Expert Witness Report
of
Craig L. Fredrickson

Pursuant to
Federal Rule of Civil Procedure
26(a)(2)(B)

Case No. 01 cv 00072 MV/WPL
Subfile ZRB-2-0038

United States District Court
District of New Mexico

June 27, 2016

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ATTACHMENTS

INTRODUCTION

The water rights associated with well 10A-5-W06, a.k.a. the Rincon Hondo Well, are being adjudicated in accordance with New Mexico water law in United States District Court for the District of New Mexico, Case No. 01 cv 00072 MV/WPL, Subfile No. ZRB-2-0038. The Defendants in this case are Craig and Regina Fredrickson, owners of the well and appurtenant land; Plaintiffs in this case are the United States of America and the State of New Mexico.

This report sets forth the opinions I have formed regarding the historic beneficial use of well 10A-5-W06 for watering cattle and establishes each element of a livestock use component: priority, beneficial use, place of use, period of use, and amount. In accordance with Rule 26 (a)(1)(2)(B) of the Federal Rules of Civil Procedure, this report contains a complete statement of all opinions used to establish these elements, including the basis and reasons for these opinions, as well as the facts or data that were considered.

As particularly described in this report, a combination of documentary evidence, field observation and technical analysis, based upon published data and established methodology, was used to form my opinions. The general approach to forming my opinions included the following:

- Utilize site-specific information and documentation to the maximum extent available,
- Test all statements or assertions, verbal or written, to ensure that they are credible,
- Utilize published data and established methodologies for all quantitative analyses,
- Where assumptions are required, provide the complete bases and reasons,
- Use the same core assumptions throughout to ensure consistency in the analyses,
- Where uncertainty may be involved, err on the side of a conservative result, and
- Cite references such that results can be objectively reproduced by others.

This report contains exhibits, including documents, photographs, figures and tables, that summarize or support these opinions and which may be used at trial. I may find it appropriate to revise or supplement my opinions, analysis, and conclusions stated herein in the future.

Well 10A-5-W06 is located on section 19, township 5N, range 18W N.M.P.M. in Rincon Hondo Canyon. I have owned and maintained this 640-acre section of land since February, 2006. I am an engineer with more than 27 years of experience in conducting complex technical analysis and providing consulting services related to compliance with a wide range of Federal laws and associated regulations. As such, I have both the personal, site-specific knowledge of the land and its improvements, and the qualifications, by virtue of my skills, experience, training and education, to assess the historic beneficial use of well 10A-5-W06 for livestock watering.

I retired in the year 2000 and have not authored any publications in the previous 10 years nor have I ever testified as an expert at trial or by deposition. I represent the Defendants, including himself, in this case without compensation. My resume is included as Attachment 7.

OPINIONS RENDERED

OPINION No. 1: The priority date for well 10A-5-W06 is 1955. The date is without further clarification of actual month or day of first beneficial use and is therefore assumed to be December 31, 1955.

OPINION No. 2: The historic, beneficial use of well 10A-5-W06 included livestock watering. The well supported livestock operations uninterrupted from 1955 through 2000 and, more particularly, a cow-calf operation from at least 1983 through 2000.

OPINION No. 3: The place of use of well 10A-5-W06 is the NE ¼ of the NE ¼ of the NW ¼ of Section 19, Township 5N, Range 18W N.M.P.M.

OPINION No. 4: The period of use of well 10A-5-W06 for livestock watering was throughout the year (12 months).

OPINION No. 5: With a reasonable degree of scientific certainty, the maximum amount of groundwater diverted through well 10A-5-W06 for the beneficial purpose of livestock watering was 3.779 acre-feet per annum.

BASIS FOR OPINIONS

Background

The Cox Ranch was established by Robert L. "Bert" and Anna S. Cox in the 1920s and eventually grew to include approximately 140 sections of private and leased land. A portion of the ranch included land in the region of Rincon Hondo Canyon where cow-calf operations were conducted. A regional map, including well locations, is included as Attachment 1. The upper canyon where well 10A-5-W06 is located is as pictured in Figure 1.

Figure 1 – Upper Rincon Hondo Canyon

In 1955, Bert Cox had well 10A-5-W06 drilled on section 19, township 5N, range 18W. Groundwater was diverted through the well and placed to beneficial use for the watering of cattle. The well was drilled and placed to beneficial use prior to the declaration of the Gallup

Water Basin. Tommy Cox, a son of Bert and Anna Cox, filed a Declaration of Water Right for this well in 1990 (Attachment 2).

Well 10A-5-W06 is 505 feet deep and remains equipped with its original, 14-foot wheel diameter Aermotor windmill mounted on a 35-foot tower. The tower was designed with an open side where a Jensen pump jack is positioned such that water can be pumped when wind power is either unavailable or insufficient to meet water demand; two older pump jacks are abandoned at the site. There is no flow meter on the well nor is electrical service provided to the well location. Water diverted from the aquifer is discharged to a large, uncovered water storage tank (see Figures 2 and 3).

Figure 2 - Well 10A-5-W06

Figure 3 - Well Maintenance, 2006

The large storage tank supplies two livestock drinkers by gravity flow through underground piping, fittings and valves; water level in the drinkers is automatically controlled by a float valve in a float box (tank). All four of these tanks/drinkers have steel sides and concrete bottoms. Two relocatable water troughs are also present at the well location, these troughs being constructed of steel. All existing infrastructure appears to be original to the well installation. There is no evidence of any livestock pond that might otherwise have been used to store diverted well water. Table 1 summarizes the characteristics of well 10A-5-W06 and the associated water delivery, storage and distribution infrastructure.

Well Characteristics					
Well Casing Diameter (in.)	6	(extends ~25 ft below surface)			
Well Depth (ft)	505				
Static Water Level (ft)	470				
Windmill					
Aermotor 702 Model					
Wheel Diameter (ft)	14				
Drop Pipe Diameter (in.)	2.5	(extends 505 ft below surface)			
Weep Hole Diameter (in.)	0.125	(4 ft below surface)			
Stand Pipe Diameter (in.)	2.5	(extends 10 ft above surface)			
Steel Sucker Rod Diameter (in.)	1	(extends 505 ft below surface)			
Well Cylinder Specifications	1 7/8" diameter x 20" stroke x 30" barrel length				
Cylinder Pump Specifications	1 7/8", 4-leather Ball Valve Plunger Assembly				
Bottom Check Specficiations	1 7/8", 1-leather Ball Valve Bottom Check Valve				
Pump Rate (gal/hr)	180	(at windspeed of 18-20 mph)			
Pump Jack					
Jensen Straight Lift Jack	Size 100DC				
Wisconsin Air Cooled Engine	Model AGND				
Pump Rate (gal/hr)	1080	(see Attachment 2)			
Water Tanks/Drinkers/Troughs					
	Diameter (ft)	Depth ft)	Surface Area (ft^2)	Volume (ft^3)	Volume (gallons)
Main Storage Tank	16.33	10.00	209.44	2,094.41	15,666.21
Float Box (Tank)	3.00	1.33	7.07	9.40	70.32
Drinker 1	7.33	1.33	42.20	56.12	419.81
Drinker 2	5.00	1.33	19.63	26.11	195.34
Trough 1	2.00	2.25	3.14	7.07	52.87
Trough 2 (rectangular)	2.00 x 5.00	1.00	10.00	10.00	74.80
Totals			291.48	2,203.12	16,479.35

Table 1 - Well 10A-5-W06 and Infrastructure

1.0 Basis for Opinion No. 1: Priority

Defendant's ownership of an underground water right was first claimed on March 14, 1990 by Declarant Thomas R. "Tommy" Cox. Tommy Cox was the then owner of deeded property within Rincon Hondo Canyon including Section 19, Township 5N, Range 18W, N.M.P.M. The New Mexico Office of the State Engineer accepted for filing that claim as Declaration of Ownership of Underground Water Right No. 33-8, one of eleven declarations accepted for filing by R.Q. Rodgers, Supervisor, District 3 of the State Engineer Office on March 27, 1990. The declaration is included as Attachment 2.

Declaration of Ownership of Underground Water Right No. 33-8 documented the existence of a well located in the "Rincon Hondo" at the NE ¼ of the NE ¼ of the NW ¼ of Section 19, Township 5N, Range 18W N.M.P.M. That well and well 10A-5-W06 are one and the same. Paragraph 7 of the referenced document specifically identifies that the well had been first applied to beneficial use in 1955 and since that time had been used fully and continuously on all of the above described lands or for all of the described purposes. As such, **the priority date for well 10A-5-W06 is 1955**. The date is without further clarification of actual month or day of first beneficial use and is therefore assumed to be December 31, 1955.

2.0 Basis for Opinion No. 2: Beneficial Use

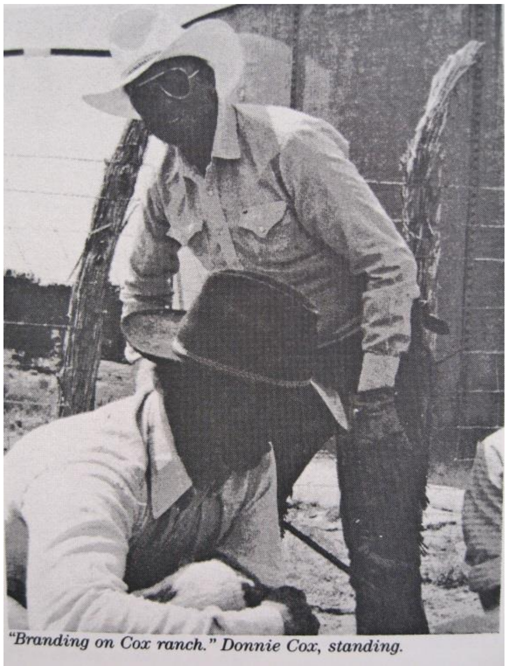
Declaration of Ownership of Underground Water Right No. 33-8 documents the purpose of well 10A-5-W06. Paragraph 5 of the referenced document (Attachment 2) identifies the beneficial use as for livestock watering purposes. More particularly, and as described below, the well had been used to raise cattle through a cow-calf operation whereby beef cows and their calves were grazed within the Rincon Hondo Canyon region and watered at this well.

As a matter of explanation, a cow-calf operator keeps a herd of mature cows to produce calves to sell to other producers. Cows are bred to have a calf every year, usually in late winter or early spring. Generally, calves are weaned at 6 to 10 months of age and generally weigh in the range of 450 to 700 pounds at that time. Other typical beef cattle operations are the backgrounder-stocker operator and the feedlot operator. The backgrounder-stocker operator buys weaned calves and turns them out on pastures until they reach 800 to 900 pounds. The feedlot operator purchases weaned calves or backgrounded calves and feeds them to market weight (Cattlemen's Beef Board and National Cattlemen's Beef Association, 2016).

The specific use of well 10A-5-W06 to support a cow-calf operation was verbally conveyed through several personal telephone conversations the author had in 2006 through 2008 with the two surviving sons of Tommy Cox, Tim A. Cox of Quemado, NM and Tom W. Cox then of Rogers, NM. The deposition of Tom W. Cox, taken on May 18, 2016, confirmed this specific use ([Cox, 2016] Cox Dep. 23:25-24:10) for the period of his involvement in ranch operations, approximately 1983 through 2000. Paragraph 7 of the 1990 Declaration indicates that the well had been used continuously for livestock watering since 1955 (Attachment 2). When the Tom W. Cox deposition and the Tommy Cox declaration are considered together, well 10A-5-W06 had been in continuous use for livestock watering purposes from 1955 through 2000.

Figure 4 is an undated photograph of Donald P. “Donnie” Cox, brother of Tommy Cox, branding a calf at the well location (Fence Lake Book Committee, 1987). As described in the family history of the late Robert (Bert) and Anna Cox, “many people far and wide still talk about

Bert and his gathering cattle and the big branding each year" (Fence Lake Book Committee, 1987). In the background of the Figure 4 photograph is the large, water storage tank associated with well 10A-5-W06. It is identified as such by the overflow pipe for this tank and the unique fence post and fencing in the foreground.



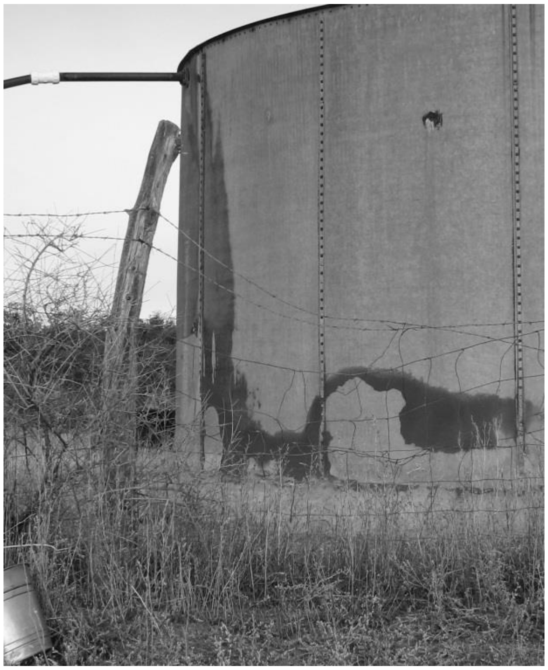


Figure 4 - Branding a Calf

Figure 5 - Same Location, 2016

A recent photograph of the tank is provided as Figure 5; through comparison with Figure 4, it helps validate the specific nature of the cattle operations occurring at this location at that time. As such, **the historic, beneficial use of well 10A-5-W06 included livestock watering.** The well supported livestock operations uninterrupted from 1955 through 2000 and, more particularly, a cow-calf operation from at least 1983 through 2000.

