Radio Telemetry-Movement Study of Brown Trout in Rush Creek

Prepared for Los Angeles Department of Water and Power

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Introduction

In 2005 a movement study of brown trout in Rush Creek was initiated. The purpose of this study was to document the seasonal movement patterns and corresponding habitat occupied by brown trout in the Rush Creek system between Grant Reservoir and Mono Lake, including the Mono Gate One Return Ditch (MGORD). The MGORD is a low-gradient trapezoidal canal that carries Rush Creek water from Grant Reservoir downstream to the natural channel which is located approximately 1.4 miles below the upper end of the MGORD. The MGORD consists of deep, slow glide and pool habitats with extensive beds of aquatic vegetation. Within the lower 1,200 ft of the MGORD a series of boulder grade-control weirs step the canal down to its confluence with Rush Creek's natural channel. These weirs also retain ample amounts of suitable sized spawning substrate.

The movement study data were also used to develop adult brown trout winter holding criteria for habitat mapping during the Rush Creek Instream Flow Study (IFS). Data generated by the movement study will also add to the information base necessary to establish realistic and sustainable termination criteria for Rush Creek. Study objectives included:

Objective (A): Document movement patterns of -

(1) Large adult brown trout (≥age 3+ and >640 g in weight) implanted with radio transmitters in the MGORD during September 2005 and 2006 to determine if these fish seasonally utilized other reaches of Rush Creek.

(2) Adult brown trout (age 2+ and between 180 - 225 g) and juveniles (age 1+/2 between 85 - 105 g) implanted with radio transmitters in sections of Rush Creek during September 2005 to determine if these fish made seasonal migrations or moved upstream into the MGORD.

Objective (B): Document habitat occupied by radio-implanted adult and juvenile brown trout in Rush Creek -

(1) During all seasons and hydrologic periods, determine how (or if) habitat occupied by the tagged fish changed throughout the year. Particular emphasis was placed on documenting the habitat occupied by adult brown trout and secondarily the survival of juvenile brown trout before, during and after winter (ice) conditions as well as before, during and after the spring runoff (high stream discharge) period.

(2) During brown trout spawning in October – December, determine the locations and habitat characteristics of the most heavily-used spawning areas.

(3) After the spawning period, document the characteristics of brown trout winter holding habitat. This information was utilized to develop measureable criteria for the Rush Creek IFS.

Literature Reviews

Brown Trout Radio Telemetry Studies and Movement Patterns

Radio telemetry has been used by numerous researchers to document the movements of trout with surgically implanted transmitters (Clapp et al. 1990; Meyers et al. 1992; Brown and MacKay 1995; Jakober et al. 1998; Meka et al. 1999; Burrell et al. 2000; Hilderbrand and Kershner 2000; Schmetterling 2001; Bettinger and Betolli 2004; Diana et al. 2004; James et al 2007; Monnot et al. 2008). Various study objectives have included: effects of body size on distance, rate and final destination of migration (Monnot et al. 2008); effects of migration barriers and development of system-wide management plans (Meyers et al. 1992); investigations of diurnal aspects of movement (Diana et al. 2004); and determination if establishment of special-regulation fishing reaches was a viable management option to reduce mortality of large brown trout (Bettinger and Betolli 2004). Depending on study objectives, the frequency of relocation events may vary from daily (Diana et al. 2004), weekly (Burrell et al. 2000; Hilderbrand and Kershner 2000; Monnot et al. 2008), bi-monthly (Bettinger and Betolli 2004), or less frequently (Meka et al. 1999). Diana et al. (2004) also made hourly relocations for 36 days continuous days to closely examine the diel activity of three radio-tagged brown trout.

Previous movement studies of stream-dwelling brown trout have suggested that smaller fish (<400 mm) are largely residential, with limited long-range movements (Shetter 1968; Jenkins 1969; Bachman 1984; Ovidio et al. 2002). Shetter (1968) reported that movements of brown trout larger than 13 inches in length were significantly greater than smaller trout. Larger brown trout tend to be more nomadic, including long-range displacements, often occurring at night (Clapp et al. 1990; Young 1999; Diana et al. 2004). Nocturnal movements have been associated with high-levels of dusk and dawn foraging, followed by individual fish returning to a specific home site the following day (Clapp et al. 1990; Young 1999). Meyers et al. (1992) reported that their tagged brown trout were relatively sedentary during the summer months, making night-time foraging movements of less than one mile and generally returning to the same pools for daytime holding. Some large brown trout were shown to have multiple home sites and used these same locations consistently over multiple seasons (Diana et al. 2004).

Most brown trout movement studies have documented fall into early winter as the period of greatest movement, most likely for spawning purposes (Solomon and Templeton 1976; Clapp et al. 1990; Meyers et al. 1992; James et al. 2007). For example, in the South Branch of the Au Sable River the mean displacement distance between relocations of eight radio tagged brown trout during spring-summer months was 239 m, whereas the same fish had a mean displacement distance of 3,013 m during autumn-winter relocations (Clapp et al. 1990). Burrell et al. (2000) reported that brown trout moved an average of 2,091 m (≈6,800 ft) during spawning and most fish returned to their pre-spawning locations within a few days post-spawning. Meyers et al. (1992) reported the greatest movement of large brown trout occurred during the fall spawning period; however their study fish also made fairly large upstream migrations in the spring which were attributed to rising water temperatures. Similarly, James et al (2007) reported the greatest gross movement of radio-tagged brown trout occurred in the fall, in an upstream direction and that post-spawn fish moved back to within a few meters of their pre-spawn locations. James et al (2007) also reported extensive movements during the spring, but these occurred in a downstream

direction in their study watershed, Rapid Creek within the City limits of Grand Rapids, North Dakota.

Brown Trout Winter and Holding Habitat Preferences

In his comprehensive evaluation of habitat selection by resident brown trout populations native to streams in Norway and Scotland, Heggenes (2002) found that macrohabitats favored by juvenile and adult brown trout were deep and slow-flowing pool areas. More specifically, quoting Heggenes, "On a microscale, however, the niche selected was rather narrow (i.e., brown trout occupied holding positions in slow-flowing water, usually in association with the riverbed)". When defining "association with the riverbed", he reported that the holding positions of nearly all brown trout observed during snorkeling surveys were within 0-15 cm (0-6 in) of the stream bottom, regardless of water column depth.

During our 2002 and 2008 pool surveys on Rush Creek, many larger pools with excellent depth and cover components were found to have mean water column velocities ranging from 1.0 to 1.5 ft/s (Hunter et al. 2009). Flows in Rush Creek during the 2002 pool survey varied between 50 and 92 cfs; whereas during the 2008 pool survey flows varied between 42 and 73 cfs. Heggenes found that brown trout essentially avoided areas with water velocities >1.5 ft/s. He further found that very few fish (only 3.9% of those fish observed during his study) selected holding positions where water column velocities were greater than 30 cm/s (1.0 ft/s), even though habitats with water velocities >1.0 ft/s were abundant in the streams he studied. Heggenes (2002) also observed that most brown trout (48.6%) selected holding positions where water velocities ranged from 0-10 cm/s (0-0.3 ft/s).

Finally, Heggenes (2002) noted that the brown trout populations that he studied clearly exhibited "size structured habitat use"; i.e., there was a distinct pecking order wherein the largest fish occupied the most suitable habitats and progressively smaller fish were forced to occupy increasingly less suitable sites. Again, quoting Heggenes (2002), "Smaller fish more often held positions close to the bottom in slower, shallower water with less cover, typically along the stream banks". During ten years of electrofishing and snorkeling surveys on Rush Creek, similar hierarchical habitat use by brown trout has been noted, with juvenile fish primarily occupying the shallower areas of runs and pools, while the majority of fry were found in riffle habitats and along the margins of pools and runs (Hunter et al. 2000-2009).

Similar brown trout habitat preferences have also been reported by a number of other researchers when focal point velocities were measured. Adult brown trout's preference for direct overhead cover was another consistent theme found throughout the published literature.

Cunjak and Power (1986) examined habitat utilization by brook trout (*Salvelinus fontinalis*) and brown trout during three winters of underwater observations in the Credit River, located in southern Ontario. In winter, at sites of sympatry, brown trout occupied greater focal point water depths than brook trout; however both species had similar average focal point water velocities (0.18 ft/s in the Spring tributary and 0.56 ft/s in the North Branch). At all sites, and for both age groups and species, there was a strong preference for positions beneath cover. Relative to summer, trout positions in winter were characterized by slower water velocities and greater overhead cover. In winter, most trout were in aggregations, usually in pools beneath cover and close to point sources of groundwater discharge. Gregarious behavior appeared to increase as

water temperatures decreased; no such relationship was evident in the summer. Specific strategies for overwintering varied between sites and age groups but generally conformed to the theory of energetic cost minimization for position choice.

Greenberg et al. (1996) studied the microhabitat preferences of brown trout and grayling in the upper portion of the River Vojmån, northern Sweden in 1990-1993. Summer microhabitat preference was quantified for open water fish during the day and at dusk and for fish residing under stones during the day. In total, measurements were made for 665 trout and 230 grayling, ranging in size from 2.5 to 50 cm total length. Relationships were found between most microhabitat variables and fish length. All size classes of brown trout preferred waters with low current velocities, generally less than 10 cm/s (0.33 ft/s). However, medium to large sized trout did not show as strong avoidance of fast currents as smaller trout.

Raleigh et al. (1986) included an extensive literature review of brown trout habitat preferences during their development of habitat suitability index models and instream flow suitability curves for brown trout. In describing "fish nose" velocities, Raleigh et al (1986) stated that velocity preferences of adult brown trout in other studies ranged from 0.0 to 0.7 ft/s for resting fish and 0.5 to 1.5 ft/s for feeding. Cover was considered an essential component of viable trout streams and adult brown trout seek cover more than any other trout species (Raleigh et al. 1986). In winter, brown trout showed a strong hiding or cover response and sought deep, low-velocity areas associated with cover (Hartman 1963 in Raleigh et al. 1986).

Meyers et al. (1992) monitored four radio-tagged brown trout during most of the winter period on the Beaver Creek watershed in northeast Wisconsin. Winter sites for these trout were in five different pools with average depths of 2.4 ft. bottom substrate was either sand or rubble/boulder in two pools. The mean nose velocity in the sites was 0.5 ft/sec (range = 0.1-0.9 ft/sec) within pockets of slower water associated with boulders or sandbars. Most "active" fish were positioned in mid-stream areas, but the pools were covered with ice for most of the winter period.

Clapp et al. (1992) reported that large brown trout in the South Branch of the Au Sable River selected areas with water velocities less than 10 cm/s, logs or over-hanging cover, and water depths greater than 30 cm. Their radio-tagged brown trout used the deepest parts of the river for daytime refuge sites and rarely moved to alternate refuge sites during daylight hours.

Methods and Materials

All tags and tracking equipment were purchased from Lotek Wireless Inc. located in Ontario, Canada. For the initial round of surgeries in 2005, a total of 60 tags were purchased, in three different sizes (Table 1). Tags were divided among four radio frequencies (148.400, 148.440, 148.640, 148.660 MHz) and a unique code number identified each tag. To further extend the battery life of the smallest tags (NTC-4-2L) the pulse rate was set for 10 seconds (Table 3). In 2006, an additional 40 tags (20 MCFT-3A and 20 NTC-6-2) were purchased to implant primarily in brown trout residing in the MGORD section of Rush Creek. The NTC-6-2 tags ordered in 2006 were custom-programmed to extend their battery life from 416 days to 641 days.

Fish selected for surgery were captured during our annual population estimation electro-fishing sampling period in mid-September. Radio tags were surgically inserted into the peritoneal cavity generally following techniques described by Schmetterling (2001). To reduce surgery time and risk of infection, surgical staples were utilized instead of sutures to close incisions (Swanberg et al. 1999). Surgeries typically required one to three minutes to complete (from initial incision to closure). After surgery, fish were placed in a nine gallon plastic tote (drilled with holes for circulation) within the creek and then released when they appeared fully recovered. Recovery times were relatively quick, generally less than ten minutes.

Table 1. Specifications of 60 Lotek Wireless Inc. tags purchased for the Rush Creek brown trout movement study, 2005.

LOTEK Tag Model	Air Weight (grams)	Duty Cycle (hours)	Signal Burst Interval (seconds)	Operational Life (days)	Minimum Weight Range of Fish (g)
MCFT-3A	16.0	24	5	761	640-800
NTC-6-2	4.5	12	5	416	180-225
NTC-4-2L	2.1	12	10	299	85-105

Radio-tagged brown trout were relocated with two receivers, the first being an SRX 400A W7A fixed-station receiver/data logger located at the downstream end of the MGORD. This fixed station was comprised of two, AN-4YG-150 antennas routed into an ASP-8 switch box attached to the receiver. This receiver was powered by three deep-cycle 12-volt batteries (size = 27 group) wired to a solar panel (Figure 1). The receiver and batteries were locked in a waterproof steel cylinder to protect them from theft and weather (Figure 1). The antennas were installed with one facing upstream approximately 225 feet from the receiver (Figure 2) and one facing downstream approximately 25 feet from the receiver (Figure 3). The upstream antenna was located around a bend in the channel to reduce the back-signal which would occur if the antenna array was set-up along a straight channel reach. This isolation of the antennas produced a much more interpretable data set of fish "hits" that allowed us to easily determine the direction of movement. Due to a greater length of coaxial cable the upstream antenna was set at a gain of 40, whereas the lower antenna was set at a gain of 0. The spread of the antennas enabled identification of which direction a tagged fish was moving, dependant on which antenna initially detected signals and changes in signal strength. The antenna array was initially tested by a crew member walking two enabled tags through the array while a second crew member observed the receiver and recorded signal strengths from the antennas when the tags were at specific locations.

The fixed station provided continuous, 24-hour tracking of individual fish movements into or out of the MGORD for all the large brown trout equipped with MCFT-3A transmitters. The SRX 400A W7A fixed-station receiver/data logger was programmed to scan each of the four radio frequencies for 11 seconds on each antenna, separately, starting with the upstream antenna and then cycling to the lower antenna. However, potential movements of smaller fish (implanted with NTC-6-2 and NTC-4-2L tags) into or out of the MGORD was not as thorough due to the twelve-hour off/on duty cycles of these transmitters.

Figure 1. Solar panel and fixed station receiver location at lower end of the MGORD in September, 2005.

Figure 2. Upstream antenna location of fixed station receiver at lower end of the MGORD in September, 2005.

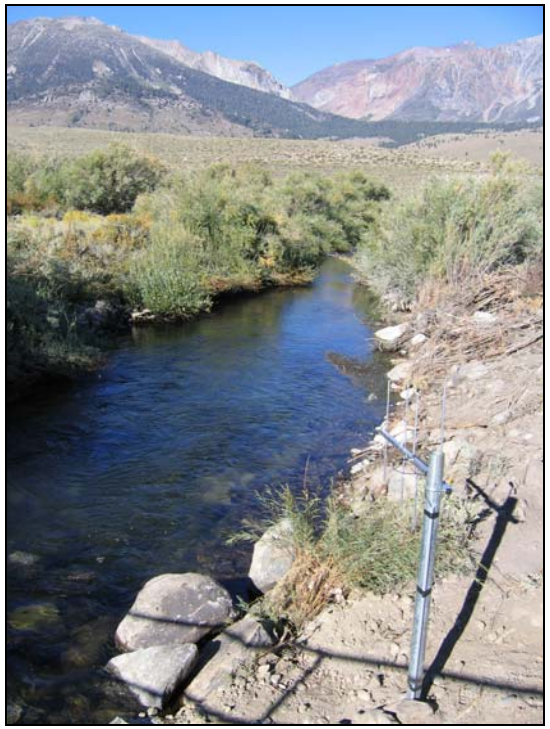

Figure 3. Downstream antenna location of fixed station receiver at lower end of the MGORD in September, 2005.

