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CHAPTER 18

PROBABLE HYDROLOGIC CONSEQUENCES

Introduction

This chapter contains a discussion of the probable hydrologic consequences of the life-of-mine mining plan upon the quality and quantity of surface and ground water for the proposed permit and adjacent areas. The significance of each impact or potential impact is determined. The determination of significance has been made considering the impact of any probable hydrologic consequence on: (1) the quality of the human environment; (2) any critical habitats or important plant species; or (3) any threatened and endangered wildlife species within the proposed life-of-mine permit and adjacent areas.

Ground Water

Interruption of Ground-Water Flow and Drawdown. A comparison of five year average Wepo water level contours and isopach maps which show pit bottom contour elevations for all areas to be mined, along with review of historic and recent records, indicates that portions of the J-1/N-6, N-2, N-7, N-10, N-11, J-16, J-19/20 and J-21 pits have already or will intercept the upper part of the Wepo aquifer for some period during the life of the mining areas. Flow in the portions of the Wepo aquifer truncated by overburden and coal removal will be intercepted since the ground-water gradient will rapidly orient itself in the direction of the sinks (pits). Review of Wepo water level contours developed from recent data (1995-2010) and actual field observations during mining indicates that pits in the J-7, J-21W, N-9, and N-14 mining areas will not appreciably intercept the Wepo aquifer.

Previously developed estimates of Wepo ground-water inflow to the above identified pits are presented in Tables 1 through 7, respectively. These estimates were prepared assuming that the total inflow would be derived from two principal sources: (1) the interception of pre-mining flow rates under a natural hydraulic gradient; and (2) the drainage of ground water from storage in the aquifers. It is assumed that the major portion of the Wepo ground-water inflow would be derived from lateral flow along bedding planes and fractures. Upward leakage from underlying aquifers was assumed to be negligible.

Two different techniques have been used to estimate the rates of groundwater inflow into the pits, depending on the technology available at the time the estimates were developed.

TABLE 1

Pit Inflows by Year for N-10

Pit Year	Total Length of Pit (Ft)	Constant Length in Water (L_W) (Ft)	Days in Water (t) (Day)	Constant Pit Adv./Day (Ft/Day)	Weighted T_F-Transmissivity (Gal/Day/Ft)	Weighted $T_{L,R}$ (Ft^2/Day)	I-Gradient (Ft/Ft)	Weighted Q_F (Gal/Yr)	Weighted Q_L (Gal/Yr)	Weighted Q_R (Gal/Yr)	Q_T (Gal/Yr)
2002*	8913	-	-	24.4	-	-	.018	-	-	-	-
2003*	8913	-	-	24.4	-	-	.018	-	-	-	-
2004*	8913	-	-	24.4	-	-	.018	-	-	-	-
2005	8913	1081	44	24.4	16.1	2.2	.018	20,833.0	12,541.0	832.0	34,206.0
2006	9566	2810	107	26.2	14.43	1.93	.018	123,834.2	34,176.8	271.0	158,282.0
2007	9566	2810	107	26.2	14.43	1.93	.018	243,574.7	67,223.8	533.1	311,331.6
2008	9566	2810	107	26.2	14.43	1.93	.018	331,589.0	91,514.8	725.8	423,829.6
2009	9566	2810	107	26.2	14.43	1.93	.018	324,425.1	89,537.6	710.1	414,672.8

*No mined area in water

Approach A was used for pits J-1/N-6, N-10, N-11, N-14, and J-16. This approach, described in more detail below, sums flow rates calculated from equations for steady flow under a hydraulic gradient, and transient, confined flow toward a linear drain (representing the sides of an approximately linear cut) and toward a well (representing the ends of the cut). The second approach (Approach B) was developed later, and applied to J-16, J-19/J-20, and J-21 in previous versions of this chapter, and to the N-11 extension (N11 Ext) in the current version. This approach can be used to calculate inflow under unconfined and/or confined conditions.

Approach A - Aquifer and pit characteristics and the definitions of terms used in pit inflow calculations may be found in Attachment 1. Pre-mining flow calculations are based on the following form of Darcy's law:

Q = TIL

Where:

Q = Quantity of water flowing through the aquifer at the proposed highwall locations in gal./day.

T = Transmissivity of the exposed aquifer in gal./day/ft.

I = Natural hydraulic gradient in ft./ft.

L = Length of aquifer exposed in the highwall normal to the natural hydraulic gradient in ft.

Aquifer testing at Wepo monitoring wells indicates that water in the Wepo aquifer is under some confining pressure. Some of the coal seams have very low hydraulic conductivities and act as aquitards. Water in the alluvium is believed to be in both unconfined and confined conditions depending on depth and location. Those units in the Wepo aquifer believed to transmit water are most of the coal seams and sandstone units below the prevailing water level. Alluvial ground water is assumed to flow from the entire saturated thickness of the alluvium.

In Approach A, the removal of ground water from aquifer storage was calculated using two equations; one to compute the radial component of inflow to the ends of a pit and the other to compute the linear component of inflow to the longitudinal sections of the pit. Radial inflow to each end of the pit was calculated using the following constant drawdown-variable discharge equation (Jacob and Lohman 1952 and Lohman 1972, pp. 23-24).

$$Q = 2\pi T G(\alpha) s$$

$$\alpha = \frac{Tt}{S r_w^2}$$

Where:

Q = Radial discharge into one end of the pit in ft^3/day

T = Transmissivity of the exposed aquifer in ft^2/day

S = Storage coefficient

s = Drawdown in the aquifer at the pit face in ft.

r_W = Radius of the pit opening in ft.; equal to ½ the width of the initial box cut

$G(\alpha)$ = The G function of α (see Lohman, 1972, p. 23)

t = Time since discharge began in days

The linear portion of inflow from aquifer storage was calculated using the constant drawdown-variable discharge drain equation derived by Stallman (Lohman, 1972, pp. 41-43):

$$q = \frac{2s\sqrt{ST}}{\sqrt{\pi t}}$$

Where:

q = Discharge from an aquifer to both sides of a drain per unit length of drain in ft^2/day

S = Storage coefficient

s = Drawdown in water level at drain in ft.

T = Transmissivity of exposed aquifer in ft^2/day

t = Time since drain began discharging in days

With confined aquifer conditions, lowering of the water level occurs with the lowering of hydrostatic head. The release of water from aquifer storage under confined conditions is small per unit area, because it is only a function of the secondary effects of water expansion and aquifer compaction. After some length of exposure, the hydrostatic head may decline far enough that the aquifer becomes unconfined. Further declines in the water level would then be accompanied by significantly greater quantities of ground water discharge per unit area. It is assumed that during the life of the pits, ground water flow in the affected portions of the Wepo aquifer will remain under confined conditions or that the unconfined area would only extend a short distance from the pit.

The equation for radial inflow assumes that a constant concentric head surrounds each end of the pit. The actual situation representing radial flow to the ends of the pit can be described as an arc of a circle whose center coincides with the center of the pit. If overestimate the inflow rate. This approach is described in detail in Appendix 2. This method was used to predict inflow rates for J-16, J-19/J-20, and J-21 (Tables 5 through 7).

The following procedures were used and assumptions made in estimating inflow to the N11 Ext pit for calendar years 2005-2013. Plans for mining the N11 Ext pit that were originally developed in 2004 have been delayed beyond 2018. However, the mining sequence used to estimate inflows has not been revised and remains valid for the purposes of predicting impacts as described in the following discussion:

- Wepo wells in the area surrounding the N11 Ext pit were selected, and recent water level data were evaluated to determine whether water table elevations had changed significantly from those used in the calculation of the 1985 water-table map. The Wepo wells evaluated include: 38, 39, 40, 41, 42, 43, 44, 49, 52, 53, 54, 159, and 178. Data available through May of 2003 were used in this evaluation.

  Although there were obvious trends in the data for the majority of the 13 wells, the most recent data point was used in this evaluation, since this should be most representative of the water table at start of mining in N11 Ext. These data were compared to the 1985 water table map, and revisions made as necessary. As a result of these comparisons, Drawing No. 85611, 2003 Wepo Water Level Contour Map, has been constructed (see Volume 23, PAP).

- The May 2003 water-table map was then compared with the anticipated elevations for the bottom of the N11 Ext pit, and a 'difference' contour map was constructed that identified those areas where the 2003 water table was above the bottom of N11 Ext. The difference map indicates that the water table will be above base of pit along the majority of the eastern boundary, and in the northwestern section of N11 Ext (in the area between pits N11 and N6). The difference map was then overlaid on the projected cuts for Calendar Years (CY) 2005-2013, which indicated that only those cuts in the northwestern section of the pit will encounter water within this time period. Cuts to be completed in CY2005-2007 are all located within the southwestern section of N11 Ext, and will therefore encounter minimal water. In Calendar Years 2008-2013, cuts will be made both within the southwestern section of N11 Ext, and in the northwestern section where water inflow to the cuts is expected.

- The analytical code Mine1-2_3 was used to estimate the amount of flux entering the cuts in the northwestern section of N11 Ext for CY2008-2013. [Mine1-2_3 is a modification of Mine1-2 allowing pit geometry information to be input yearly, rather than using a single set of values for the entire mining period.] General parameters, and the selected values used as input to the code include:

- o The Wepo was simulated as confined, based on the lithology of the formation, and the low values of storage coefficient determined from aquifer tests.
- o The hydraulic conductivity was set to 0.03432 ft/day, which is the geometric mean of the 24 hydraulic conductivity values for Wepo wells listed in Table 32 (Chapter 15, Hydrologic Description, PAP). The arithmetic average conductivity value was not used, since this weighted the calculated value towards the fewer, significantly higher values of conductivity, and would have overestimated this parameter.
- o The regional hydraulic Gradient (0.014) was estimated from the May 2003 water-table map.
- o A conservative value for the storage coefficient ($1x10^{-4}$) was estimated from the larger of the two values presented in Table 32. Use of a lower value would result in lower values of inflow.

The remaining parameters are specific to the cuts within each calendar year, and include: saturated area; average width of cut; average saturated thickness, days open, and whether this was the first cut in the pit (inflow is assumed through both sides of the initial cut only).

There are two components that contribute to inflow into the cuts: flux controlled by the regional hydraulic gradient (termed $Q_{natural}$ in the code), and flux from water in storage (termed $Q_{drainage}$ in the code). The code assumes that the regional hydraulic gradient, and therefore the regional flux component, is perpendicular to the long axis of each cut. This assumption is generally valid for the southern two-thirds of the cuts located within the northwestern section of N11 Ext; however, the gradient is not perpendicular in the northern one-third of the cuts. In this area, groundwater discharge into the cuts will be less than if the gradient was perpendicular, and a correction factor must be applied to decrease the inflow appropriately (this is done outside of the code). Therefore, an approximate *dividing line* was identified between these two areas, separating Area A representing the northern one-third of the cuts, from Area B representing the southern two-thirds of the cuts, and the *area, saturated thickness,* and *days open* parameters were calculated separately for the sections of the cuts located within areas A and B. The correction used to calculate the regional component of inflow to the cuts in Area A is:

Corrected $Q_{natural}$ = $Q_{natural}$*([width of cut]*sin(alpha) + [length of cut]*cos(alpha))

Alpha is the angle between a line perpendicular to the length of the cut, and the regional hydraulic gradient. The first component within the parentheses represents flux across the end of the cut, and the second component represents flux across the length of the cut. Maximum inflow to the cuts occurs when the regional hydraulic gradient is perpendicular to the length of the cut (angle alpha is 0 degrees in the above equation), and minimum inflow occurs when the gradient is parallel to the length of the cut (angle alpha is 90 degrees - this results in flux across the end of the cut only).

The regional hydraulic gradient is approximately parallel to the cuts in CY10-13, indicating that the regional flux component is minimal and is simulated as occurring across the end of the cuts only. The cut within CY08 does not extend north of the *dividing line*. For the cuts in CY09, an angle of 45 degrees was used to calculate the regional flux component.

Total lengths for all cuts within the northeastern section of N11 Ext for each calendar year were measured and summed in ArcView, and total areas were calculated. These were used to calculate average widths for each of the cuts as input to Mine1-2_3.

- Output from Mine1-2_3 includes values for $Q_{natural}$, $Q_{drainage}$, and Q_{total} for Areas A and B. For each of the cuts in Area A, a corrected $Q_{natural}$ value was calculated using the equation above, this value was added to $Q_{drainage}$, and a corrected Q_{total} determined. The corrected Q_{total} values were summed for each calendar year, and added to the corresponding Q_{total} values for that calendar year from Area B to derive a total flux per calendar year.

Results for N11 Ext are presented in Table 7a. [This nomenclature was adopted to avoid changes in table number throughout the remainder of this Chapter.] The predicted inflow varies from year to year because of changes in the length of the pits beneath the water table, and the estimated depth below the water table. In addition, drainage from two directions is assumed for the first year (2008), but from only one side in later years. The maximum estimated rate, which occurs in 2008, is approximately 10 gallons per minute (gpm); the lowest rate is predicted to be approximately 2.5 gpm, in 2010.

Table 7a. Estimated annual inflow for pit N11 Ext and length of time the base of the pit is below the pre-mining water table.

Year	**Inflow (gallons)**	**Total No. of Days in Water**
2008	1170710	84
2009	2105469	226
2010	485396	135
2011	607995	106
2012	1050225	264
2013	783849	241

For all pits including N11 Ext, the drawdown in the Wepo aquifer was estimated by using the predicted inflow rates and the analytical-element simulation program TWODAN (Fitts Geosolutions, 2000). This program solves the groundwater flow equations in two dimensions based on spatial and temporal superposition. Time-varying withdrawals can be simulated using wells. TWODAN solves a transient flow equation and can produce maps of drawdown. Although TWODAN can address cases where the aquifer is not continuous or infinite in extent, the limited drawdown that has been observed in Wepo wells in the vicinity of the pits indicated that it was not necessary to develop a more complex model incorporating the finite extent of the Wepo formation. The permeable units within the Wepo formation that have been mined or will be disturbed by mining are perched aquifers in some locations (e.g., J16 mining area near Wepo well 62R, J19 mining area near Wepo well 65), pinch out and/or are vertically displaced owing to some minor structure within the Peabody leasehold.

The estimated pit inflow rates change each year, because both the depth of the pit below the pre-mining water table and the length of time the pit is below the water table vary yearly. For each pit, the estimated inflow estimates were examined to determine if there was significant, systematic variation in the estimated inflow rate. If not, the average inflow rate was used in the model for each year that the pit was predicted to intercept the water table. If there was systematic variation, the time period was split into 2 or 3 periods of similar inflow, and the average inflow rate within each period was used. Thus, when a significant change in the estimated influx rate occurred, the change was incorporated in the model. When mining of a pit ceased, water production stopped, and inflow rate was set to zero. TWODAN simulates temporal changes in water budget by simulating discharge through wells. Two to five wells distributed around the perimeter and in the interior were used to represent each pit. The temporal changes in the location of the mining cuts within a pit are ignored.

The geometric mean of the hydraulic conductivities determined from aquifer tests of Wepo monitoring wells (Table 32, Chapter 15, Hydrologic Description, PAP), 0.03432 ft/d was used for the horizontal hydraulic conductivity of the Wepo, and the storage coefficient was set to 0.0001. The Wepo was assumed to be 200 feet thick uniformly through out the leasehold because of the limited depth of the pits, even though it is over 300 feet thick in the vicinity of these pits. This value was chosen to approximate the effect of partial penetration of the pits into the saturated Wepo, and to subtract the thickness of the Wepo above the water table. No recharge was assumed, which will cause drawdown to be over-predicted.

Figure 1 shows the locations of the 5-, 20-, 40-, and 60-foot drawdown contours, simulated using the TWODAN model, at the end of 2013. 2013 is the year when mining of N11 Ext below the water table and south of the beltline is scheduled for completion, and incorporates most of the mining currently underway or projected for the other pits such as J21. Thus, the drawdown contours shown on Figure 1 are cumulative of all past and proposed mining through 2013. A 5-foot drawdown cutoff was selected because natural water level fluctuations measured in the Wepo and alluvial monitoring wells on the PWCC leasehold are of that magnitude. Figure 1a shows the locations of the 5-, 20-, 40-, and 60-foot drawdown contours at the end of 2030. Both Figures 1 and 1a depict the locations of pre-existing shallow private wells and springs within and adjacent to the leasehold.

Because the approach used to estimate the pit inflow rates does not take into consideration the decline in water levels caused by inflow into the pit in previous years, it will tend to over-estimate the pit inflow rate in the later years. In addition, the predicted inflow rates have tended to be considerably higher than observed during mining. For example, Western Water & Land (2003) noted:

> The total [annual] inflows for pit J-1/N-6 were projected to range from approximately 50,000 gallons in 1972 to 3,182,179 gallons in 2003. As mining has progressed over the last several decades, it has generally been observed that pit inflows were overestimated, and in some cases no inflow has occurred at all. For example, initial mining of the southern portion of the N-6 Pit saw enough inflow to require pumping, but subsequent mining of this pit to the north has not resulted in any observed pit inflows.

In general, the drawdown estimates shown on Figure 1 are much larger and extend outward to distances much greater than has been observed in monitoring wells. No attempt was made to match these observations with the analytical model, as differences between the observed and estimated drawdown values would be expected. Most Wepo and many alluvial wells exhibit only a few feet of change during their period of record.

Table 8 presents a comparison of water-level changes predicted to occur because of dewatering of all the pits through 2013 with historical variability in currently active monitoring wells. Projected drawdowns, and water level ranges measured as background, during four historical periods of record (1988-1995, 1995-2000, and 2000-2004), and during the most recent seven-year period (2004-2010) are presented for both alluvial and Wepo monitoring wells. Table 8 also includes projected drawdown, historic completion and water level information, and an estimate of the percentage of available water height that may be lost due to pit inflows for two local wells (4K-389 and 8T-506) that were partially completed in the Wepo aquifer.

Table 8 shows current maximum water levels at nine of the twenty-five Wepo monitoring wells are greater than background or historic maximum water levels. At WEPO62R, current maximum water levels are 68.6 feet deeper than background maximum water levels for WEPO62. This deepening exceeds the theoretical maximum projected drawdown for WEPO62R by

Table 8

Projected Pit Inflow Drawdowns at Well Locations Versus Measured Water Level Ranges at Alluvial and Wepo Monitoring Wells and Static Water Levels at Local Wells

PWCC Well Id	Pit Inflow Analysis Maximum Projected Drawdown (feet)	Background Water Level Range		Historic Water Level Range 1988-1995		Historic Water Level Range 1995-2000		Historic Water Level Range 2000-2004		Current Water Level Range 2004-2010		Current Maximum Versus Background/ Historic Maximum (d)
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	
ALUV13R(a)	36.0	-	-	22.5	28.9	25.7	29.4	28.2	29.4	27.7	29.6	0.2 ft deeper
ALUV17	53.0	5.0	7.4	5.4	8.0	5.1	8.9	5.9	7.9	5.1	7.5	No change
ALUV19	32.0	5.6	9.4	6.2	9.6	7.0	14.9	14.7	Dry	9.7	Dry	> 7.5 ft deeper
ALUV23R	53.0	-	-	19.2	Dry	Dry	Dry	Dry	Dry	Dry	Dry	No change
ALUV27R	36.0	-	-	21.5	26.7	26.3	28.6	27.6	29.5	-	-	(b)
ALUV29	25.0	0.4	5.3	0.4	7.2	0.2	6.7	0.5	7.9	0.0	2.4	No change
ALUV31R(c)	39.0	7.3	15.8	6.2	17.9	18.1	26.0	23.2	24.2	9.5	23.8	8.0 ft deeper
ALUV69(b)	43.0	4.6	10.0	6.0	10.8	8.3	11.6	11.6	12.2	10.1	11.9	1.9 ft deeper
ALUV71(b)	28.0	14.6	16.6	15.6	16.9	15.7	16.6	16.4	16.8	15.4	17.5	0.9 ft deeper
ALUV72(b)	54.0	11.6	13.3	9.2	13.5	10.8	13.4	12.1	13.2	9.6	12.7	No change
ALUV77(c)	32.0	26.6	30.3	28.9	30.2	29.4	30.8	29.6	30.3	29.1	29.7	No change
ALUV80R	54.0	-	-	8.9	11.7	10.5	12.9	11.4	12.0	10.2	12.4	No change
ALUV83	40.0	0.9	3.3	1.0	3.4	0.8	3.5	-1.3	3.5	-3.4	2.1	No change
ALUV87	45.0	14.2	22.5	17.8	23.1	19.1	23.4	21.4	24.1	17.3	22.2	No change
ALUV89R	61.0	-	-	2.5	5.0	2.8	6.3	1.2	6.0	0.5	4.3	No change
ALUV93	23.0	25.2	29.1	25.9	29.8	26.0	32.8	33.4	37.4	38.0	39.6	10.5 ft deeper
ALUV95	20.0	3.0	4.9	3.1	5.3	3.7	5.6	5.4	7.5	7.3	8.7	3.8 ft deeper
ALUV98R	57.0	-	-	9.6	14.3	11.6	14.7	12.4	16.2	13.1	15.2	No change
ALUV99R	46.0	-	-	9.8	13.8	11.9	16.0	13.2	18.4	12.4	Dry	5.2 ft deeper
ALUV101R	65.0	-	-	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	No change
ALUV104R	15.0	-	-	15.6	20.3	19.4	20.3	18.9	20.4	17.3	20.6	0.2 ft deeper
ALUV105R	19.0	-	-	8.1	Dry	9.5	10.2	9.7	Dry	6.9	Dry	No change
ALUV106R	22.0	-	-	4.6	Dry	6.7	8.2	7.8	Dry	5.1	Dry	No change
ALUV108R	33.0	-	-	7.1	11.0	8.8	11.6	11.2	13.6	12.3	14.9	1.3 ft deeper
ALUV165	65.0	-	-	20.3	28.7	27.2	30.2	29.2	31.9	31.4	33.0	1.1 ft deeper
ALUV168	34.0	-	-	- 0.4	1.4	0.6	1.9	1.3	2.6	2.4	2.8	0.2 ft deeper
ALUV169	36.0	-	-	7.2	9.0	7.2	9.2	7.9	9.7	7.5	9.6	No change
ALUV170	34.0	-	-	4.5	5.8	4.2	6.3	4.7	7.0	3.4	5.7	No change
ALUV172	19.0	-	-	13.1	14.1	14.5	18.7	17.8	21.4	10.0	19.0	No change
ALUV180	47.0	-	-	6.1	10.3	9.4	12.4	11.6	12.6	-	-	(b)
ALUV181(a)	32.0	-	-	11.8	16.8	15.0	20.1	19.7	20.6	14.7	18.6	No change
ALUV182	32.0	-	-	13.6	17.8	16.8	19.4	17.2	19.3	15.1	18.2	No change
ALUV193	46.0	-	-	10.9	12.4	9.8	13.0	10.6	12.6	12.7	14.7	1.7 ft deeper
ALUV197	32.0	-	-	10.2	13.2	11.8	19.9	19.7	24.9	14.3	22.8	No change
ALUV199	62.0	-	-	13.5	17.2	12.5	18.3	13.7	18.8	13.7	16.8	No change
ALUV200	53.0	-	-	4.1	5.9	3.8	6.4	4.4	5.8	3.0	5.4	No change
ALUV201	n/a	-	-	-	-	-	-	-	-	27.7	28.0	No change

Notes:

(a) Discontinued monitoring at these wells in 2002, but reinstated monitoring in 2005, due to opening of N9 mining area.
(b) Discontinued monitoring at these wells in 2002 (idled).
(c) Discontinued monitoring at these wells in 2002, but periodic measurement of water levels since then.
(d) Compared with background maximum (if available) or pre-2004 historic maximum.