3.0 Basis for Opinion No. 3: Place of Use

Declaration of Ownership of Underground Water Right No. 33-8 documents the place of use of well 10A-5-W06. Paragraph 3 of the referenced document (Attachment 2) specifically identifies the well location as “Rincon Hondo” at the NE ¼ of the NE ¼ of the NW ¼ of Section 19, Township 5N, Range 18W N.M.P.M. The fact that Tommy Cox intentionally added “Rincon Hondo” to the description of the location is important when considered in the context of paragraphs 5 and 7 of the declaration. Paragraph 5 describes the beneficial use as “livestock watering” and paragraph 7 describes the beneficial use as “on all of the above described lands” to include his phrase “Rincon Hondo.” By virtue of its topography, Rincon Hondo Canyon represents a physical obstacle to cattle that might otherwise range outside the confines of the canyon. “Rincón Hondo” literally translates from Spanish as “deep piece of land,” providing insight into the nature of the topography (see Figure 1).

The Cox family owned private property in and around Rincon Hondo Canyon until the years 1999 and 2000 (Attachment 3). In 1999, Tim A. Cox and family members entered into a real estate contract with Great Western Properties, Inc. Subsequently, and over a period of several years, all deeded property within the Rincon Hondo previously owned by Tim W. Cox was sold to others through Great Western Properties, Inc. In addition, in 2000, Tom W. Cox, hereafter referred to as Tom Cox, and family sold additional deeded property within the Rincon Hondo to Edward and Donna Wagner.

Included in these multiple transactions were all or portions of Sections 18, 19, 20 and 29, Township 5N, Range 18W, and all or portions of Sections 12, 13 and 25, Township 5N, Range 19W. All or portions of each of these seven privately-owned sections lie within Rincon Hondo

Canyon and all are within a two-mile grazing distance of well 10A-5-W06. Guidelines established for determining initial stocking rates generally exclude pasture that is greater than two miles from a reliable water source (NRCS, 2009) (Holechek, 1988).

Public land within Rincon Hondo Canyon is managed by the Bureau of Land Management (BLM) and includes all of Section 30, Township 5N, Range 18W and Section 24, Township 5N, Range 19W. Until the year 2000, grazing permits for this public land were held by the Cox family. The associated grazing allotments are included as Attachment 4. They show that Tommy and Donnie Cox were using these two BLM sections of public land as part of their adjoining grazing allotments. Portions of these two sections of public land lie within Rincon Hondo Canyon and are within a two-mile grazing distance of well 10A-5-W06. The deposition of Tom Cox confirmed that the Cox family had a BLM permit to graze as many as 270 head of cattle in the Rincon Hondo Canyon region (Cox Dep. 30:12).

Taken together, all or portions of the aforementioned nine sections of private and public land were owned or controlled by the Cox family for the purposes of grazing livestock. Moreover, all or portions of the nine sections of land are within two-miles grazing distance of well 10A-5-W06. No other reliable source of water exits within a two-mile radius of well 10A-5-W06.

Potential sources of stock water that do or did exist within Rincon Hondo Canyon have been identified by ground truth observation and include: an intact livestock pond on BLM Section 30, Township 5N, Range 18W; an intact livestock pond on BLM Section 24, Township 5N, Range 19W; a breached livestock pond on Section 13, Township 5N, Range 19W; an intact livestock pond on Section 12, Township 5N, Range 19W; and an abandoned well, known as the Amado Windmill, on Section 12, Township 5N, Range 19W.

The Amado Windmill served a 40-foot deep well (Office of State Engineer [OSE] File No. G 01149) and is in ruin. The OSE file indicates that the well was never deepened or repaired. Figures 6, 7 and 8 show the Amado Windmill and associated permanent infrastructure.

Figure 7 – Six-Foot Windmill Motor

Figure 6 – Amado Windmill

Figure 8 – Amado Drinker

The scattered livestock ponds identified above are only fed by precipitation run-off. The only one that holds substantial water for more than a few weeks is the first one identified above. In three of the past ten years it collected water, that being in association with short-duration, heavy monsoon rains up-gradient of the pond. In those three instances, water was retained through spring until evaporation and infiltration depleted the pond (personal observation).

It is evident that well 10A-5-W06 provided water for livestock that was grazed on pasture within Rincon Hondo Canyon and not solely on Section 19, Township 5N, Range 18W, N.M.P.M. where the well is located. It was and is the only reliable source of water within a two-mile grazing distance of itself. **The place of use of well 10A-5-W06 is the NE ¼ of the NE ¼ of the NW ¼ of Section 19, Township 5N, Range 18W N.M.P.M.**

4.0 Basis for Opinion No. 4: Period of Use

The Cox family was in the beef cattle business as a cow-calf operator. The deposition of Tom Cox was limited to specific operations that occurred during the deponent's involvement, i.e., approximately 1983 until 2000 (Cox, 2016). Each year, all cows and calves were gathered up and removed from the Rincon Hondo Canyon region in November; pregnant cows were reintroduced for winter pasturing in December (Cox Dep. 33:13-22). Bulls were kept in the Rincon Hondo Canyon region year-round (Cox Dep. 25:4-16). Unlike operations at any of the other water sources in the Rincon Hondo Canyon region, the Rincon Hondo Well (well 10A-5-W06) supported cattle operations year-round (Cox Dep. 37:5-7 and 37:21-22). Section 5.0 provides additional details regarding the cow-calf operations throughout this region.

In the Rincon Hondo Canyon region, forage for cattle is largely provided by perennial grasses (Allison, 2011). Cool-season perennial grasses, e.g. western wheatgrass, appear in early April; warm-season perennial grasses, e.g. blue grama, mature in August and go dormant in early winter. Protein supplements were used to support wintering cattle from approximately Christmas until early April; bulls were also fed hay during this period in drought years (Cox Dep. 26:9-18). Ranchers need to provide hay and other supplements to their cattle during the winter, provide shelter, ensure the availability of fresh water, and maintain the health and viability of their herd (Anderson, 2011).

Accordingly, **the period of use of well 10A-5-W06 for livestock watering was throughout the year (12 months)**.

5.0 Basis for Opinion No. 5: Amount

Cattle ranchers, like farmers, are subject to climatic conditions that are beyond their control; there is no guarantee of profitability in any single year. A successful rancher will strive to be profitable over the long-term with financial losses in years of drought offset by financial gains in years of plenty. To ensure continuing success, herd size and grazing period must be matched with the quantity of forage available within grazable distance of a water source. As such, the amount of water withdrawn for livestock from any particular source, including well 10A-5-W06 (also referred to as the Rincon Hondo Well in this section), would vary from year to year.

The Rincon Hondo Canyon region of the former Cox ranch is generally characterized by rough, broken terrain, including mesas intermingled with steep canyon walls, escarpments and valleys (SCS, 1993). There is no surface water and very few springs. The soils of the region generally support commercial wood cutting and/or cattle ranching. A cow-calf operation was established in this particular part of the ranch. To exploit the available forage, livestock water sources, including the Rincon Hondo Well, were developed proximate to locations where the forage naturally grew.

This section includes a description of the cow-calf operation in the Rincon Hondo Canyon region as described by Tom Cox in his deposition of May 18, 2016 (Cox, 2016). It addresses the size and composition of the cow-calf herd as well as the distribution of the herd across the region as a function of time. Water sources exploited by the herd are then characterized in terms of location, infrastructure, efficacy and period(s) of seasonal use.

Available forage proximate to these water sources is evaluated to determine the cattle carrying capacity of the associated pasture measured in animal-unit days (AUDs) of forage. The animal-unit is a convenient denominator for use in calculating relative grazing impact of different kinds and classes of domestic livestock and of common wildlife species (NRCS, 1997). The amount of water withdrawn for livestock from any particular water source will be limited by the carrying capacity of the associated pasture or the capacity of the water source itself.

The quantity of water consumed by the herd from a water source is calculated based upon the number of cattle, the number of days at the water source, and the water intake rate for each class of cattle in the herd. Finally, the consumptive loss and other losses associated with the water delivery process can be quantified based upon site-specific knowledge and cattle management procedures. The quantity of water directly consumed by cattle, when added to the losses associated with the delivery of that water, represents the total amount of water beneficially used each year for livestock watering at the Rincon Hondo Well.

The use of a specific water source on open rangeland will necessarily vary from year to year based upon the available forage proximate to that water source. To provide for the amount of water necessary to maintain a profitable cattle operation over time, appropriated livestock water rights must reflect the maximum need, not the minimum or average need, of the cattle.

5.1 Cow-Calf Operations in the Rincon Hondo Canyon Region

The March 18, 2016 deposition of Tom Cox provided details concerning the cow-calf operations conducted in the Rincon Hondo Canyon region during the period approximately 1983 through 2000 (Cox, 2016). In summary terms, he described the operations as follows.

Based on forage conditions, between 150 and 200 pregnant cows would be brought into Rincon Hondo Canyon each December. The cows would be distributed among three pastures during the so-called “winter season,” December through June. Twenty percent were pastured near and watered exclusively by the Rincon Camp Well (see Attachment 1 for well locations). Forty percent would be pastured between the Rincon Camp Well and the Amado Well. The remaining 40 percent were pastured between the Amado Well and the Rincon Hondo Well. Water duty was reportedly shared between these wells. Spring calving would occur in the period March through May with an average calf crop of approximately 90%.

Bulls were maintained in Rincon Hondo Canyon year-round at a ratio of one bull to every ten cows. From November through spring these bulls were kept separate from the cows in two pastures, a section pasture watered from the Rincon Camp Well and an eighty-acre pasture watered from the Rincon Hondo Well. In June the bulls were released to run with the cows until round-up occurred.

When the rains began in early July, all cattle were moved to the upper country for the “summer season” and isolated from the winter pastures by existing fences and gates. The cattle were free to roam these higher elevations based on available forage. Four water sources reportedly served this summer range, the Rincon Hondo Well, Zuni Spring, the High Lonesome Well and the Perry Canyon Well. The free range upper country began at the Rincon Hondo Well and extended south and then west to the High Lonesome Well (see Attachment 1). In November, all cows and calves were rounded up for shipment and all calves were weaned; bulls were returned to their winter pastures.

5.2 Rincon Hondo Canyon Region Water Sources

In total, six potential water sources were available to the Rincon Hondo Canyon regional herd, five wells equipped with windmills and one natural spring (see Attachment 1). Table 2 provides a comparison of these six water sources in terms of location, infrastructure, and operational characteristics. The details are drawn from the testimony of Tom Cox (Cox, 2016), Zuni Basin adjudication court records (Document 2276) (NRCE, 2005), OSE files for the respective points of diversion, Google Earth satellite imagery and personal observation.

Name	**Rincon Camp Well**	**Amado Well**	**Rincon Hondo Well**	**Zuni Spring**	**High Lonesome Well**	**Perry Canyon Well**
Zuni Basin Designation	9C-5-W03	9C-5-W04	10A-5-W06	9C-6-SPR01	Outside Basin	Outside Basin
OSE Designation	G 01150	G 01149	G 02469	None	G 01153	None
Location	34°41'01.9"N 108°50'07.4"W	34°40'21.7"N 108°47'41.5"W	34°39'07.4"N 108°46'29.6"W	34°38'45.25"N 108°49'37.63"W	34°38'11.41"N 108°51'35.65"W	Unknown
Elevation	6634 ft.	6815 ft.	6963 ft.	6926 ft.	7217 ft.	Low elevation
Production Method(s)	Windmill + Pump Jack	Windmill	Windmill + Pump Jack	Natural	Windmill (now solar?)	Windmill
Storage Method	Large Storage Tank	None	Large Storage Tank	None	Large Storage Tank	None
Delivery Method	Underground piping through float box to drinker(s)	Above ground piping to drinker	Underground piping through float box to drinkers	None	Piping through float box to drinker(s)	Unknown
Permanent Drinkers	3	1	2	0	2?	1
Period of Use	December - June	December - June	December - November	July-November	July-November	July-November
Livestock Water Right	1.841 afy	1.841 afy	To Be Determined	0.000 afy	N/A	N/A
Comments	Appears to have a small associated livestock pond.	Infrastructure now in ruin. Water was allowed to spill continuously when used.	Only source used by cattle year-round.	Water puddles on ground.	This well is also known as the Perry Lake Well.	Shared with others. Gypsum-contaminated water. Water was allowed to spill continuously when used.

Table 2 – Comparison of Rincon Hondo Canyon Regional Water Sources

Several observations are important in understanding how each source might contribute to the water requirements of the Rincon Hondo Canyon regional herd:

- Two of the wells, the High Lonesome Well and the Perry Canyon Well, are outside the boundary of the Zuni Basin; their water rights are not within the scope of this adjudication.
- The Amado Well and Perry Canyon Well did not have associated water storage capability; the associated windmills were left in the pumping position and water was produced when wind speed was sufficient. This water was directed to a drinker and, when full, overflowed to the ground.
- Water from the Perry Canyon Well was contaminated with gypsum. This water source was shared with a neighbor whose historic usage requirement is unknown.
- The Zuni Spring had no water storage capability or drinker; it has been allocated no water right under the Zuni Basin adjudication.
- The Rincon Camp Well, Rincon Hondo Well and High Lonesome Well each have some similar infrastructure, i.e. windmill, storage tank, float box and drinker(s). The Rincon Hondo Well and Rincon Camp Well were each equipped with an auxiliary pump jack to allow water production during periods of calm wind.
- Only the Rincon Hondo Well served both the winter and summer seasons.

As described above, the five wells were each equipped with a windmill; the Rincon Hondo and Rincon Camp wells were also equipped with a pump jack. The Natural Resource Conservation Service (NRCS) has published water facility design criteria for cattle (NRCS, 2010). As stated therein:

> “Undependable water supply – These are defined as water sources that are inspected infrequently, sources with high maintenance requirements, or sources which have power requirements that are not dependable (solar, wind, etc.). A minimum of three days of storage is required for these water sources. The maximum storage is determined by the dependability of the water source and the power source. For practical purposes, a maximum of seven days of storage is recommended.”

As such, the Rincon Hondo and Rincon Camp wells, each with their windmill and auxiliary pump jack, represented the only reliable water supplies for the Rincon Hondo Canyon regional herd. The High Lonesome Well, while classified by NRCS as “undependable,” does appear to meet the minimum design requirement of three days of storage for its respective cattle water duty. Storage is based on the maximum summer water demand (NRCS, 2010). For Rincon Hondo Canyon region cow-calf pairs, this summer maximum was calculated to be 24.05 gallons per day (see Section 5.5, Figure 16). Although both were equipped with windmills, neither the Amado Well nor the Perry Canyon Well, had any storage capability and fail this basic NRCS design requirement.