All radio-tag recapture events recorded by the fixed-station receiver's data logger recorded both the date and time, thus the duration of fish movements through the antenna array was captured. Data stored in the receiver were retrieved on a monthly basis using Lotek's WinHost Version 4.324 program on a laptop computer. After WinHost captured these data, they were converted into Excel spreadsheets for analysis.

The second receiver was an SRX 400W5XG mobile receiver. This receiver utilized an F150-3-FB hand-held antenna to relocate tagged brown trout to specific habitat locations throughout Rush Creek. A two-person crew manually relocated tagged fish. One person operated the receiver and completed the field data form, while the second crew member carried a flow meter, GPS unit, and measuring rod and measured habitat variables and took latitude/longitude readings. Manual relocations generally comprised the following steps:

1. Started relocation at the upstream end of the reach to be surveyed. Next, conducted a four-channel scan at a high gain (≥40) in both directions (upstream and downstream) to determine which channel/frequency was closest.

2. Set receiver to the appropriate channel and kept gain at a high setting. Adjusted receiver to display signal strength and code number. Walked in the direction of the signal and confirmed increase in signal strength.

3. When signal strength increased to a range of 210-238, reduced gain and proceeded towards signal.

4. Attempted to relocate fish on a gain of 20 or less. Locations were fine-tuned by aiming antenna at specific locations and holding steady until a new power reading was displayed. Fish was relocated to point of the highest power reading.

5. Once a tagged fish was relocated to a specific spot the person operating the receiver would hold the antenna steady as the second crew member waded to the spot and attempted to make the relocated fish move by poking around with the measuring staff or with their feet. This procedure was done to assess if a tagged fish was alive or dead. If a tagged fish was spooked and moved, the power reading on the receiver dropped. The receiver operator would then attempt to determine if the fish moved upstream or downstream. Whether a fish moved, or not, was noted in the data sheet's "comments" column.

6. Data collected for each relocated fish included: date, time of relocation, tag code #, power and gain, habitat type (pool, riffle, run), depth (to 0.1 ft), velocity at 0.6 of total depth (to 0.1 ft/sec.), and velocity at 0.9 of total depth. Velocities were measured with a Marsh-McBirney Flo-mate using the integrated "real-time averaged" setting in which velocities were continuously measured and an average value was computed every ten seconds (Figure 4). The latitude and longitude were measured with a handheld GPS unit in decimal-degrees and WGS84 datum at the relocation spot. Accuracy of the GPS reading was typically ±10-25 feet.

7. Distance to various cover types was measured to the nearest 0.1 ft and included: bubble curtain, over-hanging vegetation, undercut bank (depth of undercut also measured),

woody accumulation, root wad, large rock, submerged vegetation, and depth >3.0 ft. Maximum distances measured were up to 10.0 ft, but cover type was noted up to 20 ft if present within the habitat unit.

8. If a fish moved prior to us establishing its focal location within a habitat unit, we did not measure depths, velocities, or distances to cover.

Movements of large brown trout tagged in the MGORD were evaluated by measuring the distance between consecutive relocations. GPS coordinates from manual relocations were plotted onto digitized USGS topographic maps and distances were measured to the nearest 25-foot increment using the Maptech-Terrain Navigator® mapping software. When a tagged fish was detected by the Fixed Station array, the date of detection and the Fixed Station's lat/long coordinates were used in determining movement. Total, or gross, movement was defined as the sum of all recorded distances moved by an individual fish during its tracking period regardless of upstream or downstream direction (Brown et al. 2001; James et al. 2007). Total movements were calculated to evaluate differences in an individual fish's activity between spawning season (October – December) and the post-spawning period (January – May).

Figure 4. Velocity measurement at Code 48's focal location in Lower Rush Creek on 1/27/06.

Results

In September of 2005, radio tags were implanted in a total of 54 brown trout (Table 2). Fourteen tags (model MCFT-3A) were deployed in larger brown trout captured in the MGORD on September 9th. Fifteen tags (one MCFT-3A, seven NTC-6-2's and seven NTC-4-2L's) were deployed in the Upper Rush section on September 13th. Eleven tags (five NTC-6-2's and six NTC-4-2L's) were deployed in the County Road Rush section on September 14th. Thirteen tags (eight NTC-6-2's and five NTC-4-2L's) were deployed in the Lower Rush section on September 15th. The final tag deployed (model MCFT-3A) was on September 16th in a large male brown trout captured between the County Road and Lower Rush sections. Immediate post-surgery mortality occurred on one fish that was found dead the day after surgery (Code 17).

In September of 2006, radio tags were implanted in a total of 29 brown trout (Table 3). Twenty-seven of these tags were implanted in fish captured in the MGORD and two tags were implanted in large brown trout captured just upstream of the County Road Ford. Within the MGORD, nine large tags were deployed and 18 medium-sized tags were deployed (Table 3).

Table 2. Specifications of 54 Lotek Wireless Inc. tags deployed in September 2005 for the Rush Creek brown trout movement study.

LOTEK Tag Model	Air Weight (grams)	Duty Cycle (hours)	Signal Burst Interval (seconds)	Operational Life (days)	Minimum Weight Range of Fish (g)
MCFT-3A	16.0	24	5	761	640-800
NTC-6-2	4.5	12	5	416	180-225
NTC-4-2L	2.1	12	10	299	85-105

Table 3. Specifications of 29 Lotek Wireless Inc. tags deployed in September 2006 for the Rush Creek brown trout movement study.

LOTEK Tag Model	Air Weight (grams)	Duty Cycle (hours)	Signal Burst Interval (seconds)	Operational Life (days)	Minimum Weight Range of Fish (g)
MCFT-3A (11 tags)	16.0	24	5	761	640-800
NTC-6-2 (18 tags)	4.5	12	5	416	180-225

Fourteen relocation surveys occurred between September 2005 and March 2008, with a majority of the effort (eight surveys) occurring within the first year of the study (Table 4). The first sampling episode involved learning to use the manual receiver, assessing post-surgery survival, and refining methods for measuring habitat variables. The remaining sampling episodes occurred during 13 distinct time periods covering all major seasons and hydrological events (Table 4). The Fixed Station receiver was downloaded 11 times; however a partial loss of the data set occurred during the September 2006 download.

Table 4. Dates of Rush Creek brown trout movement study relocation surveys, fixed station downloads and seasonal objectives.

Relocation Date	Objectives of Relocation Survey
September 19-21, 2005	Learned proper use of radio-tracking equipment. Assessed post-surgery survival. Fine-tuned habitat measurement protocol. Documented habitat occupied by brown trout during late summer.
October 17-20, 2005	Documented movement of brown trout just prior to, or during early part of spawning season to assist in identifying important spawning habitats.
November 14-17, 2005	Documented movement of brown trout during spawning season to assist in identifying important spawning habitats. Downloaded fixed station receiver.
December 14-17, 2005	Documented post-spawn movement of mature brown trout. Documented winter habitats occupied by brown trout. Downloaded fixed station receiver.
January 25-28, 2006	Documented winter habitat areas occupied by brown trout. Downloaded fixed station receiver.
March 12-15, 2006	Documented the occupied habitat and survival rates of brown trout after ice-out.
May 13-16, 2006	Determined how or if occupied habitat changed prior to snowmelt runoff conditions. Downloaded fixed station receiver.
September 2006	Downloaded Fixed Station receiver.
December 4-6, 2006	Relocated fish in MGORD and in the reach from the MGORD downstream to Highway 395. Downloaded Fixed Station receiver.
February 2007	Relocated fish in MGORD and in the reach from the MGORD downstream to County Road culvert. Downloaded Fixed Station receiver.
May 2007	Relocated fish in MGORD and in the reach from the MGORD downstream to County Road culvert. Downloaded Fixed Station receiver.
September 2007	Relocated fish in MGORD and in the reach from the MGORD downstream to Highway 395. Downloaded Fixed Station receiver.
January 21-23, 2008	Relocated fish in MGORD and in the reach from the MGORD downstream to Highway 395. Downloaded Fixed Station receiver.
March 2008	Relocated fish in MGORD and in the reach from the MGORD downstream to Highway 395. Downloaded Fixed Station receiver.

Movements of Large Brown Trout Tagged in the MGORD in September 2005

Fourteen tags were implanted in MGORD brown trout on 9/09/05. Ten days later we conducted a relocation survey which determined that the 13 tagged fish still alive (one found dead on 9/10) had re-distributed from 25 ft to 825 ft away from post-surgery release locations (Table 5). Seven of the 13 (54%) tagged fish migrated downstream out of the MGORD in October-December 2005 during the season when brown trout typically spawn. The distance traveled downstream from the MGORD by these seven fish ranged from 4,450 ft to 24,475 ft (Table 5). The length of time spent downstream of the MGORD by five of these seven fish ranged from seven days to six months, and two fish never returned to the MGORD.

Four of the seven fish that left the MGORD on downstream migrations were female brown trout. Two of these fish (Codes 21 and 23) conducted relatively quick downstream migrations to spawning areas and returned immediately to the MGORD (Table 5). From her pre-spawning location in the MGORD on October 17th to her post-spawning location in the MGORD on December 14th, Code 21's total (or gross) movement was 20,450 ft (Figure 5). Code 21 left the MGORD for a total of 10 days and in that time-span travelled 6,675 ft downstream, spawned, and travelled 6,675 ft back up to the MGORD. On December 14th she was located another 2,650 ft upstream of the Fixed Station and stayed in this location through March of 2006 (Table 5 and Figure 5). Between December 14, 2005 and May 13, 2006 Code 21's total movement was 1,650 ft (Table 5). Code 21 was killed by a fisherman in the MGORD shortly after our mid-May relocation. The fisherman called the DWP phone number on the tag and mailed the tag to DWP's Bishop Office.

Code 23's total movement between October 17th and December 14th was 19,800 ft (Table 5). Code 23 left the MGORD for 14 days and in that time-span travelled 6,200 ft downstream, spawned, and travelled 6,200 ft back up to the MGORD (Table 5). On our November 16th relocation we made visual contact with Code 23 in a lateral scour pool that had several freshly constructed redds at the tail-out. On December 14th she was located another 3,800 ft upstream of the Fixed Station (Table 5 and Figure 6). Between December 14, 2005 and May 13, 2006 Code 23's gross movement was 1,675 ft (Table 5). Code 23 died during our September 2006 electrofishing.

The third female fish (Code 22) left the MGORD on October 16, 2005, but we failed to relocate her during the November and December relocations. Finally, on January 27, 2006 we relocated the tag at the parking area at the Lower Rush Creek annual sampling site; however we were unable to find the tag because it was buried in snow. We marked the location with a piece of orange surveyor's flagging and retrieved the tag on the March 12, 2006 relocation survey when the snow had melted. We suspect that Code 22 was also killed by a fisherman due to the location of tag, approximately 300 ft from the channel and right next to the parking area.

The fourth female (Code 25) made the latest movement out of the MGORD, passing through the Fixed Station array on December 1, 2005 (Table 5). She was relocated on December 16th, 9,450 ft downstream of the Fixed Station in the braided channel reach upstream of the Old Highway 395 Bridge (Table 5). Code 25 remained in or near the braided channel reach in January through March. She then migrated back to the MGORD in the spring, passing through the Fixed Station array on April 22, 2006 and travelling another 4,175 ft upstream to her May 13th location (Table 5). Code 25's total movement between November 16th and December 16th was 13,550 ft; and her

total movement between November 16, 2005 and May 13, 2006 was 27,325 ft (Table 5). Between December 16, 2005 and March 15, 2006 Code 25's total movement was only 825 ft (Table 5).

In contrast to the extensive migrations made by Codes 21, 22, 23, and 25; Code 19 was a sedentary female fish that moved upstream 525 ft in the 10-day period post-surgery and then never moved more than 75 ft on subsequent relocations. Between September 9, 2005 and May 13, 2006 Code 19's total movement was only 700 ft (Table 5). We had considered Code 19 as a probable mortality until we had confirmed upstream movement on the January and May 2006 relocations.

The farthest ranging male brown trout tagged in the MGORD was Code 14 who made an extensive downstream migration, but never returned to the MGORD. Code 14's total movement between October 17th and December 17th was 24,475 ft, all in a downstream direction (Table 5). He was confirmed alive on May 16, 2006 in the channel reach within the gravel extraction plant located upstream of the Narrows (Table 5). Code 14 was relocated on December 6, 2006 and was classified as a suspected mortality because the tag appeared to be buried in leaf litter and fine substrate within a side-channel located 7,125 ft downstream from its previous location (Table 5).

Interestingly, five of the six brown trout that stayed within the MGORD during the 2005 spawning season were males. Based on our monthly relocations Codes 12, 16, 20, and 24 all exhibited limited total movements; moving a total of 1,825 ft, 500 ft, 1,025 ft, and 2,250 ft; respectively (Table 5). Code 27 never moved downstream out of detection range of the Fixed Station antenna array; however this large male brown was quite active during the fall spawning period based on numerous detections recorded by the Fixed Station receiver (Table 5). In 2005 from October 9th to November 11th, Code 27 was periodically within detection of the Fixed Station's upper antenna, with an occasional hit on the downstream antenna. Code 27's longest consecutive days of being detected by the upper antenna were eight days on October 9th-16th. On October 17th we relocated Code 27 2,700 ft upstream of the Fixed Station and two days later, the fish was back down within range of the upper antenna (Table 5). Almost exactly one year later, on October 8, 2006 Code 27 was detected by the upper antenna at 1:59AM and stayed within range until 6:14 AM on October 9th. Three days later, Code 27 was re-detected by the upper antenna and for the next 27 consecutive days was periodically detected by the upper antenna. During this 27-day period, detections typically started at 9:00-11:30 PM, occurred throughout the night and early morning, and then ceased by mid-morning.

During the first year of the movement study we confirmed two angling mortalities of radio-tagged fish from the MGORD which comprised 16% of our sample. The DFG fishing regulations for Rush Creek downstream of Grant Reservoir is catch-and-release only with barbless artificial lures; however this regulation is loosely interpreted by some fishermen and possibly wardens to start at the natural channel downstream of the spillway. We recommend that the DFG regulations are modified to clearly state that the MGORD is, in fact, Rush Creek downstream of Grant Reservoir.

Five of the fish MGORD radio-tagged in 2005 were recaptured during the September 2006 sampling efforts. All five fish were longer and heavier, suggesting that the effects of radio-tagging were minimal. The range of length gain was five to 23 mm and the range weight gain was 12 to 445 g.

Table 5. Relocation summaries of brown trout radio-tagged in the MGORD in Sept-05.