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Table 8 (cont.)

Projected Pit Inflow Drawdowns at Well Locations Versus Measured Water Level Ranges at Alluvial and Wepo Monitoring Wells and Static Water Levels at Local Wells

PWCC Well Id	Pit Inflow Analysis Maximum Projected Drawdown (feet)	Background Water Level Range		Historic Water Level Range 1988-1995		Historic Water Level Range 1995-2000		Historic Water Level Range 2000-2004		Current Water Level Range 2004-2010		Current Maximum Versus Background/ Historic Maximum (f)
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	
WEPO40	47.0	71.5	81.0	66.0	74.4	67.1	71.9	72.0	76.8	77.3	80.6	No change
WEPO41(a)	26.0	86.9	93.4	81.3	94.4	86.6	92.9	87.9	91.9	86.1	91.1	No change
WEPO42	54.0	-2.1	-1.5	-1.8	-1.3	-1.7	-1.0	-1.4	-1.0	-1.5	-1.2	0.3 ft deeper
WEPO43R(b)	43.0	138.6	150.6	138.9	144.4	135.3	138.1	138.3	142.2	130.4	142.1	No change
WEPO44	49.0	183.5	187.8	177.7	187.3	175.2	180.9	172.0	175.9	169.3	172.5	No change
WEPO45	37.0	83.4	88.2	80.0	86.4	80.8	82.8	82.7	83.1	82.2	83.2	No change
WEPO46	38.0	117.9	157.2	149.8	155.4	151.2	155.0	154.2	155.5	154.2	155.6	No change
WEPO47R(c)	15.0	-	-	-	-	31.4	32.6	30.7	32.4	27.7	30.6	No change
WEPO49	55.0	4.3	9.6	1.8	4.8	1.1	3.0	0.4	1.4	0.1	0.8	No change
WEPO51(a)	26.0	43.0	52.0	48.9	52.1	51.2	52.5	52.3	53.2	51.8	52.4	0.4 ft deeper
WEPO52(a)	35.0	16.3	24.3	18.0	23.8	17.8	19.0	17.9	18.0	17.9	31.0	6.7 ft deeper
WEPO53	65.0	36.7	55.4	46.4	54.7	54.8	66.0	66.9	73.2	70.5	71.5	16.1 ft deeper
WEPO54	60.0	47.4	55.7	49.5	51.4	50.3	51.8	50.8	52.1	50.4	51.5	No change
WEPO55	27.0	159.4	162.2	159.8	161.3	159.8	161.8	161.4	161.7	161.2	161.8	No change
WEPO56	35.0	30.9	40.4	32.8	38.4	35.0	37.6	36.6	38.0	38.1	39.7	No change
WEPO57	40.0	150.1	158.3	155.9	158.8	157.9	161.4	161.4	163.8	162.6	164.2	5.9 ft deeper
WEPO58	24.0	130.3	140.1	137.5	141.2	140.0	140.9	140.5	141.2	140.6	141.4	1.3 ft deeper
WEPO59	20.0	142.7	144.6	142.7	144.3	143.1	145.1	144.7	145.8	143.8	145.5	0.9 ft deeper
WEPO60	19.0	81.2	87.3	88.2	95.7	90.8	93.7	90.3	91.6	89.5	91.4	4.1 ft deeper
WEPO61	10.0	154.3	155.4	153.4	155.9	152.8	154.8	154.3	154.8	154.2	155.1	No change
WEPO62R(d)	63.0	114.1	139.7	133.1	197.7	213.1	227.7	207.9	212.1	205.8	208.3	68.6 ft deeper
WEPO65	50.0	71.9	164.5	113.8	128.7	125.0	143.5	143.6	146.6	141.7	145.9	No change
WEPO66	35.0	75.4	89.1	82.0	87.6	86.1	88.0	87.5	89.4	77.6	87.3	No change
WEPO67	25.0	129.5	204.5	182.4	187.7	181.4	184.0	175.9	181.2	183.2	185.8	No change
WEPO68 (e)	37.0	-	-	-	-	107.9	110.8	107.7	109.9	108.3	110.7	No change

Local Well Id	Pit Inflow Analysis Maximum Projected Drawdown (feet)	Total Well Depth (feet)	Static Water Level (feet)	Percent of Potential Water Height in Well Bore Lost to Pit Pumpage
4K-389	30.0	417	356	49.2
8T-506	49.0	552	34	9.5

Notes:

(a) Discontinued monitoring at these wells in 2002 (idled).

(b) Background and historic water levels through 2/97 are from WEPO43, corrected for ground surface elevation. WEPO43 was removed ahead of gravel-pit expansion in 1997 and WEPO43R was installed that same year.

(c) Background and historic water levels through 3/98 are from WEPO47, and from 4/98 to present are from WEPO47R; both uncorrected for ground surface elevation differences. WEPO47 was removed ahead of pond construction and WEPO47R was installed in 1998.

(d) Background and historic water levels through 3/98 (including 1995-2000 maximum) are from WEPO62, corrected for ground surface elevation. WEPO62 was removed in 1998 and WEPO62R was installed in 1997.

(e) WEPO68 was installed in 1997.

(f) Compared with background maximum (if available) or pre-2004 historic maximum.

5.6 feet. WEPO62 appears to have been open to one or more perched zones, which were gradually dewatered as the adjacent J-16 pit was mined. These perched zones are usually of limited aerial extent and can influence large well bore water level changes, which are not indicative of true aquifer water level changes. At WEPO53, current maximum water levels are 16.1 feet deeper than background and historic maximum water levels, yet are only 6.5 feet deeper than the theoretical projected maximum drawdown at 2013 for this well (65 feet). The 16.1 feet deepening at WEPO53 has likely been influenced by pit dewatering in both the N-6 and N-11 pits. The maximum current water levels that are deeper than historical values in the remaining four Wepo monitoring wells range from 0.3 feet to 6.7 feet, which are comparable to natural water fluctuations in the Wepo formation. Sixteen of the Wepo monitoring wells show no change in current maximum water levels compared with historic values. Wepo monitoring wells WEPO40, WEPO43R, and WEPO44, situated adjacent to the J1/N6 pit, show no change in current maximum water levels compared to their historical records. Out of a total of twenty-five Wepo monitoring wells, there are only two wells adjacent to wet pits that have exhibited drawdowns in excess of natural fluctuations (greater than seven feet), and that were most likely affected by dewatering of an adjacent pit. The remaining twenty-three wells have not shown appreciable drawdown impacts from pit dewatering even though many are within one-mile of the nearby pit, suggesting that the projected drawdowns depicted in both Figures 1 and 1a are extremely conservative.

Table 8 shows current maximum water levels at 4 of the 37 alluvial wells are deeper than 5 feet of their historical record. Three of the wells (ALUV19, ALUV31R, and ALUV93) are shallow monitoring wells constructed in the alluvium along the lower reaches of the major washes, several miles downstream of any of the wet pits. ALUV99R is located to the north of the J21 pit. These deeper water levels are a result of recent trends in lower precipitation and subsequent recharge from runoff and discharge from the Wepo formation. Many of the remaining 32 alluvial wells exhibit deeper current maximum water levels compared to their historical record, but they are generally comparable to or less than the several-feet natural fluctuation of water levels in the alluvium, and all have been influenced to some degree by recent trends in lower precipitation. Projected drawdowns at each alluvial monitoring well location using the TWODAN analytical method are generally an order of magnitude greater than the drawdowns measured to date.

Figure 1 shows drawdowns in the Wepo formation in the vicinity of the N11 Ext pit are projected to be 60 feet or greater by 2013. In addition, drawdowns beneath the adjacent portion of Coal Mine Wash are projected to range between 40 feet at ALUV83 and 54 feet at ALUV80R. The Wepo is believed to be the source of discharge into the wash downstream from where Coal Mine Wash passes beneath the overland conveyor. Peabody does not believe that there will be significant impacts on this discharge for several reasons. First, observations of pit discharge suggest that the technique overestimates the inflow rate, as noted above. Second, the mining of N6 has not caused a noticeable impact on the locations of discharge into Coal Mine Wash. Although the baseflow of Coal Mine Wash is not measured, a reduction in discharge caused by declining water levels beneath the wash would be also manifested by downstream movement of the location of the uppermost area of discharge. This has not been observed over many years of mining. Third, the water levels in WEPO40, a well close to both N6 and Coal Mine Wash, appear to be affected more by changes in local recharge than by dewatering.

Based on the theoretical pit inflow drawdown contours, local well 4K-389 is projected to have its water level deepened by 30 feet, or 49.2 percent of its total available water height of 61 feet. Local well 8T-506 is projected to have its water level deepened by 49 feet, or 9.5 percent of its available water height of 518 feet. Both wells were selected for comparison purpose due to their proximity to wet pits; however, local well 8T-506 was removed in advance of the mining operations in the N-6 mining area. From the historic and current water levels at Wepo and alluvial monitoring wells in the vicinity of the two local wells, it appears likely that the projected water level declines at the two local wells will be significantly less than that theoretically calculated. The drawdown that will eventually occur in the Wepo formation in the vicinity of local well 8T-506 and at local well 4K-389 from pit inflows will not be significant.

As mentioned previously, Figures 1 and 1a depict the locations of numerous pre-existing wells, springs, and ponds within and adjacent to the leasehold. Chapter 17, Protection of the Hydrologic Balance, provides a thorough discussion of the nature and status of the pre-existing water sources shown on Figures 1 and 1a. Many of the wells are inoperable, or are completed in different formations or multiple formations in addition to the Wepo. Many of the springs are undeveloped, have little to no measurable discharge, or emanate from a formation other than the Wepo. Chapter 17 provides a discussion of plans to provide replacement sources of water for those wells and springs that have been or will be removed by mining. All of the pre-existing wells and springs that are operable and have measureable output within the leasehold are monitored, and none of the recent measurements indicate a significant reduction in output as a result of pit dewatering.

In summary, water from the Wepo formation is expected to enter N11 Ext (and other) pits. Based on operational experience, the inflow rates have generally been lower than predicted by the techniques described here. Similarly, the simulated drawdowns caused by dewatering are no doubt much higher than will be encountered. Only two monitoring wells in the immediate vicinity of pits that have already been mined exhibit declines in water levels attributed to pit inflows, and drawdowns in other wells adjacent to previously mined pits are not evident. Inflow in the N11 Ext and other wet pits is likely to be less than indicated in Tables 1 through 7a. Drawdowns expected to occur in the Wepo formation as a result of pit dewatering should not extend as far nor be as high as depicted on Figures 1 and 1a, and will not be significant.

Removal of Local Wells and Springs. One existing local well (4T-404), completed in the Toreva aquifer, is located within the proposed life-of-mine mining plan area (J-19 mining area). In addition, two other local wells (4T-403 and 8T-506), both completed in the Toreva aquifer were removed in advance of the mining operations in the J-7 and N-6 mining areas, respectively. One local spring (Site #97) was removed in advance of mining at N-14. The impacts have been mitigated during mining by providing alternative water sources (N-aquifer public water standpipes). The three local wells will be replaced with ones of comparable quality and yield following the completion of mining and reclamation in the respective mining areas. The spring will be mitigated by retention of a permanent impoundment (see Chapter 19).

Containment of Pit Inflow Pumpage. It is sometimes necessary to pump ground water which seeps into pits to allow work to continue and to prevent slumping of spoil piles resulting from saturation near the bottom of the pit. Several sediment ponds and large dams (see Table 9) exist or will exist around the pits to contain all pit pumpage as well as storm water runoff and sediment from the disturbed areas up-watershed from the ponds.

Referring to Tables 1 through 7a, it can be seen that the maximum pit pumpage in any one year will be 19 to 37 acre-feet and will occur in the J-19/20 pit. Typical quantities of pit pumpage will be on the order of 2 or less acre-feet per year. The larger dams are designed to contain this additional volume of water with adequate freeboard. Reed Valley Dam has been designed to impound 475 acre-feet of water and J-7JR dam will hold an estimated 700 acre-feet of water. The capacity of smaller sediment ponds to contain storm runoff will be maintained by pumpage from the ponds. The current NPDES Permit (Chapter 16, Attachment 3) allows for pond dewatering or pond to pond pumpage.

Impact of Replaced Spoil Material on Ground-Water Flow and Recharge Capacity. Pits remain open only until the coal has been removed. Following the short-term impacts on the ground-water system associated with open pits, a longer term impact is experienced due to the placement of spoil material in the mined-out pits. A wide range in permeabilities for spoil material can occur depending on how it is placed.

Rahn (1976) reported that spoil material replaced using a dragline in one instance and a scraper in another, yielded hydraulic conductivities of 35.3 ft./day and 0.4 ft./day, respectively. Van Voast and Hedges (1975) concluded that greater porosities and hydraulic conductivities will result from volume changes (approximately one-fourth greater) between the spoil material in its original compacted, stratified state, and in its rearranged state following replacement, regardless of the method of replacement used.

Spoil material will be regraded by dozers and scrapers and final contouring will be accomplished with dozers. Based on the conclusions of the above studies, the spoil material should have higher porosities and permeabilities than it did in its original state. The topsoil surface will be disked as part of the reclamation activity; this procedure should further enhance the rainfall and overland flow infiltration rates.

that would account for these increases in TDS are Ca, Mg, Na, SO_4 and HCO_3.

On a related matter, Montana Department of State Lands personnel have noticed in their review of mine overburden data that materials with high salinity are generally quite shallow (less than 15 meters). Normal dragline operation would generally place some of the near surface overburden in the lower portions of the pit. This mining practice could cause the placement of some of the more saline materials in the resaturated zone and result in a greater degree of ground-water degradation. A review of overburden core data for portions of the pits that will intercept the Wepo aquifer (N-6, N-10, N-11, N-14, N99, J-16, J-19/20 and J-21) indicates that there are no significantly high conductivity zones in the overburden material. Therefore, significant salinity increases are not expected in resaturated graded spoil on the Black Mesa leasehold.

The second principal chemical reaction that occurs in spoil material and could affect ground-water quality is the oxidation and reduction of sulfides and organic sulfur. In the west, waters which contact spoil are rarely acidic. Acid zones will probably form in the spoil; however, sufficient carbonate materials and alkaline salts are available to neutralize acid production resulting from the oxidation of sulfides.

Cores from within or immediately adjacent to the wet portions of the pits have been analyzed to determine the acid potential of the overburden (see Appendix B). The overall acid-forming potential of core material involves a comparison of the acid potential and the neutralization potential expressed in terms of tons of $CaCO_3$ required per 1000 tons of material for neutralization (acid potential) and tons of $CaCO_3$ excess per 1000 tons of material (neutralization potential). Table 10 is a summary of: (1) the percent of the total core that is comprised of material with acid potential; (2) the mean weighted acid potential; and (3) the mean weighted neutralization potential. Cores from within or adjacent to wet pits, and new cores (2003) drilled in the J-21W, N-9, and N-11 Ext coal resource areas are also included. Only 1 core; Core #30356EO in the N-9 mining area had a higher mean weighted acid potential. All other cores indicate excess ($CaCO_3$) neutralization potential. The neutralization of the acid produced from the oxidation of sulfides and sulfates does have an adverse water quality related side effect. In the process of the carbonate minerals reacting to achieve neutralization, there is increased dissolution of alkaline salts and consequently elevated TDS levels.

Considerable controversy surrounds the potential activity of the different forms of sulfur and the significance of organic sulfur. In western mine settings as much as 70% of the total sulfur analyzed has been found to be organic sulfur. According to Dollhopf

TABLE 10

Summary of Acid and Neutralization Potential for
Cores in Mining Areas Projected to Intercept the Wepo Aquifer

Overburden Core No.	% of Core With Negative Potential	Mean Weighted Acid Potential (Tons $CaCO_3$ Needed for Neutrality per 1000 Tons Material)	Mean Weighted Neutralization Potential (Tons $CaCO_3$ Excess per 1000 Tons Material)
N-6 Mining Area			
21104C	16.63	9.76	40.94
23163C	4.48	7.98	45.01
23164C	15.38	11.26	39.39
23165C	26.35	10.36	39.51
23166C	14.97	7.41	62.12
24093C	14.42	8.21	44.63
24094C	12.98	7.13	61.89
24095C	12.60	6.94	50.53
24096C	5.39	6.92	52.68
24097C	22.77	8.61	40.35
24098C	23.32	7.21	38.85
24099C	11.93	2.82	36.39
24400C	12.50	9.23	51.70
24401C	20.14	10.90	21.81
24402C	21.67	12.54	38.14
J-16 Mining Area			
23146C	44.57	24.37	32.29
23147C	33.14	17.81	28.66
23148C	41.22	30.79	39.28
23149C	1.42	4.59	24.60
23325C	37.64	13.89	28.80
23326C	32.34	11.06	40.85
23327C	45.26	23.06	39.89
23328C	34.72	24.12	39.41
26462C	12.28	2.65	27.30
J-19 Mining Area			
24406C	33.23	5.05	27.74
24407C	32.03	16.48	32.03
24408C	17.97	4.34	32.01
24418C	24.09	15.39	34.28
J-21 Mining Area			
24403C	12.02	7.44	79.73
24404C	11.98	4.97	73.07
24405C	12.36	8.49	54.99
J-21W Mining Area			
30365EO	13.04	7.71	48.83
N-9 Mining Area			
30355EO	29.64	16.10	51.16
30356EO	54.64	21.25	20.63
30357EO	34.30	18.57	41.57
30358EO	32.14	17.42	72.61
N-10 Mining Area			
21099C	46.63	20.02	21.97
21100C	40.09	23.89	28.40
21101C	38.21	20.86	24.10
30354EO	12.32	15.81	43.99
N-11 Mining Area			
26272C	29.61	18.73	42.57
26364C	25.91	18.50	49.32
26367C	20.76	14.00	69.67
26463C	37.84	17.98	58.24
N-14 Mining Area			
26269C	31.41	18.73	30.73
26271C	40.04	16.51	19.65

TABLE 10 (Continued)

Summary of Acid and Neutralization Potential for Cores in Mining Areas Projected to Intercept the Wepo Aquifer

Overburden Core No.	% of Core With Negative Potential	Mean Weighted Acid Potential (Tons $CaCO_3$ Needed for Neutrality per 1000 Tons Material)	Mean Weighted Neutralization Potential (Tons $CaCO_3$ Excess per 1000 Tons Material)
N-11 Ext Mining Area			
30351EO	11.06	10.09	34.62
30352EO	32.00	14.47	28.76
30353EO	18.88	14.12	33.72
30368EO	28.11	15.11	33.91
30369EO	32.48	16.34	24.77
30370EO	17.19	15.12	33.15
30381EO	26.65	15.72	46.39

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(1984), organic sulfur when oxidized produces approximately one-third less acid than the sulfide forms of sulfur in a low (< 4) pH environment. A comparison of total sulfur versus pyritic sulfur in cores taken on Black Mesa suggests that organic sulfur is approximately 20 percent of the total sulfur. In this comparison it was assumed that only the above two forms comprised the total amount of sulfur. Whether it is pyritic or organic sulfur, not all the forms of either will react to form acid. Considerable research remains to be done in this area.

Oxidation of sulfides primarily occurs above the water table in the zone of water level fluctuations or in zones of significant infiltration of precipitation. As was explained previously, significant recharge will not occur to the aquifer through the spoil material, so the potential of this as a mechanism for additional leachate movement and acid production on the leasehold is minimal. Also, the typical Wepo water level fluctuations range from 2 to 3 feet or less. This does not constitute a significant zone in which alternate weathering and leaching of ions could occur.

Below the water table, less oxygen may be available than in the overlying unsaturated vadose zone resulting in less sulfide oxidation-reduction increases in salinity or acidity of the water. Pionke and Rogowski (1979) state that water has an oxygen diffusion coefficient four magnitudes less than for sulfides in air. The opportunity exists during the mining process to minimize the oxidation of pyrites and the production of sulfates by burying localized pyritic zones in the postmining saturated zone. Sulfide reduction may be the dominant process occurring below the water table if substantial populations of sulfate reducing bacteria are present. No information exists regarding the possibility of the presence of these bacteria on the leasehold.

A final concern associated with the oxidation and reduction of sulfides and sulfates is the mobilization of trace metals in the ground-water system. Dollhopf et al. (1979, 1981) compared column leach extracts with spoil water quality. They found that the statistical means and ranges for the comparisons between column leachates and water from spoil wells often differed by as much as a factor of ten. Though they did state that column leachates were comparable to well water concentrations to a degree, they allowed that these correlations would have to be made at many mines with contrasting chemical conditions in order to verify the usefulness of this method for judging which overburden materials would be most suitable for aquifer reestablishment.

Evaluation of cores taken in the N-11, N-14, J-16, J-19/20 and J-21 mining areas for B, As, Se, Mo, Hg, Cu, Cd, Cr and Zn indicates that there are not high concentrations of any of these chemical constituents in the overburden material. During the oxidation and reduction stages of the sulfide zones in the saturated portions of the pits, trace metals will be alternately taken into solution as the pH drops and precipitated out as the acid is neutralized and additional alkali salts go into solution. Total recoverable metal analyses performed on Wepo and alluvial ground-water samples collected at below-mining monitors also support the core chemistry. Wepo and alluvial ground-water trace metal analyses presented in the annual "Hydrological Data Reports" and summarized in Table 11 indicate that both the dissolved and total recoverable concentrations of trace constituents at monitoring sites downgradient of wet pits are typically well below the livestock drinking water limits.

The above discussion has addressed the sources of potential ground-water quality degradation. In order to assess the significance of this potential degradation, the historic and potential use of the Wepo and alluvial ground water is considered. Table 12 is a summary of the principal constituents in both aquifers that render the water sources unsuitable for livestock drinking water. The monitoring sites chosen for Table 12 are either at or in the immediate vicinity (downgradient) of a pit that will intersect the Wepo and or alluvial aquifer. Recently promulgated Tribal water quality standards (NNEPA, 2008; Hopi, 2010) were principally used, as well as recommended standards for both TDS (NAS, 1974) and sulfate (Botz and Pederson, 1976). All chemical parameter values listed are for water quality sampling at each site from 1986 through 2010, and comparisons of standards for trace elements were limited to dissolved analyses.