For perspective, the Amado windmill was allowed to operate continuously, producing water to fill a single, permanent drinker; all excess water produced by the wind was spilled to the ground (Cox Dep. 48:1-7). Based on measurements taken by the author, the drinker measures 92 inches in diameter by 18 inches deep and has a maximum capacity of 518 gallons (see Figure 8). This single volume would support no more than seven cows for three days based on summer water requirements. As with all of the water sources, it is also subject to exploitation by wildlife.

By contrast, water withdrawn from the Rincon Hondo Well was stored in a large holding tank; the tank was kept full (Cox Dep. 50:3-51:2). The stored water supply at the Rincon Hondo Well was more than thirty times greater than that which was available at the Amado Well location and could support 227 cows for three days before the pump jack would need to be used to restore water reserves.

The Perry Canyon Well reportedly had no storage but a drinking tub, and was operated similarly to the Amado Well and windmill; the water was contaminated with gypsum and allowed to continuously spill to the ground (Cox Dep. 52:13-24). This well was shared with a neighbor; no information was provided on the neighbor’s usage or on the associated windmill

(Cox Dep. 41:2-6). As such, it is impossible to determine what contribution it could have made to the water needs of the Rincon Hondo Canyon regional herd. With no storage capability, its usefulness as a water source was marginal.

The Zuni Spring was also represented as a potential water source for the Rincon Hondo Canyon regional herd in the summer. No drinkers were present and water would pool on the ground (Cox Dep. 43:5-10). As shown in Figure 9, very little water is associated with Zuni Spring and no water right was assigned to this source under the Zuni Basin adjudication.

Figure 9 – Zuni Spring

Based on the above, the Amado Well, Zuni Spring and Perry Canyon Well did not represent significant or credible water sources for the Rincon Hondo Canyon regional herd. Moreover, the reported practice of allowing the drinkers at the two wells to continuously overflow would appear to be a significant waste of water, not water put to useful or beneficial purpose. For assessing the maximum quantity of livestock water withdrawn from the Rincon

Hondo Well, these three potentially competing sources are incidental at best and reasonably can be ignored. Tom Cox confirmed that 40% of the regional herd watered at the Rincon Hondo Well from December until the first of July (Cox Dep. 36:22-37:13) (Cox Dep. 66:17-67:1).

For the summer season all cattle, consisting mostly of lactating cows with one to four-month old calves, were moved from the three winter pastures to upper, higher elevation starting with the Rincon Hondo Well (Cox Dep. 37:14-24). Testimony provided by Tom Cox did <u>not</u> suggest that these cow-calf pairs were kicked up Rincon Hondo Canyon and distributed throughout the summer range. He testified that he did not move the cattle within the summer range until they were gathered in the fall (Cox Dep. 42:14-20). Nor were they enticed to use any particular part of the range by the placement of salt (Cox Dep. 67:12-17). Rather, cattle in the summer range were free to roam over more than 15 sections of land (Cox Dep. 43:20-44:1).

Potential water sources in the summer range included the Rincon Hondo Well and High Lonesome Well, as well as the aforementioned Zuni Spring and the Perry Canyon Well (Cox Dep. 37:14-24). As discussed above, these two latter sources are not considered reliable or significant for livestock watering. The straight line distance between the Rincon Hondo Well and the High Lonesome Well is 4.99 miles; this straight line path crosses impassable terrain. The trail path, as identified by ground truth, measures 9.26 miles (Image 1). Both measurements were calculated using the Google Earth, Line and Path Distance Tool.

There is consensus on the placement of water sources used for livestock watering. Distances between water sources in flat country should be no more than four miles and, in rough country, no more than one mile (Holechek, 1997). “Areas over 2 miles from water should be considered unusable by cattle because high energy expenditure in animal travel nullifies

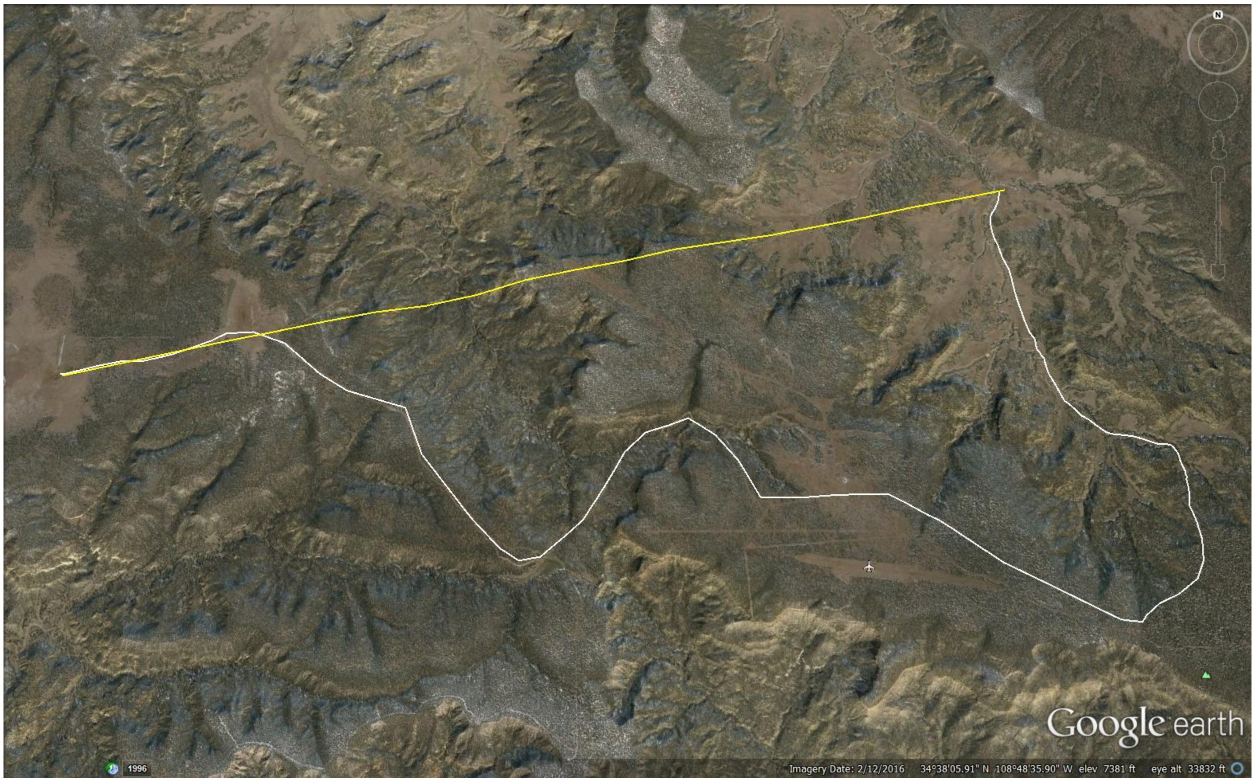


Image 1 – Straight Line and Trail Path between Rincon Hondo and High Lonesome Wells

weight gains, heavy trampling loss of forage occurs from excessive trailing, and severe grazing will occur on forage plants within 1 mile of water" (Holechek, 1997). "Livestock, particularly cattle, are predictable in their grazing behavior. One of their most conspicuous habits is to graze convenient areas. These are generally areas close to water or those that are easily accessible, such as level terrain within an area of rough topography. Given the choice and/or lack of sufficient enticement, cattle will abuse these convenience areas" (Volesky, 1996).

Given the above, it is reasonable to conclude that, starting in July, the regional herd would initially water at and feed on pasture grass surrounding the Rincon Hondo Well; it is the first water source they would encounter. Its infrastructure includes a 15,666-gallon holding tank for water storage and it was identified by Tom Cox as being equipped with a pump jack to allow water production when wind was lacking. In addition, the two permanent livestock drinkers identified in Table 1 provide 39 feet of water access, enough for a herd size of 390 cattle based on NRCS watering facility design criteria (NRCS, 2010).

Unless forage within the grazing area serviced by the Rincon Hondo Well was insufficient for the summer season, cattle would have no incentive to move elsewhere. However, if the available forage within a two-mile radius was depleted, the cattle would have the ability to find new forage and water at the High Lonesome Well. Remaining is the question of available forage to support the herd at these two locations.

5.3 Carrying Capacity

The carrying capacity of a pasture is simply the maximum number of animals a site can support over a given period of time without causing detriment to future forage production. The carrying capacity is initially established by assigning a stocking rate based upon such factors as the class of livestock (lactating cow, bull, growing heifers and steers, etc.), acres available for grazing, topography, water distribution, forage species, forage productivity including regrowth characteristics, and grazing practices.

Setting the appropriate initial stocking rate consists of determining (1) how much forage is produced during the year and how much is available for livestock consumption (available forage); (2) how much forage is required by the type and class of animals raised (forage demand); and (3) how long will animals be using the area (duration of grazing). Successful ranchers balance animal performance and forage production over the long term, while making short-term adjustments to stocking rate and/or duration of grazing as climatic conditions dictate.

Available Forage: Available forage was calculated for both the Rincon Hondo Well and the High Lonesome Well. The acreage of grazing pasture was determined assuming a grazing distance of no more than two miles from each well (NRCS, 2009) (Holechek, 1988). In the case of the Rincon Hondo Well, the acreage available for grazing was further reduced by limiting the pasture to only that which is contained within Rincon Hondo Canyon and not on the mesa tops that surround it. Available forage was then calculated using soil survey maps prepared by the Soil Conservation Service (SCS, 1993).

Rincon Hondo Well Forage: From the SCS soil survey of Rincon Hondo Canyon, only two soil units provide forage for cattle and lie below the surrounding mesa tops: soil unit 25, Hickman-Catman complex; and soil unit 515, Rock Outcrop-Vessilla-Mion complex. The Hickman-Catman complex soils are in valleys and swales and on alluvial fans. The Rock Outcrop-Vessilla-Mion complex soils are on escarpments, ridges and hills (SCS, 1993).

The SCS soil survey is supplemented by 102 detailed maps of the region. Sheet 71 of 102 includes Section 19, Township 5N, Range 18W N.M.P.M., the location of the Rincon Hondo Well, and the surrounding sections of land. Figure 10 is a scanned image of that portion of Sheet 71 of 102. To determine the acreage of land associated with each of these two soil units, the scanned image shown in Figure 10 was colorized to delineate each soil unit using the GNU Image Manipulation Program (GIMP), see Figure 11. The yellow-shaded area corresponds to soil unit 25, Hickman-Catman complex and the blue-shaded area corresponds to soil unit 515, Rock Outcrop-Vessilla-Mion complex.

GIMP is a cross-platform image editor and its use in this way allows the number of pixels of each color, corresponding to a soil unit, to be counted. This provides the means to accurately

Figure 10 - Sheet 71 of 102

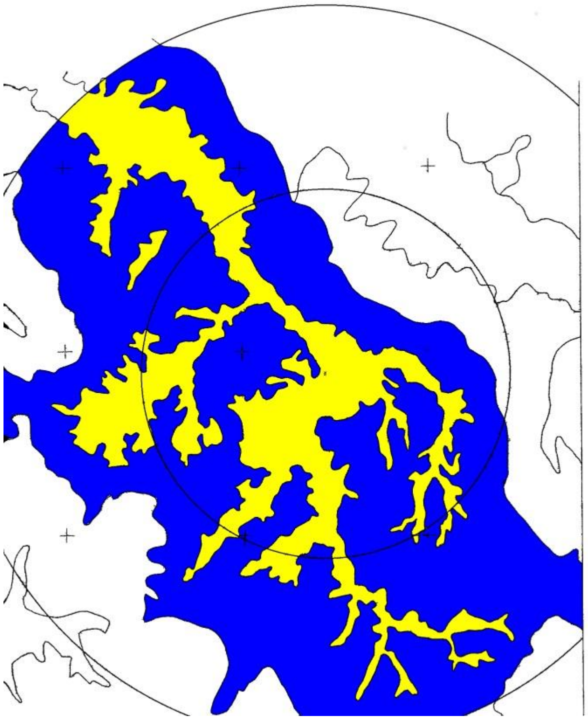


Figure 11 - Unit 25 (Yellow), Unit 515 (Blue)

determine the acreage associated with each soil unit. As shown in Figure 11, two concentric circles, whose center-point is the Rincon Hondo Well, were drawn at radii of one and two miles. Although the outer circle is partially truncated, the exclusion of this relatively small area from the forage calculation is not considered significant to this determination; its exclusion will provide a conservative result, i.e., it will understate the available forage.

Based upon the pixel count, of the soil unit 25, Hickman-Catman complex soils, there are 616 acres and 462 acres within one mile and between one and two miles of the Rincon Hondo Well, respectively. Of the soil unit 515, Rock Outcrop-Vessilla-Mion complex soils, there are 1,065 acres and 2,038 acres within one mile and between one and two miles of the Rincon Hondo Well, respectively. Collectively, there are 4,181 acres of these two soil units both within two miles of the well and within the confines of Rincon Hondo Canyon. The remaining 3,861 acres of land within a two-mile radius of the well were conservatively assumed to contribute nothing to the forage production for livestock watered at the Rincon Hondo Well.

Soil unit 25, Hickman-Catman complex has 1 to 6 percent slopes and is used for livestock grazing. The unit is 45% Hickman loam, 40% Catman silty clay loam and 15% a combination of Silkie and Flugle soils on valley sides, Vessilla and Mion soils on hills, and Goesling soils on fan terraces (SCS, 1993). These three lesser types are assumed to occur in equal proportions of 5% each. Soil unit 515, Rock Outcrop-Vessilla-Mion complex has 3 to 55% slopes and is also used for livestock grazing. The unit is 45% rock outcrop, 20% Vessilla loam, 20% Mion loam, and 15% a combination of Nogal, Celacy and Galestina soils on hills, Catman and Silkie soils in valleys, Hickman soils in valleys and on alluvial fans, and Flugle soils on hillsides (SCS, 1993). These four lesser types are assumed to occur in equal proportions of 3.75% each.