Fish Code #, Sex, Length, and Weight	Date of Relocation	Lat/long of Relocation	Distance from Previous Relocation	Summary of Movement Activities
Code 12 – Male 508 mm and 1,118 g	Tag Release	37.86671 119.09378	--	Consistent up and down movement patterns ranging over several hundred ft of MGORD from Sept-05 through May-06. The fish appeared very skinny when visually sited on 5/13/06. Left MGORD sometime during summer of 2006. Code 12 was relocated in the gorge about 500 ft above the sheepherder's cabin in same pocket pool during both Dec-06 and Feb-07. Possible post-spawning MORT. Signal moved on Dec-06 relocation, but not on Feb-07. *Fish definitely moved in upstream direction.
	Sept-19-05	37.86578 119.09328	275 ft upstream	
	Oct-17-05	37.86656 19.09492	700 ft downstream	
	Nov-14-05	37.86613 119.09353	450 ft upstream	
	Dec-14-05	37.86514 119.09231	400 ft upstream	
	Jan-25-06	37.86533 119.09306	50 ft downstream	
	March-13-06	37.86484 119.09340	200 ft upstream	
	May-13-06	37.86491 119.09336	<25 ft – fish was obs. alive	
	Dec-5-06	37.87679 119.10792	9,875 ft Downstream	
	Feb-07	37.87676 119.10796	<25 ft	
	May-1-07	37.87676 119.10776	<25ft*	
Code 14 – Male 465 mm and 925 g	Tag Release	37.86670 119.09570	--	Code 14 left the MGORD on 10/27/05 and never returned. Spent Dec-05 through at least May-06 in vicinity of gravel operation upstream of the Narrows. Exhibited definite upstream movement when relocated on 5/16/06. Signal was relocated downstream of the Narrows on Dec-06 in a side-channel location. Tag appeared to be buried within the substrate in a shallow side-channel. Probable MORT during 2006 runoff.
	Sept-19-05	37.86447 119.09350	750 ft upstream	
	Oct-17-05	37.871897 119.09833	3,800 ft downstream	
	Oct-27-05 at Fixed Station	37.86974 119.10425	2,750 ft downstream	
	Nov-05	Weak signal u.s. of Narrows	--	
	Dec-17-05	37.90427 119.08395	17,925 ft down-stream	
	Jan-27-06	Weak signal u.s. of Narrows	--	
	March-13-06	37.90419 119.08394	50 ft upstream of 12/17/05	
	May-16-06	37.90418 119.08391	<25 ft from 3/13/06 loc.	
	Dec-6-06	37.91943 119.07333	7,125 ft downstream	

Table 5. Relocation summaries of brown trout radio-tagged in the MGORD in Sept-05.

Fish Code #, Sex, Length, and Weight	Date of Relocation	Lat/long of Relocation	Distance from Previous Relocation	Summary of Movement Activities
Code 15 – Male 515 mm and 1,375 g	Tag Release	37.86650 119.09289	--	Code 15 was in and out of detection range of upper antenna array from 10/02/05 through 10/22/05. Relocated 1,200 ft upstream of upper antenna on 10/17/05. *Fish then went downstream of lower antenna from 10/22-10/29/05; location was unknown for this seven-day period. Fish then traveled upstream through the array and beyond detection of the upper antenna on 10/29/05. Returned during the 2006 spawning season and was within the two antennae from 10/20/06 through 11/14/06.
	Sept-19-05	37.86581 119.09331	225 ft upstream	
	Oct-2-05 at Fixed Station	37.86974 119.10425	6,000 ft downstream	
	Oct-17-05	37.87188 119.10261	1,200 ft upstream	
	Oct 18-22-05 Fixed Station	37.86974 119.10425	1,200 ft downstream	
	Oct-29-05 at Fixed Station	37.86974 119.10425	<25 ft*	
	Nov-14-05	37.86665 119.09635	5,000 ft upstream	
	Dec-14-05	37.86914 119.09611	1,125 ft downstream	
	Jan-25-06	37.86903 119.09708	50 ft upstream	
	March-13-06	37.86898 119.09707	25 ft downstream	
	May-13-06	37.86901 119.09708	25 ft upstream	
	Feb-07	37.86898 119.09706	--	
	April-30-07	37.86896 119.09706	<25 ft	
Code 16 – Male 532 mm and 1,850 g	Tag Release	37.866583 119.09453	--	Code 16 made consistent upstream and downstream movement patterns within a relatively short segment of the MGORD throughout the study. This fish was never detected by the Fixed Station. Code 16 made definite upstream movements on the May-06, Dec-06 and Feb-07. *During each of these relocations we were able to make the fish swim in an upstream direction, thus confirming that Code 16 was alive. **Made visual contact of fish and blue floy tag.
	Sept-19-05	Not relocated	--	
	Oct-17-05	37.866722 119.09533	500 ft downstream	
	Nov-14-05	37.86693 119.09447	<25 ft upstream	
	Dec-14-05	37.86650 119.09497	<25 ft upstream	
	Jan-25-06	37.86692 119.09669	575 ft downstream	
	March-13-06	37.86687 119.09667	<25 ft downstream	
	May-13-06	37.86722 119.09679	225 ft downstream*	
	Dec-4-06	37.86669 119.09644	200 ft upstream*	
	Feb-16-07	37.86650 119.09590	450 ft upstream*	
	April-30-07	37.86697 119.09466	375 ft upstream**	

Table 5 (con't). Relocation summaries of brown trout radio-tagged in the MGORD in Sept-05.

Fish Code #, Sex, Length, and Weight	Date of Relocation	Lat/long of Relocation	Distance from Previous Relocation	Summary of Movement Activities
Code 19 – Female – 319 mm and 332 g	Tag Release	37.86671 119.09378		The largest movement we confirmed by Code 19 was immediately after the radio tag was implanted. *We had suspected that Code 19 was dead, and then we confirmed strong upstream movements by the fish during two relocations. We also observed completed redds along the right-bank in the vicinity of Code 19's general location near the top of the MGORD.
	Sept-19-05	37.86503 119.09325	525 ft upstream	
	Oct-17-05	37.86503 119.09236	<25 ft	
	Nov-14-05	37.86488 119.09338	25 ft downstream	
	Dec-4-05	37.86494 119.09242	75 ft upstream	
	Jan-25-06	37.86490 119.09335	50 ft upstream*	
	March-13-06	37.86492 119.09333	<25 ft	
	May-16-06	37.86497 119.09330	25 ft downstream*	
	Dec-4-06	37.86491 119.09333	50 ft downstream	
	Feb-07	37.86496 119.09329	25 ft downstream	
	April-30-07	37.86486 119.09340	50 ft upstream	
Code 20 – Male 418 mm and 573 g	Tag Release	37.86717 119.09586		The largest movement we confirmed by Code 20 was immediately after the radio tag was implanted. *We were unable to make the fish move during the March and May 2006 relocations; thus the fish may have been a MORT at this time.
	Sept-19-05	37.86861 119.09692	825 ft downstream	
	Oct-17-05	37.86867 119.09594	125 ft upstream	
	Nov-14-05	37.86858 119.09683	25 ft upstream	
	Dec-4-05	37.86866 119.09594	50 ft downstream	
	Jan-25-06	37.86860 119.09687	25 ft upstream	
	March-13-06	37.86860 119.09688	<25 ft*	
	May-13-06	37.86860 119.09686	<25 ft*	
	Dec-4-06	37.86863 119.09692	25 ft upstream	
	Feb-07	37.86859 119.09690	25 ft downstream	
	April-30-07	37.86860 119.09693	<25 ft	

Table 5 (con't). Relocation summaries of brown trout radio-tagged in the MGORD in Sept-05.

Fish Code #, Sex, Length, and Weight	Date of Relocation	Lat/long of Relocation	Distance from Previous Relocation	Summary of Movement Activities
Code 21 – Female 515 mm and 1,318 g	Tag Release	37.86717 119.09586	--	Code 21 left the MGORD on 11/06/05. Relocated 11/16/05, spawning between the sheepherder's cabin and the Upper Rush efishing section. We observed a large redd at the tail of this pool. Code 21 returned to MGORD on 11/20/05. Active, generally upstream movement patterns between Dec-05 and May-05. Confirmed MORT, was poached by angler shortly after 5/16/06. Angler returned the radio tag to DWP.
	Sept-19-05	37.86758 119.09664	550 ft downstream	
	Oct-17-05	37.86769 119.09566	50 ft downstream	
	Nov-6-05 at Fixed Station	37.86974 119.10425	4,450 ft downstream	
	Nov-16-05	37.88155 119.09977	6,675 ft downstream	
	Nov-20-05 at Fixed Station	37.86974 119.10425	6,675 ft upstream	
	Dec-14-05	37.87238 119.09736	2,650 ft upstream	
	Jan-25-06	37.87230 119.09824	50 ft upstream	
	March-13-06	37.87223 119.09889	150 ft upstream	
	May-13-06	37.86804 119.09653	1,450 ft upstream	
Code 22 – Female 444 mm and 442 g	Tag Release	37.869 119.096111	--	Code 22 made an initial upstream movement after having the radio tag surgically implanted. This fish then migrated downstream out of the MGORD on Oct-16-05. We failed to locate Code 22 on the next two relocations. *The tag was found next to the parking area near the Lower Rush sampling section about 300 ft from the stream channel– we suspect the fish was caught and kept by a fisherman who cleaned the fish and discarded the guts and tag at the parking area.
	Sept-19-05	37.867138 119.096833	725 ft upstream	
	Oct-16-05 at Fixed Station	37.86974 119.10425	4,650 ft downstream	
	Nov-05	Not Relocated	--	
	Dec-05	Not Relocated	--	
	Jan-27-06	**MORT –** relocated to Lower Rush*	--	
	March-12-06	**MORT -** recovered tag on 3/12/06*	--	

Table 5 (con't). Relocation summaries of brown trout radio-tagged in the MGORD in Sept-05.

Fish Code #, Sex, Length, and Weight	Date of Relocation	Lat/long of Relocation	Distance from Previous Relocation	Summary of Movement Activities
Code 23 – Female 338 mm and 392 g	Tag Release	37.86900 119.09611	--	Fish made limited movements within MGORD after radio tag was implanted. Code 23 left the MGORD on 11/05/05. She was relocated on 11/16/05, spawning just upstream of the Upper Rush efishing section. Code 23 returned to MGORD on 11/24/05. Active up and down movement patterns within MGORD from Dec-05 to May-06. Confirmed MORT – was killed during efishing on 9/11/06.
	Sept-19-05	37.87014 119.09689	825 ft downstream	
	Oct-17-05	37.86956 119.09597	275 ft downstream	
	Nov-11-05 at Fixed Station	37.86974 119.10425	3,600 ft downstream	
	Nov-16-05	37.88118 119.10155	6,200 ft downstream	
	Nov-25-05 at Fixed Station	37.86974 119.10425	6,200 ft upstream	
	Dec-14-05	37.86994 119.09592	3,800 ft upstream	
	Jan-25-06	37.87001 119.09687	275 ft downstream	
	March-13-06	37.87013 119.09686	50 ft downstream	
	May-13-06	37.86690 119.09673	1,350 ft upstream	
Code 24 – Male 476 mm and 1,448 g	Tag Release	37.86903 119.09608	--	Code 24 made its largest movements after the radio tag was implanted and also during October. Then this fish stayed within a small area for the next seven months. *We confirmed upstream movement of Code 24 during the May-06 relocation, thus the fish was alive at this point. **We could not make the fish move, probable MORT.
	Sept-19-05	37.86775 119.09656	500 ft upstream	
	Oct-17-05	37.87197 119.09828	1,650 ft downstream	
	Nov-14-05	37.87193 119.09933	25 ft upstream	
	Dec-14-05	37.87231 119.09781	75 ft downstream	
	Jan-25-06	37.87192 119.09927	75 ft upstream	
	March-13-06	37.87193 119.09926	<25 ft	
	May-13-06	37.87191 119.09926	<25 ft*	
	Dec-4-06	37.87194 119.09924	<25 ft	
	Feb-07	37.87191 119.09921	<25 ft	
	April-30-07	37.87193 119.09922	<25 ft**	

Table 5 (con't). Relocation summaries of brown trout radio-tagged in the MGORD in Sept-05.

Fish Code #, Sex, Length, and Weight	Date of Relocation	Lat/long of Relocation	Distance from Previous Relocation	Summary of Movement Activities
Code 25 – Female 362 mm and 510 g	Tag Release	37.86903 119.09608	--	Fish made limited movements within MGORD after tagging. Code 25 left the MGORD on 12/01/05. Spent Dec-05 through at least March-06 in a braided channel segment between the Upper Rush electro-fishing section and the old Highway 395 bridge. Code 25 then returned to the MGORD on 4/21/06. She then made limited movement within MGORD between May-06 and Dec-06. *Fish's signal moved in an upstream location after being relocated.
	Sept-19-05	37.86803 119.09653	400 ft upstream	
	Oct-17-05	37.86836 119.09572	150 ft downstream	
	Nov-16-05	37.86845 119.09668	50 ft downstream	
	Dec-1-05 at Fixed Station	37.86974 119.10425	4,100 ft downstream	
	Dec-16-05	37.88657 119.09493	9,450 ft downstream	
	Jan-28-06	37.88500 119.09547	750 ft upstream	
	March15-06	37.88499 119.09547	75 ft downstream	
	April-22-06 at Fixed Station	37.86974 119.10425	8,775 ft upstream	
	May-13-06	37.86824 119.09661	4,175 ft upstream	
	Dec-4-06	37.86835 119.09669	75 ft downstream	
	Feb-07	37.86843 119.09673	75 ft downstream	
	April-30-07	37.86834 119.09673	50 ft upstream*	
Code 26 – sex unknown 357 mm and 461 g	Tag Release	37.869027 119.096083	--	Code 26 left MGORD on 10/22/05. *Not specifically relocated, but weak signal detected between Highway 395 and Narrows on 11/15/05. Returned to MGORD on 12/02/05 Limited movement within MGORD from Jan-06 through May-06. Left MGORD exactly one year later (10/22/06) and was relocated in Dec-06 and Feb-07 in the braided channel segment upstream of Old Hwy 395 bridge – 8,750 ft downstream of the Fixed Station.
	Sept-19-05	37.868944 119.097083	25 ft upstream	
	Oct-17-05	37.86900 119.096111	50 ft downstream	
	Oct-22-05 at Fixed Station	37.86974 119.10425	3,875 ft downstream	
	Nov-15-05	Not relocated – weak signal*	approx 16,500 ft downstream	
	Dec-2-05 at Fixed Station	37.86974 119.10425	approx 16,500 ft upstream	
	Dec-14-05	37.86894 119.09605	3,950 ft upstream	
	Jan-25-06	37.86881 119.09698	75 ft upstream	
	March-13-06	37.86880 119.09698	<25 ft	
	May-13-06	37.86883 119.09695	<25 ft	

Table 5 (con't). Relocation summaries of brown trout radio-tagged in the MGORD in Sept-05.