The principal constituent rendering Wepo aquifer water unsuitable for use as livestock drinking water is pH (at four wells). The NO3, Se, TDS and sulfate standards were also exceeded at one site (WEPO46). Low pH levels appear to be isolated occurrences at two of the four wells, where only one or two low pH values appear in twenty or more measurements. Low pH values at these wells range from 6.2 to 6.5, which is only slightly below the livestock drinking water limit (lower limit is 6.5). A single high pH value (9.16) appears in 58 measurements taken at well 40 (higher limit is 9.0). Elevated NO3 levels can lead to methemoglobinemia and impaired liver function, whereas elevated Se can cause white muscle disease in livestock. Ingestion of sulfate levels greater than 3000 mg/l and TDS concentrations greater than 7000 mg/l in livestock drinking water tends to cause diarrhea, rundown ragged appearances, weakening, and death. Principal constituents in the alluvial aquifer that preclude livestock use are sulfate and TDS. Almost all occurrences of trace elements Cd, Pb and Se greater than the standards result from laboratory method detection limits greater than the standards. Alluvial well 199 consistently exhibits low pH values below the standard. Those portions of the Wepo aquifer potentially affected by pit interception do not appear to be significantly

Table 11.

Summary of Dissolved and Total Recoverable Trace Metal Concentrations in Portions of the Wepo and Alluvial Aquifers Below Mining (1986 – 2010)

Wepo Aquifer

Chemical Constituent	Range of Minimum Values (mg/l)	Range of Mean Values (mg/l)	Range of Maximum Values (mg/l)	Livestock Standards (mg/l)#
Arsenic (D)	<.0005-.003	.001-.004	<.0005-.004	0.2
Arsenic (TR)	.001-.003	.001-.004	<.001-.005	0.2
Boron (D)	.03-.79	.065-.88	.08-1.2	5.0
Cadmium (D)	<.003-.008	.003-.011	<.003-.02	0.05
Cadmium (TR)	<.003-.009	.005-.009	<.005-.009	0.05
Chromium (D)	<.01-.01	.01-.02	<.01-.01	1.0
Chromium (TR)	<.01-.01	.01-.01	<.01-.01	1.0
Copper (D)*	<.01-.01	.01-.03	<.01-.02	0.5
Copper (TR)	<.01-.02	.01-.037	<.01-.06	0.5
Lead (D)*	<.02-.02	.02-.02	<.02-.02	0.1
Lead (TR)	<.02-.08	.02-.08	<.02-.08	0.1
Mercury (D)*	<.0001-.0003	.0003 - .0003	<.0001-.0003	0.01
Mercury (TR)	<.0001-<.0001	-	<.0002-<.0002	0.01
Molybdenum (D)	<.001-.002	.001-.003	<.001-.003	N/A
Molybdenum (TR)	<.001-.002	.001-.003	.001-.005	N/A
Selenium (D)*	<.001-.011	.001-.09	<.001-.21	0.05
Selenium (TR)	<.001-.007	.001-.09	<.001-.21	0.05
Zinc (D)	<.01-.30	.01-.34	<.01-.40	25
Zinc (TR)	.01-.03	.02-.20	<.01-.53	25

Alluvial Aquifer

Chemical Constituent	Range of Minimum Values (mg/l)	Range of Mean Values (mg/l)	Range of Maximum Values (mg/l)	Livestock Standards (mg/l)#
Arsenic (D)	<.001-.013	.001-.013	<.0005-.015	0.2
Arsenic (TR)	<.001-.006	.001-.008	.001-.03	0.2
Boron (D)	<.02-.66	.088-.78	.07-.90	5.0
Cadmium (D)*	<.003-.02	.003-.02	<.01-.02	0.05
Cadmium (TR)	<.003-.02	.003-.02	<.01-.021	0.05
Chromium (D)*	<.01-.03	.01-.038	<.01-.07	1.0
Chromium (TR)	<.01-.03	.01-.11	<.01-.35	1.0
Copper (D)*	<.01-.04	.01-.055	<.01-<.1	0.5
Copper (TR)	<.01-.02	.01-.062	<.01-.22	0.5
Lead (D)*	<.02-.08	.02-.08	.02-.12	0.1
Lead (TR)	<.02-.04	.02-.14	<.02-.59	0.1
Mercury (D)*	<.0001-.0009	.0002-.002	<.0002-.003	0.01
Mercury (TR)*	<.0001-.0004	.0001-.0007	<.0001-.0013	0.01
Molybdenum (D)	<.001-.002	.001-.004	<.001-.01	N/A
Molybdenum (TR)	<.001-.002	.002-.008	<.001-.016	N/A
Selenium (D)	<.001-.017	.001-.014	<.002-.032	0.05
Selenium (TR)	<.001-.004	.001-.011	.002-.024	0.05
Zinc (D)*	<.01-.67	.02-.32	.02-.77	25
Zinc (TR)	<.01-.02	.02-.08	<.01-.47	25

* Range adjusted to exclude suspected outliers. Criteria used for identifying suspected outliers include measureable dissolved concentrations yet the pH is alkaline; dissolved concentrations higher than total recoverable concentrations; and one or two abnormally high dissolved values mixed with 40 below detection limit values.
# Standards are taken from Navajo Nation Surface Water Quality Standards (NNEPA, 2008), and from Draft Hopi Water Quality Standards (Hopi, 2010 – mercury only).

Table 12 - Downgradient Wepo and Alluvial Well Chemistry vs. Livestock Drinking Water Standards

Analyte	Standard		No. Sites	Sites	Frequency	Exceedence Date Range	Exceedence Value Range		Exceedence Median
LIVESTOCK DRINKING WATER STANDARDS -- NNEPA (2008), HOPI (2010), BOTZ AND PEDERSON (1976)									
Aluminum, Dissolved	0.0000 -	5.0000	1	ALUV199	1/0/0/45	07/03/01-07/03/01	8.2000 -	8.2000	8.2000
Arsenic, Dissolved	0.0000 -	200.0000	0	none					
Boron, Dissolved	0.0000 -	5000.0000	0	none					
Cadmium, Dissolved	0.0000 -	50.0000	6	ALUV180	0/0/1/37	08/25/97-08/25/97(<)	200.0000 -	200.0000	200.0000
				ALUV181	0/0/1/42	08/25/97-08/25/97(<)	200.0000 -	200.0000	200.0000
				ALUV182	0/0/1/45	03/24/98-03/24/98(<)	60.0000 -	60.0000	60.0000
				ALUV19	0/0/1/62	01/27/98-01/27/98(<)	80.0000 -	80.0000	80.0000
				ALUV193	0/0/1/54	11/03/97-11/03/97(<)	400.0000 -	400.0000	400.0000
				ALUV197	0/0/2/54	11/03/97-01/27/98(<)	80.0000 -	400.0000	240.0000
Chromium, Dissolved	0.0000 -	1000.0000	0	none					
Copper, Dissolved	0.0000 -	500.0000	0	none					
Field Ph	6.5000 -	9.0000	5	ALUV199	22/0/0/45	05/31/94-05/07/10	5.8500 -	6.4800	6.3050
				WEPO40	1/0/0/58	10/25/95-10/25/95	9.1600 -	9.1600	9.1600
				WEPO42	2/0/0/59	02/16/94-03/09/95	6.3700 -	6.3700	6.3700
				WEPO46	5/0/0/50	03/11/93-06/03/09	6.2100 -	6.4900	6.2500
				WEPO49	2/0/0/55	06/29/92-03/09/95	6.2300 -	6.4700	6.3500
Lead, Dissolved	0.0000 -	100.0000	16	ALUV169	0/0/12/44	11/20/97-02/04/05(<)	200.0000 -	200.0000	200.0000
				ALUV170	0/1/31/55	04/21/97-08/23/10(B)	200.0000 -	200.0000	200.0000
						(<)	200.0000 -	200.0000	200.0000
				ALUV180	0/0/18/37	03/07/97-05/20/02(<)	200.0000 -	2000.0000	200.0000
				ALUV181	0/0/23/42	03/07/97-05/03/10(<)	200.0000 -	2000.0000	200.0000
				ALUV182	0/1/20/45	03/07/97-12/01/10(B)	300.0000 -	300.0000	300.0000
						(<)	200.0000 -	800.0000	200.0000
				ALUV19	0/0/16/61	02/04/97-02/25/09(<)	200.0000 -	200.0000	200.0000
				ALUV193	0/0/26/54	11/03/97-03/22/10(<)	200.0000 -	1000.0000	200.0000
				ALUV197	0/0/26/54	08/26/97-03/22/10(<)	200.0000 -	1000.0000	200.0000
				ALUV199	0/0/24/45	07/16/96-05/07/10(<)	200.0000 -	200.0000	200.0000
				ALUV27R	0/0/16/50	11/06/97-07/29/02(<)	200.0000 -	200.0000	200.0000
				ALUV80R	0/1/5/67	07/19/99-07/23/10(B)	200.0000 -	200.0000	200.0000
						(<)	200.0000 -	400.0000	200.0000
				ALUV83	0/0/34/70	07/16/96-08/13/10(<)	200.0000 -	200.0000	200.0000
				ALUV89R	0/0/24/67	03/02/98-10/11/10(<)	200.0000 -	200.0000	200.0000
				WEPO178	0/0/8/22	03/10/97-05/20/02(<)	200.0000 -	200.0000	200.0000
				WEPO46	0/0/4/29	09/18/97-05/19/06(<)	200.0000 -	200.0000	200.0000
				WEPO55	0/0/1/27	08/26/97-08/26/97(<)	200.0000 -	200.0000	200.0000
Mercury, Dissolved	0.0000 -	10.0000	0	none					
NO3_NO2 Nitrogen_N	0.0000 -	100.0000	2	ALUV200	1/0/0/55	03/25/08-03/25/08	323.0000 -	323.0000	323.0000
				WEPO46	2/0/0/25	09/18/97-11/06/97	202.0000 -	270.0000	236.0000
Nitrate Nitrogen_N	0.0000 -	100.0000	2	ALUV200	1/0/0/55	03/25/08-03/25/08	323.0000 -	323.0000	323.0000
				WEPO46	2/0/0/29	09/18/97-11/06/97	202.0000 -	269.0000	235.5000

Table 12 (cont.) - Downgradient Wepo and Alluvial Well Chemistry vs. Livestock Drinking Water Standards

Analyte	Standard	No. Sites	Sites	Frequency	Exceedence Date Range	Exceedence Value Range	Exceedence Median
Nitrite Nitrogen_N	0.0000 - 10.0000	0	none				
Selenium, Dissolved	0.0000 - 50.0000	2	ALUV200	2/0/0/55	03/25/08-04/16/08	56.0000 - 300.0000	178.0000
			WEPO46	13/0/0/29	06/24/86-06/03/09	51.0000 - 560.0000	160.0000
Solids, Dissolved	0.0000 - 6999.0000	7	ALUV170	13/0/0/55	03/18/93-04/17/01	7010.0000 - 9540.0000	7470.0000
			ALUV19	1/0/0/64	04/28/06-04/28/06	7120.0000 - 7120.0000	7120.0000
			ALUV197	26/0/0/54	08/28/98-09/14/10	7040.0000 - 7730.0000	7315.0000
			ALUV199	38/0/0/45	12/17/92-07/09/08	7050.0000 - 9692.0000	8400.0000
			ALUV200	1/0/0/55	03/25/08-03/25/08	13900.0000 - 13900.0000	13900.0000
			ALUV83	31/0/0/71	10/23/87-08/13/10	7002.0000 - 7670.0000	7210.0000
			WEPO46	2/0/0/59	09/18/97-11/06/97	7840.0000 - 8010.0000	7925.0000
Sulfate	0.0000 - 3000.0000	14	ALUV170	55/0/0/55	10/01/92-08/23/10	3300.0000 - 5800.0000	3960.0000
			ALUV180	18/0/0/37	08/09/94-08/17/01	3010.0000 - 3380.0000	3100.0000
			ALUV181	1/0/0/42	04/23/97-04/23/97	3140.0000 - 3140.0000	3140.0000
			ALUV182	4/0/0/45	09/05/95-04/28/97	3050.0000 - 3160.0000	3080.0000
			ALUV19	22/0/0/63	02/04/97-08/09/10	3040.0000 - 4200.0000	3355.0000
			ALUV193	30/0/0/54	09/21/93-08/09/10	3020.0000 - 4000.0000	3190.0000
			ALUV197	54/0/0/54	10/30/92-09/14/10	3441.0000 - 4640.0000	4110.0000
			ALUV199	45/0/0/45	12/17/92-05/07/10	4000.0000 - 6610.0000	5360.0000
			ALUV200	1/0/0/55	03/25/08-03/25/08	7900.0000 - 7900.0000	7900.0000
			ALUV27R	49/0/0/50	06/02/89-07/29/02	3293.0000 - 4110.0000	3676.0000
			ALUV83	70/0/0/71	07/17/86-08/13/10	3239.0000 - 5038.0000	4108.0000
			ALUV89R	4/0/0/67	01/13/00-04/15/05	3020.0000 - 3120.0000	3075.0000
			WEPO178	1/0/0/22	07/21/97-07/21/97	3170.0000 - 3170.0000	3170.0000
			WEPO46	7/0/0/29	10/17/88-06/03/09	3130.0000 - 4290.0000	3457.0000
Vanadium, Dissolved	0.0000 - 100.0000	2	WEPO40	0/0/1/37	04/23/86-04/23/86(<)	500.0000 - 500.0000	500.0000
			WEPO55	0/0/1/27	04/16/86-04/16/86(<)	500.0000 - 500.0000	500.0000
Zinc, Dissolved	0.0000 - 25.0000	4	ALUV19	0/0/1/61	01/12/00-01/12/00(<)	50.0000 - 50.0000	50.0000
			ALUV199	0/0/1/45	01/12/00-01/12/00(<)	50.0000 - 50.0000	50.0000
			ALUV83	0/0/1/70	01/14/00-01/14/00(<)	50.0000 - 50.0000	50.0000
			ALUV89R	0/0/1/67	01/13/00-01/13/00(<)	50.0000 - 50.0000	50.0000

Frequency = uncensored/between MDL&PQL/censored/no. samples, (B) = Between MDL&PQL range, (<) = Censored range

affected as relatively few of the twelve Wepo wells exhibit unsuitable livestock water use potential. Also, those portions of the alluvial aquifer potentially affected by pit interception of the Wepo aquifer do not appear to be significantly affected because 4 of the 18 alluvial wells have typically had unsuitable livestock water use potential owing to TDS, and eight of the 18 wells have exhibited high levels of sulfate historically.

In summary, increases in concentrations of Ca, Mg, Na, SO_4 and HCO_3 and TDS will occur regardless of the nature of the spoil material placed in the saturated zone. The potential for acid formation and acid and trace metal migration is minimal, because of the overall buffering capacity of the overburden material. There will be some amount of additional TDS increases as a result of the neutralization of acid forming material placed in the saturated zones. Acid formation will occur primarily in response to oxidation of sulfides in advance of the wetting front during spoil resaturation. Reduction of sulfates will primarily occur following resaturation. Based on climatic conditions and the transmissivities of the material, resaturation and reestablishment of premining ground water flow gradients could take 10 years or more. The magnitude of the impact to either aquifer should be limited to the immediate pit areas, because gradients and transmissivities are very low.

The overall significance of this impact is minor. There are no present water users of the Wepo aquifer within the leasehold. In fact, only two wells (4K-389 and 4T-405) in the region are reported to be completed only in the Wepo aquifer (see Chapter 17). An inspection of the lithologic log for one of the wells suggests that it is actually completed in the upper member of the Toreva (155 feet of sandstone at the bottom of the well). No log could be found for the other well. Local wells are not completed in the Wepo aquifer for two reasons; (1) the yields are too low, and (2) the quality of the water may be unsuitable for domestic or livestock purposes

Interception of Wepo Recharge to the Alluvial Aquifer by Pits. Based on Drawing No. 85610, Wepo Water Level Contour Map, ground-water flow is from the Wepo aquifer to the alluvial aquifer system. Pit interception of portions of the Wepo aquifer in the N10, N11, N11 Ext, N6, J16, J19/20 and J21 pits can potentially cause local decline in the alluvial aquifer system. Distance drawdown projections for the combined pit pumpage (Figure 1 and Table 8) suggest portions of the alluvial aquifer system (Reed Valley, Red Peak Valley, Upper Moenkopi and Dinnebito alluvial aquifers) could potentially be affected to the extent that drawdowns exceed natural water level fluctuations.

It is difficult to predict the magnitude of the drawdowns as the alluvial aquifers have a large range of transmissivities and storage coefficients. Comparing this situation to the N-7/8 pit pumpage effects on the Yellow Water Canyon alluvial aquifer (Alluvial Well 74 and 75), it is estimated that drawdowns in the alluvial aquifer near the N-14, J-16 and J-19/20 pit areas could range from 8 to 20 feet during the period of maximum combined pit interception (1980 to 1983). Also, drawing on what was experienced at the N-7/8 pit, the alluvial aquifer drawdowns should be quite localized and limited in extent (less than one mile downgradient). These impacts should be partially offset by recharge to the aquifers from water impounded in Reed Valley, N-14D, N-14E, N-14F and J-16A dams. The significance of this impact is minimal because of the limited portions of the alluvial aquifer system affected and the absence of local use of the alluvial aquifer. As with the Wepo aquifer, the alluvial aquifer is low yielding throughout most of the leasehold and the quality is not suitable for domestic purposes and is marginal to unsuitable for livestock use. Therefore, water from the alluvium does not support the pre- or post-mining land use nor does it support any critical habitats or plant species (see Chapters 9 and 10).

Interception of Channel Runoff Recharge to Alluvial Aquifers by Dams and Sediment Ponds. Dams, sediment ponds and internal permanent impoundments will intercept the runoff from about 29 and 12 percent, respectively, of the Moenkopi and Dinnebito watersheds to the down drainage lease boundaries. These structures will remove some potential channel bottom transmission loss recharge to the alluvial aquifers downstream from the structures. Downstream aquifer recharge impacts associated with the dams should be offset by the impounded water recharge to the alluvial aquifer. The alluvial aquifer water level monitoring program indicates that the impact of the structures on alluvial water levels is insignificant. There is no evidence suggesting gradual water level declines in the alluvial aquifer system over time (see Chapter 15).

Truncation of Portions of the Alluvial Aquifers by Dams. Eight large dams have been constructed such that the embankments cut through the entire thickness of alluvium to bedrock. The embankments are designed and constructed to be impervious. These structures impact the alluvial aquifer system by disrupting the ground-water flow. A review of the five-year alluvial ground-water level hydrographs (Chapter 15) indicates that these impacts are of no significance probably owing to the following reasons. All dams, with the exception of J-7 Dam are on small tributaries, which only contribute minimal amounts of water to the alluvial ground-water system. Seepage occurs around J-7 Dam along sandstone bedding planes. The Wepo aquifer discharges to the alluvial aquifer all along the channel reaches. Any localized ground-water flow disruptions would be offset within short distances below the dams.

Effects of Altered Wepo Aquifer Water Quality on Alluvial Aquifer Water Quality. The effects of higher TDS water from resaturated spoil in the Wepo aquifer recharging the alluvial aquifer are expected to be minimal. The pits will require anywhere from several years to 100 years to resaturate and reestablish ground-water flow gradients because of limited precipitation recharge and very low Wepo ground-water flow rates. These same low transmissivities will continue to limit the Wepo feed and contaminant transport into the alluvial aquifer. In contrast, responses to snowmelt and rainfall runoff recharge are rapid and greater than Wepo feed during three seasons of the year. The potential for rapid dilution of elevated TDS inputs from the Wepo would be quite high during these significant recharge periods.

The significance will be minimal because, the alluvial aquifer water within the leasehold is unsuitable for domestic purposes and marginal to unsuitable for livestock drinking water. Water from the alluvial aquifer is not essential to support the postmining land use or critical habitats or plant species.

Mining Interruption of Spring Flow. To date, eleven natural and one artificial spring of any significance (more than just a damp spot along the side of a channel) have been identified and monitored within and immediately adjacent to the leasehold. Of these, one spring (NSPG97) at the northwest edge of N-14 has been removed by mining activities (N-14 channel realignment). Reference to the statistical water quality summary for springs in Chapter 15, Hydrologic Description, indicates that the water quality of the spring was unsuitable for livestock use. Those parameters and parameter concentrations above the livestock drinking water limits are presented in Table 13. Peabody has provided two alternate water supplies for this spring: (1) water impounded in the N14-D dam; and (2) two public water outlets on the leasehold. The alternate water supplied is greater in quantity and better in quality than the spring water. The water supplied at the public water outlets meets domestic drinking water requirements.

Impact of Peabody Wellfield Pumpage on Regional Water Levels and Stream and Spring Flows. Peabody operates a wellfield consisting of eight wells completed in the D aquifer and N aquifer (Navajo Sandstone, Kayenta Sandstone, and Wingate Sandstone) that provided water for the coal slurry pipeline serving the Mohave Generating Station through the end of 2005, and for other continuing operational uses. Pumpage was initiated in 1969 and has averaged about 4,000 acre-feet per year (1969-2005).

The pumping of water from the N aquifer by Peabody since 1969 has produced one of the longest term pumping tests ever. Water-level changes have been measured in wells at

TABLE 13

Chemical Parameters and Concentrations at Spring 97

Which Exceed Livestock Drinking Water Limits

Parameter	Mean Concentration (mg/l)	Recommended Livestock Limits[1] (mg/l)
Lead	0.167	0.1
Sulfate	4077	3000
Total Dissolved Solids	6846[2]	6999

(1) Limits are based on Navajo Nation (2008), Hopi Tribe (2010), National Academy of Science (1974), and Botz and Pederson (1976).

(2) One of four TDS values was greater than 6999 mg/l.

considerable distances and in several directions from the PWCC wellfield. The rates of pumping at the well field have been measured throughout the period of pumping. The result is a data set which, if properly evaluated, provides considerable information about the aquifer, and about the response of the aquifer to pumping. These measurements also provide information with which to estimate the effects of future water use. It is important to use appropriate tools to interpret this information. The analytical models, such as the Theis, Cooper-Jacob, Hantush, or other solutions of the flow equations, while appropriate for short-term tests, are commonly not suitable for longer tests because many of their simplifications affect long-term results. Material properties can vary over reasonably short distances, and boundaries can affect aquifer responses to pumping. Therefore, numerical models are better tools with which to properly interpret these long-term pumping tests, and to predict the effects of future pumping. In short, monitoring the effects of past water use provides information with which to predict future effects. This approach was first applied in the Black Mesa area in 1985 and 1987 by the USGS, through the development of a ground water flow model of the N aquifer beneath and surrounding the Black Mesa basin, and use of the calibrated model to predict the effects of future pumping. In 1998, consultants for Peabody started development and calibration of a more realistic, three-dimensional model of the aquifer and incorporating more recently collected information; this improved model is used to predict the effects of N aquifer water use by Peabody.

The following analysis of the effects of Peabody's pumping of the N Aquifer is based on data measured before and during the period of pumping through 2012, and on models based on these data. It considers the effect of pumping on drawdown at existing locations of groundwater use, groundwater discharge at springs and to streams, the structural integrity of the N aquifer, and water quality of the N aquifer that might be affected by increased leakance of water through the overlying Carmel.