Data reported by the SCS soil survey was used to determine the quantity of forage available to cattle utilizing both “favorable” year forage production rates and “unfavorable” year forage production rates for each soil type and for the percentage of the soil unit it represents (SCS, 1993) (NRCS, 2007). The “favorable” year production rates were used to establish the upper limit carrying capacity of the pasture.

The long-term, annual average precipitation for Fence Lake, NM is 14 inches per year (WRCC, 2010). Consideration of “favorable” year forage production rates is justified based on precipitation over the years 1983 through 2000, the time period during which Tom Cox ranched. As shown in Figure 12, the precipitation measured at the Fence Lake, NM meteorological station exceeded the location historical average of 14 inches per year, eleven of the eighteen years during this time period (Weather Warehouse, 2016).

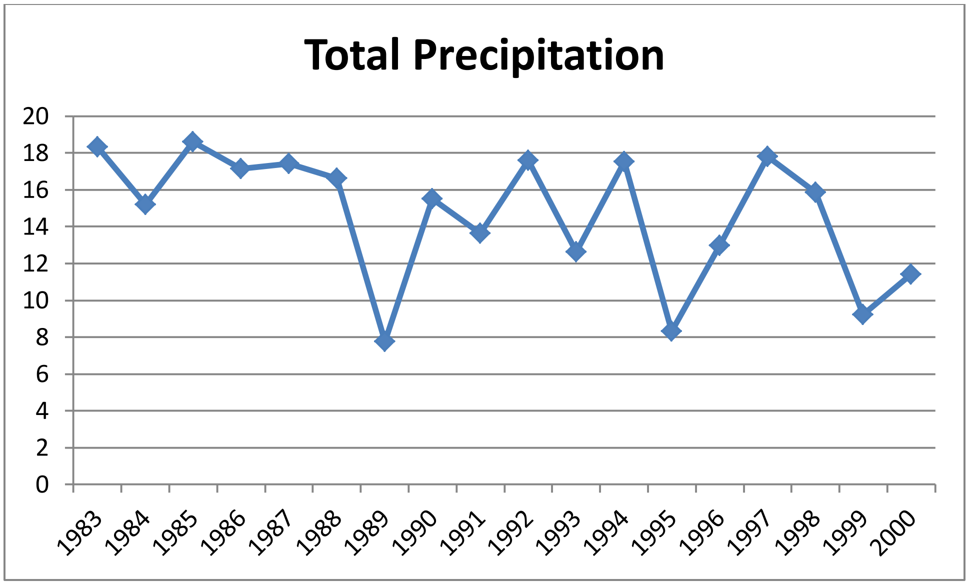


Figure 12 – Annual Precipitation for Fence Lake, NM (1983-2000)

Using established methodology, forage utilization was limited to 45% to prevent overstocking of the pasture; additional restrictions were placed on utilization based on the actual slope of the land and grazable distance to water (Holechek, 1988). For soil unit 25, Hickman-Catman complex, the slope of land is less than 10% throughout its area of occurrence and therefore, no reduction of utilization is necessary. For soil unit 515, Rock Outcrop-Vessilla-Mion complex, the slope of land varies between 3% and 55% and, as such, an average slope reduction factor of 30% was applied to utilization. This is considered conservative since the Hickman and Catman loams that dominate actual production for this soil unit exist in the low-sloped valley; the steep rock outcrop contributes nothing to forage production for this soil unit. Utilization of all pasture beyond a one-mile radius of the Rincon Hondo Well was reduced by 50%.

Table 3 compiles these results based on soil unit and distance. Collectively, a total of 1,348,717 pounds of forage was calculated to be available for consumption in “favorable” years

Soil Unit 25: Hickman Catman Complex, 1 to 6 percent slopes							
Unit Composition by Soil	Hickman	Catman	Other (totaling 15% of acreage)				
			Silkie	Vessilla	Goesling		
Percent of Unit Acreage (%)	45%	40%	5%	5%	5%		
Favorable Year Production Rate (lb/acre)	3,000	3,200	1,100	750	1,100		
Favorable Forage Production Rates (lb/unit acre)	1,350	1,280	55	38	55		
Unfavorable Year Production Rate (lb/acre)	1,200	1,250	600	375	600		
Unfavorable Forage Production Rates (lb/unit acre)	540	500	30	19	30		
Distance to Water (miles)	≤ 1		> 1 ≤ 2				
Pasture Area (acres)	616		462				
Total Favorable Forage Production Rate (lb/unit acre)	2,778		2,778				
Total Unfavorable Forage Production Rate (lb/unit acre)	1,119		1,119				
Utilization Based on Slope (%)	100%		100%				
Utilization Based on Distance (%)	100%		50%				
Utilization to Preserve Pasture (%)	45%		45%				
Favorable Year Usable Forage (lb)	769,923		288,721				
Unfavorable Year Usable Forage (lb)	310,118		116,294				
Soil Unit 515: Rock Outcrop-Vessilla-Mion Complex, 3 to 55 percent slopes							
Unit Composition by Soil	Rock	Vessilla	Mion	Other (totaling 15% of acreage)			
				Nogal	Hickman	Catman	Flugle
Percent of Unit Acreage (%)	45%	20%	20%	3.75%	3.75%	3.75%	3.75%
Favorable Year Production Rate (lb/acre)	0	700	0	750	3,000	3,200	1,100
Favorable Forage Production Rates (lb/unit acre)	0	140	0	28	113	120	41
Unfavorable Year Production Rate (lb/acre)	0	300	0	375	1,200	1,250	600
Unfavorable Forage Production Rates (lb/unit acre)	0	60	0	14	45	47	23
Distance to Water (miles)	≤ 1		> 1 ≤ 2				
Pasture Area (acres)	1,065		2,038				
Total Favorable Forage Production Rate (lb/unit acre)	442		442				
Total Unfavorable Forage Production Rate (lb/unit acre)	188		188				
Utilization Based on Slope (%)	70%		70%				
Utilization Based on Distance (%)	100%		50%				
Utilization to Preserve Pasture (%)	45%		45%				
Favorable Year Usable Forage (lb)	148,238		141,835				
Unfavorable Year Usable Forage (lb)	63,216		60,486				
Total Usable Forage of Rincon Hondo Well Pasture							
Favorable Year Total Usable Forage (lb)	1,348,717						
Unfavorable Year Total Usable Forage (lb)	550,113						
Favorable Year Carrying Capacity of Pasture (AUDs)	51,874						
Unfavorable Year Carrying Capacity of Pasture (AUDs)	21,158						

Table 3 – Available Forage and Carrying Capacity of the Rincon Hondo Well Pasture

without creating detrimental effects to future forage production; available forage for "unfavorable years" was calculated to be 550,113 pounds. While trampling, soiling and insect damage could impact harvest efficiency, the relatively high stocking density helps ensure that forage will be consumed before it senesces, transfers to litter or otherwise leaves the area. The dominant grasses of the Rincon Hondo Canyon region, cool-season western wheatgrass and warm-season blue grama, provide for the regeneration of forage during the grazing period (Allison, 2011).

High Lonesome Well Forage: From the SCS soil survey of Santa Rita Mesa, only two soil units provide forage for cattle and lie on the mesa top: soil unit 535, Millpaw Loam; and soil unit 515, Rock Outcrop-Vessilla-Mion complex. The Millpaw Loam soils are in swales and valleys. The Rock Outcrop, Vessilla-Mion complex soils are on escarpments, ridges and hills (SCS, 1993).

The SCS soil survey is supplemented by 102 detailed maps of the region. Sheet 71 of 102 includes Section 29, Township 5N, Range 19W N.M.P.M., the location of the High Lonesome Well; the surrounding sections of land are included on sheets 70, 87 and 88. Figure 13 is a scanned image of relevant portions of Sheet 70, 71, 87 and 88. To determine the acreage of land associated with each of these two soil units, the scanned image shown in Figure 13 was

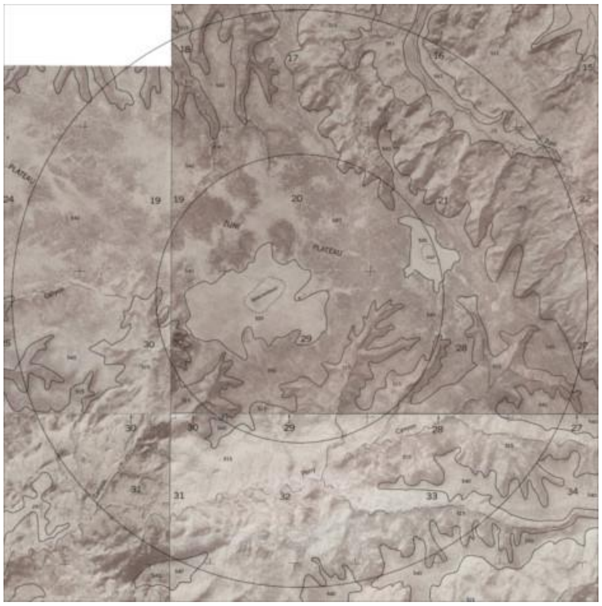


Figure 13 - Sheets 70, 71, 87 and 88 of 102

Figure 14 - Unit 535 (Green), Unit 515 (Blue)

colorized to delineate each soil unit using GIMP, see Figure 14. The green-shaded area corresponds to soil unit 535, Millpaw Loam and the blue-shaded area corresponds to soil unit 515, Rock Outcrop-Vessilla-Mion complex.

Based upon the pixel count, of the soil unit 535, Millpaw Loam soils, there are 330 acres and 16 acres within one mile and between one and two miles of the High Lonesome Well, respectively. Of the soil unit 515, Rock Outcrop-Vessilla-Mion complex soils, there are 379 acres and 3,358 acres within one mile and between one and two miles of the High Lonesome Well, respectively. Collectively, there are 4,083 acres of these two soil units both within two miles of the well and on Santa Rita Mesa. The remaining 3,959 acres of land within a two-mile radius of the well contribute nothing to the forage production for livestock watered at the High Lonesome Well (SCS, 1993) or are inaccessible to cattle by terrain.

Soil unit 535, Millpaw Loam, has 0 to 5 percent slopes and is used for livestock grazing. The unit is 85% Millpaw Loam and 15% a combination of Catman soils on valley bottoms and depressions, Montecito soils on valley sides and bottoms, and Flugle, Galestina, and Pintos soils on valley sides (SCS, 1993). The forage production rates for the Millpaw Loam and the three lesser soil types are combined and not reported separately. Soil unit 515, Rock Outcrop-Vessilla-Mion complex has 3 to 55% slopes and is also used for livestock grazing. The unit is 45% rock outcrop, 20% Vessilla loam, 20% Mion loam, and 15% a combination of Nogal, Celacy and Galestina soils on hills, Catman and Silkie soils in valleys, Hickman soils in valleys and on alluvial fans, and Flugle soils on hillsides (SCS, 1993). These four lesser types are assumed to occur in equal proportions of 3.75% each.

Data reported by the SCS soil survey was used to determine the quantity of forage available to cattle utilizing both “favorable” year forage production rates and “unfavorable” year forage production rates for each soil type and the percentage of the soil unit it represents (SCS, 1993) (NRCS, 2007). The favorable year production rates were used to establish the upper limit carrying capacity of the pasture.

Using established methodology, forage utilization was limited to 45% to prevent overstocking of the pasture; additional restrictions were placed on utilization based on the actual slope of the land and grazable distance to water (Holechek, 1988). For soil unit 535, Millpaw Loam, the slope of land is less than 10% throughout its area of occurrence and therefore, no reduction of utilization is necessary. For soil unit 515, Rock Outcrop-Vessilla-Mion complex, the slope of land varies between 3% and 55% and, as such, an average slope reduction factor of 30% was applied to utilization. This is considered conservative since the Hickman and Catman loams that dominate actual production for this soil unit grow in the low-sloped valley; the steep rock outcrop contributes nothing to forage production for this soil unit. Utilization of all pasture beyond a one-mile radius of the High Lonesome Well was reduced by 50%.

Table 4 compiles these results based on soil unit and distance. Collectively, a total of 453,656 pounds of forage was calculated to be available for consumption in “favorable years” without creating detrimental effects to future forage production; available forage for “unfavorable years” was calculated to be 213,353 pounds. While trampling, soiling and insect damage could impact harvest efficiency, the relatively high stocking density helps ensure that forage will be consumed before it senesces, transfers to litter or otherwise leaves the area. The dominant grasses of the Rincon Hondo Canyon region, cool-season western wheatgrass and

Soil Unit 535: Millpaw Loam, 0 to 5 percent slopes							
Unit Composition by Soil	Milapaw						
Percent of Unit Acreage (%)	100%						
Favorable Year Production Rate (lb/acre)	1,100						
Favorable Forage Production Rates (lb/unit acre)	1,100						
Unfavorable Year Production Rate (lb/acre)	600						
Unfavorable Forage Production Rates (lb/unit acre)	600						
Distance to Water (miles)	≤ 1		> 1 ≤ 2				
Pasture Area (acres)	330		16				
Total Favorable Forage Production Rate (lb/unit acre)	1,100		1,100				
Total Unfavorable Forage Production Rate (lb/unit acre)	600		600				
Utilization Based on Slope (%)	100%		100%				
Utilization Based on Distance (%)	100%		50%				
Utilization to Preserve Pasture (%)	45%		45%				
Favorable Year Usable Forage (lb)	163,171		3,977				
Unfavorable Year Usable Forage (lb)	89,002		2,169				
Soil Unit 515: Rock Outcrop-Vessilla-Mion Complex, 3 to 55 percent slopes							
Unit Composition by Soil	Rock	Vessilla	Mion	Other (totaling 15% of acreage)			
				Nogal	Hickman	Catman	Flugle
Percent of Unit Acreage (%)	45%	20%	20%	3.75%	3.75%	3.75%	3.75%
Favorable Year Production Rate (lb/acre)	0	700	0	750	3,000	3,200	1,100
Favorable Forage Production Rates (lb/unit acre)	0	140	0	28	113	120	41
Unfavorable Year Production Rate (lb/acre)	0	300	0	375	1,200	1,250	600
Unfavorable Forage Production Rates (lb/unit acre)	0	60	0	14	45	47	23
Distance to Water (miles)	≤ 1		> 1 ≤ 2				
Pasture Area (acres)	379		3,358				
Total Favorable Forage Production Rate (lb/unit acre)	442		442				
Total Unfavorable Forage Production Rate (lb/unit acre)	188		188				
Utilization Based on Slope (%)	70%		70%				
Utilization Based on Distance (%)	100%		50%				
Utilization to Preserve Pasture (%)	45%		45%				
Favorable Year Usable Forage (lb)	52,783		233,725				
Unfavorable Year Usable Forage (lb)	22,509		99,672				
Total Usable Forage of High Lonesome Well Pasture							
Favorable Year Total Usable Forage (lb)	453,656						
Unfavorable Year Total Usable Forage (lb)	213,353						
Favorable Year Carrying Capacity of Pasture (AUDs)	17,448						
Unfavorable Year Carrying Capacity of Pasture (AUDs)	8,206						

Table 4 – Available Forage and Carrying Capacity of the High Lonesome Well Pasture

warm-season blue grama, provide for the regeneration of forage during the grazing period (Allison, 2011).