Fish Code #, Sex, Length, and Weight	Date of Relocation	Lat/long of Relocation	Distance from Previous Relocation	Summary of Movement Activities
Code 26 – sex unknown 357 mm and 461 g	Oct-22-06 at Fixed Station	37.86974 119.10425	4,100 ft downstream	*Code 26 had moved upstream to the channel reach above the Gorge, but still neatly 2,000 ft below the Fixed Station.
	Dec-5-06	37.88462 119.09558	8,750 ft downstream	
	Feb-07	37.88464 119.09559	<25 ft	
	May-1-07	37.87278 119.10764	6,975 ft upstream*	
Code 27 – Male 522 mm and 1,575 g	Tag Release	37.86903 119.09608	--	*From 10/09/05 through 11/11/05, Code 27 moved in and out of the upper antenna's detection range as well as being detected by the lower antenna on 10/15/05. The first movement down into the antenna array was for approximately eight days (9th-16th). The fish then moved back upstream for about two days and then was recorded again by the upstream antenna on the 19th and 20th. Periodically, Code 27 was detected on the 24th, 27th, and 29th – 31st. **Almost exactly one year later (10/08/06), Code 27 was again within the detection range of the upper antenna. Exhibited similar in-and-out-of detection movements as occurred during 2005. Code 27 was last detected by upstream antenna on 11/17/06. Significant upstream movement in MGORD between Dec-06 and Feb-07. ***Signal moved on these relocations.
	Sept-19-05	37.86989 119.09694	350 ft downstream	
	Oct 9th-15th at Fixed Station*	37.86974 119.10425	3,550 ft downstream	
	Oct-17-05	37.87233 119.09744	2,700 ft upstream	
	Oct 19th-21st Fixed Station*	37.86974 119.10425	2,700 ft downstream	
	Oct 24th at Fixed Station*	37.86974 119.10425	--	
	Oct 27th-31st at Fixed Station*	37.86974 119.10425	--	
	Nov-14-05	37.87227 119.10093	1,650 ft upstream	
	Dec-14-05	37.87231 119.09781	1,075 ft upstream	
	Jan-25-06	37.87062 119.09680	650 ft upstream	
	March-13-06	37.87059 119.09680	<25 ft	
	May-13-06	37.87058 119.09680	<25 ft	
	Oct – Nov 2006	At Fixed Station**	--	
	Feb -2007	37.87021 199.09683	--	
	April-30-07	37.87025 119.09690	<25 ft***	
	Sept-11-07	37.87151 119.09737	550 ft downstream***	

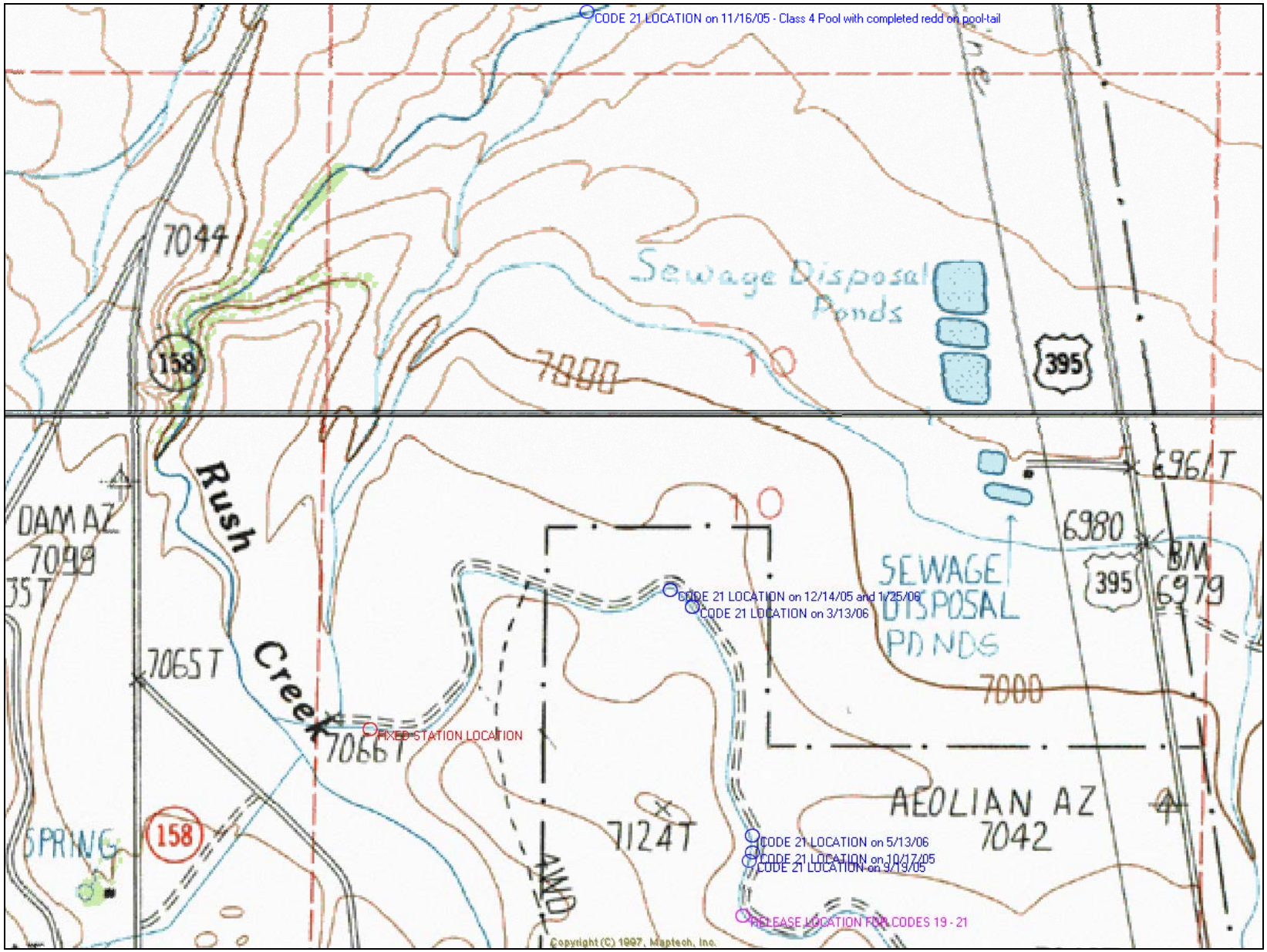

Figure 5. Map of Code 21's movements between September 9, 2005 (date of tag surgery) and May 13, 2006 in Rush Creek.

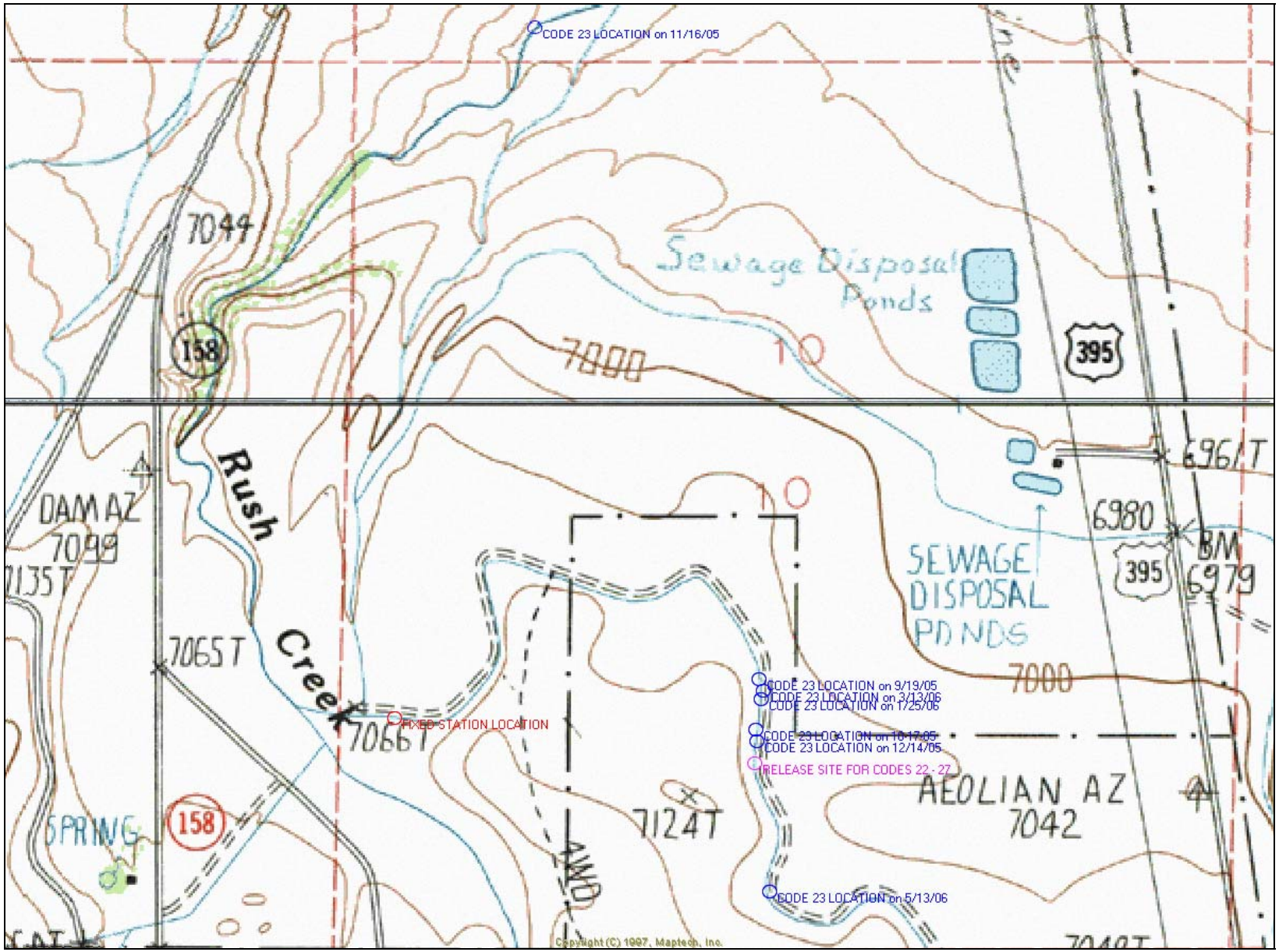

Figure 6. Map of Code 23's movements between September 9, 2005 (date of tag surgery) and May 13, 2006 in Rush Creek.

Movements of Brown Trout Tagged in the MGORD in September 2006

In September 2006 an additional 29 transmitters were implanted in brown trout residing within the MGORD – nine large transmitters (MCFT-3A's) and 20 medium transmitters (NTC-6-2's). In addition to the 29 transmitters deployed in 2006, 12 trout implanted with large transmitters in 2005 were assumed alive as determined during the May 2006 relocation. Of these 12 fish, nine were determined to be upstream of the Fixed Station in May of 2006.

Thus at the time of the December 4, 2006 fixed station receiver download it was assumed that 38 radio-tagged brown trout were within the MGORD upstream of the Fixed Station. The downloaded data indicated that 17 fish (45% of sample size) migrated downstream of the MGORD (below detection range of the lower antenna). By size class, the group of 20 fish with the medium-sized transmitters (12-15 inches in length) had 10 individuals (50% of sample) that migrated downstream of the MGORD in 2006. Seven of the 18 (39% of sample) large brown trout migrated out of the MGORD in 2006. Two of the nine fish from the September 2005 surgeries (still assumed to be in the MGORD) migrated out of the MGORD during the 2006 spawning season, compared to five of the nine fish implanted with large radio tags in September of 2006.

During the 2006 spawning season, seven radio-tagged fish were detected periodically by the upper antenna or within the antenna array. The lower 800-1,200 ft of the MGORD contains ample spawning habitat in the gravels retained by the grade-control weirs. On numerous occasions we observed groups of brown trout and completed redds within this lower reach of the MGORD. This lower reach of the MGORD was also utilized by spawning brown trout during the 2005 season.

Summaries of the movements of the fish tagged in 2006 are located in Appendix A. Summaries of several of the Fixed Station downloads are located in Appendix B.

Manual Receiver Tracking Results

The 13 manual tracking relocation surveys performed between September 2005 and March 2008 generated the instances where a fish was relocated to a specific point where micro-habitat measurements were collected. In total, we collected 69 focal-point velocity measurements and 81 focal-point depth measurements. After the fall-early winter spawning period, the preferred habitat during winter and spring for most fish was low velocity areas within pools and glides with cover such as undercut banks, woody accumulations, bubble curtains, boulders, and submerged vegetation. In fact, all fish relocated to specific micro-habitats during winter and spring were associated directly with cover. The fall spawning period when adult fish were actively spawning was the only time we observed radio-tagged fish out in the open.

Most measured observations of occupied velocities were less than 0.5 ft/sec (Figure 7). On a cumulative basis, 85% of the occupied velocity measurements were ≤0.5 ft/sec. Although most of the relocations confirmed that the fish were in pools, fish were not necessarily located in the deepest parts of pools. Depths at focal locations ranged from less than 0.5 ft to >4.0 ft; however 52 of the 81 measurements were at depths between 1.0 - 2.4 ft (Figure 8).

Total movements were not calculated for the younger fish radio-tagged in Upper, Lower, and County Road sections of Rush Creek; however these fish exhibited much less movement than the MGORD fish or the several large fish tagged in the Bottomlands section. According to the Fixed Station's receiver no fish from other sections of Rush Creek moved upstream into the MGORD. We also documented limited movement of radio-tagged fish through the Narrows.

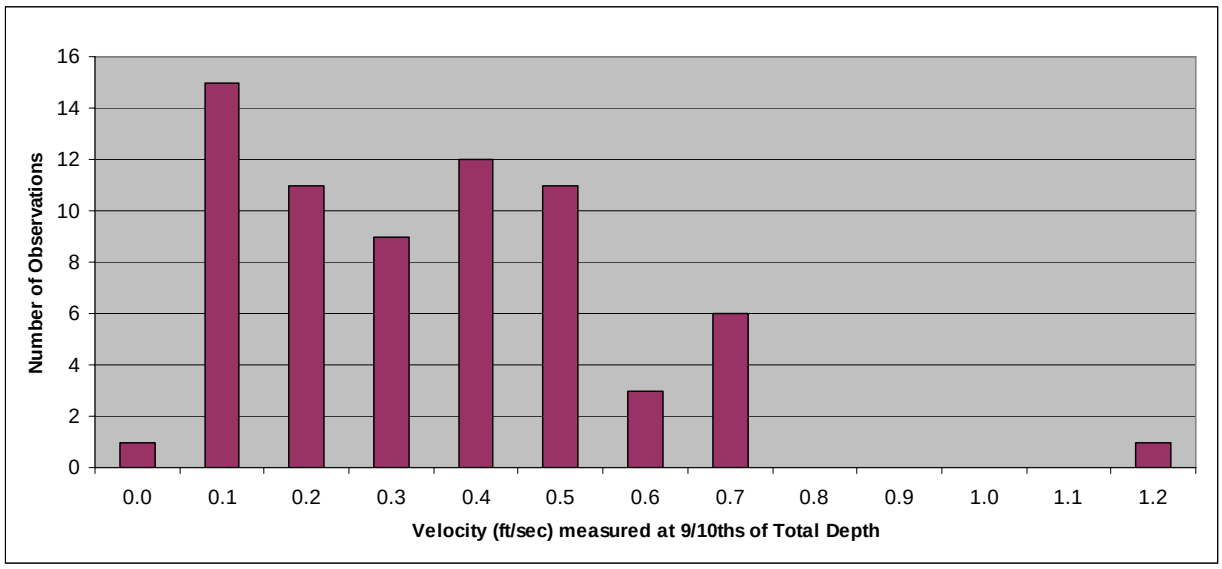

Figure 7. Occupied velocities of radio-tagged brown trout in Rush Creek measured in 2005-08.