Numerical Modeling. Several numerical models have been developed to estimate the impacts of pumping by Peabody and the tribal communities on the N Aquifer, beginning in 1983 (Eychaner, 1983). Most recently, Peabody has developed a model that includes the overlying D Aquifer (PWCC, 1999). The D Aquifer is also used as a water resource, but to a much lesser extent than the N Aquifer; model simulation results indicate that over the calibration period, approximately 3% of Peabody pumping is from the D. These models are the best tools available for determining the individual contribution of each pumping stress on the observed or measured effects (i.e., water levels and stream flows). The models are not of sufficient resolution to simulate flow at individual springs, but can be used to make intelligent observations of regional spring flow. Each model includes:

- Development of a basic description of the real system, including geologic controls on material properties (i.e., geometry of the rock layers, deformation of the rocks, etc.), areas and amounts of recharge and discharge, and distribution of water levels.
- Formulation of a mathematical description of the system to be modeled. This formulation is based on

  - o Darcy's Law - a mathematical expression that relates the rate of groundwater flow to observable differences in water levels.
  - o Mass balance - a mathematical expression of conservation of mass. For a groundwater-flow system, this means that flow into the system (recharge) must equal flow out of the system (pumping or discharge to streams or springs) plus the change in the amount of water held or released from storage as water levels change.
  - o Boundary conditions - mathematical statements of various conditions that exist on the boundaries of the modeled system. These require knowledge of the geometry of the rock formations and the processes and locations through which water enters and exits the system.
  - o Initial conditions - description of the water levels everywhere in the system at the beginning of the modeled time period.

- Development of a set of numerical values for all parameters appearing in the mathematical formulation. These include hydraulic conductivity, specific storage, and specific yield, all of which may be spatially variable.

- Application of a numerical algorithm that "solves" the mathematical formulation for different applied stresses. The algorithm calculates the spatial and temporal distribution of water levels and groundwater flow rates that satisfy the mathematical model for different pumping rates, recharge rates, etc.

Each model is put through a calibration process whereby model parameters are adjusted by either manual or automated methods until simulated results reasonably match measurements. This usually means matching historic water-level measurements at wells against model output. The model parameters adjusted towards calibration are typically flow and storage properties of the geologic material. They are adjusted within ranges reported in the scientific literature for the specific rock type. Boundary conditions such as recharge may also be adjusted if calibration can not be achieved with the independently derived estimates. The geometry of the flow system is typically held fixed during this process. Calibration can be performed for non-pumping (steady state) and pumping (transient) conditions whereby a single set of flow properties is derived to match water levels model-calibration process. In previous models, the model parameters represented a lumped average for the properties of several different formations. The calibration period was extended from 1956 through 1996 and the number of wells providing information on changes in water levels caused by pumping increased from nine to 47. This work was based on a database that included and went beyond the one compiled by SSPA (1993), in part, by adding information for the Carmel Formation and the D Aquifer, and including eleven additional years of pumping stresses, water-level measurements, and spring and streamflow measurements.

Recalibration of this 3D model to different assumptions of recharge and discharge rates determined that predictions of the effects of Peabody's pumping were not very sensitive to the assumed recharge rate. While the estimated hydraulic parameters changed when these models were recalibrated, indicating that the model was sensitive to recharge rate, the predicted impacts of the Peabody pumping on discharge and water levels remained only slightly changed. The many years of data on which these models' calibration were based resulted in models that produced similar results with regard to drawdown, and thus to effects on streams.

The 1999 PWCC model was periodically tested by obtaining Peabody and community annual water use, rerunning the model, and comparing the simulated drawdown at the BM observation wells against their measured drawdown. These simulations were done without any recalibration or any other changes. The model performed well, including simulating the effects of the significant reduction in Peabody's pumping at the end of 2005. In 2013, it was determined that an update of the model was warranted, because of the number of years that had passed since the model was originally calibrated. During this effort, many updates were implemented:

- The simulation code was changed from MODFLOW-96 to MODFLOW-NWT, to take advantage of MODFLOW-NWT's improved ability to simulate water-table conditions and changes in water levels, such as would be caused by pumping.
- With the change in the simulation code, several newer MODFLOW packages became available to improve the model. These include:
  - Multinode-Well (MNW) Package. This package allows the simulation code to calculate the pumping from each model layer for wells that penetrate several model layers, based on the hydraulic properties of each layer and the simulated water levels in the layers.

- Streamflow Routing (SFR) Package. The SFR package simulates stream-aquifer interactions and calculates the rate of streamflow, allowing streamflow measurements to be compared against simulated streamflow at different locations. In combination with the collection of streamflow data collected since calibration of the 1999 model, this package allowed the model to estimate the recharge to the model area.

- Satellite spectral data were used to estimate evapotranspiration (ET) of groundwater along washes. This evaluation determined that a very significant percentage of the recharge to the groundwater system is discharged by ET.
- Individual springs were included in the updated model.
- The spatial variation in the hydraulic conductivity of the Navajo Sandstone was described by using the pilot-point approach, rather than using zones. The pilot-point technique, which was not available when the 1999 model was developed, results in more gradual spatial changes in hydraulic conductivity, and removes the arbitrary assignment of zonal boundaries.
- The model was calibrated to water levels during the period of 1956 through 2012, rather than drawdown during the period of 1956 through 1996. Both the 1999 model and the 2013 updated model used water-level data for the period prior to 1956. This change (using water levels rather than drawdown) results in a more robust calibration. The longer calibration period, besides simply using more data, includes the water level response to the approximately 60% reduction in pumping at the PWCC leasehold at the end of 2005.

OSMRE has been briefed on the new model on two different occasions, as the report describing the updated model is still in draft form (Tetra Tech, 2014).

The updated model was used to develop predictions of the cumulative effects of mining and associated use of water produced from the D and N aquifers. These predictive simulations and the simulation results are presented in Attachment 3, Predicted Effects of Pumping by PWCC 2014-2044 Mine Plan Revision. In these simulations, the pumping by PWCC was simulated as being at actual rates through 2012, at 1,500 af/y for the period of 2013 through the end of 2044, and at 600 af/y during a reclamation period from 2045 through the end of 2057. Community pumping was simulated at actual rates through 2013, and at exponentially increasing rates based on annual average population growth rates provided by the Hopi Tribe and Navajo Nation. For the Hopi communities, the provided growth rates varied by community, and averaged 1.9%. The Navajo estimated their population growth at 2.48% at all communities. The per capita water use was assumed to be 100 gallons per capita per day, which is approximately 50% greater than current community use.

These predictive simulations indicated:

- The greatest effect on water levels was caused by PWCC's pumping prior to 2006, because of the higher pumping rates prior to 2006. Over a large area near the PWCC wellfield, water levels are recovering, and the effects will be diminishing in other areas. The simulated extent of PWCC's drawdown, defined by the 1-foot drawdown contour, in 2005 is very similar to the location of the confined/unconfined boundary as interpreted by the USGS. The extent of drawdown is predicted to increase a short distance between 2005 and 2044, but not to change noticeably between 2044 and 2057.
- Drawdown caused by community pumping is currently occurring throughout most of the model area, and will increase through time as the community pumping increases.
- The effect of pumping on stream flow is predicted to be minor at most streams. The streamflow at the Polacca gage is more sensitive than at the gages on other streams. The effect at the Polacca gage is predicted to be the result of both PWCC and community pumping.
- The effect of pumping at the four springs that are frequently monitored by the USGS is greatest at Pasture Canyon, where the effect is entirely the result of community pumping. There are pumping effects at Susunova Spring (Moenkopi School Spring), also caused entirely by local pumping. Burro Spring is predicted to be affected by pumping from local communities and by PWCC. However, the model simulates an effect at Burro Spring during the calibration period (prior to 2013) but none has been observed, suggesting that the modeling predictions are likely to also be greater than will occur. No effects of pumping are apparent at the Unnamed Spring near Dinnehotso.
- The only community well which is predicted to have curtailed production is a well at Oraibi. The model predicts that the pumping from this will be impacted in 2052. Causes are both locally caused drawdown (which is increasing) and PWCC-caused drawdown (which is declining). This well produces only from the Navajo Sandstone, and the operator may have to consider deepening it to tap deeper formations in the N aquifer to extend this water supply. The model does not include the effects of drilling new wells at communities, except where none currently exist.

The model predictions are quite similar to those obtained with the 1999 model with respect to the effects from community and PWCC pumping, but are more quantitative than available from the 1999 model. Even with the pumping anticipated under the 2014-2044 mine plan revision, the groundwater system will continue to recover from the effects of pumping prior to 2006. Effects of PWCC-caused pumping on streamflow, springs, and community water supplies will be very minor, but the effects of local pumping will be of concern.

Further, the discharge rates of springs are likely to be more sensitive to changes in local recharge than to drawdown caused by distant pumping. Springs are typically located near recharge areas, and temporal changes in their discharge rates caused by short-term changes in local recharge rates would be expected. Observations of springs discharging from the Wepo formation on the leasehold confirm the temporal variability of these smaller springs. Tree-ring studies performed throughout the southwestern U.S. document the variability of precipitation on the scale of decades (see, for example, Stahle and others, 2000). Even if good spring flow data were available, the variability in precipitation rates would make calibration to the spring discharge data difficult. Because of the character of these springs and of the groundwater system, the effects of Peabody's pumping are expected to be negligible. Measurement of pumping effects on springs will be difficult because of the expected small magnitude of these effects, seasonal changes of precipitation and evapotranspiration rates, and longer term changes in local precipitation rates.

In summary, groundwater models are the best tools available for evaluating the contributions of different pumping stresses on water levels and stream flows. Models of the N Aquifer flow system have been developed by both the USGS and by Peabody since the 1980's, with each successive effort improving on the previous. As additional data have been collected and improved computational tools made available, the models have incorporated more knowledge of the groundwater system.

The models have varied in detail; however, they were each based on the data available at the time of the model's development and incorporate the major components of the N Aquifer flow system. Further, each model has been subjected to a calibration process whereby the ability of the model to simulate historical measurements is demonstrated. The 2013 update of the 1999 model is greatly improved from the 1999 model, and has similar predictions relative to the effects of PWCC's pumping. They predict that water levels in the confined part of the N aquifer will be reduced by pumping but that the water levels will remain well above the top of the N aquifer. The effect of Peabody's pumping on discharge to streams has been and will continue to be minimal.

Effect on the Structural Integrity of the N Aquifer. Lowering of water levels by pumping has resulted in compaction of unconsolidated sediments in some areas of the western U.S.

(e.g., Las Vegas valley, Nevada; Antelope Valley, California; San Joquin Valley, California). The U.S. Geological Survey (Galloway and others, 1999) published a Circular documenting examples of aquifer compaction and related land subsidence associated with reduction of water pressures, oxidation of organic deposits, and formation of sinkholes in carbonate terrains. It states (p. 8-9):

> REVERSIBLE DEFORMATION OCCURS IN ALL AQUIFER SYSTEMS
>
> The relation between changes in ground-water levels and compression of the aquifer system is based on the principle of effective stress first proposed by Karl Terzaghi (Terzaghi, 1925). By this principle, when the support provided by fluid pressure is reduced, such as when ground-water levels are lowered, support previously provided by the pore-fluid pressure is transferred to the skeleton of the aquifer system, which compresses to a degree. Conversely, when the pore-fluid pressure is increased, such as when ground water recharges the aquifer system, support previously provided by the skeleton is transferred to the fluid and the skeleton expands. In this way, the skeleton alternately undergoes compression and expansion as the pore-fluid pressure fluctuates with aquifer-system discharge and recharge. *When the load on the skeleton remains less than any previous maximum load, the fluctuations create only a small elastic deformation of the aquifer system and small displacement of land surface.* [Emphasis added] This fully recoverable deformation occurs in all aquifer systems, commonly resulting in seasonal, reversible displacements in land surface of up to 1 inch or more in response to the seasonal changes in ground-water pumpage.

The USGS circular was primarily addressing basin fill materials of relatively young age. The rocks of the N aquifer are more than 135 million years old, have been buried to sufficient depth to cause pressure welding of the quartz grains, and exhumed. Thus, it is unlikely that production of water from the N aquifer will cause the load on the skeleton to exceed the previous maximum load or produce sufficient compaction to be of concern.

To provide information with which to calculate the amounts of compaction that might occur, rock mechanics studies were performed (GeoTrans, 1993; Peabody, 1994). Because cores of the Navajo Sandstone beneath the Peabody leasehold were not available, samples were collected from outcrop areas. These samples had been subjected to near-surface weathering processes that would remove calcite cement, and thus the testing results are believed to overestimate the effect of drawdown on the material properties. Reduction of water pressure (by pumping, for example) removes some of the support that helps maintain the thickness of the aquifer, and thus allows the rock or aquifer to compact. The laboratory tests were designed to measure this compaction process and its effect on the porosity and hydraulic conductivity of the rock samples. These were performed by placing the samples in a test cell in which the pressure was increased to simulate the pressures at the depth of the aquifer in the deepest parts of the basin. The resulting changes in the samples' porosities and their hydraulic conductivity were measured.

Five samples were placed under effective stresses of up to 2,000 psi, which is approximately equivalent to a depth of burial of 3,000 feet and a depth to water of 600 feet. This is greater than the actual stress conditions near the deepest part of the basin. Measurements of the reduction in porosity of these outcrop samples as the effective stress was increased (water pressure decreased) indicate that the compressibility of the sandstone is about $4x10^{-6}$/psi, which is higher than expected for many un-weathered sandstones. This value is consistent with the weathered nature of the samples. The data also indicate that the samples had previously been subjected to higher pressures than in the outcrop setting, consistent with the geologic history of the area and microscopic observations that the sand grains had been pressure welded. Derivation of compressibility from specific storage measurements for the aquifer (based on model-based interpretations of the observed drawdown caused by Peabody pumping of the aquifer) yield numbers approximately one-tenth of the laboratory compressibility measurements. This observation suggests that the compressibility of the weathered rock is approximately 10 times that of the un-weathered rock. Thus, the laboratory compressibility measurements should not be used to characterize the specific storage of the aquifer, but they do provide insight into the maximum changes in the porosity and hydraulic conductivity as water levels change as a result of pumping.

Calculations based on these laboratory compressibility measurements indicate that there could be as much as 1.5 feet reduction in the thickness of the aquifer by 2007. This is approximately a 0.12 percent decrease in thickness. Using compressibility values that are more representative of un-weathered sandstone, the decrease in thickness would be approximately one order of magnitude smaller, or 0.15 feet. The reduction in hydraulic conductivity as a result of the drawdown-induced compaction was also measured on the samples. These measurements indicate that the reduction would be approximately 5% in the immediate vicinity of the Peabody water-supply wells. If un-weathered samples had been tested, the measured reduction would have been considerably less.

Peabody has run video logs in its water-supply wells to evaluate the condition of well screens and the amount of scale that might clog the screen openings. If compaction of the N aquifer sufficient to cause concern were occurring, buckling of the screens would be expected. Many of the wells were logged in the early 1980's, after the majority of drawdown at the wells had occurred; no damage attributable to compaction has been observed. The most recent video log was run in June, 2001, in NAV 8, and no evidence of compaction effects was found. If compaction is not significant at these wells where drawdown and overburden stress are greatest, then compaction in other areas of the aquifer will also be negligible.

In summary, the data indicate that there is no risk of damage to the structural integrity of the aquifer resulting from projected drawdown. Similarly, compaction has been and will be insignificant, and any compaction is expected to be recoverable.

Effects of Induced Leakage of Poorer Quality Water from the Overlying D-Aquifer System on N-Aquifer Water Quality. In the vicinity of the leasehold, water levels in the D aquifer are 100 to 250 feet higher than in the N aquifer. Thus, there is natural downward movement of water from the D to the N aquifer. The large difference in water levels suggests that hydraulic conductivity of the Carmel is low, and therefore that the rate of downward movement is slow. Drawdown in the N aquifer caused by pumping of water from the N aquifer will increase the rate of water movement in proportion to the increase in water level change. Thus, several hundred feet of drawdown in the N aquifer could increase the leakage rate several fold. Whether this is important depends on the magnitude of leakage prior to any pumping. If the pre-pumping leakage rates were very small, increasing it several fold would still produce a small leakage rate.

The most direct means to evaluate the impact of leakage from the D aquifer on N aquifer water chemistry is to evaluate water-chemistry data. Water samples have been collected from well 4T-402, a windmill that is completed in the D aquifer near the center of the leasehold. Water from this well has a high TDS, with concentrations of major ions as shown in Table 14. The chemistry of this water is distinct from that of the N aquifer. Wells in the Peabody wellfield have been routinely sampled since approximately 1981; results have been provided to OSM in annual monitoring reports. Until the mid 1980's, laboratory problems produced data of uncertain quality. These problems have since been resolved, and the analytical results over the last fifteen years show only occasional "noise" and no clear temporal trends.

Four of the wells (NAV 4, NAV 5, NAV 7, and NAV 8) in the wellfield are completed in both

Table 14

Average Concentrations of Major Ions from D and N Aquifer Wells on or near the PWCC Leasehold, and Calculated Contribution from the D Aquifer Based on Chloride Concentrations

Well	Ca (mg/l)	Na (mg/l)	Alkalinity as CaCO3 (mg/l)	Cl (mg/l)	SO4 (mg/l)	%D Aquifer (Cl)
4T-402	7.1	540	401	200.	554	100.0
NAV 2	9.5	28.5	80.3	2.0	10.5	0.25
NAV 3	4.5	37.8	82.8	1.8	5.0	0.15
NAV 4	5.2	44.2	86.5	3.6	11.4	1.06
NAV 5	3.1	61.1	107.6	4.0	20.3	1.26
NAV 6	3.9	38.5	83.6	1.5	5.4	0.00
NAV 7	4.0	48.8	86.8	3.3	17.4	0.91
NAV 8	25.1	69.2	96.8	5.2	120.6	1.86
NAV 9	4.1	33.5	71.5	1.8	4.6	0.15

the N and D aquifers. Based on the chemical data, the contribution to the wells' pumpage from the D aquifer is small. Table 14 presents average concentrations of major ions for D aquifer well 4T-402 and the Peabody production wells. The percentage of water derived from the D aquifer is also presented, based on the mixing equation for chloride:

$$X\ Cl_{Daq} + (1-X)\ Cl_{Naq} = Cl_{sample}$$

where X is the proportion of water from the D aquifer, Cl_{Daq}, Cl_{Naq}, and Cl_{sample} are the chloride concentrations in the D aquifer, N aquifer, and the water sample, respectively. Even in the wells that are partially completed in the D aquifer, the chloride-based values are less than 2% contribution from the D aquifer, even after more than 30 years of pumping. The chloride data indicate that the percent of D aquifer-derived water is approximately 0.2% or less. The lack of a significant trend of increasing concentrations suggests that these concentrations are largely determined by pre-pumping N aquifer chemistry. The sulfate values suggest a greater contribution from the D aquifer, but may be affected by gypsum particles deposited with the quartz and other mineral grains.

Beginning in 2006, pumping from Peabody's wellfield was significantly reduced due to the shutdown of Mohave Generating Station and the cessation of coal shipments via the coal slurry pipeline. As a result, pumping of wells 3, 4, 5, 7, and 9 has been significantly reduced, limited to incidental withdrawals of groundwater for mine related uses and for collecting water quality samples in accordance with procedures summarized in Chapter 16, Hydrologic Monitoring Program. Reductions in pumping at individual wells partially completed in the D-Aquifer (wells 4, 5, and 7) may slightly alter water quality within the bore hole and in the N-Aquifer for some distance adjacent to each well bore. However, a review of water quality data collected in these wells and reported in the 2010 Annual Hydrologic Data Report (PWCC, 2011) indicate no significant impacts have occurred through 2010. No trends in chloride concentration have been detected in any of the N aquifer wells through 2010, and the ranges of TDS, sulfate, and dissolved sodium measured in wells 4, 5, and 7 during 2010 are comparable to the historical ranges for these parameters from 1986 through 2005 when pumping was significantly higher. Through 2010, the water use potential for all N aquifer wells is unchanged over previous years and remains suitable for domestic drinking water uses.

The program ZONEBDGT (Harbaugh, 1990) was used to calculate flow within the N aquifer across a specified block that encompassed the Peabody wellfield, using fluxes calculated from a predictive run using the base-case 1999 3D model. The ZONEBDGT results indicate that the leakage rate from the D to the N aquifer within this block increased by a factor of 1.8 between the pre-pumping period and 2005 (this factor will decrease in later years as N Aquifer pumping is reduced). They also indicate that lateral flow into the block from the N aquifer would increase by a factor of about 20. Thus, the chemistry of the water pumped from the wellfield would primarily be determined from chemistry of the water in the N aquifer in areas surrounding the wellfield. The small component of D aquifer water in the N aquifer water (Table 14), even if assumed to be entirely representative of pre-pumping conditions in the N aquifer, indicates that the effect of pumping on the water quality is insignificant. This results because of (1) the limited leakage rate under non-pumping conditions (evidenced by the present water chemistry), (2) the limited increase in leakage rate (factor of 1.8), and (3) the flow dynamics produced by pumping water primarily from the N aquifer.

Based on ZONEBDGT calculations and mixing equations, the change in sulfate concentrations in several different areas within the N aquifer basin was calculated. The results are shown in Table 15, respectively, and reflect the cumulative effect of pumping by PWCC between 1956 and 2057. Because of the small amount of leakage through the Carmel under natural conditions (indicated by the low TDS levels in the N aquifer even after leakage from the D aquifer for thousands of years), the increase in leakage due to pumping is predicted to cause very minor changes in the chemistry of the N Aquifer water. Where natural leakage is believed to be higher (in the eastern part of the basin) based on water chemistry data, approximately 100 years of pumping is predicted to cause an increase in sulfate concentrations of about 0.6%. In all other areas, the increase is predicted to be less than 0.3 percent.

Surface Water

Effects of Dams, Sediment Ponds and Permanent Internal Impoundments on Runoff and Channel Characteristics. Nine major dams (MSHA) have been constructed on principal tributaries confluent to Moenkopi Wash during the life of the mining operation. Portions of the drainages above as well as below the dams will be affected. The reach immediately above a dam will gradually aggrade headward as more and more water is impounded until a pool level is reached that is in equilibrium with water gains and losses. Channel reaches below the dams will become incised by smaller active meandering channels whose widths are a function of drastically reduced runoff potential, channel gradients and sediment load particle size ranges. Vegetation will begin encroaching on the edges of the new active channels as there will be insufficient runoff to remove it.