<u>Forage Demand</u>: The carrying capacity is determined based upon the size and class of cattle to be grazed, in this case cow-calf pairs. The NRCS defines a free ranging, 1,000-pound lactating beef cow, with a calf as old as six-months, as 1.00 AU and elects to use 26 pounds of

oven-dry weight or 30 pounds air dry weight (as fed) of forage per day as the standard forage demand (NRCS, 1997). This high forage demand assumption is appropriate for high-quality forages that are more digestible but is not consistent with the low to average quality (52-59% total digestible nutrients) of the native range. As such, and for the purpose of this analysis, it is assumed that a lactating cow consumes 26 pounds air dry weight of forage per day (Lalman, 2004). This forage demand rate is still 30 percent larger than the 20 pounds of forage per day assumed by Holechek and its use ensures a conservative determination of carrying capacity.

The carrying capacity of the Rincon Hondo Well and High Lonesome Well pastures are reported in Table 3 and 4, respectively. Total carrying capacity is reported for both “favorable” and “unfavorable” years for each pasture. Through comparison, the available forage within grazable distance of the Rincon Hondo Well is approximately three times greater than that of the High Lonesome Well in “favorable” years. It is approximately two and one-half times greater in “unfavorable” years.

5.4 Herd Composition

For the Rincon Hondo Canyon region cow-calf operation, the cattle herd is necessarily composed of pregnant cows, lactating cows with calves, mature cows, and bulls for breeding purposes. Based on testimony, the number of cows in the Rincon Hondo Canyon regional herd varied between 150 and 200 each year, depending upon weather and grass (Cox Dep. 32:13-19). It is reasonable to conclude that the 150 cow count corresponds to an “unfavorable” forage year and the 200 cow count corresponds to a “favorable” forage year.

Each December the cows would be distributed among three pastures. Twenty percent were pastured near and watered exclusively by the Rincon Camp Well. Forty percent would be pastured between the Rincon Camp Well and the Amado Well. The remaining 40 percent were pastured between the Amado Well and the Rincon Hondo Well (Cox Dep. 34:3-37:7). They would remain in these separate pastures for the winter period, from December through the first of July (Cox Dep. 37:11-13). In the absence of further clarification, this period is assumed to be mid-December through the end of June. Under questioning, Tom Cox confirmed that 40% of the regional herd watered at the Rincon Hondo Well during this period (Cox Dep. 37:5-7).

Spring calving would occur in the period March through May (Cox Dep. 20:23-24) with an average calf crop of approximately 90% (Cox Dep. 24:13). Calves were weaned and shipped in November (Cox Dep. 20:23-24). In the absence of further clarification, it is assumed that 25% of the births occurred on March 1, 50% on April 1 and the remaining 25% on May 1, each group being weaned in mid-November. For comparison, beef calves are typically weaned at 6 and 10 months of age (Cattlemen's Beef Board and National Cattlemen's Beef Association, 2016).

As described above, the calf crop was reported as 90%. Mathematically the calf crop percentage is the number of calves weaned (numerator) divided by the number of females exposed to produce that calf crop (denominator) and this number times 100 to get it to a percentage.

Regional statistics from the U.S. Department of Agriculture were used to assess the mortality of calves (APHIS, 2010). Statistically, for a herd size of 100 to 199 beef cows, 3.2 % of calves are born dead and another 3.5% are lost before weaning. Using a calf crop of 90%, 3.3% of the cows are assumed to have never become pregnant. As such, and for every 100 cows, 96.7 are pregnant, 93.5 give birth to a live calf, and 90 raise a calf to weaning.

Assuming calves have a constant probability per unit time of dying (λ) over the period between birth and weaning, the rate at which the calf population changes (dN/dt) is

$$\frac{dN(t)}{dt} = -\lambda N(t),$$

where $N(t)$ is the calf population for time t. Solving for $N(t)$ gives

$$N(t) = N_0 e^{-\lambda t},$$

where N_0 is the number of calves at some initial time. Solving for λ gives

$$\lambda = \frac{-\ln\left(\frac{N(t_f)}{N_0}\right)}{t_f},$$

Using the regional statistics for calf survival gives the value of λ. "$N(t_f)$" represents the percentage of calves alive at time "t_f" (90%), "N_0" represents the percentage of calves born alive (93.5%), and "t_f" represents the number of days before weaning (an average of 229 days). Solving, the exponential loss constant "λ" is calculated to be 0.000167 per day.

For clarification, 3.3% of the cows are assumed not to be pregnant when introduced to the Rincon Hondo Canyon region in December. These are referred to as "mature cows." The remaining classes of cows are either "pregnant cows" or "lactating cows." Because some pregnant cows lose their calves at birth and some lactating cows lose their claves before weaning, the population of mature cows will grow from March through May. Thereafter, and because all cows are exposed to bulls starting in June, all mature cows are assumed to become pregnant in June. Note that all lactating cows with calves also become pregnant when exposed.

Bulls were maintained in Rincon Hondo Canyon region at a ratio of one bull to every ten cows (Cox Dep. 24:24). From November through spring these bulls were kept separate from the cows in two pastures, a section pasture watered from the Rincon Camp Well and an 80-acre pasture watered from the Rincon Hondo Well (Cox Dep. 24:25-25:12). In June the bulls were released to run with the cows until round-up in the fall (Cox Dep. 24:21-22). It is assumed that 40% of the bulls were kept in the separate 80-acre pasture watered from the Rincon Hondo windmill from mid-November through May, i.e. the same percentage at the well as cows. On the first of June these bulls would be released to service the cows at the Rincon Hondo Well.

When the rains began in early July, all cattle were moved to the upper country for the “summer season” (Cox Dep. 37:11:19) and isolated from the winter pastures by existing fences and gates (Cox Dep. 43:11-16). For the summer season all cattle, consisting of lactating cows with one to four-month old calves, pregnant cows and all the bulls, were moved from the three lower pastures to upper, higher elevation starting with the Rincon Hondo Well (Cox Dep. 37:14-24). Cattle in the summer range were free to roam over more than 15 sections of land (Cox Dep. 43:20-44:1) and were not moved within the summer range until they were gathered in the fall (Cox Dep. 42:14-20). The cattle were free to roam these higher elevations based on available forage and water (Cox Dep. 67:2-11). In November, all cows and calves were rounded up for shipment (Cox Dep. 57:20-23). In the absence of further clarification of the date, it is assumed that all cows and calves were gathered up in mid-November. As such, only bulls remain in the region thereafter until cows are reintroduced in mid-December.

Details described in the foregoing discussion were used to create two scenarios for quantitative analysis of livestock water use at the Rincon Hondo Well. Table 5 represents the composition of the herd watering at the Rincon Hondo Well based upon "favorable" year forage conditions and includes a total Rincon Hondo Canyon regional herd consisting of 200 cows and 20 bulls. During the period December 16 through June 30, 40% of the cows (or cow-calf pairs) and 40% of the bulls are watering at the Rincon Hondo Well. For the period July through November 15, 100% of the cows (or cow-calf pairs) and 100% of the bulls are watering at the Rincon Hondo Well. For the period November 16 through December 15, 40 % of the bulls are watering at the Rincon Hondo Well; no cows are present during this period.

Favorable Forage Scenario									
Month	Days	Pregnant Cows	Lactating Cows	Mature Cows	March Calves	April Calves	May Calves	Bulls	AUDs
January	31	77.36		2.64				8	2,833
February	28	77.36		2.64				8	2,559
March	31	58.02	18.70	3.28	18.70			8	2,833
April	30	19.44	56.00	4.56	18.60	37.40		8	2,742
May	31	0.00	74.42	5.20	18.51	37.21	18.70	8	2,821
June	30	5.96	74.04	0.00	18.42	37.02	18.60	8	2,742
July	31	15.82	184.18	0.00	45.81	92.09	46.28	20	7,082
August	31	16.77	183.23	0.00	45.57	91.62	46.04	20	7,082
September	30	17.71	182.29	0.00	45.34	91.15	45.80	20	6,854
October	31	18.62	181.38	0.00	45.11	90.69	45.57	20	7,082
November (1-15)	15	19.56	180.44	0.00	44.88	90.23	45.34	20	3,427
November (16-30)	15							8	171
December (1-15)	15							8	171
December (16-31)	16	77.36		2.64				8	1,462
Total AUDs									49,860

Table 5 – Herd Composition and Animal Unit Days at Rincon Hondo Well in Favorable Years

The number of cattle of each class represents the number on the first day of each month. The fractional numbers reflect the statistical effect of non-pregnant cows in the cow count as well as the loss of calves at birth and before weaning. All cows, whether lactating or not, become pregnant during the period June through August. The AUDs for each month were calculated based on 1.00 AU per pregnant or mature cow, 1.00 AU per lactating cow-calf pair, and 1.423

AU per bull (Manske, 1998). All cows are assumed to weigh an average of 1,000 pounds and all bulls are assumed to weigh an average of 1,600 pounds (see Section 5.5).

The total AUDs of forage available in "favorable" years (from Table 3) is greater than the AUDs corresponding to the "favorable" year herd composition (Table 5). As such, years of "favorable" rainfall and forage conditions provide more forage within grazable distance of the Rincon Hondo Well than is required annually. Moreover, and consistent with the behavior of cattle (Lyons and Machen, 2001), there is no incentive for cattle to range beyond the Rincon Hondo Well in "favorable" years. Therefore, the herd composition in favorable years (Table 5) can be used to establish the maximum amount of water withdrawn from the Rincon Hondo Well for livestock consumption.

Table 6 represents the composition of the herd watering at the Rincon Hondo Well based upon "unfavorable" year forage conditions and includes a total Rincon Hondo Canyon regional herd consisting of 150 cows and 15 bulls. The relative proportion of cattle of each class is the

Unfavorable Forage Scenario										
Month	Days	Pregnant Cows	Lactating Cows	Mature Cows	March Calves	April Calves	May Calves	Bulls		AUDs
January	31	58.02	0.00	1.98				6		2,125
February	28	58.02	0.00	1.98				6		1,919
March	31	43.52	14.03	2.46	14.03			6		2,125
April	30	14.58	42.00	3.42	13.95	28.05		6		2,056
May	31	0.00	55.82	3.90	13.88	27.91	14.03	6		2,116
June	30	4.47	55.53	0.00	13.81	27.77	13.95	6		2,056
July	31	11.87	138.13	0.00	34.36	69.07	34.71	15		5,312
August	31	12.58	137.42	0.00	34.18	68.71	34.53	15		5,312
September	30	13.28	136.72	0.00	34.00	68.36	34.35	15		5,140
October	31	13.97	136.03	0.00	33.83	68.02	34.18	15		5,312
November (1-15)	15	14.67	135.33	0.00	33.66	67.67	34.00	15		2,570
November (16-30)	15							6		128
December (1-15)	15							6		128
December (16-31)	16	58.02	0.00	1.98	0.00	0.00	0.00	6		1,097
Total AUDs										37,395

Table 6 – Herd Composition and Animal Unit Days at Rincon Hondo Well in Unfavorable Years

same as determined for “favorable” years. Simply put, the number of cattle by class is 75% of the total for “favorable” years.

The total AUDs of forage available in “unfavorable” years (from Table 4) is less than the AUDs corresponding to the “unfavorable” year herd composition (Table 6). As such, years of “unfavorable” rainfall and forage conditions provide less forage within grazable distance of the Rincon Hondo Well than is required for all cattle that could water at the well throughout the year. Cattle could either overgraze the Rincon Hondo Well pasture or be incentivized (by the lack of food) to seek forage and water at other locations such as the High Lonesome Well. Even then, the combined forage available to the herd within grazable distance of the two wells in “unfavorable” years (Tables 3 and 4) is insufficient to meet the forage requirement of 37,943 AUDs (Table 6). Under these conditions, it would be expected that both pastures would be overgrazed unless the Cox family cut short the grazing season and conducted an early round-up.

5.5 Water Consumption

Water requirements of cattle vary widely depending on many factors including species, breed, size, age, sex, forage quality and quantity, water accessibility, water temperature, rate and composition of gain, reproductive status, lactation, physical activity, supplementation, feed intake, forage dry matter content, and ambient temperature (Ward et al., 2015). The hydrographic survey for the Zuni River Basin states that “the water consumption rate of an animal unit is estimated at an average of 10 gallons/day” (NRCE, 2005). This “estimate” was taken from a New Mexico State Engineer Office water use report and was derived, in that report, from the water consumption rate of 800-pound beef cattle confined to a feedlot (Wilson and Lucero, 1997).

The water use report makes no mention of the term "animal unit" nor does it suggest that the water consumption rate of an 800-pound animal confined to a feedlot is the reliable equivalent to the water consumption rate of a 1,000-pound lactating beef cow with calf on rangeland. In fact, the 10-gallon per day "estimate" for feedlot animals was based solely on undocumented personal communication, i.e., hearsay (Sweeten, 1990). As an alternative, this section provides a comprehensive assessment of the drinking water requirements associated with the Rincon Hondo Canyon, cow-calf operation on west-central New Mexico rangeland as derived from published research data on this subject.