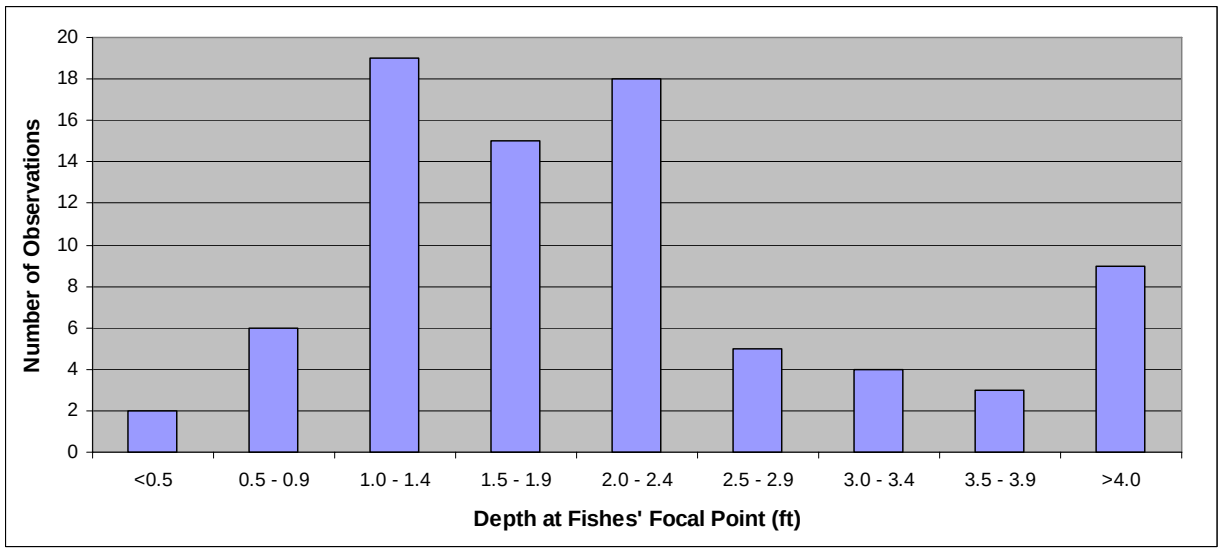

Figure 8. Occupied depths of radio-tagged brown trout in Rush Creek measured in 2005-08.

Survival rates of fish radio-tagged in September 2005 were estimated by number of fish confirmed as alive during May 2006 relocations and/or were captured during the September 2006 electro-fishing (Table 6). A fish was considered a mortality either if we found the tag or we were unable to relocate the fish in May and Sept of 2006. The MGORD fish had the highest survival rate, and two of these mortalities were caused by fisherman (Table 6). Fish tagged in the County Road section of Rush Creek had the lowest one-year survival rate (Table 6).

Table 6. Estimated survival rates of brown trout radio-tagged in September of 2005 in selected reaches of Rush Creek.

Reach where Fish were Tagged	**Large Radio Tags**	
MGORD	10 of 13 fish = 77%	
	Age >2+ (medium tags)	**Age 1+ (small tags)**
Upper Rush	57%	14%
Lower Rush	75%	20%
County Road	0%	17%

Discussion

The relatively high cost and effort required to conduct the telemetry study severely limited the number of individual fish that we were able to monitor. We assumed that the brown trout we tagged in the MGORD and monitored adequately represented the behavior of large brown residing within the MGORD reach of Rush Creek. The percent of tagged fish that left the MGORD during the two spawning seasons (2005 and 2006) we monitored was consistent at approximately half the sample size, 54% in 2005 and 45 % in 2006. In general, the fish behaved similarly during both spawning seasons, exhibiting extensive or frequent movements during fall-early winter spawning period and limited movements during other periods of the year. We only calculated total (or gross) movements for the MGORD fish during the first year of the movement study (Sept 2005 through May 2006.) because the frequency of relocations was adequate. During this nine-month period, our calculated total movements were consistent with other studies. James et al. (2007) reported that gross movement was greatest in the fall, followed by spring movements. Gross movements in the fall averaged 503 m and the greatest recorded was 2,554 m (James et al. 2007). Bettinger and Bettoli (2004) also reported the greatest levels of activity and range occurred during the fall, with some fall movements covering more than 5 km. Their study fish showed little difference in their limited movements during other periods of the year (Bettinger and Bettoli 2004). The similar movement behavior we documented in 2005 and 2006 along with the agreement of our findings with other brown trout movement studies supports the credibility of our assumptions that a large portion of adult brown trout in the MGORD migrate downstream for spawning purposes. We also documented that fish residing within the MGORD had limited home ranges within this 1.4 mile length of channel.

Our annual population sampling in conjunction with the movement study has revealed that the MGORD is a functional section of Rush Creek which consistently produces large (>15 inches) brown trout. Based on movements of our tagged fish, a sizeable portion of the MGORD fish seasonally moves downstream into other reaches of Rush Creek. Because the fecundity of brown trout is related to body size, the contribution of age-0 recruitment from MGORD female brown trout to the downstream channel is probably substantial. Based on our ten years of annual sampling, the Upper Rush sampling section has consistently had the highest densities of age-0 fish (Hunter et al. 2009). We speculate that the relatively high densities of age-0 brown trout in the Upper Rush sampling section is influenced by the spawning of large female brown trout that reside for most of the year up in the MGORD.

The seasonal presence of MGORD fish in the downstream channel occurs after the time of our annual population sampling in mid-September, thus we rarely capture large (>15 inches) brown in the Upper Rush sampling section. Because the original Termination Criteria developed for Rush Creek in D-1631 and Order 98-05 was based, in part, on size structure of the population to include larger fish (>13-14 inches); we proposed the metric of relative stock density (RSD) as a means to assess the size structure of the catchable portion of the trout population. In 2006, we started to apply this metric on an annual basis to the MGORD for two reasons: (1) to document that there is a section of Rush Creek which consistently produces Termination Criteria-sized trout and (2) to document that the RSD values for the MGORD are comparable to other high-quality eastern-Sierra trout fisheries such as the East Walker River, the upper Owens River and Hot Creek (Hunter et al. 2009).

As previously mentioned, during the 2005 season we confirmed two angling mortalities of radio-tagged fish from the MGORD. We also confirmed three additional angler-induced mortalities of radio-tagged MGORD fish in 2006 and 2007. DFG regulations state that Rush Creek below Grant Reservoir is a catch-and-release section where one must use barbless artificial lures only. We recommend that the State Water Resources Control Board (SWRCB) communicate to DFG the need to clarify the Rush Creek fishing regulations to state that the MGORD is, in fact, Rush Creek downstream of Grant Reservoir.

The depth, velocity, and cover data we collected during winter and spring manual relocations was consistent with other researchers; confirming that brown trout utilize holding habitats with low focal-point velocities in close association with the channel bed and direct cover. Our velocity measurements were consistent with those reported by Raleigh et al (1986); Clapp et al. (1992); Meyers et al. (1992); and Heggenes (2002). These velocity results along with the tagged fishes' strong association with direct cover were utilized in developing winter holding habitat criteria for the Rush Creek Instream Flow Study. Winter habitats were also periodically affected by snowfall and/or icing that actually increased the amount of overhead cover (Figures 9 and 10). During three winters of conducting relocations we never observed icing conditions within Rush Creek that were detrimental to winter holding habitat conditions, such as the formation of anchor ice or frazil ice.

Figure 9. Code 61's location under woody accumulation and snow/ice shelf on 1/26/06.

Figure 10. Code 68's location under shelf ice in Lower Rush section on 1/25/06.

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APPENDIX A: RELOCATION DATA OF BROWN TROUT TAGGED IN 2006

Movement activities of large brown trout implanted with large radio transmitters during September 2006 (as of February 2007).

Fish Info.	Date	N 37º	Difference	W 119º	Difference	Summary of Movement Activities
Code 71	Release	.86667		.09583		Within detection range of upper antenna on 11/06/06 and again from 11/20-11/23/06. **MORT** on Jan-08 relocation – recovered tag.
Male	Dec 06	.86740	+.00073	.09682	+.00099	
553 mm	Feb 07	.86668	-.00072	.09409	-.00273	
1950 g	April 07	.86612		.09357		
	Sept 07	.86248		.09237		
	Jan-08	.87030		.09682		
Code 72	Release	.86972		.09682		Within detection range of upper antenna on 11/10/06. Moved through antennae array and out of detection of lower antenna on 11/11/06. Relocated in pool at the downstream end of the Upper Rush electrofishing section on 12/5/06 and 2/17/07. Signal moved u.s. on 9/07 relocation. Approx 100 ft d.s. of lower antenna on 3-18-08.
Male	Dec 06	.88367	+.01395	.09595	-.00087	
410 mm	Feb 07	.88366	-.00001	.09595	.00000	
695 g	April 07	.88371		.09597		
	Sept 07	.86248		.09237		
	Jan-08	.86777		.09653		
	Mar-08	.86988		.10458		
						Moved through the antennae array and out of detection of the lower antennae on 11/11/06-- the same day as Fish 72. Relocated on 12/5/06 in the same pool as Fish 72 (at the lower end of the UpRu efishing section). **MORT**--tag was found near the "duck pond" at upstream end of the UpRu section on 2/17/07.
Code 73	Release	.86972		.09682		
Male	Dec 06	.88367	+.01395	.09595	-.00087	
382 mm	Feb 07	.88181	-.00186	.09889	+.00755	
607 g						
						W/in detection of antennae array from 11/14-11/18/06. Moved beyond detection of lower antenna on 11/19/06. Relocated between the sheepherder's cabin and UpRu section on 12/05/06. Relocated in gorge (w/in the large Jeffery Pine pool complex u.s of sheepherder's cabin) on 2/17/07. Signal moved u.s. on 9/07 relocation. Probable **MORT** on Jan-08, signal approx 50' from channel.
Code 74	Release	.87191		.09722		
Male	Dec 06	.88142	+.00951	.10067	+.00345	
378 mm	Feb 07	.87613	-.00529	.10822	+.00755	
593 g	April 07	.87039		.09684		
	Sept 07	.87047		.09686		
	Jan-08	.88034		.10222		
						Within detection range of upper antenna from 9/15-9/17/06. Within antennae array 9/18-9/20/06. In and out of detection of lower antenna from 9/21-11/17/06. Relocated on 12/5/06 at the upper end of the gorge. Relocated on 2/17/07 just upstream of the Jeffery Pine pools. **MORT** –tag found 5/07.
Code 75	Release	.87191		.09722		
Male	Dec 06	.87514	+.00323	.10818	+.01096	
387 mm	Feb 07	.87585	+.00071	.10809	-.00009	
622 g	May 07	.91653		.07455		
Code 76	Release	.87120		.10251		Within detection range of antennae array from 10/27-12/28/06. Approx. 1,000 ft d.s. of the MGORD on 3-19-08.
Male	Dec 06	.87016	-.00104	.10322	+.00071	
425 mm	Feb 07	.87214	+.00189	.10277	-.00045	
650 g	May 07	.87242		.10266		
	Sept 07	.87235		.10275		
	Jan-08	.87197		.10268		
	Mar-08	.87097		.10730		

Fish Info.	Date	N 37º	Difference	W 119º	Difference	Summary of Movement Activities
Code 77	Release	.87120		.10251		Within detection range of upper antenna on 11/7/06. Moved beyond detection of lower antenna on 11/8/06. Not relocated during December 2006. Returned within detection of antennae on 12/11/06. Still within detection of upper antenna as of 12/14/07. Signal moved quickly d.s. during 3-18-08 relocation.
Male	Dec 06	NR		NR		
397 mm	Feb 07	.87062	-.00058	.10256	+.00005	
605 g	May 07	.87008		.10326		
	Sept 07	.87194		.09978		
	Jan-08	.86951		.09694		
	Mar-08	.86957		.09691		

Fish Info.	Date	N 37º	Difference	W 119º	Difference	Summary of Movement Activities
Code 78	Release	.87120		.10251		Moved upstream in MGORD after surgery. Limited movement between Dec 06 and Feb 07.
Male	Dec 06	.86666	-.00454	.09634	-.00617	
373 mm	Feb 07	.86666	.00000	.09638	+.00004	
581 g	May 07	.86661		.09637		
	Sept 07	NR				
	Jan-08	NR				
	Mar-08	NR				

Code 79	Release	.87120		.10251		Moved upstream in MGORD after surgery. Limited movement between Dec 06 and Feb 07.
Male	Dec 06	.87191	+.00071	.09953	-.00298	
452 mm	Feb 07	.87192	+.00001	.09946	-.00007	
1209 g	May 07	.87189		.09950		
	Sept 07	.87189		.09945		
	Jan-08	.87193		.09949		
	Mar-08	.87185		.09940		

Movement activities of 12-15 inch brown trout radio-tagged in the MGORD during September 2006.

Fish Info.	Date	N 37º	Difference	W 119º	Difference	Summary of Movement Activities
Code 91	Release	.86487		.09335		Noticeable downstream movement within the MGORD between Sep 06 and Dec 06. Slight downstream movement between Dec 06 and Feb 07. Signal moved d.s. on 9/07 relocation.
Sex Unkn	Dec 06	.86836	+.00349	.09672	+.00337	
312 mm	Feb 07	.86844	+.00008	.09679	+.00007	
353 g	April 07	.87244		.10178		
	Sept 07	.87197		.09994		
	Jan-08	NR				
	Mar-08	NR				

						Noticeable downstream movement within the MGORD between Sep 06 and Dec 07. Within detection range of upper antenna on 12/17/06, 12/20/06 and from 2/4/07-2/6/07. Passed through antennae array and beyond the detection of the lower antenna on 2/13/07. Relocated in the gorge (within the large Jeffery Pine pool complex above the sheepherder's cabin) on 2/17/07.
Code 92	Release	.86487		.09335		
Female	Dec 06	.87215	+.00724	.09795	+.00460	
308 mm	Feb 07	.87613	+.00398	.10822	+.01027	
310 g	May 07	.88118		.10134		
	Sept 07	NR				
	Jan-08	NR				
	Mar-08	NR				

Fish Info.	Date	N 37º	Difference	W 119º	Difference	Summary of Movement Activities
Code 93	Release	.86487		.09335		Noticeable downstream movement within the MGORD between Sep 06 and Dec 06. Some upstream movement within the MGORD between Dec 06 and Feb 07.
Sex Unkn	Dec 06	.86932	+.00445	.09703	+.00368	
301 mm	Feb 07	.86842	-.00090	.09676	-.00027	
309 g	April 07	.86388		.09290		
	Sept 07	NR				
	Jan-08	NR				
	Mar-08	NR				
Code 94	Release	.86667		.09583		Passed through antennae array and out of detection of lower antenna in slightly over nine hours on 10/23/06. Not relocated during Dec 06 or Feb 07. **MORT** – tag found on 5/2/07 at Hwy 395.
Male	Dec 06	NR				
349 mm	Feb 07	NR				
460 g	May 07	.89084		.09232		
Code 95	Release	.86667		.9583		Noticeable upstream movement within the MGORD between Sep 06 and Dec 06. Essentially in same location during Dec 06 and Feb 07. *Weak signal near lowermost boulder weir d.s. of MGORD.
Male	Dec 06	.86596	-.00071	.09346	-.00237	
336 mm	Feb 07	.86596	.00000	.09348	+.00002	
417 g	April 07	.86586		.09337		
	Sept 07	NR*				
	Jan-08	NR				
	Mar-08	NR				
Code 96	Release	.86882		.09694		In and out of detection range of upstream antenna from 2/04/07-2/13/07. Still within detection range of upstream antenna on 2/14/07 (the last fixed-station download).
Female	Dec 06	.86738	-.00144	.09679	-.00015	
362 mm	Feb 07	.87054	+.00316	.10268	+.00589	
488 g	April 07	NR		NR		
	Sept 07	.86644		.09557		
	Jan-08 Mar-08	NR NR				
Code 97	Release	.86667		.09583		Considerable upstream movement within MGORD between Sep 06 and Dec 06. Essentially in same location during Dec 06 and Feb 07.
Female	Dec 06	.86496	-.00171	.09336	-.00247	
325 mm	Feb 07	.86497	+.00001	.09329	+.00003	
383 g	April 07	.86538		.09307		
	Sept 07	.86535		.09305		
	Jan-08	NR				
	Mar-08	NR				
Code 98	Release	.86667		.09583		Considerable downstream movement within the MGORD between Dec 06 and Feb 07. Fish moved from bank to mid-channel when disturbed on 2/16/07.Signal moved u.s. on 9/07, within a pack of approx. 20 fish.
Male	Dec 06	.86680	+.00013	.09519	-.00064	
344 mm	Feb 07	.86917	+.00237	.09703	+.00184	
489 g	April 07	.86691		.09460		
	Sept 07	.87221		.09865		
	Jan-08	NR				
	Mar-08	NR				