The effects of sediment ponds and permanent internal impoundments on runoff and channel characteristics will be minimal on an individual basis, but comparable to the effects of

Table 15

Maximum predicted sulfate concentrations (mg/L) resulting from PWCC pumping, 1956-2057

Subarea	Initial Concentration (mg/L)		Final Concentration (mg/L)	Change
	D Aquifer	Navajo sandstone	Navajo sandstone	
Northeast	250	70	70.064	0.0913%
East	850	100	100.623	0.6230%
Hopi Buttes	360	50	50.143	0.2866%
Forest Lake	1000	100	100.059	0.0595%
Kitsillie	75	30	30.002	0.0071%
Pinon	200	5	5.006	0.1274%
Rocky Ridge	250	10	10.013	0.1286%
Preston Mesa	400	10	10.000	0.0006%
Leasehold	400	30	30.019	0.0628%
Pinon to Kitsillie	1000	20	20.037	0.1873%
Surrounding leasehold	100	45	45.002	0.0040%
Red Lake to Tuba City	400	50	50.013	0.0270%
Hotevilla to Kabito	200	35	35.007	0.0189%
Pinon to Rocky Ridge	210	140	140.003	0.0024%

dams when considered in total. It is estimated that more than 320 sediment ponds and several permanent internal impoundments have been or will be constructed during the life of the mining operation. The internal impoundments are typically small, excepting PIIs like N2-RA, N7-D and the one impoundment proposed for the J-19 coal resource area, and most have been built on pre-law lands. Channel effects will be similar to those described for dams. Since most of the sediment ponds are on very small side tributaries, there will not be any up-drainage impacts of any significance. Because of the number of ponds and their wide range of locations, the downstream effects (active channel narrowing and vegetative encroachment) will be manifested over longer channel distances.

In addition to the permanent internal impoundments, 31 sediment control structures (see Chapter 6, Table 9) are proposed for consideration as permanent impoundments that will remain as permanent features of the postmining landscape. The total drainage area that these 31 permanent impoundments will encompass amounts to only 0.5 percent and 2.2 percent of the entire Dinnebito and Moenkopi watersheds, respectively (down to each confluence with the Little Colorado River).

The impacts of the sediment ponds and dams will be of little significance as there are no local users of water for flood irrigation (see Alluvial Valley Floor section of Chapter 17). Following removal of the dams and sediment ponds, there will be certain short-term impacts to the channel reaches immediately below these structures. Sediment loads will temporarily increase as the active channel widens in response to the increased runoff potential. The increased channel bank vegetation should provide some stability during this active channel readjustment period. The potential for flood flows overtopping the channels will be negligible as the typical channel banks are 15 to 20 plus feet high above the active channel. The frequency of the larger runoff events will dictate how fast the channels reestablish themselves in quasi-equilibrium with the environmental conditions.

Effects of Dams, Sediment Ponds and Permanent Internal Impoundments on Downstream Users. As of December 2010, the total Dinnebito and Moenkopi watershed areas to the leasehold boundary draining to PWCC dams, ponds and impoundments are 4.56 and 65.76 square miles, respectively. There are numerous large tributaries to both washes between the leasehold and the Little Colorado River. Comparing the above impounded drainage areas to the total drainage areas for both washes (812.8 square miles for Dinnebito Wash and 2,605.3 square miles for Moenkopi Wash) suggests that this loss of runoff is of little significance at the points where the runoff water has any potential for being used for flood irrigation. As of December 2010, the impounded drainage areas on the leasehold amounted to only 0.6 percent and 2.5 percent of the total Dinnebito and Moenkopi watersheds, respectively.

Busby (1966) developed estimates of average annual runoff in the counterminous United States, including Northeastern Arizona. Based on these average annual estimates, runoff was calculated for the total watershed areas of both Dinnebito and Moenkopi washes to their respective confluences with the Little Colorado River. Average annual runoff for each basin was determined by summing the calculated runoff for partial areas defined as the watershed area lying between each pair of average annual runoff isopleths that transect the basin. The average annual runoff isopleths shown for the Black Mesa region on the Hydrologic Investigation Atlas HA-212 were used. Therefore, the lower portions of each basin were assigned an average annual runoff value of 0.1 inches, and the upper portions of each basin, including those portions in which PWCC's leasehold are situated, were assigned much higher average annual runoff numbers (1.25 to 1.75 inches). Based on Busby's empirical estimates, the average annual runoff for the entire Dinnebito basin was calculated to be 17,242 acre-feet, and 57,022 acre-feet of average annual runoff for the entire Moenkopi basin was determined.

Table 16 presents combined annual runoff measured from 1987 through 2008 at continuous flow monitoring sites SW155, SW25, and SW26, as well as annual runoff measured for the same period at the USGS Streamflow-gaging station (09401260) located on Moenkopi Wash at Moenkopi, Arizona. The runoff values are presented as acre-feet and inches of runoff. The inches of runoff for the PWCC sites were calculated by dividing the total runoff in acre-feet by the combined drainage area (in acres) above all three monitoring sites that was not controlled by PWCC dams, ponds and impoundments for each year shown (e.g., 188.65 square miles in 2000) and multiplied by 12. Similarly, the inches of runoff for the USGS Moenkopi gage was calculated by first subtracting baseflow contributions from ground water discharge from each year's total measured runoff, then dividing the adjusted total runoff (acre-feet) by the total drainage area (in acres) above the gage that was not controlled by PWCC impoundments (e.g., 1564.38 square miles in 2000). The inches of runoff presented for both locations represent runoff generated from precipitation events.

For the twenty-two year period presented in Table 16, the upper sites (SW155, SW25, and SW26) averaged 0.15 inches of runoff, and the USGS gage at Moenkopi averaged 0.07 inches of runoff. The average annual runoff in inches determined from the 22-year record at the USGS gage at Moenkopi (0.07 inches) was used to estimate the average annual runoff (in acre feet) for the entire watersheds of both the Dinnebito and Moenkopi basins, and are presented on Table 17. Comparing Table 17 values with the average annual runoff estimated for both basins using Busby's estimates (17,242 acre-feet for Dinnebito; 57,022 acre-feet for Moenkopi), it is obvious that Busby's empirical estimates of average annual runoff for the Black Mesa region are extremely high and unrealistic compared to average annual runoff calculations that are based on local stream flow measurements.

Table 16

Measured Annual Runoff at PWCC's Continuous Flow Monitoring Sites and at the USGS Streamflow-Gaging Station 09401260, Moenkopi Wash at Moenkopi, Arizona

	PWCC Sites[1] Total		USGS Station 09401260[2]		
Calendar Year	Total Runoff (acre-ft)	Runoff[3] (in.)	Total Runoff (acre-ft)	Adjusted Total Runoff[4] (acre-ft)	Runoff[5] (in.)
1987	3,307.2	0.32	10,030	9,230	0.11
1988	3,387.7	0.32	8,970	7,990	0.10
1989	1,475.4	0.14	3,270	2,480	0.03
1990	1,899.0	0.19	7,610	6,680	0.08
1991	276.2	0.03	1,750	1,000	0.01
1992	1,864.2	0.18	3,820	3,110	0.04
1993	414.4	0.04	8,000	7,050	0.08
1994	124.1	0.01	1,370	410	0.005
1995	1,092.7	0.11	2,720	1,790	0.02
1996	374.9	0.04	1,610	730	0.01
1997	2,860.7	0.28	8,520	7,620	0.09
1998	548.8	0.05	1,650	610	0.01
1999	1,618.1	0.16	13,810	12,870	0.15
2000	210.9	0.02	3,430	2,370	0.03
2001	800.1	0.08	14,739	13,974	0.17
2002	920.4	0.09	9,026	8,215	0.10
2003	2,647.2	0.26	12,448	11,590	0.14
2004	909.8	0.09	7,327	6,433	0.08
2005	896.6	0.09	6,409	5,569	0.07
2006	4,105.8	0.41	13,650	12,812	0.15
2007	1,976.2	0.20	9,972	9,126	0.11
2008	1,036.7	0.10	4,135	3,384	0.04
	Avg.	0.15		Avg.	0.07

1 - Combined Measured Annual Runoff from Sites SW155, SW25, and SW26 (PWCC Annual Hydrology Reports, 1987 - 2008)

2 - USGS records (NWISWeb, 2003 and 2010)

3 - Based on the combined drainage area for all three sites (253.27 square miles) less total PWCC-impounded area during each calendar year

4 - Runoff numbers adjusted to remove groundwater baseflow component and reflect only snowmelt and rainfall runoff

5 - Based on the total drainage area for USGS Station 09401260 (1629 square miles) less total PWCC-impounded area during each calendar year

Table 17

Drainage Areas and Estimates of Annual Runoff

	Moenkopi Wash Basin		Dinnebito Wash Basin	
	Total Area (mi^2)	Runoff (ac-ft)	Total Area (mi^2)	Runoff (ac-ft)
Totals without PWCC Ponds	2,605.3	9,726.5[1]	812.8	3,034.5[1]
PWCC Dams, Ponds, and PII's - December 2010	65.76	526.2[2]	4.56	36.5[2]
PWCC Dams, Ponds, and PII's - December 2018[3]	63.96	511.7[2]	5.47	43.7[2]
Post-mining Permanent Impoundments[4]	57.50	460.0[2]	3.71	29.7[2]

1 - Based on 22-year average annual runoff measured at USGS Station 09401260.

2 - Based on 22-year average annual runoff measured at PWCC gages SW155, SW25, and SW26.

3 - Year 5 of the 5-year mine plan (2014 to 2018).

4 - See Table 9, Chapter 6, Facilities.

Table 17 also presents drainage areas and average annual runoff estimates for the watershed areas draining PWCC dams, ponds and impoundments (impounded areas) within both Dinnebito and Moenkopi washes as of December 2010 and for December 2018, the last month of Year 5 of the five-year mining plan for 2014 through 2018. Impounded areas are based on summing designed drainage areas for the existing impoundments (December 2010) and those proposed to be constructed from 2011 through 2018(see Drawing 85406, Volume 22). Table 17 shows the December 2010 impounded area is 0.6 percent and 2.5 percent respectively of the total drainage areas for the Dinnebito and Moenkopi basins. In December 2018, the total impounded area increases slightly to 0.7 percent of the total Dinnebito drainage area and decreases to 2.45 percent of the total Moenkopi drainage area. Between December 2010 and December 2018, 3 new temporary sediment ponds are proposed for construction in the Dinnebito basin, and 14 new temporary sediment ponds are proposed for construction in the Moenkopi basin. Impounded areas shown on Table 17 also take into account reclamation of ponds J7-CD, J7-E and J7-F in 2011 and additional temporary sediment ponds scheduled for reclamation from 2012 through 2018.

The 22-year average measured runoff at the three PWCC sites (Table 16) was used to estimate average annual runoff for the December 2010 and December 2018 impounded areas. The estimates of average annual runoff for the December 2010 impounded area are 1.2 and 5.4 percent respectively of the average annual runoff calculated for the entire Dinnebito and Moenkopi basins. Table 17 shows average annual runoff for December 2018 will increase slightly to 1.4 percent of the average annual runoff calculated for the entire Dinnebito basin, and will decrease for the entire Moenkopi basin. Additional impounding area for the life of mining will include construction of three proposed permanent impoundments in the J19, J21, and N10 reclaimed landscapes (see Chapter 6, Facilities). Additional temporary sediment structures may be constructed after 2018 to provide treatment of disturbed area runoff from future mining areas (e.g., J21W); however, the dates for construction and reclamation of these facilities are unknown at this time.

Table 17 also presents the total impounded area of permanent impoundments proposed to remain in the post-mining landscape in both the Dinnebito and Moenkopi basins (see Chapter 6, Facilities, and Chapter 14, Land Use). Following final reclamation of all mining areas, the drainage area associated with PWCC's proposed permanent impoundments will comprise 0.5 percent of the total Dinnebito drainage area and 2.2 percent of the total Moenkopi drainage area. Using the annual average runoff of 0.15 inches determined from 22 years of stream flow measurements collected at the three PWCC gages, the permanent impoundments may impound about 1.0 and 4.7 percent of the average annual runoff at the lower ends of the Dinnebito and Moenkopi basins, respectively.

Based on percentages of impounded drainage areas presented in Table 17 for the December 2010, December 2018, and permanent impoundments with the total basin areas of Dinnebito and Moenkopi washes, loss of runoff in each basin is of little significance at downstream points where runoff water has any potential for being used.

An alluvial farm plot and phreatophyte survey performed by Intermountain Soils, Inc. in June, 1985 documented that there is no evidence that flood irrigation was ever practiced in the past or that it is presently being practiced along the major washes and tributaries within the leasehold. All agricultural plots inspected were located on high terraces and were planted with shallow rooting cultivars, which are solely reliant on rainfall infiltration. Inspection of regional reservation land use maps indicates that flood irrigation is not practiced below the leasehold along lower Dinnebito and Moenkopi Washes other than some 70 miles below the leasehold at the town of Moenkopi. PWCC is not aware of any other diversions immediately downstream of, or further downstream for approximately 70 miles in either Dinnebito or Moenkopi Washes. Runoff from precipitation events in both washes typically occurs as flash floods, with rapidly rising water levels, high velocities, and very high concentrations of suspended solids. The channel beds and banks of both channels are subject to significant changes in width and depth as a result of runoff events, often changing appreciably during each event, which can create significant problems regarding the construction and maintenance of water diversion structures.

Comparisons of average annual runoff estimates indicate the impounded areas through December 2018 have the potential to, on average, reduce average annual runoff in the Dinnebito basin by about 1.4 percent, and in the Moenkopi basin by approximately 5.3 percent. Total runoff in the basins is greatly affected by depression storage, channel transmission losses and evapotranspiration. Channel transmission losses along the sand-bed channel bottoms within the leasehold have been estimated to be quite high, potentially resulting in more than a 50 percent reduction of flow volumes during runoff events that occur along the major channels within the leasehold (see Chapter 15, Hydrologic Description).

Review of historical daily records from both the three upper PWCC sites (PWCC Annual Hydrology Reports, 1997 through 2002, see Preface to Chapter 15, Hydrologic Description) and the USGS Moenkopi gage (NWISWeb, 2002) indicate significant loss of runoff from the upper basin area can occur. From August 7 through August 8, 1987, 1,328.7 acre-feet of runoff was measured at the three PWCC gages. One large event was measured at SW155 on August 8, featuring a peak discharge of 10,100 cfs and a total runoff volume of 638.7

acre-feet. Total runoff volume measured at the USGS gage from August 8 through 9, 1987 was 668.7 acre-feet, suggesting almost 50 percent of the total runoff (1,328.7 acre-feet) from the three upper sites was lost downstream if these were the sole source of runoff recorded at Moenkopi. On August 16, 1989, summer thunderstorms generated moderate-sized flash floods at all three gages at about 1600 hours, resulting in a total runoff volume of 524.8 acre-feet. No runoff had occurred at any of the three sites for at least 6 days prior. Runoff at the USGS Moenkopi gage was only 1.3 acre-feet on the same day, and only 117 acre-feet was measured on August 17, 1998. The record comparison indicates about 77 percent of the 524.8 acre-feet of runoff generated from this portion of the basin was lost. On July 27, 1998, a flash flood passed by SW25 at a peak flow of 1,650 cfs resulting in a total runoff volume of 206.7 acre-feet. This one event was more than 37 percent of the total runoff measured at the three PWCC gages in 1998. The USGS gage measured only 14 acre-feet of runoff from July 27 through 29, 1998, indicating a loss of more than 93 percent of the 206.7 acre-feet. It is likely the 14 acre-feet measured at the USGS gage was comprised of return flow from bank storage from the upstream, 70-mile channel reach, and that the entire volume of the 200-plus acre-feet runoff event from the upper basin was lost in the channel. It should be pointed out that these comparisons assume no additional inflows to Moenkopi Wash below the leasehold occurred. This is an unlikely assumption considering that the entire basin above the USGS gage is large, and summer thunderstorms in the region often move great distances while maintaining high rainfall amounts and intensities, even though the areal extent of individual storm cells may be relatively small.

Table 16 indicates actual runoff is highly variable from year to year in both the upper and lower portions of the Moenkopi basin. Runoff variability is closely related to the highly variable climatic differences typical in this semi-arid environment, and the limited areal extent and varying intensities of the storms that do occur. From 1987 through 2008, measured annual runoff at the three PWCC gages has ranged from 124.1 acre-feet in 1994 to a high of 4,105.8 acre-feet in 2006. For the same 22-year period, measured runoff at the USGS Moenkopi gage was also lowest in 1994, but the highest annual runoff was 13,974 acre-feet in 2001. Total measured runoff at the three PWCC gages in 1988 was greatly influenced by one extremely large runoff event measured at SW25 on August 26, 1988. The peak discharge was estimated at 25,000 cfs for a total runoff volume of 1,836 acre-feet. This one event accounted for more than 50 percent of the total runoff measured at the three PWCC gages in 1988. The total runoff measured at the three PWCC gages from August 25 through August 27, 1988 was 2,624.5 acre-feet, about 69 percent of the annual total measured in 1988. For the same period, the USGS gage measured 2,945.5 acre-feet, indicating that this extreme event fell on other portions of the Moenkopi basin and contributed additional runoff to the gage some 70 miles downstream.

By contrast, the total runoff measured at the USGS Moenkopi gage in 1988 was only the seventh highest of the twenty-two years presented for this gage (see Table 16). Combined total measured runoff at the three PWCC gages as a percentage of the USGS Moenkopi gage ranged widely from 5.7 percent in 2001 to 90.0 percent in 1998, illustrating the considerable variability in runoff within the basin. In fact, total measured runoff from the upper part of the basin (PWCC gages) in 2001 was only 5.7 percent of the highest annual measured runoff at the USGS Moenkopi gage (13,974 acre-feet).

Review of the measured daily records at both the three PWCC gages and USGS Moenkopi gage and the annual measured runoff shown in Table 16 suggests that 1) considerable amounts of runoff generated in the upper basin can be lost before reaching downstream locations, ranging from 50 percent of runoff events in excess of 1,000 acre-feet upwards to 100 percent for smaller events (200 acre-feet); 2) areal and temporal variability of runoff within both Dinnebito and Moenkopi basins is high; 3) channel transmission losses can significantly reduce annual runoff contributed from the upper portions of both basins; and 4) the impact of PWCC impounded areas in the upper part of both the Dinnebito and Moenkopi basins is minimal.

Peabody has monitored annual water levels and volumes in the MSHA size dams since construction, beginning with J7-DAM in August 1978. Estimates of water volumes in all ponds based on quarterly and monthly inspections were compiled for the years 1989, 1990, and 1996 through 2010. Table 18a is a compilation of the results of the above-referenced monitoring and water volume estimates. The values listed in each column are the volumes of water in acre-feet measured or estimated in the ponds and MSHA dams for each year or period presented.

Table 18a shows a 722 acre-foot increase in the amount of water impounded from 1996 to 1997, a 465 acre-foot increase from 1998 to 1999, and a 566 acre-foot increase from 2002 to 2003. Assuming the increases shown for these three periods represent only surface water runoff, dividing the amounts by the total impounded area present during each period yields values of annual runoff in inches of 0.22 for 1997, 0.13 for 1999, and 0.17 for 2003. The values compare reasonably well with the inches of runoff measured at the three PWCC gages in 1997 (0.28) and 1999 (0.16) as shown on Table 16. The annual runoff measured at the PWCC gages in 1999 was only 12.6 percent of the annual runoff measured some 70 miles downstream at the USGS Moenkopi gage. The estimate of runoff based on the increase in the amount of water impounded for 2003 (0.17 inches) is lower than the 0.26

TABLE 18a

Summary of Maximum Impounded Surface Runoff in

MSHA Dams and Sediment Ponds by Year

(Acre-feet)

Year	J2-A	J-7	J7-JR	J16-A	J16-L	N14-D	N14-E	N14-F	N14-G	N14-H	All Other Ponds[1]	Total
8/78-8/79		137										
8/79-8/80		117										
8/80-8/81		37										
8/81-8/82		182		**		8	**	0.5	5		60	256
8/82-8/83		180		**		80	**	2	6		60	328
8/83-8/84		425		13	220	153	**	4	40		60	915
8/84-8/85		305		4	***	150	**	4	26		60	549
8/85-8/86	*	335		10	65	153	**	4	13	2	60	642
1989-1990	42	300		50	69	107	0.1	6	35	38	305	952
1996	24	100		3	36	29	2	1	2	29	88	314
1997	47	338		48	101	90	**	3	33	47	329	1036
1998	36	140		8	44	53	**	0.4	15	39	295	630
1999	23	293		63	235	123	1	6	43	73	235	1095
2000	17	184		15	137	70	**	3	33	59	158	676
2001	14	157	*	44	104	34	**	2	19	30	233	637
2002	30	96	4	34	115	24	**	1	21	21	172	518
2003	36	85	72	92	222	162	13	17	63	68	255	1084
2004	63	162	166	93	207	159	4	16	61	68	205	1205
2005	32	221	198	29	136	90	2	6	43	57	247	1061
2006	5	252	178	43	103	72	1	6	20	30	326	1036
2007	21	369	164	47	160	120	4	7	24	27	427	1370
2008[2]	131	424	156	103	286	146	2	26	65	48	395	1782
2009[3]	38	342	146	59	29	74	1	16	37	30	173	945
2010[4]	24	232	119	168	254	52	9	27	64	32	291	1272

* Pond under construction ** Negligible amount of water impounded *** Pond drained for repair

1 Assumed 60 acre-feet impounded each year between 8/81 and 8/86

2 Ponds J2-A and J16-L were dewatered 78 acre-feet and 242 acre-feet, respectively, during 2008

3 Pond J-7 was dewatered 9 acre-feet during 2009

4 Pond J16-A was dewatered 34 acre-feet during 2010

inches of runoff measured at the three PWCC gages in 2003 (PWCC, 2004), but likely resulted from the variability of storm events that occurred during 2003 in the upper portion of the Moenkopi basin. Considering the variability in measured annual runoff from year to year at the upper portion of the Moenkopi basin at PWCC's leasehold compared to measurements made further downstream at the USGS gage at Moenkopi, impounded runoff in PWCC's dams, ponds and impoundments appear to have had a minimal effect on downstream runoff.

Based on the pond and dam monitoring information presented in Table 18a, the following analysis was performed to further assess the potential impact of the dams and ponds on flow volumes at the town of Moenkopi. The analysis considers whether the amount of water captured by the impoundments in a year would reach the town of Moenkopi if the total amount was due to a single, large storm at the leasehold. Further review of Table 18a indicates that one of the years with significant increases in water impounded from the previous year was 1983-1984. Five hundred eighty-seven acre-feet of additional water was impounded from overland runoff, Navajo well pumpage and pit pumpage. The latter two water sources were not considered to be a significant part of the total and were thus ignored. In Table 18a, 60 new acre-feet of water was assumed to be impounded by all the non-MSHA sized sediment ponds combined for each of the years 1978 through 1986. This 60 acre-feet added to the 1983-1984 increase in water impounded by MSHA structures yields a total of 647 acre feet of new water for that year.

The analysis approach employed moving a flow volume equal to 644 acre feet down a 70 mile length of Moenkopi Wash in a channel with a constant 80 foot flat bottom width (based on a cross section of Moenkopi Wash that is being measured and monitored within the leasehold for indirect flow calculations) as shown in Figure 4. Although flow loss to the channel banks is significant, infiltration loss through the channel bottom was the only one considered. An hourly loss rate of 1 inch per hour was used and is the lowest loss rate determined from particle size analyses of bed material from the principal channels transgressing the leasehold (see Table 12, Chapter 15).