The National Research Council has published guidance on total daily water intake rates for beef cattle based on cattle class (lactating cow, bull, growing heifers and steers, etc.) and animal weight as a function of ambient temperature (NRC, 2000). This guidance was taken from a more comprehensive study of this topic conducted by the U.S. Department of Agriculture that contains the full compilation of water intake rates appropriate to the analysis conducted herein (Winchester and Morris, 1956). As noted therein, "the difference between total water intake, which includes the moisture content of the feed, and free water consumption is small, and in practical situations can be ignored."

The free water intake rates used to determine the seasonal quantity of water consumed by the cattle herd grazing within Rincon Hondo Canyon and drinking from well 10A-5-W06 are provided in Table 7 (Winchester and Morris, 1956). The water intake rates for fattening, two-year old cattle were assigned to mature cows on the basis that no other class of cattle more closely correspond to non-pregnant cows in the tabulated rates (Winchester and Morris, 1956).

Ambient Temperature (°F)		**40°**	**50°**	**60°**	**70°**	**80°**	**90°**
Cattle Class	**Weight (lb)**	**Gallons**	**Gallons**	**Gallons**	**Gallons**	**Gallons**	**Gallons**
Growing Heifers, Steers and Bulls							
	400	4.0	4.3	5.0	5.8	6.7	9.5
	600	5.3	5.8	6.6	7.8	8.9	12.7
	800	6.3	6.8	7.9	9.2	10.6	15.0
Wintering Pregnant Cows							
	1000	6.0	6.5	7.4	8.7		
Lactacting Cows							
	900-1100	11.4	12.6	14.5	16.9	17.9	16.2
Mature Cows							
	1000	9.0	9.7	11.2	13.1	15.1	21.4
Mature Bulls							
	1600+	8.7	9.4	10.8	12.6	14.5	20.6

Table 7- Total Daily Water Intake

It is evident from a summary review of these guidelines that 10-gallons per day, as assumed in the hydrographic survey for the Zuni River Basin, is a gross understatement of the free water consumption rate of 1.00 AU equivalent of beef cattle. This is particularly true for lactating cow-calf pairs where the drinking water rates of the cow and the calf are combined.

Ambient temperature, meaning the temperature of the surrounding environment, is variable by time of day and by time of year. Over the temperature range of interest, water intake by cattle increases exponentially with increasing temperature. “Until the ambient temperature exceeds 80° F, cattle tend to do most of their drinking in the forenoon and late afternoon and evening while very little water is consumed during the night or in the early morning and early afternoon hours;” thereafter they drink more often (Winchester and Morris, 1956). Since free water intake requirements are correlated with temperature and water consumption occurs primarily during the daytime, it is necessary to consider the ambient daytime temperature when determining cattle free water intake. The alternatives to the use of ambient daytime temperature for this purpose, i.e. the use of average daily temperature or the use of daily high temperature, would tend to understate or overstate water consumption by cattle, respectively.

Historic meteorological data is available for Fence Lake, NM 87315 (Intellicast, 2016). The average daily temperature for each day of the year was calculated as being the average of the historic daily high temperature and the historic daily low temperature for the day. The ambient daytime temperature for each day was then calculated as being the average of the historic daily high temperature and the historic daily average temperature as determined above; water intake was then correlated to this derived ambient daytime temperature data set. Since daily high temperatures usually occur in the late afternoon when cows are drinking in response to heat load, this approach will still tend to understate the actual quantity of drinking water consumed.

Daily free water intake for each class of cattle was calculated using the daily ambient daytime temperature "t" and performing a linear interpolation of the water intake rate "g" from Table 7. If two known points are given by the coordinates (t_0, g_0) and (t_1, g_1), the linear interpolant is the straight line between these points. For a value "t" in the interval (t_0, t_1), the value "g" along the straight line is given from the equation

$$(g - g_0)/(t - t_0) = (g_1 - g_0)/(t_1 - t_0)$$

Solving this equation for "g", which is the unknown value at "t", gives

$$g = g_0 + (g_1 - g_0)((t - t_0)/(t_1 - t_0))$$

which is the formula for linear interpolation in the interval (t_0, t_1). Outside this interval, the formula is identical to linear extrapolation.

Water Intake of Cows: Water intake rates for lactating cows are reported in Table 7 for a live weight range between 900 and 1,100 pounds (NRC, 2000). These rates were assigned to lactating cows, each weighing 1,000 pounds, from calving until November 15 when the calves are weaned.

Cows lose considerable weight as a consequence of giving birth and must recover body condition to meet both the demands of lactation and subsequent breeding/pregnancy. The cows are lactating from as early as March through mid-November and are exposed to bulls for breeding purposes starting in June. The water intake rates for lactating cows (Table 7) are based upon a maintenance ration where no weight gain occurs; the temperature-dependent dry matter intake (DMI) rates for cows nursing calves vary from 25.0 to 16.8 pounds per day for the first three to four months after parturition (Winchester and Morris, 1956). No allowance in DMI rates for recovery of body condition for breeding/pregnancy is apparent in these numbers. By comparison, the time-dependent DMI rates over the period March through November vary between 25.4 and 19.5 pounds per day (Gadberry, 2002); these reflect the fact that cows are lactating during this entire period. The National Research Council assigns the water intake rates for "cows nursing calves" to "lactating cows" as guidance without noting any time or DMI intake dependency (NRC, 2000).

Water Intake of Bulls: As discussed in Section 5.4, mature bulls are present with the Rincon Hondo Canyon region for the entire year; each bull is assumed to weigh an average of 1,600 pounds. The metabolic weight of a 1,600-pound bull is 1.423 AUs (Manske, 1998).

Water Intake of Calves: Calves gain considerable weight from birth to weaning. At birth, calves weigh between 60 and 100 pounds and will grow to weigh between 450 and 700 pounds by the age of weaning (Cattlemen's Beef Board and National Cattlemen's Beef Association, 2016). Using the average birth and weaning weights, and at a linear rate of growth, calves grow at an average rate of approximately 62 pounds per month, approximately two pounds per day.

The average beef cow produces 13 pounds of milk per day during the suckling period (Eversole, 2009). Initially, the nutrient requirements of a calf are met by the cow’s milk alone and the quantity of forage and free choice water that is consumed by the calf is small. However, even very young calves require water, e.g. to prevent dehydration, and the relationship between environmental temperature and water intake is exponential rather than linear (Jenkins, 2014). Calves don't start grazing in earnest until they reach approximately three months of age, the age that their rumens start to work. From this point onwards they eat more forage than milk to meet their nutrient requirements and the cow's milk production will gradually decline.

The National Research Council provides no specific guidance for water intake by calves prior to developing a functional rumen, the period during which their nutritional requirements are provided by milk. By one or two days of age, calves may drink as little as a pint or two of water per day; by two months of age they require between 10 and 12 quarts of water per day (Earleywine, 2015). Using this data, the water consumption of young calves during the first three months after parturition was modeled as a temperature-dependent function of weight and age, starting at zero gallons per day at birth and exponentially increasing to the age of three months when their rumen is functional.

Thereafter, linear interpolation (or linear extrapolation) was used to determine the water intake rate for a given weight of calf using the temperature-dependent rates for growing heifers, steers and bulls from Table 7. These temperature-dependent water intake rates are based upon a weight gain of 1.4 to 1.6 pounds per day (Winchester and Morris, 1956). The cow’s milk provides the additional nutrition necessary to achieve a total weight gain average of two pounds per day (Eversole, 2009).

To facilitate the calculation of drinking water consumed as a function of animal class, time, temperature and weight, the required computational analysis was coded using Python (see Attachment 5).

> “Python is an interpreted, interactive, object-oriented programming language. It incorporates modules, exceptions, dynamic typing, very high level dynamic data types, and classes. Python combines remarkable power with very clear syntax. It has interfaces to many system calls and libraries, as well as to various window systems, and is extensible in C or C++. It is also usable as an extension language for applications that need a programmable interface. Finally, Python is portable: it runs on many Unix variants, on the Mac, and on Windows 2000 and later.” (https://docs.python.org/3/faq/general.html#what-is-python).

For the Rincon Hondo Well, the maximum historic quantity of water consumed by livestock is calculated to have been 815,802 gallons per year, i.e. 2.504 acre-feet per year. These results are derived by applying the temperature-dependent water intake rates outlined in Table 7 to the time history of the herd at the well location as detailed in Table 5.

Information that can be gleaned from the analysis is the use of water by the herd as a function of time and cattle class. As shown in Figure 15, there is a clear demarcation between the “winter” and “summer” seasonal use at the Rincon Hondo Well. The daily free water intake rate for the herd peaks at 4,848 gallons per day in early August when the entire herd is drinking at the well and ambient daytime temperatures are the highest. Thereafter, the overall rate of water use declines with the cooler temperatures of the fall. The minimum daily free water intake rate for the herd of 69 gallons per day occurs during the period mid-November through mid-December when only eight bulls are drinking at this source.

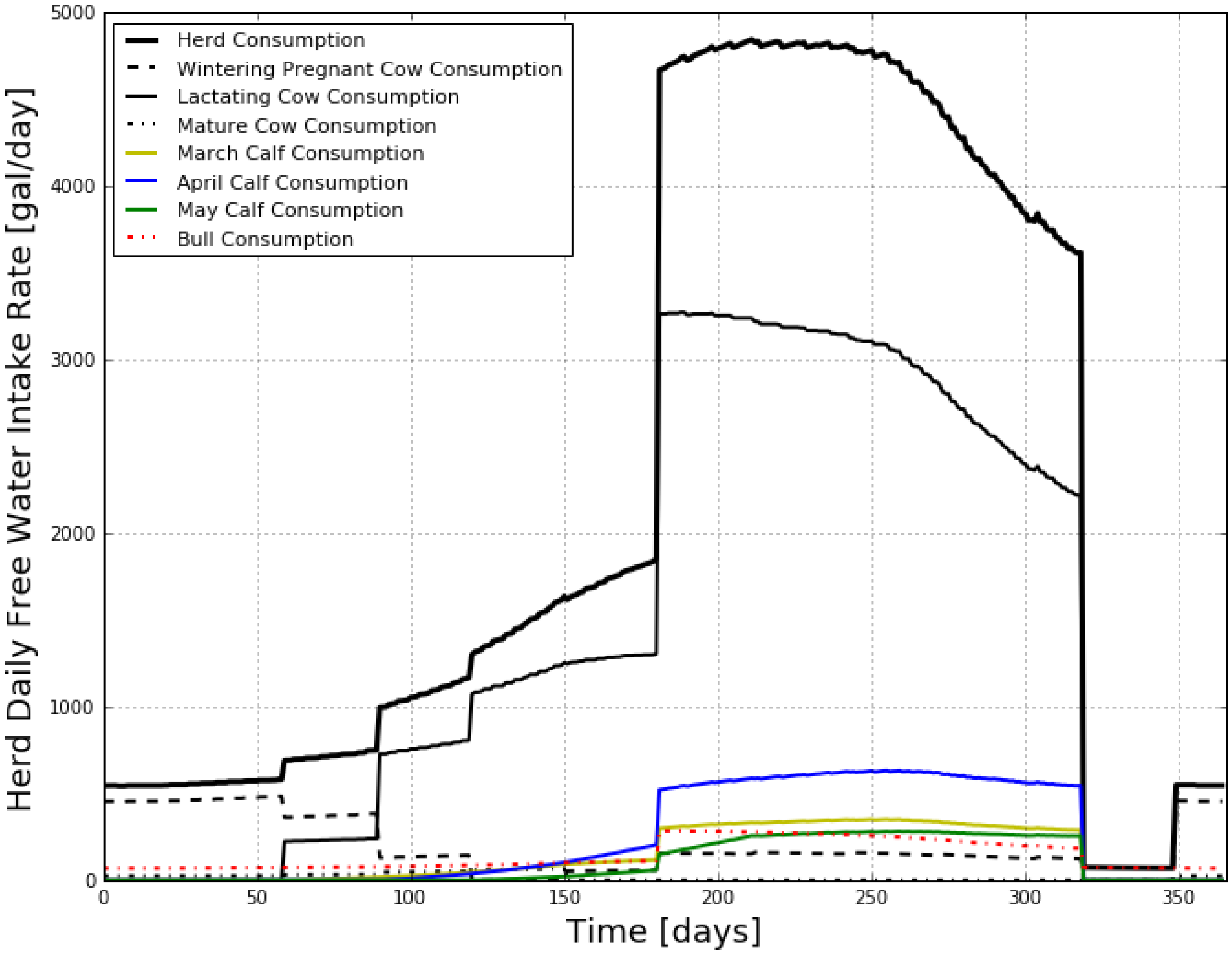


Figure 15 – Herd Free Water Intake Rate

The free water intake rate of a cow-calf pair as a function of time is shown in Figure 16. Since calving occurs over a period of three months, these water intake rates are a weighted average of the water intake rate for each calf group, based on birth time and their respective percentage of the calf crop. The free water intake rate for a 1,000 pound cow with calf (a cow-calf pair) varies from a minimum of 12.00 gallons per day at the beginning of April to a maximum of 24.05 gallons per day near the middle of the grazing season. The subsequent decline in water consumption of the cow-calf pair reflects the lower water intake needs associated with the cooler temperatures of fall. The average free water intake for a cow-calf pair during the entire grazing season was calculated to be 19.66 gallons per day.