Fish Info.	Date	N 37º	Difference	W 119º	Difference	Summary of Movement Activities
Code 99	Release	.86667		.09583		Noticeable downstream movement within the MGORD between Sep 06 and Feb 07. Moved upstream when disturbed on 2/16/07.
Sex Unkn	Dec 06	.86770	+.00103	.09661	+.00078	
339 mm	Feb 07	.86809	+.00039	.09659	-.00002	
433 g	April 07	.86845		.09678		
	Sept 07	.86762		.09662		
	Jan-08	NR				
	Mar-08	NR				
Code 100	Release	.86882		.09694		Moved through antennae array and beyond detection of lower antenna in less than two hours on 11/20/06. Relocated, including a visual siting, at old Highway 395 bridge on 12/5/06. Relocated near old sheepherder's cabin on 2/17/07.
Female	Dec 06	.88827	+.01945	.09353	-.00341	
314 mm	Feb 07	.87772	-.01055	.10626	+.01273	
317 g	May 07	.88149		.09973		
	Sept 07	NR				
	Jan-08	NR				
	Mar-08	NR				

Code 101	Release	.86882		.09694		Within detection range of upper antenna on 2/4/07 and 2/6/07, then moved through array and beyond detection of lower antenna on 2/13/07. Relocated in the "rock garden" just downstream of the MGORD on 2/17/07.
Female	Dec 06	.86805	-.00077	.09666	-.00028	
342 mm	Feb 07	.86992	+.00187	.10581	+.00915	
414 g	May 07	.87234		.10145		
	Sept 07	.86869		.09701		
	Jan-08	NR				
	Mar-08	NR				

Code 102	Release	.86882		.09694		Within the detection range of the antennae array from 10/25/06-11/15/06, except for a 36 hour period, spanning 11/06/06-11/08/06, when it was downstream of the detection range of the lower antenna.
Sex Unkn	Dec 06	.86879	-.00003	.09669	-.00025	
343 mm	Feb 07	.86873	-.00006	.09703	+.00034	
458 g	May 07	.86823		.09663		
	Sept 07	.86895		.09707		
	Jan-08	NR				
	Mar-08	NR				

						Within the detection range of the upper antenna for two brief periods on 10/20/06 and 11/1/06. Moved through antennae array and beyond detection of the lower antenna in about nine hours on 11/8/06. Not relocated during Dec 06. Relocated in a braided channel segment between the Upper Rush efishing section and the old Highway 395 bridge on 2/17/07.
Code 103	Release	.86885		.09694		
Male	Dec 06	NR				
338 mm	Feb 07	.88638	+.01756	.09559	-.00135	
427 g	May 07	.86823		.09663		
	Sept 07	.88090		.10171		
	Jan-08	NR				
	Mar-08	NR				

Fish Info.	Date	N 37º	Difference	W 119º	Difference	Summary of Movement Activities
Code 104	Release	.86972		.09682		Moved through antennae array on 10/31/06 and then beyond the detection of the lower antenna on 11/1/06. Relocated just downstream of the new Highway 395 bridge on 12/6/06. Not relocated during Feb 07.
Male	Dec 06	.89183	+.02211	.09131	-.00551	
340 mm	Feb 07	NR				
450 g	May 07	.89694		.08849		
	Sept 07	NR				
	Jan-08	NR				
	Mar-08	NR				

Code 105	Release	.87191		.09772		Within detection range of antennae array from 9/15/06-9/16/06. Moved beyond detection of lower antenna early in the morning of 9/17/06 (five days after surgery). Relocated on 12/5/06 and on 2/17/07 with the large Jeffery Pine pool complex above the sheepherder's cabin.
Female	Dec 06	.87606	+.00415	.10821	+.01049	
341 mm	Feb 07	.87613	+.00007	.10822	+.00001	
462 g	May 07	.87609		.10826		
	Sept 07	.87610		.10835		
	Jan-08	NR				

Code 106	Release	.87191		.09772		Within detection range of upper antenna for two brief periods on 11/21/06 and 11/26/06. Relocated in the MGORD upstream of its release site on 12/4/06. In and out of detection of upper antenna from 11/29/06-1/12/07. Not relocated in Feb-07, May 07, and Sept-07.
Male	Dec 06	.87139	-.00052	.09734	-.00038	
353 mm	Feb 07	NR				
445 g	May 07	NR				
	Sept 07	NR				
	Jan-08	NR				

Code 107	Release	.87191		.09772		Moved through antennae array on 11/13/06. In and out of detection range of lower antenna from 11/14/06-12/9/06. Relocated in the "rock garden" downstream of the MGORD on 12/5/06. Moved through the array and beyond detection of the upper antenna on 12/10/06. **MORT**. Probably pouched, since the tag was found near the MGORD's spillway.
Female	Dec 06	.86995	-.00196	.10505	+.00733	
331 mm	Feb 07	.86331	-.00664	.09263	-.01242	
395 g						

Code 108	Release	.87120		.10251		Quickly moved through the antennae array and beyond the detection of the lower antenna in less than an hour on 11/17/06. Not relocated during Dec 06. Relocated on 2/18/07 upstream of the Narrows near the gravel plant operation.
Female	Dec 06	NR				
358 mm	Feb 07	.90657	+.03537	.08388	-.01863	
469 g	May 07	NR				
	Sept 07	NR				
	Jan-08	NR				

Code 109	Release	.87120		.10251		Moved through the antennae array in about an hour on 11/18/06. In and out of detection of the lower antenna from 11/19/06 until 11/24/06, when it moved beyond detection range of lower antenna. Not relocated during Dec 06 or Feb 07 or May 07. *Weak signal w/in Upper Rush sampling section.
Male	Dec 06	NR				
337 mm	Feb 07	NR				
417 g	May 07	NR				
	Sept 07	NR*				
	Jan-08	NR				

Fish Info.	Date	N 37º	Difference	W 119º	Difference	Summary of Movement Activities
Code 110	Release	.87120		.10251		In and out of the detection range of the upper antenna during ten separate time periods ranging in length from 1 to 14 days from 10/23/06 through 1/16/07. Relocated within the MGORD at distinctly different sites during Dec 06 versus Feb 07.
Male	Dec 06	.87016	.00104	.10322	+.00071	
343 mm	Feb 07	.87055	+.00039	.10270	-.00052	
392 g	May-07	NR				
	Sept 07	NR				
	Jan-08	NR				

APPENDIX B: RUSH CREEK, MGORD FIXED STATION DOWNLOAD SUMMARIES

OCTOBER 2005 SUMMARY:

Error codes (Code 255):

10/03 - one event at 23:22hrs.
10/09 - one event at 20:32hrs
10/10 - three events at 08:31hrs, 10:59 hrs, and 15:11hrs.
10/14 - 10 events between 01:38 – 23:21hrs.
10/15 - 301 events between 00:24-23:54 hrs.
10/16 - two events at 03:27hrs and 19:37hrs.
10/18 - two events at 01:50hrs and 09:28hrs.
10/19 - five events at 00:30hrs, 01:19hrs, 05:54hrs, 16:56hrs, and 19:50hrs.
10/20 - four events at 09:04hrs, 09:54hrs, 13:50hrs, and 23:45hrs.
10/21 - four events at 05:32hrs, 06:30hrs, 19:29hrs, and 22:47hrs.
10/22 - five events at 17:25hrs, 18:17hrs, 19:49hrs, 20:08hrs, and 21:45hrs.
10/23 – one event at 08:29hrs.
10/24 – six events at 01:19hrs (2 events), 01:24hrs, 01:29hrs (2 events), and 05:39hrs.
10/27 – one event at 18:16hrs.
10/28 – four events at 01:59hrs, 08:41hrs, 11:57hrs, and 16:12hrs.
10/29 – two events at 15:31hrs and 15:45hrs.
10/30 – one event at 00:53hrs.
10/31 – one event at 02:43hrs.

CODE 14 (465 mm male): this fish moved downstream through the antenna array on the 27th in approximately 40 minutes. Code 14 was generally located between Highway 395 and the Narrows on November 15th.

- On 10/27/05 at 17:34hrs – initial hit on upstream antenna. Total events recorded = 29.
- Final hit on downstream antenna at 18:14hrs.

CODE 15 (515 mm male): this fish periodically moved down the MGORD and spent approximately two to three days within the antenna array and then *usually* moved back upstream. On October 18th this fish appeared to leave the MGORD, then reappeared within the antenna array on the 21st-22nd, then left the MGORD on the 22nd, then reappeared on the 29th. Since then Code 15 has remained upstream of the antenna array.

- On 10/02/05 at 03:53hrs - initial hit on the upstream antenna.
- On 10/04/05 at 01:17hrs – final hit on the upstream antenna.
- Total events recorded by both antennas = 2,008.

- On 10/13/05 at 23:02hrs – initial hit on the upstream antenna.

- Between 10/13/05 (23:02hrs) and 10/14 (13:28hrs) – 236 hits on both antennas.
- On 10/14/05 at 13:35hrs – final hit on the upstream antenna.

- On 10/17/05 at 14:16hrs – single weak hit (power = 67) on upstream antenna.

- On 10/18/05 at 01:32 hrs – initial hit on upstream antenna.
- Between 10/18/05 (01:55hrs) and 10/19/05 (18:39hrs) – 1,089 hits on both antennas. Final hit is on downstream antenna.

- On 10/20/05 between 02:04-08:03hrs – 10 weak hits (power = 73-92) on downstream antenna.

- On 10/21/05 at 00:24hrs – initial hit on downstream antenna.
- Between 10/21/05 (00:24hrs) and 10/22/05 (21:57hrs) – 851 hits on both antennas. Final hit on downstream antenna.

- On 10/29/05 at 10:17hrs - initial hit on downstream antenna – 64 hits on both antennas. Final hit is on upstream antenna at 16:12hrs.

CODE 22 (444mm female): this fish swam past the antenna array on its way downstream. The fish arrived in the range of the upper antenna mid-day on the 14th and was recorded by the upstream antenna all day on the 15th. The fish then moved past the downstream antenna on the 16th in the middle of the night.

- On 10/14/05 at 13:54hrs – initial hit on upstream antenna. Total of 992 events recorded by upstream antenna.

- On 10/16/05 at 00:05hrs – final hits (5 events) on downstream antenna.

CODE 26 (357 mm sex unknown): this fish moved downstream through the antenna array on the 22nd in 35 minutes. Code 26 was not found during the November 14-17 relocations.

- On 10/22/05 at 19:01hrs – initial hit on upstream antenna. Final hit on downstream antenna at 19:36hrs.

CODE 27 (522 mm male): this fish made numerous movements downstream into the antenna array, but resided primarily in the MGORD upstream of the fixed station. The first movement down into the antenna array was for approximately eight days (9th-16th). The fish then moved back upstream for about two days and then was recorded again by the upstream antenna on the 19th and 20th. Periodically, Code 27 was detected on the 24th, 27th, and 29th – 31st.

- On 10/09/05 at 00:05hrs – initial hit on upstream antenna. Total of 1,241 events recorded on upstream antenna between initial hit and 23:27hrs on 10/15/05.

- On 10/15/05 at 00:20hrs – initial hit on downstream antenna. Total of 418 events recorded on downstream antenna between initial hit and 20:16hrs on 10/15/05.

- On 10/16/05 at 00:04hrs – initial hit on upstream antenna. Total of 74 events recorded on upstream antenna between initial hit and 23:32hrs on 10/16/05.

- On 10/19/05 at 00:26hrs – initial hit on upstream antenna. Total of 642 events recorded on upstream antenna between initial hit and 07:07hrs on 10/20/05.

- Between 10/20/05 (23:43hrs) and 10/21/05 (01:38hrs) – 32 hits on upstream antenna.

- On 10/24/05 between 04:49hrs – 06:57hrs – 68 hits on upstream antenna.

- On 10/27/05 at 23:33hrs – initial hit on upstream antenna. Total of 692 events recorded on upstream antenna between initial hit and 22:19 hrs on 10/28/05.

- On 10/29/05 between 06:56hrs – 07:39 hrs - seven events recorded by upstream antenna.

- On 10/30/05 between 00:14hrs – 00:57hrs – 10 events recorded by upstream antenna.

- On 10/31/05 between 01:47hrs – 08:28hrs – 70 events recorded by upstream antenna.

- On 10/31/05 between 23:28hrs – 23:52hrs – 21 events recorded by upstream antenna.

NOVEMBER 2005 SUMMARY

Error codes (Code 255):

11/01 – 14 events between 00:01hrs – 22:39hrs.
11/02 – one event at 00:10hrs.
11/04 – four events at 16:39hrs, 18:17hrs, 18:34hrs, and 19:43hrs.
11/06 – four events at 01:01hrs, 03:10hrs, 05:42hrs, and 20:06hrs.
11/09 – one event at 00:49hrs.
11/18 – three events at 03:07hrs, 03:42hrs, and 06:07hrs.
11/20 – one event at 06:23hrs.
11/21 – one event at 17:51hrs.
11/24 – one event at 23:46hrs.
11/25 – two events at 03:31 hrs and 04:09hrs.

CODE 21 (518 mm female): this fish swam past the antenna array on its way downstream. The fish arrived in the range of the upper antenna just before mid-night on the 1st and was

recorded by the upstream antenna on the 2nd – 6th. The fish then moved past the downstream antenna on the 6th at close to midnight.

- On 11/01/05 at 23:38hrs – initial hit on upstream antenna. A total of 1,090 events recorded on the upstream antenna between initial hit and 21:37hrs on 11/06/05.

- On 11/06/06 0 initial hit on downstream antenna. A total of 101 events recorded by both antennas. Final hit on downstream antenna at 23:38hrs.

DECEMBER 2005 SUMMARY

Error codes (Code 255):

12/02 – two events at 11:35hrs and 14:14hrs.
12/10 – one event at 16:44hrs.

Summary of Fish Movement as Interpreted by Data Downloaded on December 4, 2006 from the Fixed Receiving Station on Rush Creek

The following document summarizes the movement of radio-tagged brown past the fixed receiving station between the dates of September 15th and December 4th, 2006. The fixed receiving station is located at the downstream end of the Rush Creek MGORD.

The Rush Creek brown trout movement study is now in its second year. In September 2006 an additional 29 transmitters were implanted in brown trout residing within the MGORD – nine large transmitters (MCFT-3A's) and 20 medium transmitters (NTC-6-2's). Two large transmitters were also implanted in brown trout residing in lower Rush Creek (released several pools upstream of the county ford).

In addition to the 31 transmitters deployed in 2006, 12 trout implanted with large transmitters in 2005 were assumed to alive as determined during the May 2006 relocation. Of these 12 fish, nine were determined to be upstream of the fixed receiving station in May of 2006.

Thus at the time of the December 4, 2006 fixed station receiver download it was assumed that 38 radio-tagged brown trout were within the MGORD. The downloaded data indicates that 14 fish (37% of sample size) migrated downstream of the MGORD (below detection range of the lower antenna). None had returned to the MGORD as of December 2nd, 2006. Seven additional radio-tagged fish were detected by the upper antenna, but appeared to not move downstream into the array (between antennas) or below the lower antenna.

Code 15 – 2005 large tag (male 515 mm)

1. Initial hits on upper antenna at 6:22 AM on 10/20/06.
2. Hits on both antennas from 11:27 PM on 10/20/06 until last hit on upper antenna at 8:03 AM on 11/14/06.