A storm runoff flow with a total flow volume of approximately 644 acre feet was computed using SEDIMOT II for a portion of Moenkopi Wash within the leasehold. Trial and error 24-hour precipitation inputs were tried until a total flow volume as close to 647 acre feet as possible was achieved. The duration of this flow hydrograph (18.4 hours, refer to Table 18b) was used to determine the minimum amount of time that an infiltration loss of 1 inch per hour would occur over each square foot of the channel bottom between Moenkopi Wash on the leasehold and Moenkopi Wash at the town of Moenkopi (a distance of

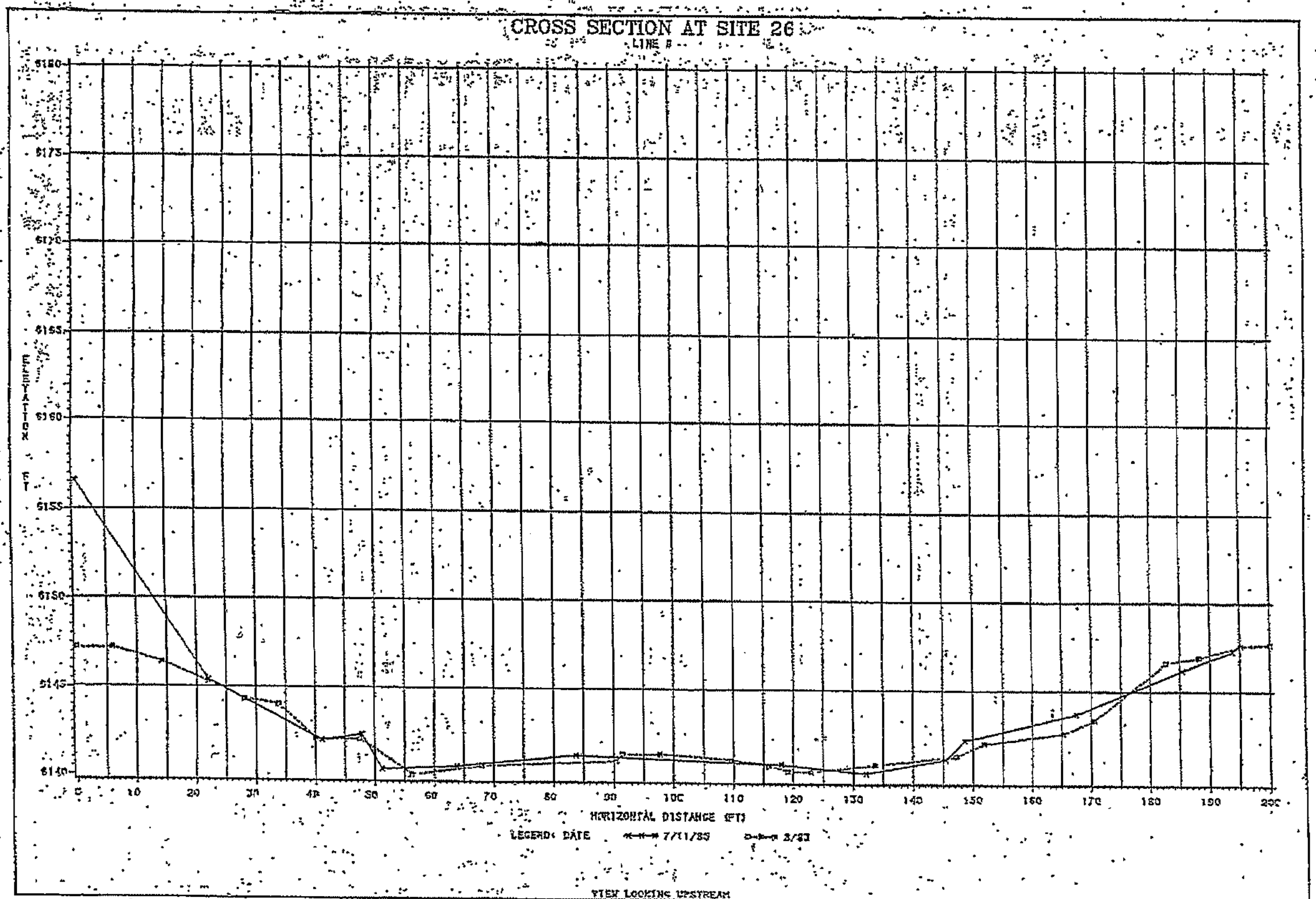


FIGURE 4 CHANNEL CROSS SECTION FOR MOENKOPI WASH ON LEASEHOLD USED FOR FLOW LOSS COMPUTATIONS DOWN TO THE TOWN OF MOENKOPI

Table 18b

Discharge Hydrograph Output From SEDIMOT II Run

for 644 Acre Foot Flow Volume on Moenkopi Wash

Time (hrs)	Discharge (cfs)	Time (hrs)	Discharge (cfs)	Time (hrs)	Discharge (cfs)	Time (hrs)	Discharge (cfs)	Time (hrs)	Discharge (cfs)
1170	0.134	1460	1302.409	1750	605.403	2040	374.685	2330	279.027
1180	1.615	1470	1287.579	1760	589.178	2050	373.363	2340	277.233
1190	6.186	1480	1263.996	1770	573.179	2060	371.934	2350	275.672
1200	15.563	1490	1232.567	1780	557.571	2070	370.334	2360	274.297
1210	31.760	1500	1195.552	1790	542.437	2080	368.501	2370	273.069
1220	54.974	1510	1155.723	1800	527.854	2090	366.421	2380	271.960
1230	80.993	1520	1115.680	1810	513.939	2100	364.215	2390	270.949
1240	138.810	1530	1077.302	1820	500.777	2110	361.935	2400	270.021
1250	205.400	1540	1041.274	1830	488.194	2120	359.478	2410	269.148
1260	281.526	1550	1007.689	1840	476.169	2130	356.731	2420	268.192
1270	361.065	1560	976.513	1850	464.747	2140	353.617	2430	267.129
1280	438.975	1570	947.754	1860	453.973	2150	350.093	2440	265.948
1290	515.344	1580	921.268	1870	443.887	2160	346.190	2450	264.557
1300	600.635	1590	896.752	1880	434.526	2170	342.010	2460	262.719
1310	701.142	1600	873.816	1890	425.950	2180	337.645	2470	260.319
1320	810.924	1610	852.136	1900	418.221	2190	333.144	2480	257.228
1330	920.040	1620	831.417	1910	411.375	2200	328.525	2490	253.426
1340	1018.324	1630	811.516	1920	405.418	2210	323.828	2500	249.172
1350	1098.921	1640	792.390	1930	400.316	2220	319.122	2510	244.594
1360	1160.101	1650	773.931	1940	395.991	2230	314.440	2520	239.480
1370	1205.486	1660	755.867	1950	392.336	2240	309.839	2530	233.614
1380	1239.773	1670	738.026	1960	389.232	2250	305.361	2540	226.834
1390	1265.835	1680	720.297	1970	386.572	2260	301.042	2550	218.062
1400	1284.288	1690	702.753	1980	384.264	2270	296.924	2560	210.368
1410	1296.290	1700	685.764	1990	382.244	2280	293.063	2570	200.974
1420	1304.311	1710	669.443	2000	380.466	2290	289.519	2580	191.094
1430	1308.856	1720	653.512	2010	378.894	2300	286.337	2590	180.841
1440	1310.865	1730	637.632	2020	377.411	2310	283.536	2600	170.265
1450	1309.468	1740	621.607	2030	376.016	2320	281.111	2610	159.467

Table 18b (Cont.)

Discharge Hydrograph Output From SEDIMOT II Run

for 644 Acre Foot Flow Volume on Moenkopi Wash

Time (hrs)	Discharge (cfs)	Time (hrs)	Discharge (cfs)
2620	148.600	2840	18.492
2630	137.759	2850	16.234
2640	127.075	2860	14.264
2650	116.645	2870	12.497
2660	106.548	2880	10.924
2670	96.878	2890	9.513
2680	87.759	2900	8.230
2690	79.320	2910	7.067
2700	71.659	2920	6.037
2710	64.817	2930	5.050
2720	58.777	2940	4.199
2730	53.468	2950	3.403
2740	48.778	2960	2.899
2750	44.591	2970	2.404
2760	40.804	2980	2.024
2770	37.338	2990	1.717
2780	34.134	3000	1.456
2790	31.146	3010	1.228
2800	28.343		
2810	25.708		
2820	23.231		
2830	20.935		

at least 70 miles). Table 18c shows the infiltration loss in acre feet (14.5) for each mile that a flow with an 18.4 hour duration moves towards the town of Moenkopi. At a rate of 14.5 acre feet per mile, the entire 644 acre foot flow generated on the leasehold would be lost to channel bed infiltration before the flow had moved 45 of the 70 miles towards the town of Moenkopi.

TABLE 18c

Channel Bed Infiltration Loss for Each Hour of
Flow Over the Channel Bed Area Between
the Leasehold and the Town of Moenkopi

Channel Bottom Area for Each Lineal Foot in Acres	Infiltration Rate in feet/hour	Acre Feet of Flow Loss for Each Mile of Flow with an 18.4 Hour Duration
.0018	.083	14.5

The above analysis was performed using very conservative numbers. Average channel bottom widths from the leasehold to the town of Moenkopi are considerably larger than 80 feet and would account for larger infiltration losses per mile than were used. Channel bed infiltration rates are considerably higher than the 1 inch per hour rate that was used. This rate is probably more indicative of saturated flow infiltration rates. The flow duration would increase as the flow hydrograph peak lowers and the flow rate slows in the downstream direction. The 18.4 hours is the shortest time span during which flow losses over each square foot of the channel would occur. Finally the total flow volume used (644 acre feet) is extreme and is an accumulation of runoff from many storms. Individual storm volume totals lost due to the impoundments would be considerably smaller and totally lost as channel bed infiltration in shorter distances from the leasehold. Considering watershed areas, estimates of annual runoff, comparisons of daily stream flow measurements and measured annual runoff, and runoff volumes impounded, the sediment ponds and dams on the leasehold do not have any measurable impact on surface water use at the town of Moenkopi.

Effects of Dams, Sediment Ponds and Permanent Internal Impoundments on Stream-Water Quality. The effects of pond and dam discharges on stream-water quality will be negligible, because all sediment ponds and dams are designed to contain the 10-year, 24-hour runoff volumes plus sediment. Pond and dam discharges resulting from storm runoff have and should continue to be infrequent. In the event of their occurrence, PWCC will make all efforts to comply with the effluent limits and monitoring requirements of the NPDES permit (No. NN0022179, Attachment 3, Chapter 16, Hydrologic Monitoring Program). The disposal of sediment removed from sediment ponds is conducted in a manner that protects stream water quality and is described in the section entitled "Design Methodology" of Chapter 6, Facilities.

The NPDES Permit allows pond dewatering as a means of providing sufficient detention time and storage to help ensure discharge effluent limits are met and there are no significant water quality impacts to the streams. Pond to pond pumping is also periodically employed. Seepage from dam embankments or around the sides of embankments is also presently being monitored in accordance with the NPDES Permit to ensure that pond seepage poses no significant threat to the receiving stream water quality.

Runoff discharges from the permanent internal impoundments are extremely unlikely. Should they occur, impacts to the stream-water quality will be negligible. Table 19 shows average concentrations for select chemical constituents measured in permanent internal impoundments from 1986 through 2010. Almost all the impoundments selected contain surface water runoff and have no appreciable ground-water contribution from resaturated spoil, with the exception of Pond N2-RA. Table 20 shows average concentrations for the same chemical constituents measured in stream flows generated by rainfall runoff at stream monitoring sites for the same period. Excepting pond N2-RA, water quality documented in the permanent internal impoundments is similar to slightly lower in range and magnitude compared to stream flows.

Annual Hydrology Reports (AHR's) present comparisons of recent and historical pond and stream water quality data with existing numeric limits for livestock drinking water and other uses. Sources of the livestock drinking water limits used in the AHR's include the Navajo EPA (2008) and Hopi Tribe (2010). In the March 5, 2001 Hydrologic Monitoring Program Permit Revision package, PWCC attached the document entitled "Justification of Monitor and Monitoring Frequency Reductions at the Black Mesa and Kayenta Mines, Arizona" (PWCC, 2001). The document presents a thorough evaluation of summary statistics, water types, trend analyses, and comparisons of historical stream water quality with livestock and other use limits. Based on the livestock limit comparisons presented in the document that used total recoverable metal analyses, all stream flow generated by storm runoff is not suitable for livestock drinking water. The document also mentions, if only dissolved analyses are used for comparison purposes, most of the stream water quality is suitable for livestock drinking.

TABLE 19

Mean Concentrations of Selected Chemical Parameters Measured In

Permanent Internal Impoundments on Reclaimed Areas

(1986-2010)

Monitoring Site

Parameter	116	124	118*	N1-RA	122*	123*	112*	113*	119*	N7-D	N2-RA	N2-RB	N2-RC	N8-RA
pH	8.2	7.8	8.6	9.5	8.0	7.5	7.8	7.9	7.9	8.1	8.7	8.1	8.6	8.0
TDS	459	205	144	440	143	177	281	603	165	939	8530	566	227	133
Alk	84	100	105	142	96	102	109	205	116	74	242	113	97	56
SO_4	225	68	16	197	15	21	98	252	25	595	5862	297	79	34
Ca	63	44	24	35	25	26	24	46	29	155	324	108	44	26
Mg	25	13	11	24	9	9	12	21	12	56	387	34	12	4
Na	29	4	5	70	4	7	44	117	9	41	1736	12	6	2
Cl	10	3	5	7	5	6	4	8	2	20	43	7	4	4

*Pre-law area ponds

TABLE 20

Mean Concentrations of Selected Chemical Parameters

Measured at Stream Station Sites

During Rainfall Runoff Events

(1986 - 2010)

Stream Monitoring Site

Parameter	Dinnebito Wash		Reed Valley Wash	Yellow Water Wash			Coal Mine Wash			R.P. Valley Wash[1]		Moenkopi Wash	
	34	78	37*	50	15	157	16	18**	25	14	155	35	26
pH	8.0	8.0	8.0	8.0	8.0	8.1	8.1	8.0	8.1	8.2	8.3	8.1	8.1
TDS	1130	1462	1485	755	686	229	471	1335	1534	271	348	292	958
Alk	98	87	121	86	85	112	80	123	129	95	99	68	101
SO_4	699	919	694	437	398	112	242	809	932	106	148	118	543
Ca	168	191	162	125	127	48	87	165	168	46	48	52	131
Mg	64	95	105	44	34	8	19	80	93	12	13	11	55
Na	65	96	100	19	16	4	13	104	140	15	35	5	71
Cl	16	22	213	17	10	3	8	27	22	10	11	4	41

Notes:

1 Red Peak Valley Wash

* Excludes chemical data for two samples that were influenced by magnesium chloride spills, upgradient of this monitoring site.

** Includes chemical data from sub-sites FLUM18 and CG18.

The Navajo Nation's surface water quality standards (NNEPA, 2008) establish livestock drinking water limits using both dissolved (B, Co, Cu & V) and total (As, Cd, Cr, Pb, Se & Zn) metal analyses. Using these standards, and those promulgated by the Hopi Tribe (Hopi, 2010), and recommended standards for TDS (NAS, 1974) and sulfate (Botz and Pedersen, 1976), comparisons were made between permanent internal impoundment and stream flow water quality collected from 1986 through 2010. Table 21 lists the comparison results for the permanent internal impoundments, and Table 22 shows the comparison results for the stream monitoring sites. Table 21 shows that, excepting the high pH values measured in PIIs N1-RA and N2-RA, the high TDS and sulfate values at pond N2-RA, and only single excursions of these same standards at four other ponds historically, the permanent impoundment water quality is suitable for use as livestock drinking water. Table 22 also indicates most of the stream flow generated by rainfall runoff meets the pH, NO3_NO2, TDS and sulfate standards. Historical analyses for the dissolved forms of trace elements indicate rainfall runoff meets livestock drinking water standards expressed as dissolved. Occurrences of high values for trace elements expressed as total or total recoverable are attributed to high sediment loads typically featured in rainfall runoff. The high pH values documented in Pond N1-RA would likely be reduced by contact with soil and channel bed materials if a discharge occurs. An unlikely discharge from either Pond N1-RA or N2-RA would be diluted when mixing with the larger volumes of stream flow runoff. Due to the similarity in water quality between permanent internal impoundments and stream flows, discharges from permanent internal impoundments would not significantly affect stream-water quality, and would not change the potential stream water use.

Effects of Stream Channel Diversions on Channel Characteristics and Runoff Water Quality. Six channel diversions affecting approximately 6.0 miles of channel in tributaries to Moenkopi Wash have or will be constructed during the life of the mining operations. The effects of channel diversions on channel characteristics and stability will be minor for the following reasons. All diversion channels will be at least as wide as the existing channel, which should eliminate the potential for flow constrictions and excessive lateral erosion. All diversion channel slopes will approximate original channel slopes so that comparable flow velocity ranges will be maintained. Energy dissipators will be constructed at the entrance and exit points of each diversion to provide an additional control on flow velocities and erosion potential at these points. The only anticipated channel effects from the diversions would be the channel's natural tendency to reestablish meanders. This will cause some minor erosion on alternating sides of the diversion where the meandering thalweg intersects side slopes. The stability of the channel diversions will be no less than the stability of the natural channels.

Table 21

Exceedances of Livestock Drinking Water Limits at Permanent Internal Impoundments (1986 - 2010)

Analyte	Standard	No. Sites	Sites	Frequency	Exceedence Date Range	Exceedence Value Range	Exceedence Median
LIVESTOCK WATERING STANDARDS -- NNEPA (2008), Hopi (2010), NAS (1974), Botz and Pederson (1976)							
Aluminum, Dissolved	0.0000 - 5.0000	0	none				
Boron, Dissolved	0.0000 - 5000.0000	0	none				
Copper, Dissolved	0.0000 - 500.0000	0	none				
Field Ph	6.5000 - 9.0000	5	N1-RA-P	11/0/0/13	01/28/92-09/18/00	9.1200 - 10.6100	9.4600
			N2-RA-P	5/0/0/28	01/13/06-07/21/10	9.1500 - 9.7200	9.3500
			N2-RB-P	1/0/0/4	01/28/99-01/28/99	9.1000 - 9.1000	9.1000
			PII116-P	1/0/0/2	07/28/98-07/28/98	9.0200 - 9.0200	9.0200
			PII118-P	1/0/0/5	05/27/93-05/27/93	9.4200 - 9.4200	9.4200
NO3_NO2 Nitrogen_N	0.0000 - 132.0000	0	none				
Solids, Dissolved	0.0000 - 6999.0000	1	N2-RA-P	19/0/0/33	03/05/86-04/10/00	7832.0000 - 18100.0000	12708.0000
Sulfate	0.0000 - 3000.0000	2	N2-RA-P	22/0/0/33	03/05/86-07/07/05	3690.0000 - 12965.0000	8080.0000
			N7-D-P	1/0/0/10	12/09/92-12/09/92	3482.0000 - 3482.0000	3482.0000
Total Recoverable As	0.0000 - 200.0000	0	none				
Total Recoverable Cd	0.0000 - 50.0000	0	none				
Total Recoverable Cr	0.0000 - 1000.0000	0	none				
Total Recoverable Cu	0.0000 - 500.0000	0	none				
Total Recoverable Hg	0.0000 - 10.0000	0	none				
Total Recoverable Pb	0.0000 - 100.0000	2	N2-RA-P	1/0/4/26	09/20/90-07/07/05	200.0000 - 200.0000	200.0000
					(<)	200.0000 - 400.0000	300.0000
			N2-RC-P	0/0/1/5	07/21/99-07/21/99(<)	200.0000 - 200.0000	200.0000
Total Recoverable Se	0.0000 - 50.0000	0	none				
Total Recoverable V	0.0000 - 100.0000	0	none				
Total Recoverable Zn	0.0000 - 25.0000	0	none				
Vanadium, Dissolved	0.0000 - 100.0000	1	N2-RA-P	0/0/1/22	03/05/86-03/05/86(<)	500.0000 - 500.0000	500.0000

Frequency = uncensored/between MDL&PQL/censored/no. samples, (B) = Between MDL&PQL range, (<) = Censored range

Table 22

Exceedences of Livestock Drinking Water Limits at Stream Monitoring Sites During Rainfall Runoff Events (1986-2010)

Analyte	Standard	No. Sites	Sites	Frequency	Exceedence Date Range	Exceedence Value Range	Exceedence Median
LIVESTOCK DRINKING WATER STANDARDS -- NNEPA (2008), HOPI (2010), NAS (1974), BOTZ AND PEDERSON (1976)							
Aluminum, Dissolved	0.0000 - 5.0000	0	none				
Arsenic, Dissolved	0.0000 - 200.0000	0	none				
Boron, Dissolved	0.0000 - 5000.0000	0	none				
Cadmium, Dissolved	0.0000 - 50.0000	0	none				
Chromium, Dissolved	0.0000 - 1000.0000	0	none				
Copper, Dissolved	0.0000 - 500.0000	0	none				
Field Ph	6.5000 - 9.0000	0	none				
Lead, Dissolved	0.0000 - 100.0000	0	none				
Mercury, Dissolved	0.0000 - 10.0000	0	none				
NO3_NO2 Nitrogen_N	0.0000 - 132.0000	0	none				
Selenium, Dissolved	0.0000 - 50.0000	1	CG37	0/0/1/10	05/07/92-05/07/92(<)	200.0000 - 200.0000	200.0000
Solids, Dissolved	0.0000 - 6999.0000	2	CG37	2/0/0/21	05/07/92-11/01/95	7600.0000 - 10170.0000	8885.0000
			SW25	1/0/0/41	07/21/98-07/21/98	7750.0000 - 7750.0000	7750.0000
Sulfate	0.0000 - 3000.0000	3	CG37	1/0/0/21	05/07/92-05/07/92	6660.0000 - 6660.0000	6660.0000
			FLUM18	1/0/0/10	07/24/91-07/24/91	3132.0000 - 3132.0000	3132.0000
			SW25	3/0/0/41	07/10/92-04/15/05	3460.0000 - 4880.0000	4116.0000
Total Recoverable Al	0.0000 - 5.0000	14	CG14	14/0/0/14	08/06/91-10/23/00	33.6000 - 1090.0000	273.5000
			CG157	10/0/0/10	07/23/91-08/22/00	14.0000 - 976.0000	273.0000
			CG18	9/0/0/9	07/23/97-07/10/01	70.4000 - 1950.0000	519.0000
			CG34	32/0/0/32	07/28/89-07/29/10	7.9100 - 2490.0000	400.5000
			CG37	17/0/0/17	07/28/89-10/23/00	15.1000 - 1440.0000	262.0000
			CG78	18/0/0/19	07/28/89-08/05/05	8.9100 - 1360.0000	223.5000
			FLUM15	12/0/0/12	07/05/90-05/19/01	15.4000 - 1480.0000	484.0000
			FLUM18	6/0/0/6	07/24/91-08/25/96	38.4000 - 507.0000	198.0000
			SW155	24/0/0/24	07/29/91-07/29/10	11.5000 - 2190.0000	359.5000
			SW16	14/0/0/15	09/05/90-07/10/01	99.4000 - 1270.0000	353.0000
			SW25	31/0/0/33	07/31/89-07/30/10	8.1300 - 1650.0000	241.0000
			SW26	31/0/0/34	07/24/91-07/29/10	12.4000 - 1650.0000	258.0000
			SW35	10/0/0/10	07/28/89-07/09/01	40.6000 - 586.0000	147.0000
			SW50	11/0/0/11	08/06/91-08/22/00	157.0000 - 1660.0000	421.0000
Total Recoverable As	0.0000 - 200.0000	11	CG157	1/0/0/10	07/23/91-07/23/91	400.0000 - 400.0000	400.0000
			CG34	6/0/0/32	07/17/90-07/29/10	210.0000 - 1550.0000	290.0000
			CG37	4/0/0/17	07/28/89-08/10/00	220.0000 - 310.0000	285.0000
			CG78	2/0/0/19	07/28/89-08/03/00	300.0000 - 540.0000	420.0000

Table 22 (cont.)