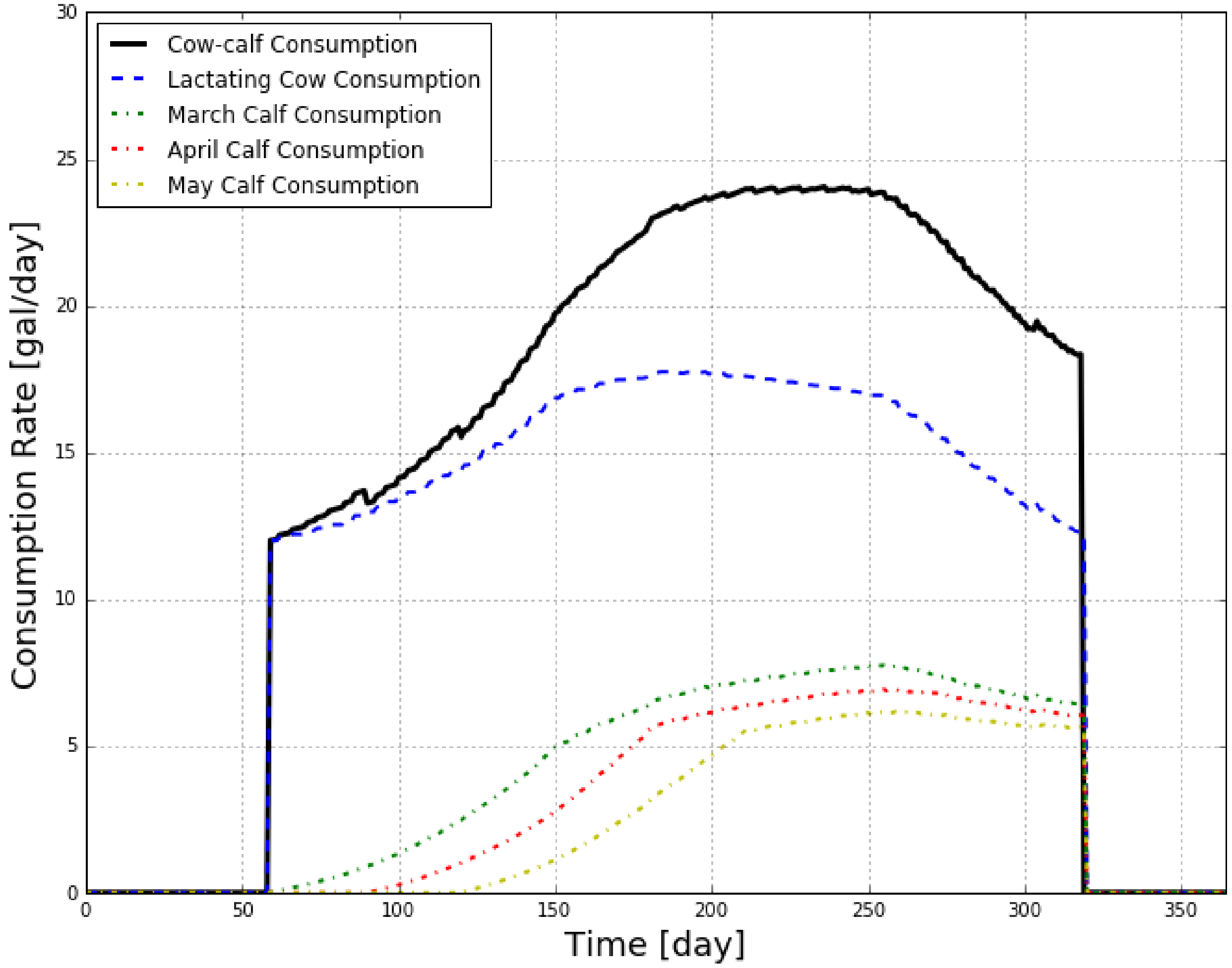


Figure 16 – Cow-Calf Pair Free Water Intake Rate

The cumulative or total free water intake of the herd drinking at the Rincon Hondo Well as a function of time is shown in Figure 17. The shape of the curve reflects the lower cumulative demand during the "winter" season (40% of herd) followed by an increase in the rate of use for the "summer" season (100% of herd). At the end of the year the total free water consumption reaches 815,802 gallons as reported above. The time-weighted average water intake rate of the herd is simply this total divided by 365 days, i.e., an average of 2,235 gallons per day. The annual average free water consumption per AU is calculated by dividing the total usage, 815,802 gallons, by 49,860 AUDs (see Table 5). The result is an annual average usage of 16.36 gallons per day per AU; the higher intake rates of summer are offset by the lower intake rates of winter.

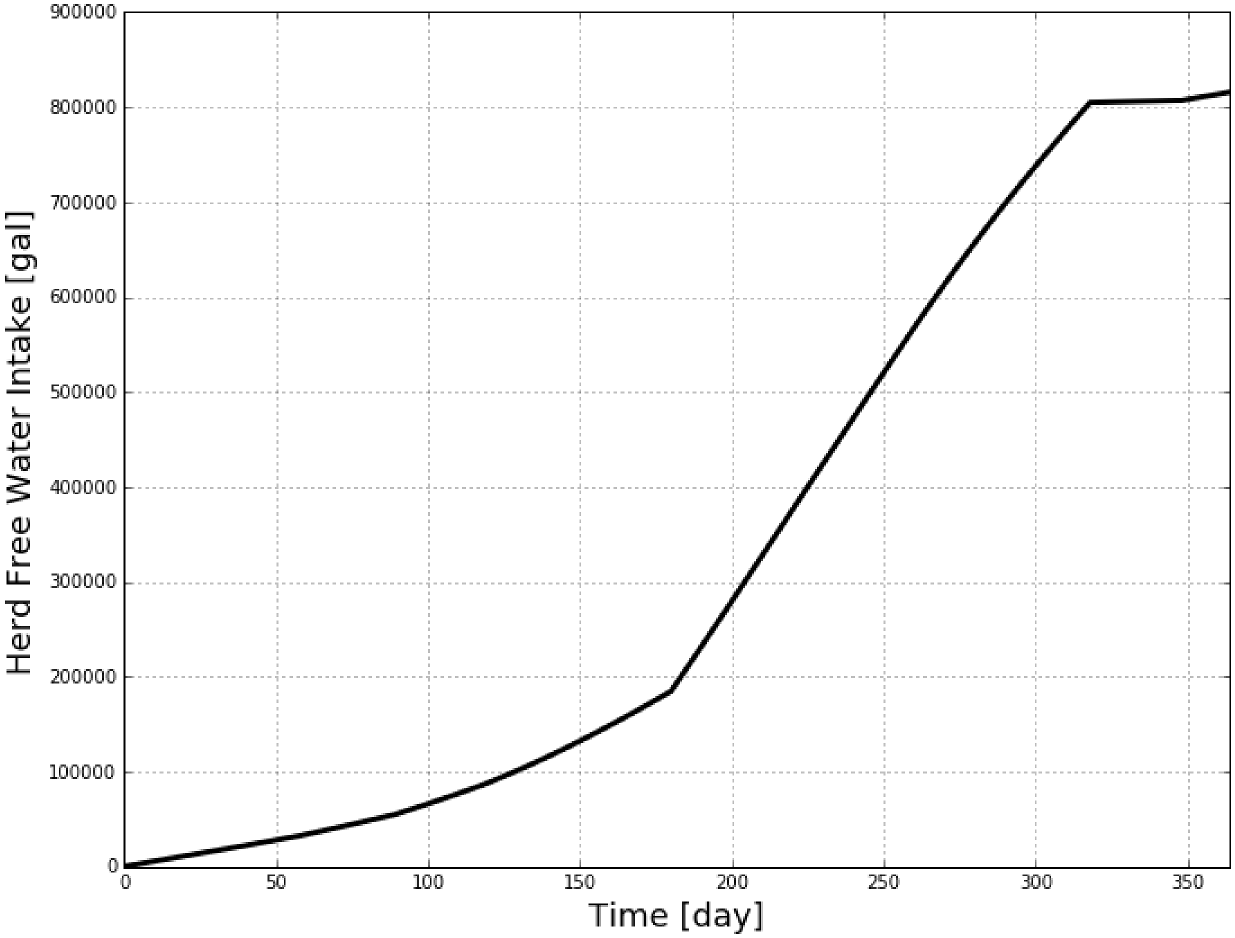


Figure 17 – Herd Total Free Water Intake

The average water intake rate for a cow-calf pair is comparable to, but less than, the 26 gallons per day guidance for cow-calf pairs provided by the New Mexico State University, Cooperative Extension Service (Ward, 2015). It is also comparable to, but less than, the water facility design guidance of 28.8 gallons per day for beef cow-calf pairs in the summer (NRCS, 2010). As such, the 19.66 gallons per day determined herein as the water intake rate for cow-calf pairs is conservative and, more likely than not, would actually be greater. The calculated annual average of 16.36 gallons per day per AU demonstrates that the assignment of a 10-gallon per day drinking water rate for beef cattle of any class, as was made in the Zuni Basin hydrographic survey, is inappropriate for the determination of water rights for cow-calf operators.

5.6 Consumptive and Other Losses

The consumptive loss and other losses associated with the delivery of water to cattle represent unavoidable components of livestock watering. Water is delivered to be consumed by cattle and some additional water is lost in the process. The precise quantity of water consumed by cattle is unknowable but, as discussed in Section 5.5, can be determined with a reasonable degree of certainty using published research on the water intake rates of cattle of various classes, weights, reproductive status, lactation, etc. The precise quantity of water lost in the delivery process is also unknowable but can be reasonably determined using knowledge of the infrastructure and operational procedures associated with water delivery as well as site-specific conditions.

The hydrographic survey for the Zuni River Basin assumes an efficiency factor of 0.5 to account for these losses (NRCE, 2005). As such, the hydrographic survey simply doubled any quantity assigned for livestock water consumption. To determine the quantity of water to divert for a cow that hypothetically drinks 10 gallons of water per day, the hydrographic survey divides

10 gallons per day by 0.5; the result is 20 gallons per day. Plaintiffs clarified this approach and its purpose in response to Requests for Admission (RFA) No.14, dated June 13, 2016, stating:

> "This increase in water quantity (referred to in this RFA as the "0.5 efficiency factor") was not arrived at based on any specific calculation, analysis, or study. Instead, the purpose of doubling the livestock water estimate was to account for the innumerable, unknowable factors that might possibly affect livestock water consumption, e.g., inherent inaccuracies of the hypothetical developed, unknown losses, etc."

There are "inherent inaccuracies" in any computational analysis. In this context, "inherent inaccuracies" are represented by the uncertainty in the computational results. In general, results determined through simplified analyses will have larger uncertainty than those determined through more rigorous analyses. Uncertainty can be reduced, but not eliminated, by the use of best available knowledge. Site-specific factors including distance to water, topography, fencing, location of shade and placement of salt/supplements can greatly influence the water use by individual animals and the herd (Lyons and Machen, 2001). It is also reasonable to project that significant, unavoidable water losses are associated with pumping, storing and delivering water to cattle.

This section includes a discussion of the types and magnitude of uncertainties and losses possible or experienced with historic water withdrawals through well 10A-5-W06. "Water withdrawal" is defined as "water diverted or withdrawn from a surface water or groundwater source" (Vickers, 2001). Calculated annual losses are compiled in Table 8 at the end of this section.

Consumptive Uncertainty: The historic, annual quantity of free water consumed by the Rincon Hondo Canyon regional herd at well 10A-5-W06 was determined to be 815,802 gallons of water in "favorable" years (see Section 5.5). This quantity was derived from the time-history of cattle, quantified by number, cattle class and characteristics, drinking at well 10A-5-W06 over the course of a year. The portion of the total quantity attributable to cow-calf pairs was calculated to be 685,254 gallons of water, Figure 18. This quantity was based on data compiled and analyzed by the U.S. Department of Agriculture in 1956 and then published by the National Research Council (Winchester, 1956) (NRC, 2000).

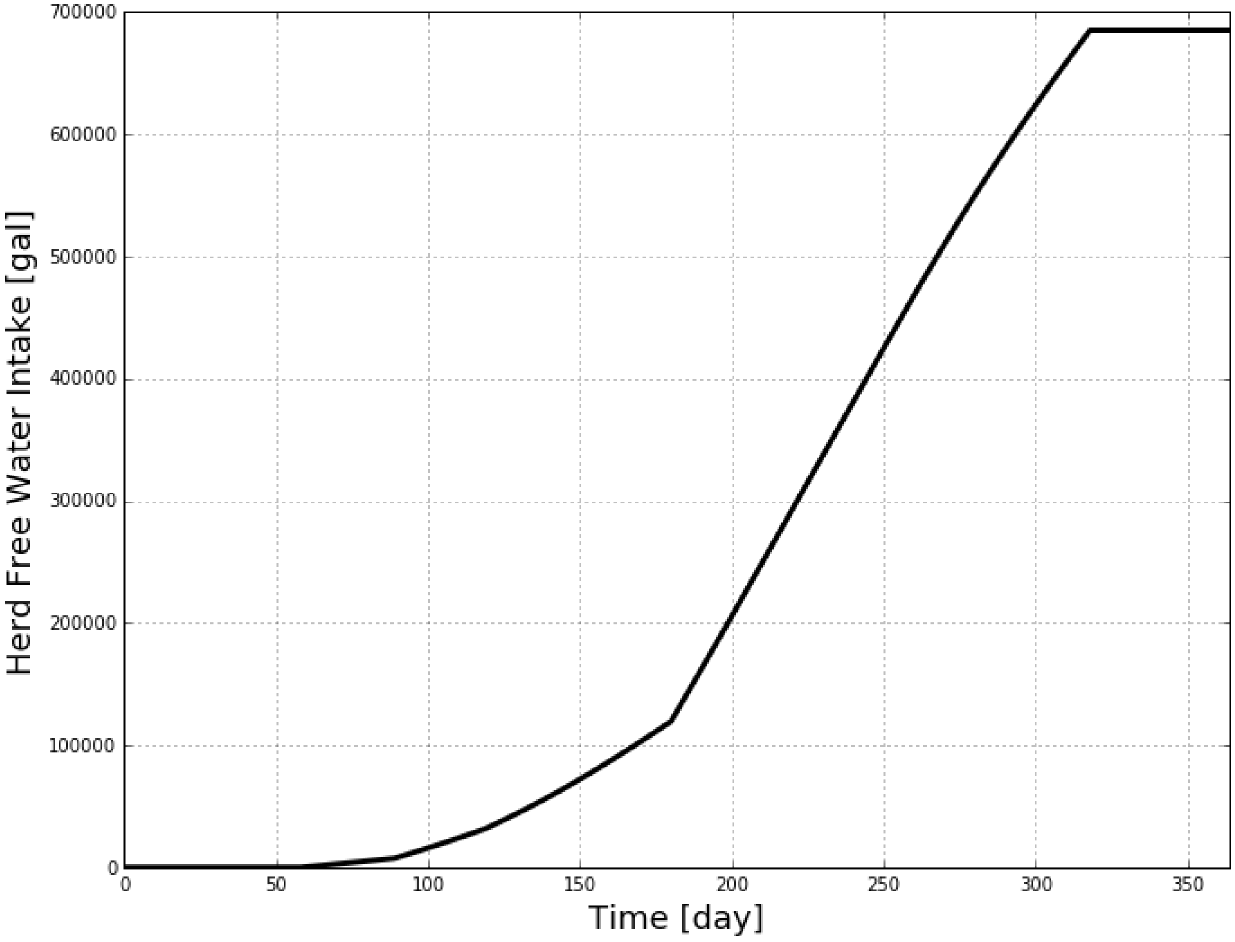


Figure 18 – Cow-Calf Consumption Using NRC Method

Recently, New Mexico State University (NMSU) published guidance that can be used to determine the water intake for rangeland cow-calf pairs (Ward, 2015). The guidance uses the empirical formula

$$WI = [-18.67 + (0.3937 \times MT) + (2.432 \times DMI) - (3.87 \times PP) - (4.437 \times DS)]/3.77$$

where WI = Water intake rate (gallons per day)
MT = Maximum ambient air temperature (°F)
DMI = Dry matter intake (pounds)
PP = Precipitation (centimeters per day)
DS = Percent of dietary salt.