Summary of action: this male brown trout spent approximately 26 days within the range of the antenna array, both above and below the array. Multiple hits bouncing from upper antenna to lower antenna suggests this fish was often within the 275-foot reach of channel between the two antennas (within the array).

Code 15 was manually relocated in the MGORD on 12/4/06 and the signal moved upstream.

Code 26 – 2005 large tag (sex unknown 357 mm)

1. Initial hits on upper antenna at 9:30 PM on 10/22/06.
2. Passed through the array (events recorded by both antennas).
3. Final hit on lower antenna at 9:59 PM on 10/22/06.

Summary of action: this brown trout passed quickly through the fixed receiving station location. This fish required 29 minutes to migrate through the approximately 1,000 feet of channel in which the antennas can capture a transmitter's signal.

Code 26 was manually relocated in Rush Creek downstream of the MGORD on 12/5/06 (within Upper-Rush study section).

Code 27 – 2005 large tag (male 522 mm) – 893 lines of data

1. Initial hits on upper antenna at 1:59 AM on 10/08/06.
2. Final hit on upper antenna at 6:14 AM on 10/09/06.
3. Re-appeared on upper antenna at 3:44 AM on 10/13/06.
4. Hits on upper antenna every day between 10/13/06 – 11/08/06 (27 days). There were often gaps during most days where Code 27 moved upstream out of detection range of the upper antenna. The hits often started at 9-11:30 PM, occurred all night and early morning, then ceased by mid-morning.
5. Final hit on upper antenna at 11:36 PM on 11/08/06.
6. Re-appeared on upper antenna at 1:45 AM on 11/14/06 – final hit at 11:59 PM.
7. Re-appeared on upper antenna between 12:42-57 AM on 11/17/06.
8. No detections since 11/17/06.

Summary of action: for approximately six weeks this fish was detected upstream of the upper antenna, with several multiple-days gaps in which the fish moved back upstream out of range of the upper antenna. Code 27 displayed similar behavior during the fall of 2005 where it was in-and-out of the upper antenna range for an extended period.

Code 27 was manually relocated in the MGORD on 12/04/06.

Code 71 – 2006 large tag (male 553 mm)

1. Initial hits on upper antenna at 4:14 PM on 11/06/06. Final hits at 5:32 PM.
2. Re-appears on upper antenna at 5:20 PM on 11/20/06.
3. Final hit on upper antenna at 5:00 PM on 11/23/06.

Summary of action: this fish spent approximately 30 minutes within detection range of the upper antenna on November 11, 2006 and then moved upstream out of detection range. Two weeks later the fish moved back down within range of the upper antenna for three days and then moved upstream out of detection range.

Code 71 was manually relocated within the MGORD on 12/4/06.

Code 72 – 2006 large tag (male 410 mm)

1. Initial hits on upper antenna at 11:34 PM on 11/10/06.
2. Constant hits on upper antenna until 10:08 PM on 11/11/06.
3. Within antenna array between 10:11 – 10:36 PM on 11/11/06.

4. Final hit on lower antenna at 11:16 PM on 11/11/06.

Summary of action: this fish moved down into the detection range of the upper antenna, spent approximately 23 hours upstream of the upper antenna, and then moved quickly through the array.

Code 72 was manually relocated in Rush Creek downstream of the MGORD on 12/05/06 (below the lower "Trehey pool" in Upper-Rush study section). Signal was active during manual relocation and numerous redds were observed on pool-tail near Code 72's location.

Code 73 – 2006 large tag (male 382 mm)

1. Initial hits on upper antenna at 12:05 AM on 11/11/06.
2. Final hits on upper antenna at 1:18 AM.
3. Hits on lower antenna from 1:26 AM – 1:55 AM on 11/11/06.

Summary of action: this fish moved through the fixed receiving station's detection range of approximately 1,000 feet of channel in just under two hours.

Code 73 was manually relocated in Rush Creek downstream of the MGORD on 12/5/06 (below the lower "Trehey pool" in Upper-Rush study section). Signal was active during manual relocation and numerous redds were observed on pool-tail near Code 73's location.

Code 74 – 2006 large tag (male 378 mm)

1. Initial hits on upper antenna at 10:49 PM on 11/14/06.
2. Within array from 7:44 AM on 11/15/06 until 10:19 AM on 11/16/06. Fish then moved upstream out of detection range of the upper antenna.
3. Re-appeared on upper antenna at 10:35 PM on 11/18/06.
4. Passed through array between 11:09 PM on 11/18/06 and 12:53 AM on 11/19/06.
5. Final hits on lower antenna at 2:10 AM on 11/19/06.

Summary of action: this fish took approximately four-plus days to move downstream through the fixed receiving station array.

Code 74 was manually relocated in Rush Creek downstream of the MGORD on 12/5/06 (between "sheep-herder's cabin" and Upper-Rush study section). Signal was active and moved in an upstream direction during manual relocation.

Code 75 – 2006 large tag (male 387 mm) – 6,517 lines of data

1. Initial hits on upper antenna at 12:09 AM on 9/15/06. Constant hits until 6:23 AM.
2. Re-appeared on upper antenna at 1:05 AM on 9/17/06.
3. Within array at 4:42 AM on 9/17/06. By 4:30 PM on 9/17/06 almost all hits are on lower antenna.

4. Moved back up into array between 10:48 AM – 12:33 PM on 9/18/06, then below lower antenna.
5. Back within array between 10:45 AM – 7:26 PM on 9/19/06, then below lower antenna.
6. Moved back up into array between 3:21 PM – 9:10 PM on 9/20/06, then below lower antenna.
7. Final movement back up within the array on 9/21/06 between 11:00 AM – 7:30 PM.
8. Downstream of lower antenna from 7:30 PM on 9/21/06 until 11/17/06. It appears that Code 75 was within range of lower antenna for most of this 50-day period.
9. Final hit on lower antenna at 1:45 PM on 11/17/06.

Summary of action: this fish spent nearly 60 days within detection range of the fixed receiving station (mostly downstream of the lower antenna) before moving farther downstream.

Code 75 was manually relocated in Rush Creek downstream of the MGORD on 12/5/06. Signal appeared to move during the manual relocation.

Code 76 – 2006 large tag (male 425 mm) – 4,186 lines of data

1. Initial hits on upper antenna at 7:31 AM on 10/27/06. Constant hits on upper antenna for nearly 12 hours.
2. Within array at 6:15 PM on 10/27/06 and stayed within array until 6:30 PM on 10/28/06.
3. Moved downstream of lower antenna from 6:30 PM on 10/28/06 until 5:27 AM on 10/29/06. Then moved upstream through the array between 5:31-6:15 AM.
4. Hits on upper antenna resumed at 6:16 AM on 10/29/06. Code 76 was mostly above upper antenna through 11/08/06 (on three occasions between November 2nd – 5th fish was within array).
5. Hits on lower antenna only from 10:52 PM on 11/08/06 until 8:20 AM on 11/09/06. Then fish moved upstream.
6. Hits on upper antenna only from 8:42 AM on 11/09/06 through 12:23 AM on 11/15/06.
7. Fish moved downstream and was within array for approximately 90 minutes on 11/15/06. Then hits on only lower antenna between 1:35 – 9:05 AM. Then back above upper antenna by 9:15 AM on 11/15/06.
8. Constant hits on upper antenna only from 11/15/06 through 11/25/06.
9. Within array from 10:43 PM on 11/25/06 until 11:57 PM on 11/26/06. Fish then moved back upstream above upper antenna.
10. Constant hits on upper antenna only from 11/26/06 through 12/03/06.
11. Hits within array from 10:44 AM – 1:23 PM on 12/03/06.
12. Constant hits on upper antenna only 12/03/06 – 12/04/06.

Summary of action: this fish moved down into the detection range of the fixed station's antennas in late October and has stayed within this area for 39 days.

Code 76 was manually relocated within the lower end of the MGORD on 12/04/06 – just upstream of the upper-most grade-control weir. There were at least 30 to 50 trout observed above this grade-control structure along with several redds. Code 76's signal moved quickly upstream when the pack of observed trout were displaced during the manual relocation.

Code 77 – 2006 large tag (male 397 mm)

1. Initial hits on upper antenna at 5:40 PM on 11/07/06.
2. Constant hits on upper antenna until 7:39 AM on 11/08/06.
3. Within array from 7:39 – 8:28 AM on 11/08/06.
4. Final hit on lower antenna at 9:05 AM on 11/08/06.

Summary of action: this fish moved through the fixed station's detection area in approximately 15 hours.

Code 77 was **not** found during the manual relocations in Rush Creek below the MGORD on 12/05/06 and 12/06/06.

Code 94 – 2006 medium tag (male 349 mm)

1. Initial hits on upper antenna at 1:32 AM on 10/23/06 – only three events recorded.
2. Initial hits on lower antenna at 1:36 AM on 10/23/06.
3. Final hit on lower antenna at 10:43 AM on 10/23/06.

Summary of action: this fish moved through the fixed station's detection area in approximately nine hours.

Code 94 was **not** found during the manual relocations in Rush Creek below the MGORD on 12/05/06 and 12/06/06.

Code 100 – 2006 medium tag (female 314 mm)

1. Initial hits on upper antenna at 7:24 PM on 11/20/06.
2. Passed through array between 8:27 – 8:58 PM on 11/20/06.
3. Final hit on lower antenna at 9:08 PM on 11/20/06.

Summary of action: this fish moved through the fixed station's detection area in one hour and 44 minutes.

Code 100 was manually relocated in Rush Creek downstream of the MGORD on 12/5/06. Fish was located just downstream of the "old" Highway 395 bridge. Knudson made visual contact with Code 100 during manual relocation – he observed blue floy tag on the fish.

Code 102 – 2006 medium tag (male 343 mm) – 767 lines of data

1. Initial hits of upper antenna at 3:10 AM on 10/25/06. Constant hits until 7:48 AM, then fish moved back upstream out of detection range of upper antenna.
2. Re-appeared on upper antenna at 12:29 AM on 10/26/06. Constant hits on upper antenna until 6:04 AM, then fish moved back upstream out of detection range of upper antenna.

3. Re-appeared on upper antenna at 7:29 PM on 11/05/06. Constant hits on upper antenna until 12:18 AM on 11/06/06.
4. Hits on lower antenna between 12:21 – 12:57 AM on 11/06/06. Then fish moved downstream out of detection range of lower antenna for approximately 36 hours.
5. Re-appeared on lower antenna at 1:06 PM on 11/08/06.
6. Within array between 1:06 – 2:22 PM on 11/08/06.
7. Hits on upper antenna only between 2:23 – 3:53 PM on 11/08/06. Fish then moved upstream out of detection range of upper antenna for approximately two hours.
8. Re-appeared on upper antenna at 6:08 PM on 11/08/06. Constant hits on upper antenna until 5:00 AM on 11/09/06. Fish then moved upstream out of detection range of upper antenna for approximately 14 hours.
9. Re-appeared on upper antenna at 7:08 PM on 11/09/06.
10. Constant hits on upper antenna until 8:39 AM on 11/15/06.

Summary of action: this fish spent approximately 22 days in-and-around the fixed receiving station's detection range. At one point, Code 102 was downstream beyond the detection range of the lower antenna for 36 hours.

Code 102 was manually relocated within the MGORD on 12/4/06.

Code 103 – 2006 medium tag (male 338 mm)

1. Initial hits on upper antenna at 7:57 PM on 10/20/06. Constant hits on upper antenna until 9:23 PM on 10/20/06. Fish then moved upstream out of detection range of the upper antenna.
2. Re-appeared on upper antenna at 4:10 AM on 11/01/06. Constant hits on upper antenna until 5:11 AM. Fish then moved back upstream out of detection range of upper antenna.
3. Re-appeared on upper antenna at 9:50 PM on 11/07/06. Hits on upper antenna until 10:34 PM on 11/07/06.
4. Initial hits on lower antenna at 10:41 PM on 11/07/06.
5. Final hit on lower antenna at 6:59 AM on 11/08/06.

Summary of action: this fish was detected briefly (86 and 61 minutes) by the upstream antenna on two occasions approximately 13 days apart. Then six days later the fish moved through the fixed receiving station's detection area in approximately nine hours.

Code 103 **not** found during the manual relocations in Rush Creek below the MGORD on 12/05/06 and 12/06/06.

Code 104 – 2006 medium tag (male 430 mm)

1. Initial hits on upper antenna at 4:04 AM on 10/31/06. Constant hits on upper antenna until 3:19 AM on 11/01/06.
2. Initial hits on lower antenna at 3:30 AM on 11/01/06.
3. Final hit on lower antenna at 4:00 AM on 11/01/06.

Summary of action: this fish moved through the fixed receiving station's detection area in approximately 24 hours.

Code 104 was manually relocated in Rush Creek on 12/06/06 downstream of the MGORD. Fish was holding under willows approximately 50-feet downstream of new Highway 395 bridge and signal moved both upstream and downstream during relocation.

Code 105 – 2006 medium tag (female 341 mm)

1. Initial hits on upper antenna at 3:58 AM on 9/15/06.
2. Initial hits on lower antenna at 4:56 AM on 9/15/06. Constant hits on lower antenna until 9:15 AM on 9/16/06. Then fish moved upstream into array (between antennas).
3. Within array between 9:25 – 9:47 AM on 9/16/06. Then fish moved upstream above upper antenna.
4. Hits on upper antenna between 9:57 AM – 12:37 PM on 9/16/06. Then fish moved downstream between antennas.
5. Within array between 12:41 – 2:41 PM on 9/16/06.
6. Constant hits on lower antenna from 2:41 PM on 9/16/06 to 1:46 AM on 9/17/06.
7. Final hit on lower antenna at 1:46 AM on 9/17/06.

Summary of action: this fish spent approximately 46 hours within the fixed receiving station's range of detection – moving downstream and back upstream before moving downstream out of range of the lower antenna. This movement occurred less than 48 hours after surgical implanting of the radio transmitter tag.

Code 105 was manually relocated in Rush Creek on 12/05/06 downstream of the MGORD. The fish was in the large plunge pool below the fully-spanning Jeffery pine tree located several 100 yards upstream of the "sheep-herder's cabin".

Code 106 – 2006 medium tag (male 353 mm)

1. Initial hit on upper antenna at 3:11 PM on 11/21/06. One event only.
2. Hits on upper antenna from 10:21 AM – 1:22 PM on 11/26/06.

Summary of action: this fish was detected by the upper antenna on two separate days in late November.

Code 106 was manually relocated within the MGORD on 12/04/06.

Code 107 – 2006 medium tag (female 331 mm) – 600 lines of data

1. Initial hits on upper antenna at 5:32 AM on 11/13/06. Final hit on upper antenna at 5:51 AM.
2. Initial hits on lower antenna at 5:55 AM on 11/13/06.

3. Since 11/13/06, Code 107 has been downstream of the lower antenna with periods of time out of range of lower antenna (mostly at night).

Summary of action: this fish moved quickly through the fixed station array and has been residing in and around the confluence of the MGORD with the natural Rush Creek channel for several weeks.

Code 107 was manually relocated in Rush Creek downstream of the MGORD on 12/05/06 – within the "boulder garden" at the MGORD's confluence with the natural Rush Creek channel. The signal moved in an upstream direction during the relocation.

Code 108 – 2006 medium tag (female 469 mm)

1. Initial hits on upper antenna at 11:41 PM on 11/16/06.
2. Initial hits on lower antenna at 12:31 AM on 11/17/06.
3. Final hit on lower antenna at 12:38 AM on 11/17/06.

Summary of action: this fish moved quickly (57 minutes) through the fixed receiving station's area of detection.