Exceedences of Livestock Drinking Water Limits at Stream Monitoring Sites During Rainfall Runoff Events (1986-2010)

Analyte	Standard		No. Sites	Sites	Frequency	Exceedence Date Range	Exceedence Value Range	Exceedence Median	
				FLUM15	1/0/0/12	07/23/91-07/23/91	500.0000 -	500.0000	500.0000
				FLUM18	1/0/0/6	07/24/91-07/24/91	800.0000 -	800.0000	800.0000
				SW155	2/0/0/24	07/29/91-07/29/10	220.0000 -	460.0000	340.0000
				SW16	3/0/0/15	09/05/90-07/24/91	350.0000 -	800.0000	400.0000
				SW25	3/0/0/33	07/31/89-07/30/10	280.0000 -	790.0000	470.0000
				SW26	3/0/0/34	07/24/91-07/29/10	230.0000 -	1200.0000	370.0000
				SW50	2/0/0/11	08/06/91-08/05/92	250.0000 -	300.0000	275.0000
Total Recoverable Cd	0.0000 -	50.0000	14	CG14	1/1/0/14	08/09/93-08/04/97	200.0000 -	200.0000	200.0000
						(B)	130.0000 -	130.0000	130.0000
				CG157	1/0/0/10	08/04/97-08/04/97	250.0000 -	250.0000	250.0000
				CG18	1/1/0/9	10/07/97-07/09/01	78.0000 -	78.0000	78.0000
						(B)	60.0000 -	60.0000	60.0000
				CG34	3/2/2/32	07/28/89-07/29/10	53.0000 -	440.0000	220.0000
						(B)	80.0000 -	90.0000	85.0000
						(<)	60.0000 -	200.0000	130.0000
				CG37	1/2/0/17	07/28/89-10/07/97	129.0000 -	129.0000	129.0000
						(B)	60.0000 -	100.0000	80.0000
				CG78	4/1/0/19	07/28/89-10/23/00	61.0000 -	120.0000	108.5000
						(B)	150.0000 -	150.0000	150.0000
				FLUM15	1/0/1/12	10/03/97-07/12/99	120.0000 -	120.0000	120.0000
						(<)	60.0000 -	60.0000	60.0000
				FLUM18	0/0/1/6	08/11/94-08/11/94 (<)	500.0000 -	500.0000	500.0000
				SW155	0/3/2/24	08/28/96-07/29/10 (B)	60.0000 -	130.0000	60.0000
						(<)	100.0000 -	100.0000	100.0000
				SW16	1/1/0/15	08/24/96-07/10/01	80.0000 -	80.0000	80.0000
						(B)	80.0000 -	80.0000	80.0000
				SW25	2/1/2/33	07/31/89-07/30/10	76.0000 -	250.0000	163.0000
						(B)	90.0000 -	90.0000	90.0000
						(<)	100.0000 -	100.0000	100.0000
				SW26	1/0/3/34	07/24/91-07/30/07	90.0000 -	90.0000	90.0000
						(<)	60.0000 -	100.0000	100.0000
				SW35	1/0/0/10	07/28/89-07/28/89	190.0000 -	190.0000	190.0000
				SW50	0/0/2/11	08/25/96-06/17/99 (<)	60.0000 -	60.0000	60.0000
Total Recoverable Cr	0.0000 -	1000.0000	10	CG14	1/0/0/14	08/06/91-08/06/91	1200.0000 -	1200.0000	1200.0000
				CG18	0/1/0/9	06/17/99-06/17/99 (B)	2200.0000 -	2200.0000	2200.0000
				CG34	9/0/0/32	07/28/89-07/29/10	1070.0000 -	3200.0000	1530.0000
				CG78	3/0/0/19	07/08/98-08/05/05	1160.0000 -	1300.0000	1300.0000
				FLUM15	2/0/0/12	07/23/91-06/17/99	1100.0000 -	1500.0000	1300.0000
				SW155	3/0/0/24	07/30/06-07/29/10	1220.0000 -	2680.0000	2300.0000
				SW16	1/0/0/15	07/21/98-07/21/98	1270.0000 -	1270.0000	1270.0000
				SW25	4/0/0/33	07/13/95-07/30/10	1050.0000 -	1900.0000	1645.0000
				SW26	2/0/0/34	07/24/91-07/23/97	1200.0000 -	1900.0000	1550.0000
				SW50	3/0/0/11	08/06/91-06/17/99	1100.0000 -	1700.0000	1500.0000

Table 22 (cont.)

Exceedences of Livestock Drinking Water Limits at Stream Monitoring Sites During Rainfall Runoff Events (1986-2010)

Analyte	Standard	No. Sites	Sites	Frequency	Exceedence Date Range	Exceedence Value Range	Exceedence Median
Total Recoverable Cu	0.0000 - 500.0000	14	CG14	7/0/0/14	08/06/91-07/14/99	520.0000 - 2200.0000	810.0000
			CG157	4/0/0/10	07/23/91-08/22/00	900.0000 - 1270.0000	1075.0000
			CG18	6/1/0/9	07/23/97-07/09/01	530.0000 - 1120.0000	770.0000
					(B)	2500.0000 - 2500.0000	2500.0000
			CG34	17/0/0/32	07/28/89-07/29/10	540.0000 - 4140.0000	1200.0000
			CG37	6/0/0/17	07/28/89-07/13/99	610.0000 - 1600.0000	985.0000
			CG78	7/0/0/19	07/28/89-08/05/05	600.0000 - 2400.0000	1620.0000
			FLUM15	6/0/0/12	07/23/91-07/12/99	640.0000 - 2100.0000	1255.0000
			FLUM18	1/0/0/6	07/24/91-07/24/91	900.0000 - 900.0000	900.0000
			SW155	13/0/0/24	07/29/91-07/29/10	560.0000 - 2600.0000	1000.0000
			SW16	7/0/0/15	09/05/90-07/10/01	650.0000 - 2010.0000	1000.0000
			SW25	12/1/0/33	07/31/89-07/30/10	560.0000 - 2920.0000	1215.0000
					(B)	900.0000 - 900.0000	900.0000
			SW26	12/0/0/34	07/24/91-09/04/09	560.0000 - 2800.0000	725.0000
			SW35	2/0/0/10	07/28/89-07/09/99	800.0000 - 900.0000	850.0000
			SW50	6/0/0/11	08/06/91-08/22/00	570.0000 - 3500.0000	1205.0000
Total Recoverable Hg	0.0000 - 10.0000	3	CG34	1/0/0/21	07/08/98-07/08/98	13.0000 - 13.0000	13.0000
			SW26	1/0/0/21	07/24/91-07/24/91	12.0000 - 12.0000	12.0000
			SW50	1/0/0/11	08/06/91-08/06/91	20.0000 - 20.0000	20.0000
Total Recoverable Pb	0.0000 - 100.0000	14	CG14	5/3/4/14	08/06/91-10/23/00	380.0000 - 1700.0000	700.0000
					(B)	230.0000 - 700.0000	400.0000
					(<)	200.0000 - 400.0000	300.0000
			CG157	4/2/1/10	07/23/91-08/22/00	190.0000 - 970.0000	745.0000
					(B)	900.0000 - 1000.0000	950.0000
					(<)	200.0000 - 200.0000	200.0000
			CG18	2/5/1/9	07/23/97-07/09/01	380.0000 - 650.0000	515.0000
					(B)	300.0000 - 3000.0000	700.0000
					(<)	400.0000 - 400.0000	400.0000
			CG34	12/9/2/32	07/28/89-07/29/10	130.0000 - 3600.0000	1490.0000
					(B)	140.0000 - 800.0000	500.0000
					(<)	200.0000 - 200.0000	200.0000
			CG37	9/4/1/17	07/28/89-10/23/00	130.0000 - 1400.0000	700.0000
					(B)	120.0000 - 500.0000	340.0000
					(<)	200.0000 - 200.0000	200.0000
			CG78	8/4/2/19	07/28/89-08/05/05	130.0000 - 2000.0000	580.0000
					(B)	200.0000 - 1500.0000	350.0000
					(<)	200.0000 - 400.0000	300.0000
			FLUM15	4/6/1/12	07/05/90-05/19/01	510.0000 - 1800.0000	895.0000
					(B)	140.0000 - 1900.0000	450.0000
					(<)	200.0000 - 200.0000	200.0000
			FLUM18	4/1/1/6	07/24/91-08/25/96	210.0000 - 700.0000	360.0000
					(B)	200.0000 - 200.0000	200.0000
					(<)	200.0000 - 200.0000	200.0000

Table 22 (cont.)
Exceedences of Livestock Drinking Water Limits at Stream Monitoring Sites During Rainfall Runoff Events (1986-2010)

Analyte	Standard	No. Sites	Sites	Frequency	Exceedence Date Range		Exceedence Value Range	Exceedence Median
			SW155	7/12/2/24	07/29/91-07/29/10		300.0000 - 2900.0000	690.0000
						(B)	140.0000 - 2000.0000	450.0000
						(<)	400.0000 - 800.0000	600.0000
			SW16	8/5/2/15	07/28/89-07/10/01		300.0000 - 1500.0000	1000.0000
						(B)	110.0000 - 600.0000	200.0000
						(<)	200.0000 - 200.0000	200.0000
			SW25	11/9/5/33	07/31/89-07/30/10		120.0000 - 2500.0000	700.0000
						(B)	170.0000 - 1900.0000	500.0000
						(<)	200.0000 - 1000.0000	200.0000
			SW26	11/13/4/34	07/24/91-07/29/10		140.0000 - 3000.0000	580.0000
						(B)	110.0000 - 900.0000	300.0000
						(<)	200.0000 - 800.0000	600.0000
			SW35	2/4/2/10	07/28/89-07/09/01		200.0000 - 400.0000	300.0000
						(B)	190.0000 - 700.0000	300.0000
						(<)	200.0000 - 200.0000	200.0000
			SW50	5/5/1/11	08/06/91-08/22/00		230.0000 - 3100.0000	450.0000
						(B)	300.0000 - 1600.0000	600.0000
						(<)	400.0000 - 400.0000	400.0000
Total Recoverable Se	0.0000 - 50.0000	1	CG34	2/0/0/32	07/08/98-08/05/05		60.0000 - 75.0000	67.5000
Total Recoverable V	0.0000 - 100.0000	14	CG14	13/0/0/14	08/06/91-10/23/00		130.0000 - 2400.0000	640.0000
			CG157	9/0/0/10	07/23/91-08/22/00		142.0000 - 2030.0000	810.0000
			CG18	9/0/0/9	07/23/97-07/10/01		143.0000 - 3800.0000	940.0000
			CG34	27/0/0/32	07/28/89-07/29/10		116.0000 - 4780.0000	1060.0000
			CG37	15/0/0/17	07/28/89-10/23/00		190.0000 - 2820.0000	760.0000
			CG78	15/0/0/19	07/28/89-08/05/05		120.0000 - 2650.0000	650.0000
			FLUM15	11/0/0/12	07/05/90-05/19/01		160.0000 - 2820.0000	990.0000
			FLUM18	5/0/0/6	07/24/91-08/25/96		400.0000 - 1500.0000	400.0000
			SW155	21/0/0/24	07/29/91-07/29/10		264.0000 - 4500.0000	860.0000
			SW16	14/0/0/15	09/05/90-07/10/01		200.0000 - 2700.0000	850.0000
			SW25	27/0/0/33	07/31/89-07/30/10		106.0000 - 3560.0000	670.0000
			SW26	27/0/0/34	07/24/91-07/29/10		109.0000 - 3180.0000	600.0000
			SW35	8/1/0/10	07/28/89-07/09/01		110.0000 - 1200.0000	380.0000
						(B)	290.0000 - 290.0000	290.0000
			SW50	11/0/0/11	08/06/91-08/22/00		340.0000 - 3100.0000	740.0000
Total Recoverable Zn	0.0000 - 25.0000	0	none					
Vanadium, Dissolved	0.0000 - 100.0000	0	none					
Zinc, Dissolved	0.0000 - 25.0000	0	none					

Frequency = uncensored/between MDL&PQL/censored/no. samples, (B) = Between MDL&PQL range, (<) = Censored range

The diversion channel construction activity and the natural meandering tendency of the active channel thalweg will expose fresh alluvial surfaces to weathering and erosion. This will result in additional amounts of sediment and dissolved chemicals being contributed to the streamflows. Several years of monitoring downstream from the Coal Mine Wash and Yazzie Wash channel changes indicates that natural background levels of sediment are so high that these minor additions are negligible (Chapter 15). Dissolved chemical loads have been historically quite variable. Stream water chemistry appears to be significantly affected by the portion of the watershed the flow originates in and the magnitude of the sediment load being transported by the flow. The cation exchange capacity of the sediment is high, and this does affect the flow chemistry. It is concluded that the water chemistry effects of channel diversions are minimal as they cannot be distinguished from natural fluctuations.

Effects of Culverts at Road Crossings on Stream Runoff and Water Quality. The effects of culverts on stream runoff and water quality will be minimal for the following reasons. All culverts or combinations of culverts are designed to pass the 10-year 6-hour flow with at least 1 foot of freeboard. If culvert exit velocities exceed six feet per second, riprapped energy dissipators will be employed to reduce the velocities. If exit velocities are between four to six feet per second, culverts will be inspected periodically for evidence of accelerated erosion immediately below their outfalls. If accelerated erosion is occurring, riprapped energy dissipators will be constructed at these points. Finally, these structures involve such minor areas of disturbance that chemical and sediment changes in the flows will be undetectable.

Removal of Pre-existing Surface Water Structures. One pre-existing surface water structure (DM-1) will be removed as a result of constructing the Reed Valley Wash channel diversion. One pre-existing structure (DM-7) was disturbed as a result of upgrading the original embankment for sediment control (K-P pond). The K-P pond has since been reclaimed because it became a redundant pond as a result of the completion of Wild Ram Valley Dam (J2-A pond) downstream. One pre-existing structure (DM-9) was impacted by construction of the main J-1/N-6 haul road. A portion of the pre-existing watershed was truncated as a result of the haul road alignment. The pre-existing watershed will not be restored because the haul road will most probably be retained as part of the postmining land use plan.

The probable hydrologic consequences of mining and related activities on 22 actual or suspected pre-existing surface water structures will be nill or inconsequential. This conclusion is reached for one or more of the following reasons: 1) minimal or no direct or indirect physical disturbance will occur at several of the pond sites or in impounding watersheds during the life-of-mine activities; 2) several sites do not actually exist; 3) several structures are non-functional due to structural failure; and 4) several structures are not applicable to this permitting action.

Interim impacts caused by the loss of the three structures previously discussed have been or will be mitigated by providing alternate water sources (N-aquifer public water standpipes and existing and proposed sediment control structures). The three structures will be replaced with one of vastly superior structural design following the completion of mining and reclamation in the affected areas.

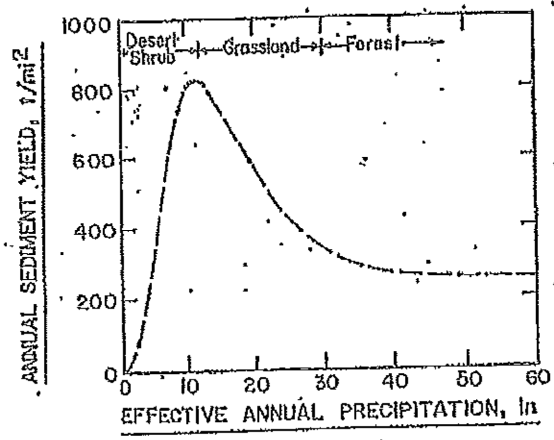
The loss of structure DM-7 will be mitigated by the retention of the J2-A pond as a permanent impoundment. The loss of DM-9 will be mitigated by the retention of several pre-law internally draining ponds in reclaimed portions of the J-1/N-6 or J-3 coal resource areas, or the retention of Ponds J3-D or J3-E as permanent impoundments. The loss of structure DM-1 will be mitigated by the retention of the J16-L sediment control structure (Reed Valley Dam) as a permanent impoundment. All the proposed permanent impoundments currently meet, or will be upgraded to meet the permanent performance standards (see Chapter 6 for design information). All proposed permanent impoundments and pre-law internally draining ponds have been demonstrated to have superior persistence capabilities (see Chapters 6 and 15 and Appendix E to Permit AZ-0001E and the 1/17/94 cover letter response, including Appendices 1 and 2, to technical Deficiency Number 3 to Chapter 16, Permit AZ-0001D). Monitoring of water quality will provide sufficient information to demonstrate the suitability of these sources to support the intended post-mining land uses.

Effects of Runoff From Reclaimed Areas on the Quantity and Quality of Streamflow. Considering the natural physiographic region in which Peabody is reclaiming lands disturbed by mining, and criteria imposed by regulatory authorities for evaluating reclamation efforts with regard to bond release, probable hydrologic consequences of runoff from post-law reclaimed areas is addressed in the following sections. Bond release criteria include the successful establishment of vegetative cover, topsoil stabilization, and the effects of runoff from reclaimed areas on the quantity and quality of waters in the receiving streams. Runoff from reclaimed areas will flow into receiving streams following the removal of sediment structures at the time of bond release.

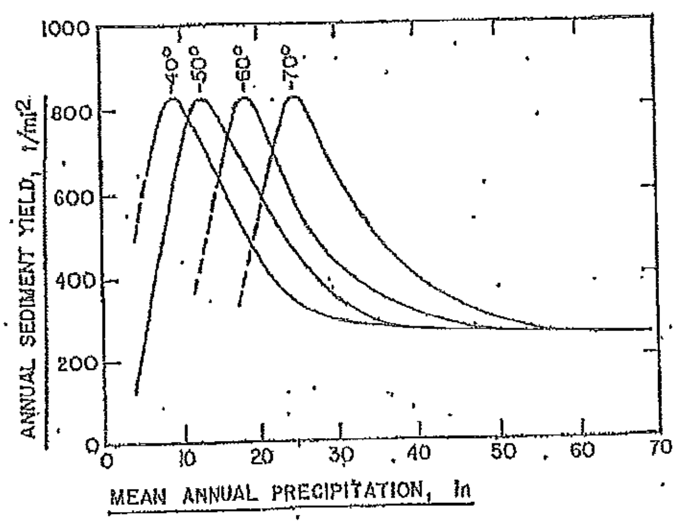
Reclamation efforts undertaken by Peabody in post-law coal resource areas on the leasehold occur in a physiographic region typified by a mild mean annual temperature (48F) and a low mean annual precipitation (10 inches). Mean annual precipitation is based on nonheated recording rain gauges. Including the contributions from snow, the mean effective precipitation on the leasehold is about twelve inches. Typical basin morphologies in the region include highly eroded landscapes of moderate to high relief, with entrenched sandbed channels and headward-cutting arroyos.

In this arid climate, intense summer thunderstorms produce flash-flooding in ephemeral channels resulting in high concentrations of sediment loads (10^5 mg/l). The highly erodible natural soils provide a significant contribution to the sediment yields produced in this climate. The limited vegetative cover in this region due to climatic and grazing conditions contributes to the flashy response of ephemeral channels from intense storms. Figure 5a shows a relationship among effective annual precipitation (EAP), climate and annual sediment yield (Langbein and Schumm 1958). Considering this diagram, EAP and climate on Black Mesa correlate to the highest annual sediment yields. Figure 5b shows the same relationship as Figure 5a, including the effect of mean annual temperature (MAT) (Schumm 1977). MAT on Black Mesa, in combination with EAP and climate, correlate to extreme annual sediment yields. Estimates of annual sediment yields (tons/mi^2) on the leasehold, incorporating site-specific parameters into the USLE, range between 4,666 tons/mi^2 and 14,477 tons/mi^2. These estimates were made taking into account the factors that affect erosion in the region, including the typical sparse cover and highly erodable soils (see Annual Sediment Yield Estimates, Chapter 15).

Reclaimed areas created by Peabody on Black Mesa will have topography characterized by long slopes no greater than 3:1 (h:v). Topsoil material used to cover regraded spoil material will be spread to a minimum depth of twelve inches. Spoil material will be compacted to some degree during regrading, as it contains higher clay contents than topsoil material. The only suitable topsoil materials available are highly erosive due



a. *Variation of sediment yield with climate in the United States (from Langbein and Schumm, 1958).*



b. *The effect of mean annual temperature (°F) on the sediment yield—climate relationship (after Schumm, 1977, p. 44).*

FIGURE 5 Climate and Sediment Yield

to their overall fine-sandy texture and lack of organic material, and are typical of those forming regionally under arid conditions. The "K" value assigned to topsoil material used for reclaimed areas by Intermountain Soils, Inc. personnel is .43 (Chapter 8), which confirms the high erosion potential of the topsoil.

Topsoiled reclaimed areas will feature vegetation established sufficiently to support the stabilization of topsoil material and the postmining land use of livestock grazing. Vegetative ground cover in the reclaimed areas will be similar to the native vegetation. For a discussion of vegetative ground cover and success standards for cover see Chapters 23 and 26, Permit AZ-0001E.

Discharge. The effects of runoff from reclaimed areas on the quantity and quality of waters in receiving streams will be minimal. Receiving streams on Black Mesa (Moenkopi, Coal Mine, Yellow Water, Dinnebito, Yucca Flat and Red Peak Washes) commonly yield discharges characterized by hydrographs with sharp peaks, short time to peaks, and short durations. These hydrograph characteristics become somewhat dampened downstream, as channel slopes lessen and cross section geometries increase.

Runoff from reclaimed areas should largely occur as overland flow, typified by hydrographs of gentle peaks and longer durations. With the controlled topography in reclaimed areas (slopes less than 3:1) and the modified drainage system, runoff times of concentration will be longer, resulting in reduced flow peaks and longer hydrograph durations than typical hydrographs of runoff from natural undisturbed basins on Black Mesa. External drainages will be established as part of the final reclamation, along with networks.

