish captured in a bag seine haul at Headquarter tank.

Table 1. Stock tank locations in Devils Canyon drainage, methods of survey, and species detected during 2010-2011. GPS coordinates are NAD83. Species codes are as follows: *Ambystoma tigrinum* AMTI, *Apalone spinifera* APSP, *Gambusia affinis* GAAF, *Lepomis macrochirus* LEMA, *Rana yavapaiensis* LIYA, *Orconectes virilis* ORVI, *Thamnophis cyrtopsis* THCY, *Trachemys scripta* TRSC.

Tank name	UTM Zone	UTM Easting	UTM Northing	Date visited	Gear/ comments	Species detected
Apache Leap tank	12S	493631	3681849	May 4, 2011	Bag seine	-
East Fork tank	12S	499668	3691252	May 16, 2011	Bag seine	GAAF, AMTI
Headquarter tank	12S	499403	3688286	May 17, 2011	Bag seine	LEMA, GAAF, ORVI, TRSC, APSP
Trail tank	12S	496227	3689116	May 3, 2011	Bag seine	AMTI
North Fork tank	12S	497862	3691181	May 16, 2011	Bag seine	-
Iron Flat tank	12S	501180	3687142	NA	Not surveyed	NA
Tank 1	12S	498048	3681746	May 3, 2011	Bag seine	-
Tank 2	12S	499420	3687490	May 4, 2011	Bag seine	-
Tank 6	12S	495572	3679069	May 4, 2011	Dipnet	-
Tank 7	12S	495145	3679552	May 4, 2011	Bag seine	-
Tank 8	12S	496149	3681830	May 4, 2011	Bag seine	-
Tank 9	12S	496371	3680246	May 4, 2011	Bag seine	AMTI
Tank 10	12S	496892	3678627	May 3, 2011	Dry	-
Tank 11	12S	496491	3681201	May 4, 2011	Bag seine	AMTI
Tank 12	12S	499160	3690444	May 16, 2011	Bag seine	AMTI
Tank 13A	12S	496304	3687523	May 3, 2011	Bag seine	AMTI
Tank 13B	12S	496258	3687512	May 3, 2011	Bag seine	AMTI
Tank 15	12S	496332	3687388	May 3, 2011	Dry	-
Tank 16	12S	498479	3687404	May 3, 2011	Bag seine	AMTI
Tank 17	12S	498512	3686340	May 3, 2011	Bag seine	AMTI, RAYA
Tank 18	12S	498891	3683325	July 6, 2010	Bag seine	AMTI
Tank 19	12S	499390	3683248	July 6, 2010	Bag seine	-
Tank 20	12S	499922	3683748	July 7, 2010	Dry	-
Tank 21	12S	500008	3683540	July 7, 2010	Bag seine	THCY
Tank 22	12S	500506	3681580	July 7, 2010	Bag seine	RAYA
Tank 23	12S	501051	3682713	NA	Not surveyed	NA
Tank 24A	12S	495145	3677638	July 6, 2010	Dry	-
Tank 24B	12S	496504	3676501	July 7, 2010	Dry	-
Tank 26	12S	494346	3681014	July 8, 2010	Bag seine	-
Tank 27	12S	493482	3682478	May 4, 2011	Bag seine	-
Tank 28	12S	500262	3679749	July 7, 2010	Bag seine	RAYA
Tank 29	12S	500229	3678238	July 7, 2010	Bag seine	-
Tank 30	12S	494440	3683152	May 4, 2011	Bag seine	-
Tank 31	12S	498734	3687969	May 4, 2011	Bag seine	ORVI, AMTI
Tank 32	12S	501289	3686552	NA	Not surveyed	NA

Table 2. Summary of fish captured and catch rates during the June 2, 2011 fish survey of Devils Canyon, Arizona, showing for each gear type: total number of individuals captured, number of sampling efforts, mean catch-per-unit-effort, and standard error of the mean catch rate. Catch rates for the electrofishing are the number of individuals (Ind) captured per minute electrofished and for trapping are the number of individuals captured per hour.

Gear type	Statistic	Green sunfish	Crayfish	Total
Electrofishing	#Individuals	137	1	138
	#Efforts	3	3	3
	Mean #Ind/min	22.05	-	22.05
	SE±	(6.23)	-	
Mini hoop	#Individuals	139	-	139
	#Efforts	6	6	6
	Mean #Ind/h	10.19	-	10.19
	SE±	(1.23)	-	(1.23)
Table Total	#Individuals	276	1	277

Table 3. Summary of results of the stock tanks containing fish and crayfish during the 2010 and 2011 stock tank in Devils Canyon drainage, Arizona.

Stock tank	Gear type	Statistic	Bluegill	Mosquitofish	Total Fish	Crayfish
East Fork tank	Bag seine	#Individuals	-	2094	2094	-
		#Efforts	-	3	3	
		Mean #Ind/m²	-	6.71	6.71	
		SE±	-	(1.23)	(1.23)	
Headquarter tank	Bag seine	#Individuals	2207	488	2695	45
		#Efforts	3	3	3	3
		Mean #Ind/m²	3.17	0.79	3.96	0.06
		SE±	(1.01)	(0.52)	(1.04)	(0.03)
Tank 31	Bag seine	#Individuals	-	-	-	1
		#Efforts	-	-	-	1

Table 4. Water quality characteristics measured in the two stock tanks that contained fish in Devils Canyon drainage, 2010-2011.

Site name	Date	Water temp. (C)	Dissolved oxygen (mg/L)	pH	Conductivity (µS)	Total dissolved solids (mg/L)	Salinity (ppm)
East Fork Tank	05/04/2011	21.9	5.57	7.33	83.5	81.8	58.8
Headquarter Tank	05/16/2011	22.8	11.18	8.45	66.1	47.8	31.8