An adult lactating cow eats approximately 2.25% of its body weight per day in DMI while a calf will eat approximately 2.5% of its body weight per day in DMI (Ward, 2015). For the Rincon Hondo Canyon regional herd, cows are assumed to weigh 1,000 pounds and calves are calculated to weigh a time-weighted average of 272 pounds between birth and weaning (Section 5.5). The maximum air temperature is taken to be 80°F; water intake rates thereby calculated are reasonable for temperatures up to 80°F but will increase for temperatures above that level (Ward, 2015). The percent of dietary salt for cows and calves is 0.1 and 0.2, respectively (Ward, 2015). Average annual precipitation measured at Fence Lake, NM is 14 inches per year, i.e. 0.1 centimeters per day (WRCC, 2010).

Using the NMSU method, the quantity of water consumed by the same cow-calf pairs was calculated to be 887,334 gallons of water, Figure 19. This result is 202,080 gallons, a 29%, higher demand than that determined using the NRC method. Through comparison, results obtained using the NRC method are conservative and tend to understate the quantity of water annually consumed by cow-calf pairs at well 10A-5-W06.

Tom Cox opined that a cow-calf pair would be expected to drink 30 gallons per day or so in the summer, somewhat less when evaporation is considered (Cox Dep. 68:1-7). His estimate is

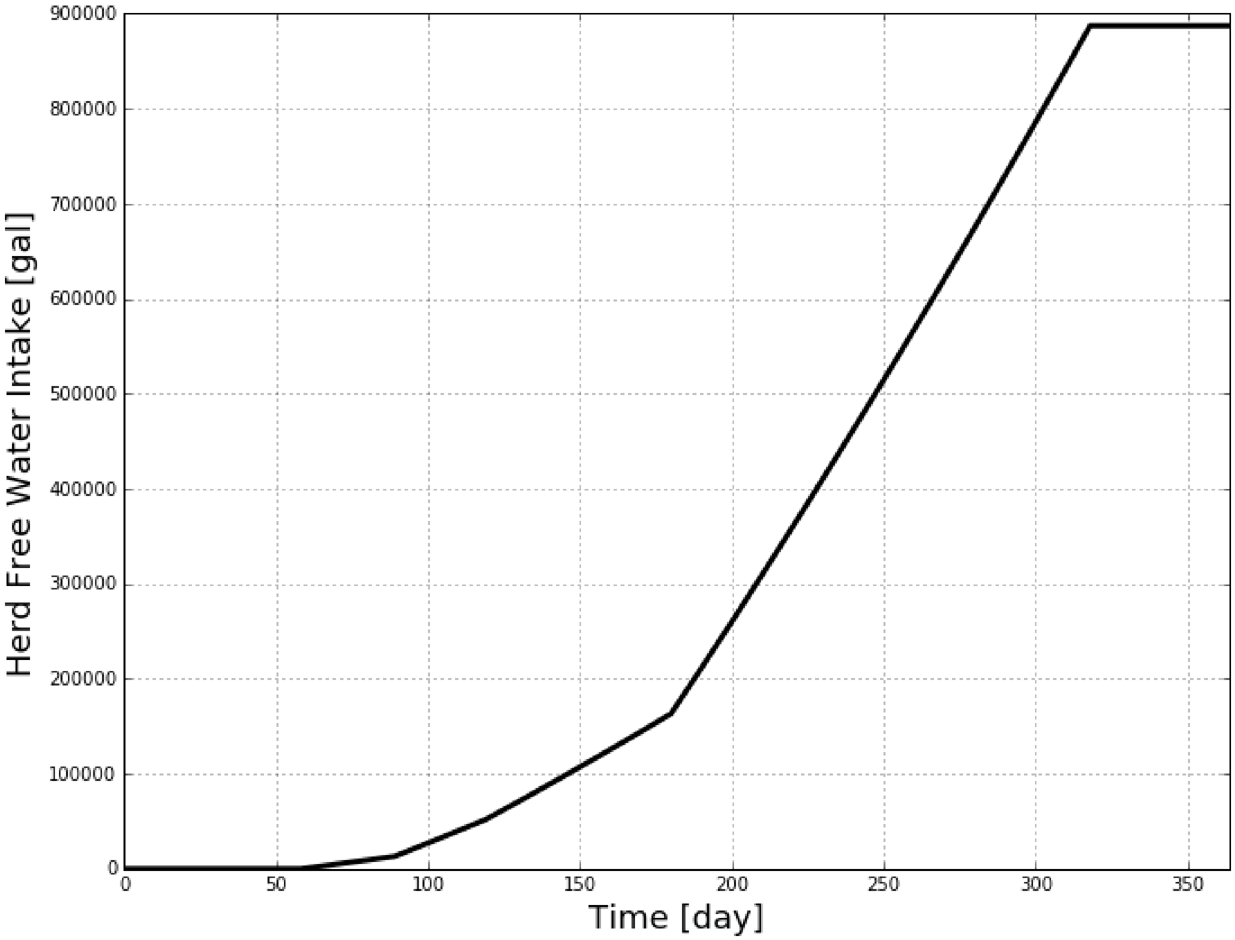


Figure 19 – Cow-Calf Consumption Using NMSU Method

approximately 25% higher than the peak summer demand of 24.05 gallons per day per cow-calf pair calculated using the NRC method (see Section 5.5, Figure 16). While anecdotal, his expectation is also suggestive of the magnitude and direction of uncertainty that exists.

It is concluded with a reasonable degree of scientific certainty that the water consumed by cattle at well 10A-5-W06 will be greater than 815,802 gallons in the year of maximum use. However, and although justified, no quantity is assigned to this consumptive uncertainty.

Consumptive Losses: For the purpose of determining historic livestock-related water withdrawals, consumptive losses are taken to mean those losses directly associated with consumptive water use by cattle. Based on the existing infrastructure, drinking water delivery to cattle at well 10A-5-W06 was exclusively by drinkers and troughs as opposed to a livestock pond.

Cattle drink with their heads down, drawing water in and then swallowing. Cattle and other ungulates can be observed raising their heads during this process allowing water to spill from the sides of their mouths, Figure 20. While some of this water will spill back into the drinker, some is lost to the ground. Additional loss mechanisms during drinking include adults using their hooves to break ice and young animals entering and exiting the drinkers, Figure 21.

Figure 20 - Consumptive Water Loss

Figure 21 – Splashing Water Loss

No data has been found that provides the basis for assigning an efficiency rate to the consumption of water by cattle. Field observations by the author and observation of video of cattle drinking suggest that there is relatively little loss associated with the drinking process. For the purposes of determining historic consumptive losses at the well 10A-5-W06 location, it is assumed that water was consumed by cattle at a 90% efficiency rate; of the remaining 10%, half is assumed to be spilled back into the drinker and the other half is assumed to be spilled to the ground. This division of water spilled into the drinker versus water spilled to the ground is reasonable, particularly when applied to large groups of thirsty cattle vying for position to drink. On this basis, it is calculated that 40,790 gallons of water were lost per year in association with cattle drinking at well 10A-5-W06.

Infrastructure-Related Losses: A variety of infrastructure-related losses would have been associated with the pumping, storage and delivery of water at the location of well 10A-5-W06. These generally fall within three categories, maintenance-related losses, chronic leakage and accident-related losses.

Maintenance-related losses are associated with the requirement to provide clean water to livestock. Livestock water is subject to contamination by minerals, manure, microorganisms and algae, some of which are sources of disease or infection and others that may affect water intake rates. A study of calf performance relative to the frequency of cleaning and rinsing drinking water vessels suggests that, although daily rinsing/cleaning is preferred, intervals between rinsing/cleaning of these single-user vessels should not exceed seven days (Weidmeier, 2006). A study of water use in feedyards reported that water troughs are cleaned about every three days in the winter and every two days in the summer (Parker, 2000).

Based on these reported practices and recommendations, the historic frequency of refreshing the water in shared drinkers at the well 10A-5-W06 location is estimated to have been at least twice per week. Despite the reported industry practice of actually cleaning drinkers, which would have resulted in additional water usage, testimony provided by Tom Cox indicated that he never scrubbed it down (Cox Dep. 51:17-52:8). Each draining and refilling of the two, permanent drinkers at the well location would produce a water loss of approximately 615 gallons (Table 1). At a rate of twice per week, this would have resulted in the use of 59,054 gallons of water over the eleven-month period December 16 through November 15; it is assumed that this practice was not employed during the intervening time period when only bulls were present. Existing valves and piping allow the rinse water to be diverted to agricultural benefit.

Chronic losses are those associated with leakage from water delivery infrastructure including well pipe, holding tanks and interconnecting piping. The primary losses of these types are discussed below.

As described above, cattle made use of water withdrawals from well 10A-5-W06 throughout the year, drinking a calculated 815,802 gallons per year at an annual average of 2,689 gallons per day. Extrapolating from recent observations, wildlife would have made use of water during the entire year as well, Figure 22 (also see wildlife discussion below).

Figure 22 – Cattle and Wildlife Share the Water Source

Given these conditions and the magnitude of the associated water withdrawals, the windmill would have been set to pump continuously throughout the year except when or if the main storage tank became full (Cox Dep. 50:3-51:4). To do so, the windmill vane would have been unfurled and left in the fully extended position allowing the windmill to cycle the cylinder pump to produce water whenever wind speed was sufficient. If the storage tank became full and was overflowing, the windmill would be turned off by furling the vane. This would occur in the late fall when cattle were shipped and only bulls were present, i.e. between mid-November and mid-December (Cox Dep. 57:17-22).

Based on observation, the Aermotor windmill installed at the location of well 10A-5-W06 will pump at a threshold wind speed of approximately 4 miles per hour (mph) with the vane fully extended. The pumping rate is a function of the wind speed; the rate is approximately 180 gallons per hour, 4,320 gallons per day, at a constant wind speed of 18 to 20 mph (Baker, 2005). In 12 mph winds, capacity is reduced about 20%; in 10 mph winds, about 38%. While the pumping rate at 10 mph is sufficient to meet the average cattle drinking water demand of 2,689 gallons per day, the average annual wind speed is approximately 7 mph and insufficient to keep up with demand (WRCC, 2016). The main holding tank serves as a reservoir to provide water on a full-time basis. A pump jack was used to cycle the cylinder pump and refill this tank as needed.

Well 10A-5-W06 is equipped with a cylinder pump that lifts water through 505 feet of well pipe and discharges it into the top of the main holding tank, 10 feet above ground. As is routine practice, the well pipe is fitted with a weep hole below the frost line to prevent water in the above ground portion of well pipe from freezing during winter months. A 1/8-inch diameter weep hole corresponds to my observation of the rate of water level drop in the stand pipe when the wind dies, ten feet over a five minute period. This leakage occurs after water is withdrawn from the aquifer but before discharge to the main holding tank. Anytime water is being pumped to the holding tank there is an associated loss of water through this weep hole.

The flow rate through a 1/8-inch diameter weep hole can be determined by the expression

$$Q = 449 \times C \times A \times (2 \times g \times h)^{½}$$

where Q = Flow rate (gpm)
C = 0.6 for sharp-edged orifices
A = Cross-sectional area of the orifice (ft^2)
g = Gravitational constant = 32.2 ft/sec^2
h = Pressure head (ft)

Since the weep hole is four feet below ground and the stand pipe is 10 feet above ground, the total pressure head while pumping is 14 feet and the flow rate through the 1/8-inch weep hole is 0.69 gpm. To determine the historic quantity of water lost through the weep hole, it is first necessary to calculate the total number of hours that pumping occurred per year.

The Gallup Municipal Airport was identified as the closest source of meteorological data available for this purpose. The joint frequency distribution of wind speed and wind direction for the Gallup Municipal Airport for the ten-year period, January 1, 2003 through December 31, 2012, was downloaded from the Western Regional Climate Center (WRCC, 2016). This data indicates that, on an annual average basis, the wind speed exceeds 4 miles per hour (mph) 59.3% of the time. Applying this pumping frequency to an eleven-month period results in a weep hole loss of 197,103 gallons at 0.69 gpm.

This is a conservative determination of historic loss through the weep hole since it ignores the small loss associated with cyclic nature of wind and the large loss associated with the time period where pumping was accomplished by use of the pump jack. Tom Cox reported that the pump jack was used in the month of June because the wind barely ever blew and demand was high (Cox Dep. 50:22-51:2). Overtopping of the main holding tank during or after filling represents an additional loss mechanism that is not included in this calculation.