Code 108 **not** found during the manual relocations in Rush Creek below the MGORD on 12/05/06 and 12/06/06.

Code 109 – 2006 medium tag (male 337 mm)

1. Initial hits on upper antenna at 4:30 PM on 11/18/06.
2. Passed through array between 4:45 – 5:09 PM on 11/18/06.
3. Hits on lower antenna only for approximately the next five days – some periods of time fish was below the detection range of the lower antenna.
4. Final hit on lower antenna at 10:02 PM on 11/24/06.

Summary of action: this fish moved quickly (39 minutes) through the fixed receiving station's array and then was generally within range of the lower antenna for five days before moving farther downstream.

Code 109 **not** found during the manual relocations in Rush Creek below the MGORD on 12/05/06 and 12/06/06.

Code 110 – 2006 medium tag (male 343 mm) – 649 lines of data

1. Initial hits on upper antenna at 6:02 AM on 10/23/06. Within range of upper antenna until 6:43 PM on 10/29/06. The fish moved upstream out of detection range of upper antenna.
2. Re-appeared on upper antenna at 12:15 AM on 11/09/06. Constant hits on upper antenna for approximately 12 hours.

3. Within array between 12:31 – 6:58 PM on 11/09/06 (approximately 7.5 hours). Fish then moved back upstream of upper antenna.
4. Nearly constant hits on upper antenna from 11/09/06 through 11/13/06. Fish then moved upstream of out of detection range of the upper antenna.
5. Re-appeared on upper antenna at 12:23 AM on 11/18/06.
6. Nearly constant hits on upper antenna from 11/18/06 through 12/02/06.

Summary of action: this fish has been in the lower MGORD (within range of the upper antenna) for three, separate extended periods. On November 9th it was within the antennas for a 7.5 hour period, but doesn't appear to have gone downstream of the lower antenna. Code 110 was manually relocated within the MGORD on 12/04/06.

Summary of Tagged Fish Movement as Determined from the May-2007 Fixed Station Data Down-load

Code 23: Tag from mort in truck – ignore these signals.

Code 74: First hits on downstream antenna at 6:53 AM on 3/19/07, continuous hits on downstream antenna until 2:07 AM on 3/25/07, then fish was within array (between antennas) until 4:51 AM, then all hits on upstream antenna. Final hits recorded on upstream antenna at 10:43 AM on 3/25/07. **Relocated on 5/1/07 within the MGORD.**

Code 76: 3,243 lines of hits on upstream antenna. **Relocated on 5/1/07 in MGORD on first bend upstream of upper antenna.**

Code 77: 5,624 lines of hits on upstream antenna. **Relocated on 5/1/07 in MGORD within 75' of upper antenna.**

Code 91: Hits on upstream antenna on 4/21/07 between 6:09 AM and 10:22 PM. One hit on upstream antenna at 7:35 AM on 4/24/07. **Relocated on 4/30/07 within the MGORD.**

Code 92: Hits on downstream antenna on 2/15/07 between 2:19 – 3:23 PM. **Relocated on 5/1/07 downstream of the "sheep-herder's cabin". Signal moved u.s. when approached.**

Code 93: Hits on upstream antenna on 3/14/07 between 8:06 – 8: 39 AM. **Relocated on 4/30/07 within the MGORD.**

Code 96: Sporadic hits on upstream antenna on 3/2/07, 3/7/07 and 3/9/07. All hits on these three mornings occurred between 6:15 – 9:00 AM. **NOT relocated in May-2007.**

Code 101: Hits on downstream antenna on 2/16/07 between 4:14 – 8:08 AM. Next hits on downstream antenna on 4/9/07 between 6:28 – 9:15 PM, then hits on upstream antenna from 9:27 PM on 4/9-07 until 7:30 AM on 4/10/07. Code 101 then dropped down into the array for most of 4/10/07 with final hits on upstream antenna at 10:30 PM on 4/10/07. Brief hits on upstream antenna on 4/13/07 and 4/18/07. **Relocated on 5/1/07 within the MGORD.**

Code 103: Passed upstream through the array on 4/28/07 between 6:51 – 11:18 AM. **Relocated on 5/1/07 within the MGORD.**

Code 110: Hits on upstream antenna on 3/2/07 and then passed through the array on 3/5/07 between 4:30 – 10:50 PM. Brief hits on downstream antenna at 8:40 AM on 3/6/07. **NOT relocated in May-2007.**

Summary of Tagged Fish Movement as Determined from the January-2008 Fixed Station Data Down-load

Code 15: 3,165 lines of hits.

1. First hits on upstream antenna at 12:24 AM on 10/8/07, continuous hits on upstream antenna until 10:51 PM on 10/12/07, the fish was within array (between antennas).
2. Drops below detection range of downstream antenna on 10/15-16/07 for about seven hours (6:40 PM – 1:45 AM).
3. Within array, the drops below detection range downstream antenna on 10/16/07 for about 5.5 hours (7:1 AM – 12:40 PM).
4. Back within array, until 10/17/07 drops below detection range of lower antenna for 3.5 hours (6:00 – 8:30 PM).
5. Back within array between 10/17-30/07. Final hit on upstream antenna at 5:55PM on 10/30/07.

Code 15 was relocated on 1/21/08 within the MGORD.

Code 16: Several hits were recorded on lower antenna at 1:54PM on 11/5/07. Not sure how these hits occurred, possibly because tag was in Doug or Karl's possession.

The Code 16 tag was found on MGORD road by Doug Smith while duck hunting and given to Karl, the LA employee at the Cain Ranch, who gave tag to Taylor on 1/22/08. Doug was unable to recall date of his find.

Code 27: 202 lines of hits on upstream antenna.

1. Hits on upstream antenna between 9/28/07 and 10/2/07.
2. Hits on upstream antenna between 10/25–27/07.
3. Hits on upstream antenna between 11/2–6/07.

Code 27 was NOT relocated during the Jan-08 relocations.

Code 76: 131 lines of hits.

1. Hits on upstream antenna on 9/12/07 between 4:08 PM and 10:23 PM.
2. Hits on upstream antenna on 11/9/07 between 2:08 AM and 6:49 AM.
3. Hits on upstream antenna on 11/21/07 between 4:13 AM and 1:57 PM.
4. Hits on upstream antenna on 12/8/07 between 1:10 AM and 9:42 AM.

Code 76 was relocated on 1/23/08 within the MGORD on the first bend upstream of the upper antenna.

Code 77: 2 lines of hits.

Hits were recorded on the upstream antenna for about 20 minutes on 9/12/07.

Code 77 was relocated on 1/23/08 within the MGORD.

Code 82: 6 lines of hits.

This fish passed quickly in a downstream direction through the antenna array on 10/19/07. Hits on upstream antenna 5:15 – 5:30 AM and hits on downstream antenna between 5:30 – 5:50 AM.

Code 82 was relocated on 1/22/08 in the large pool located approximately 100 meters upstream of the upper boundary of the Upper Rush Creek sample section.

Code 85: 7 lines of hits.

This fish passed quickly in a downstream direction through the antenna array on 9/23/07, the initial hits on upstream antenna occurred at 7:15 PM and the final hit on downstream antenna occurred at 7:37 PM.

Code 85 was relocated as a probable MORT on 1/22/08 in the gorge downstream of the MGORD.

Code 87: 32 lines of hits.

This fish passed in a downstream direction through the antenna array on 10/12/07, the initial hits on upstream antenna occurred at 12:51 AM and the final hit on downstream antenna occurred at 5:44 AM.

Code 87 was NOT relocated during the Jan-08 relocations.

Code 88: 12 lines of hits.

This fish passed in a downstream direction through the antenna array on 9/13/07, the initial hits on upstream antenna occurred at 8:30 PM and the final hit on downstream antenna occurred at 10:03 PM.

Code 88 was NOT relocated during the Jan-08 relocations.

Code 89: 12,309 lines of hits!

1. Hits on upstream antenna on 10/15/07 between 2:20 – 6:20 AM.
2. Hits on upstream antenna on 10/20/07 between 3:10 – 4:50 AM.
3. Starting on 10/21/07, fish was within antenna array until 1/14/08. Starting on 12/18/07 almost all hits were on downstream antenna.
4. Final hit on downstream antenna was on 1/14/08 at 6:33PM.

Code 89 was relocated on 1/22/08 in the gorge downstream of the MGORD.

Code 90: 11 lines of hits.

Hits were recorded on the upper antenna on 9/14/07 between 12:27 AM and 2:03 AM.

Code 90 was relocated on 1/23/08 within the MGORD.

Code 91: 3,667 lines of hits.

1. Constant hits on upstream antenna between 9/12/07 and 10/8/07.
2. Moved downstream through array on 10/8/07 between 8:46 AM and 10:29 AM.
3. Final hit recorded – did fish really move out or did battery die?

Code 91, a medium-sized tag, most likely had a dead battery when the Jan-08 relocations occurred.

Code 97: 38 lines of hits.

Hits occurred between 9/12/07 and 9/13/07 – first on the upper antenna, then on the lower antenna, and then on the upper antenna. Final hit occurred at 8:47 PM

Code 97, a medium-sized tag, most likely had a dead battery when the Jan-08 relocations occurred.

Code 98: 19 lines of hits.

Hits occurred on 9/12/07 – first on the upper antenna between 5:07 – 5:16 PM, then on the lower antenna between 5:24 – 8:27 PM, and then on the upper antenna. Final hit occurred at 8:56 PM

Code 98, a medium-sized tag, most likely had a dead battery when the Jan-08 relocations occurred.

Code 102: 59 lines of hits.

Hits occurred on upper antenna on10/12/07, between 1:29 AM and 6:22 PM.
Hits occurred on upper antenna on10/20/07, between 12:56 AM and 5:26 AM.

Code 102, a medium-sized tag, most likely had a dead battery when the Jan-08 relocations occurred.

Summary of Fish Relocated during the Jan-08 Relocations

Code 12 – relocated on 1/22/08 in pool downstream of Jeffery Pine pool within gorge downstream of the MGORD. **N37.87616 W119.10825**

Code 15 – relocated in the MGORD on 1/21/08.

Code 16 – MORT, tag was found on MGORD road by Doug Smith and given to Karl (LA employee at Cain Ranch) who gave tag to me. Exact date of when tag was recovered unknown.

Code 20 – relocated in the MGORD on 1/21/08.

Code 24 - relocated in the MGORD on 1/23/08.

Code 25 – relocated as a probable MORT in gorge below MGORD, upstream of Jeffery Pine pool. We hung orange flagging at spot where signal was strongest. **N37.87556 W119.10806**

Code 26 – relocated on 1/22/08 w/in gorge downstream of the MGORD. **N37.87281 W119.10779**

Code 71 – relocated as a MORT (found carcass and removed tag) within MGORD on 1/23/08.

Code 72 - relocated in the MGORD on 1/23/08.

Code 74 – relocated as a probable MORT below "sheep herder's hut". We hung orange flagging at spot where signal was strongest – 50' from LB in dense brush. **N37.88034 W119.10222**

Code 76 - relocated in MGORD on 1/23/08 - 1st bend u.s. of the upper antenna.

Code 77 - relocated in the MGORD on 1/23/08.

Code 79 - relocated in the MGORD on 1/23/08.

Code 82 - relocated on 1/23/08 in the large pool located approximately 100 meters upstream of the upper boundary of the Upper Rush Creek sample section. **N37.88158 W119.09956**

Code 83 - relocated in the MGORD on 1/23/08.

Code 84 - relocated in the MGORD on 1/23/08.

Code 85 – relocated as a probable MORT in gorge below MGORD, upstream of Jeffery Pine pool. We hung orange flagging at spot where signal was strongest. **N37.87472 W119.10872**

Code 86 - relocated in the MGORD on 1/23/08.

Code 89 – relocated on 1/22/08 within gorge downstream of the MGORD. **N37.87398 W119.10864**

Code 90 – relocated in the MGORD on 1/23/08, very close to Code 76.

Summary of Tagged Fish Movement as Determined from the July-2008 Fixed Station Data Down-load

Code 15: 220 lines of hits.

6. First hits on upstream antenna at 11:15 PM on 6/09/08, continuous hits on upstream antenna for approximately 10 minutes, until 11:25 PM.

7. Continuous hits on the downstream antenna from 11:35 PM (6/09/08) to 1:30 AM (6/10/08).

8. Drops below detection range downstream antenna on 6/10/08 for about 5.5 hours (1:30 AM – 7:05 AM).

9. Back within detection of the lower antenna at 7:05 AM on 6/10/08. Continuous hits on the lower antenna until 11:32 AM on 6/11/08.

10. Passes upstream through the array in approximately 23 minutes on 6/11/08, between 11:32 – 11:55 AM.

11. Within detection of the upstream antenna for approximately nine hours on 6/11/08. Final hit on upstream antenna at 9:07 PM on 6/11/08.

Code 15 was relocated on 1/21/08 and 3/18/08 within the MGORD.

Code 72: 5,417 lines of hits.

1. First hits on upstream antenna at 9:30 PM on 2/24/08, continuous hits on upstream antenna for approximately three hours, until 12:27 AM on 2/25/08.

2. Continuous hits on the downstream antenna from 12:35 AM (2/25/08) to 7:09 PM (2/26/08).

3. On the evening of 2/26/08, Code 72 starts a pattern of being detected within the array during the evening, night and/or early morning, and then moving downstream within detection of only the lower antenna during daylight hours. This pattern is consistently exhibited until March 28th at 9:36 PM when Code 72 moves downstream out of the detection range of the lower antenna.

4. On 5/17/08, Code 72 was re-detected by the lower antenna at 3:27 AM; it had been downstream out of detection range for 48 days. The fish then passed through the array between 4:01 PM and 6:36 PM. Final hit on the upstream antenna was recorded at 6:57 PM on 5/17/08.

Code 72 was relocated on 3/18/08 approximately 100 feet downstream of the lower antenna.

Code 76: 1,655 lines of hits.

5. Steady hits on upstream antenna started on 2/17/08 at 10:20 AM and continued through 12:20 AM on 2/20/08.

6. Code 76 was then detected within the array from 12:25 AM on 2/20/08 through 7:38 PM on 2/22/08.

7. Continuous hits on downstream antenna from 7:38 PM on 2/20/08 through 3/1/08. Final hit on lower antenna was at 10:55 AM on March 1st.

Code 76 was relocated on 3/19/08 approximately 1,000 feet downstream of the lower antenna.

Code 83: 10 lines of hits.

1. This fish was detected by the upstream antenna on 2/09/08 between 5:32 PM and 6:51 PM.

2. Brief detection on the upstream antenna on 2/20/08 at 9:14 AM.

Code 83 was relocated within the MGORD on 1/23/08 and on 3/18/08.

Code 84: 6 lines of hits.

1. Brief detection on the upstream antenna on 2/11/08 between 6:34 AM and 6:42 AM.

2. Brief detection on the upstream antenna on 2/13/08 between 9:47 AM and 9:50 AM.

3. Brief detection on the upstream antenna on 7/08/08 between 5:35 AM and 5:40 AM.

Code 84 was relocated within the MGORD on 1/23/08 and on 3/18/08.

Code 88: 12 lines of hits.

This fish passed in an upstream direction through the antenna array on 5/11-12/08, with the initial hits on downstream antenna occurring at 4:11 PM on 5/11/08. Code 88 was within the array between 8:36 – 8:46 PM on 5/11/08. The final hit on upstream antenna occurred at 5:31 AM on 5/12/08.

Code 88 was NOT relocated during the Jan-08 and March-08 relocations. This fish migrated out of the MGORD on 9/13/07 and is assumed to have been downstream well past Highway 395 during the January and March relocations.