Runoff volumes and discharges from reclaimed areas should result in localized decreases in runoff to receiving streams. Reclaimed coal resource areas will contribute less runoff to receiving streams for similar storms than those same areas did prior to mining. Computations using SEDIMOT II to predict runoff and sediment differences from areas in the Coal Mine Wash drainage before mining and following reclamation show reductions in peak discharges and runoff volumes for an identical storm input (see Coal Mine Wash Pre- and Postmining Sediment Yield Estimates, Chapter 15, PAP). In watersheds with large portions of mined and reclaimed areas, magnitudes of the predicted decreases in peak flows range between 2 and 24 percent. Reductions in predicted runoff volumes range between 5 and 21 percent.

Topography, soils and vegetation modeled in the Coal Mine Wash drainage are typical of final reclamation that will be established in all mined coal resource areas on the Black Mesa leasehold. Based on SEDIMOT II predictions, watersheds established in reclaimed coal resource areas will typically yield reduced peak flows and runoff volumes compared to runoff from the areas before mining activities commenced. The impact of these reductions in runoff from reclaimed areas to receiving streams will be local. SEDIMOT II predictions of peak discharge and runoff volume from the entire Coal Mine Wash watershed under postmining conditions at Site 18 (includes junctions I-XIV) were only slightly less than the runoff generated under premining conditions. Predicted peak discharge and runoff volumes were reduced by only 2 percent and 3 percent respectively. Considering the order of magnitude of flows for which predicted runoff parameters were determined by SEDIMOT II up to junction XIV (10^3), these reductions are not significant. Also, junction XIV was established only a short distance downstream from these largely reclaimed watersheds in which runoff reductions were estimated at more than 20 percent.

The prediction results for modeling Coal Mine Wash drainage under pre- and postmining conditions suggest that, for a 24-hour duration storm of uniform distribution over the entire watershed, runoff reductions from reclaimed areas will be local and will result in insignificant reductions of runoff in the main channels. As runoff in the main channel systems progresses downstream, encountering additional lateral inflow from undisturbed basins, localized runoff reductions will become less pronounced and unmeasurable.

Generally, an increase in total drainage area is accompanied by an increase in watershed discharge. Reclaimed areas on Black Mesa that will drain into the Moenkopi watershed comprise only two percent of the total Moenkopi watershed above its confluence with the Little Colorado River. Slight reductions in runoff from reclaimed areas will not affect the overall runoff from this watershed area; however, runoff from the large drainage areas above the village of Moenkopi near Tuba City has been utilized for flood irrigation purposes. Reductions in runoff discharge in Moenkopi Wash from reclaimed areas on the leasehold will not be detected some 70 miles downstream in the vicinity of Moenkopi.

Busby (1966) mentions that approximately 50 percent of the runoff produced in tributaries of the Little Colorado River is lost in transmission before reaching this major channel. Channel transmission and evapotranspiration losses of this magnitude would completely mask any runoff reductions from the small, reclaimed areas on the leasehold to receiving streams.

Sediment. Sediment concentrations measured in receiving streams as part of monitoring efforts by Peabody personnel commonly range from 10^4 to 10^5 mg/l (see Peabody Sediment Monitoring, Chapter 15). Sediment yields (tons/day) have been determined on a storm basis from measured discharges and sediment concentrations made at automated stream station sites on the leasehold. Measured sediment yields range from 10^2 to 10^3 tons per day for low discharges, and up to 10^5 tons per day in higher discharges (Automated Site Sediment Yield Analyses, Chapter 15, PAP).

Channel contributions to measured sediment yields were estimated using SEDIMOT II computations (see Coal Mine Wash Pre- and Postmining Sediment Yield Estimates, Chapter 15, PAP). Using a range of storms, peak discharge and sediment concentrations were predicted for the entire Coal Mine Wash drainage above the location of Stream Station 16. These predicted values were converted to tons per day and plotted on the sediment rating curve developed from data collected at Site 16 (Figure 6). Regression lines defining the relationships among the measured and predicted values were determined and are labeled on Figure 6. Comparisons of the regression lines at various discharges suggest that sediment contributions from the channel sides and bed to the main channel sediment load could be as high as 45 percent at discharges in the range of 3,000 cfs. It can be concluded that the main channels of the principal drainages that disect the Black Mesa leasehold could contribute up to 45 percent of the total sediment load discharge during large flow events.

Due to the likelihood of intense summer thunderstorms occurring on reclaimed areas, and the highly erosive nature of topsoil material, sediment concentrations of runoff from reclaimed areas could approach concentrations comparable to receiving streams. For purposes of comparing premining conditions (undisturbed) with postmining conditions (reclaimed coal resource areas), sedimentation estimates in runoff from Coal Mine Wash have been made using SEDIMOT II (see Coal Mine Wash Pre- and Postmining Sediment Yield

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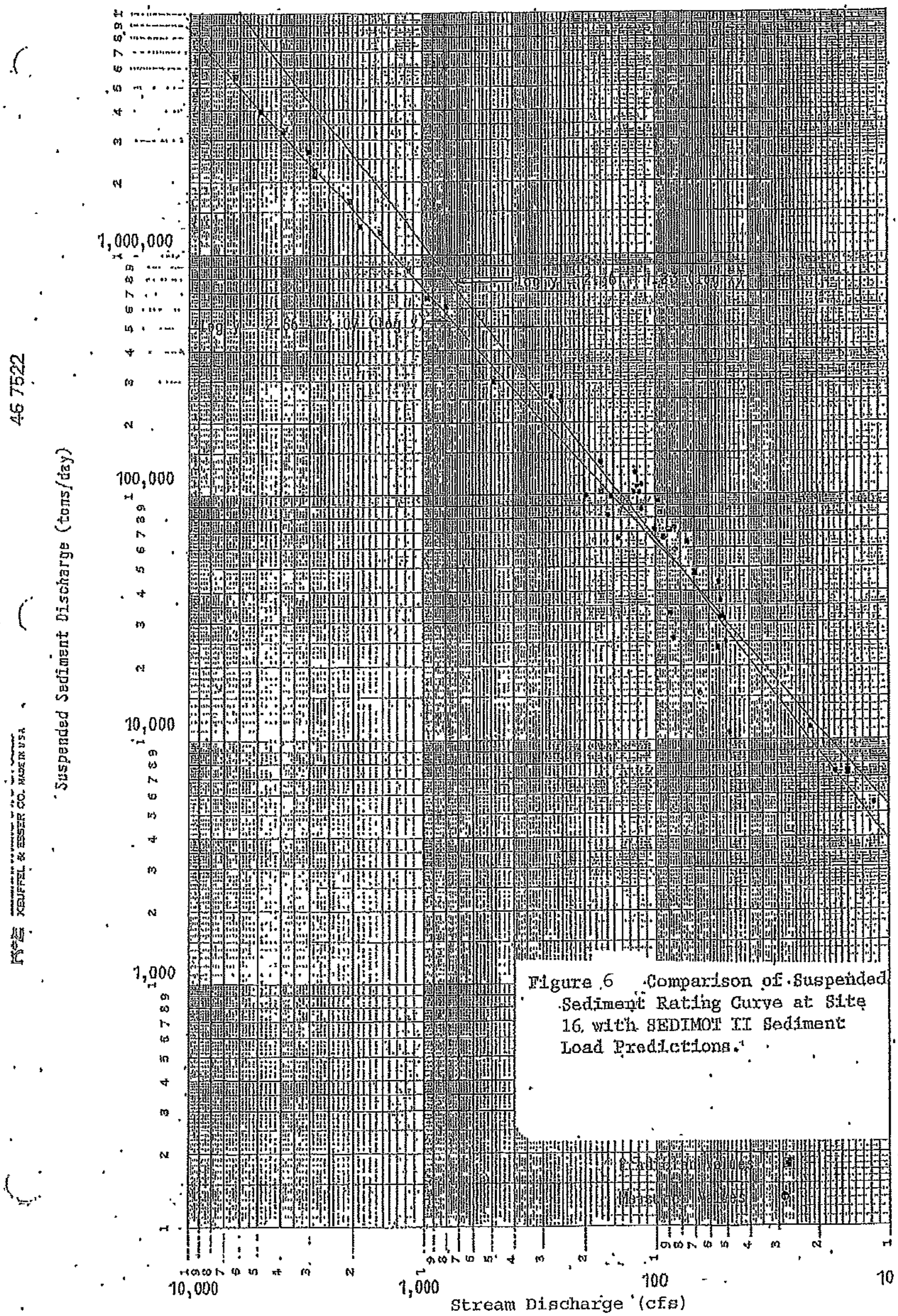

Figure 6 Comparison of Suspended Sediment Rating Curve at Site 16 with SEDIMOT II Sediment Load Predictions.

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Estimates, Chapter 15, PAP). The drainage area above the location at which these estimates were made comprised almost 43 square miles. Sediment yield calculations were made assuming that the outlet of this drainage area is located about one mile downstream from the N-1 reclaimed area at Stream Station 18. Results (Chapter 15) show decreased sediment concentrations (1 to 23 percent) and sediment yields (4 to 34 percent) in streamflow due to discharge from modeled watersheds within the Coal Mine Wash watershed largely comprised of reclaimed areas.

Again, reclaimed topography, soils and vegetation modeled in the Coal Mine Wash drainage are typical of final reclamation to be established in all mined coal resource areas. Watersheds established in reclaimed coal resource areas will typically yield reduced peak sediment concentrations and sediment yields compared to premining conditions. The effect of decreased sediment concentrations and yields in receiving stream runoff resulting from reclaimed area runoff will be local. Generally, as discharges increase in receiving streams, reduced sediment contributions from watersheds largely composed of reclaimed areas become less pronounced. Model predictions for the entire Coal Mine Wash watershed at Site 18 show a reduction in sediment yield (5 percent) and a 1 percent increase in peak sediment concentration for postmining conditions. The order of magnitude for both predicted parameters is 10^5, which diminishes the significance of the difference in these parameters between premining and postmining conditions.

As flow in receiving streams proceeds downstream, lateral inflow from undisturbed watersheds will contribute to sediment loads in the main channels. These additional contributions will tend to mask the localized decreases in sediment loads resulting from watersheds comprised mainly of reclaimed areas. Finally, sediment yield contributions from channel beds and sides may be as high as 40 percent, which will offset the predicted reductions in sediment loads from reclaimed areas. Channel contributions to sediment loads are predicted to completely mask the localized effects of reclaimed area contributions in the downstream direction.

Water Quality. Receiving stream-water quality has been monitored since 1981 at stream station sites on the leasehold (see Stream Water Quality Section, Chapter 15). Permanent internal impoundments (PII) established in both pre-law and post-law reclaimed areas on Peabody's leasehold have also been sampled for water quality. Previously introduced tables 19 and 20 are summaries of sample means for selected major chemical parameters. Table 19 presents mean parameter values measured in PII's from 1986 through 2010 that were constructed in both pre-law and post-law areas, and Table 20 presents mean parameter values measured at stream station sites for the same period.

Generally, PII's created in pre-law areas have water quality similar to post-law areas. Runoff flowing into PII's in pre-law areas occurs on regraded spoil material. Although post-law areas were topsoiled, comparisons using mean parameter values from post-law and pre-law PII's indicate no significant differences in the quality of water flowing over spoil material versus topsoil material.

Mean chemical parameter values from PII's are similar to but slightly lower in range and magnitude compared with stream flows, with the exception of PII's N1-RA and N2-RA. Mean pH measured in PII's range between 7.5 and 8.6 (except PII N1-RA), while stream pH values range similarly between 8.0 and 8.3. Excepting PII N2-RA, which receives a significant amount of high-TDS water from resaturated spoil in addition to runoff from reclaimed areas, mean TDS in PII's (144 to 939 mg/l) range lower than rainfall runoff measured in receiving streams (229 to 1534 mg/l). Although the mean values presented in Tables 19 and 20 indicate variability among PII's and stream flows, generally, TDS, sulfate, calcium, magnesium, sodium, and chloride are slightly lower in PII's compared with stream flows.

Tables 21 and 22 (previously discussed) indicate that water quality in most PII's and streams fall within the livestock drinking water limits (based largely on dissolved analyses of trace metals) recommended by Tribal agencies (NNEPA, 2008; Hopi, 2010), National Academy of Science (1974) and Botz and Pedersen (1976). Limited exceptions include high pH values in PII N1-RA, high TDS values in PII N2-RA, and infrequent exceedences of a limited number of the livestock drinking water limits at several stream sites.

Runoff water quality from reclaimed areas (including pre-law areas not topsoiled) will not significantly alter receiving stream water quality, nor change the potential use of receiving stream flows. Mixing of any infrequent pond discharge from PII's with the larger volumes of stream flow runoff will provide a slight diluting effect, rendering any potential impact on receiving stream water quality insignificant.

The Impact of the Reclamation Plan on the Stability of Reclaimed Areas. Reclamation of coal resource areas on PCC's Black Mesa leasehold occurs in a semi-arid climate. Common products of this climatic regime include flash floods in ephemeral channels resulting from very intense summer thunderstorms. Drainages exhibit high degrees of drainage densities, severly eroded landscapes of moderate to high relief, entrenched sandbed channels and the continual evolution of rills and gullies in the upslope portions of drainage basins.

No physical measurement guidelines have been found that provide distinctions between rills and gullies. Generally, gullies are classified as large rills. Quantification of the processes that form rills and gullies has not yielded conclusive results. Gullies have been classified as continuous or discontinuous (Leopold and Miller, 1956). Continuous gullies begin their downstream course with many small rills, while discontinuous gullies start with an abrupt head cut (Heede, 1975). Most rills and gullies that form naturally on Black Mesa are continuous, as abrupt head cuts in these systems are not commonplace, occurring only where lithologic controls predominate.

Several key factors contribute to the formation of rills and gullies in the semi-arid southwest. Intense thunderstorms commonly generate large raindrops that impact soil surfaces with high degrees of kinetic energy. The raindrop impacts detach soil particles, which are then entrained by overland flow. The kinetic energy imparted by very intense rainfall tends to seal some soil surfaces rapidly, concentrating overland runoff. The disruption of the soil surface and concentration of overland flow during a storm event creates an opportunity for the establishment of small rills.

Another major influence is the vegetative canopy covering the soil surface. The vegetative canopy intercepts a portion of the total rainfall volume reducing the potential for rapid runoff. The vegetative cover tends to reduce the energy of the raindrop impacts, thereby lessening the degree to which the soil surface is impacted and the quantity of detached soil particles.

The tendency of a soil to erode (detachment) also affects the degree to which rilling occurs. Sandy textured soils have a higher susceptibility for detachment than soils high in clay content. The presence of organic matter tends to provide soil cohesiveness, reducing the possibility of soil detachment. Topsoil material present on the leasehold tends to have a sandy texture and be low in organic matter and clay content.

Morphologic factors such as slope steepness, length, shape and drainage density affect the rilling process. The tractive force, a measure of detachment potential of flow, increases with slope steepness (Meyer, Foster and Romkens, 1975). Runoff increases with distance from the tops of slopes, as the contributing drainage area above increases. As the length of slopes increase, so does the potential for rill and gully development. The shape of an irregular slope will affect the development of rills depending on the interrelationships of slopes and slope lengths. Natural basins will establish drainage networks of a sufficient density to carry excess runoff to the basin outlet. Although rills and gullies are small in comparison to main channels, they are an integral part of a basin's drainage network.

Many theories and concepts have been developed in the literature that explain the development of rills in gullies in semi-arid environments. Schumm and Hadley (1957) proposed a model of semi-arid erosion in which channels (including rills and gullies) adjust, by either aggrading or downcutting, to variations in sediment loads and discharge. Bergstrom and Schumm (1981) discuss a model based on the episodic behavior of a drainage basin, in which distinct zones of a watershed adjust channel characteristics in response to episodic changes in flow and sediment with time. The concept of equilibrium is discussed at length by Schumm (1977), and involves the complex process-response concept of a fluvial system.

Regardless of whether the drainage systems on Black Mesa are in quasi-equilibrium, or whether their development over time may be explained by a model, several factors influencing the development of rills and gullies in these drainages and in reclaimed areas remain constant. Intense summer thunderstorms occurring on Black Mesa generate high-energy raindrops that result in considerable soil detachment. Also, the vegetation canopy cover to be successfully established in coal resource areas will be similar to canopy covers found in the natural surrounding landscape. Topsoil material used as plant-growth media in reclaimed areas has the same erosive texture as soils found in the surrounding highly eroded landscape. Natural drainages on Black Mesa exhibit a high degree of density, naturally forming rills and entrenched gullies in the upland areas.

Regardless of the extent of vegetal cover or the flatness of the regraded slopes, rills are going to form in the reclaimed areas as the basins adjust drainage to convey excess runoff. Summer thunderstorms are intense and localized resulting in overland flow that rapidly concentrates and scours in relatively short distances.

Peabody has developed a plan for insuring the stability of reclaimed areas (see Chapter 26). The key to the plan is to control those components of the surface runoff process to the extent that the potential for erosion is greatly minimized. By controlling the erosive nature of the surface runoff the degree of rilling and gullying will be minimized such that sufficient landform stability can be achieved and a successful vegetative cover can be developed that will promote the postmining land use of livestock grazing and wildlife habitat.

An important component of the plan (see Chapter 26) is to construct gradient terraces with slight positive drainage (no greater than 2 percent) on reclaimed slopes (greater than 10 percent) that have high potentials for excessive erosion and uncontrolled drainage development (rills and gullies). These terraces will break up slope lengths, limiting the upslope area contributions to overland flow. Distances over which tractive forces increase will be controlled, which will limit the scouring action of concentrated runoff in the downstream direction. By establishing limited drainage areas between the contour terraces, the size and density of rills that occur will be minimized.

Primary surface manipulations include: 1) deep ripping on all slopes ; and 2) contour furrowing using an offset disk unit that will promote infiltration and reduce excess runoff. The retopsoiled areas, including contour terraces, will be mulched with a cover crop or anchored straw or hay mulch, and then revegetated with the permanent seed mixes (see Chapter 26). Revegetation and mulching will promote soil cohesiveness as vegetation becomes established, providing further resistance to rilling.

In addition to the creation of gradient terraces and the surface treatments, a network of downdrains and main channels will be constructed. Downdrains will be established at specific intervals across the slopes for connecting the contour terraces to the main channel. Downdrains will enhance the stability and integrity of the contour terraces, as they will convey runoff from the inter-terrace areas to the main channel without promoting failure of the terraces. An important feature of the plan is the sizing and lengths of the terraces between the downdrains. Terrace embankment heights and lengths will be maximized to insure the containment of concentrated overland runoff and to increase the time of concentration of flow to the downdrains, respectively. This should greatly reduce the potential for extreme downcutting in the downdrains.

The downdrain systems will be constructed in some instances after topsoil has been replaced. Under these circumstances, topsoil will be removed at a minimum width of 45 feet to prevent topsoil loss. Ripping and disking will be implemented across the downdrain system creating a surface roughness perpendicular to flow. This will provide some resistance to scour in the downdrain. In addition, the non-topsoiled drains will contain a significant percentage of rock fragments further increasing the surface roughness.

The main channels will be engineered to convey the appropriate discharge contributed by the watershed areas drained. The main channels will range in width from approximately 45 to 135 feet which includes a fifteen foot apron on each side of the channel. The main channels and aprons will not be topsoiled to prevent topsoil loss. Application of the seed mixes will be used to revegetate and further stabilize the non-topsoiled areas.

The establishment of the drainage network outlined above will increase the overall time of concentration of flows and reduce peak flows from the reclaimed area basins. Flow velocities will be controlled, as surface manipulations, including those performed in downdrains and the main channels, provide roughness and resistance to scour. Thus, drainage development in reclaimed areas will be planned and controlled, thereby minimizing the number and size of rills. Landform stability and vegetative development supportive of the post-mining land use can be achieved, because the reclaimed area drainage development will have been controlled and reasonably stabilized rather than in a state of quasi-equilibrium between storms of large return periods as in the natural drainage system.

<u>Summary</u>

This chapter has presented a discussion of probable hydrologic consequences of the proposed life-of-mine mining plan. Table 23 summarizes the discussion by listing the probable hydrologic consequences and the results of the analysis of each. As can be seen, all the probable impacts have been determined to have either no impact or no short or long term significant impacts.

TABLE 23

Summary of Probable Hydrologic Consequences of the Life-of-Mine Mining Plan for the Kayenta Complex

Probable Hydrologic Consequences	Analysis Results	Significance
Ground Water		
1. Interruptions of ground-water flow and drawdown in the Wepo aquifer	Theoretical percent reductions in water levels range from 10 to 49 percent in 2 wells partially completed in Wepo Formation	No short or long term significant impacts
2. Removal or elimination of local wells and springs	Three local wells completed in the Toreva aquifer and one spring will be removed by mining. Alternate water supply is being provided until the wells and spring are replaced	Impact during the life of the pit. Following reclamation, Peabody will replace the wells and spring. No short or long term significant impacts
3. Containment and discharge of pit inflow pumpage	Pumpage can be treated with settling basins so that discharge meets applicable standards	No short or long term significant impacts

TABLE 23 (Cont.)

Summary of Probable Hydrologic Consequences of the Life-of-Mine Mining Plan for the Kayenta Complex

Probable Hydrologic Consequences	Analysis Results	Significance
Ground Water		
4. Impact of replaced spoil material on ground-water flow and recharge	Resaturation will take from a few to as many as 100 years. Water levels will recover to near premining levels. Water is not currently used to support land use activities due to quality and yield. Alternate water supply is available.	No short or long term significant impacts
5. Impact of replaced spoil on ground-water quality	Increased levels of Ca, Mg, Na, SO_4, HCO_3, and TDS in the resaturated portion of Wepo aquifer within mining areas only. Potential for acid formation and trace element migration is minimal. Water not currently used to support land use activities due to quality and yield. Alternative water supply available. Water use category will remain unchanged.	No short or long term significant impacts

TABLE 23 (Cont.)

Summary of Probable Hydrologic Consequences of the Life-of-Mine Mining Plan for the Kayenta Complex

Probable Hydrologic Consequences	Analysis Results	Significance
Ground Water		
6. Interruptions of Wepo recharge to the alluvial aquifer	0-20 foot localized (time and space) declines in portions of the alluvial aquifer near N-14, J-16 and J-19/20. No local use of alluvial aquifer on leasehold and water does not support critical habitat or species. Impact is transient.	No short or long term significant impact
7. Truncation of alluvial aquifers by dams	No observed impact on existing alluvial water levels since dams are mainly in small tributaries and Wepo discharges to alluvium.	No short or long term significant impact
8. Recharge of alluvial aquifer from resaturated spoil in Wepo formation	Low transmissivity in Wepo so this source has less impact than other sources of recharge (rainfall and snowmelt).	No short or long term significant impact

TABLE 23 (Cont.)

Summary of Probable Hydrologic Consequences of the Life-of-Mine Mining Plan for the Kayenta Complex

Probable Hydrologic Consequences	Analysis Results	Significance
Ground Water		
8. (Cont.)	No local use of alluvial aquifer on leasehold and water does not support critical habitats or plant species. Impact is transient.	
9. Interruptions of spring flows (Wepo or alluvial)	No Wepo or alluvial springs expected to be impacted by remaining mining operations. One spring at N-14 removed by mining has been mitigated by alternative water sources.	No short or long term significant impacts
10. Peabody wellfield pumpage reducing regional water levels and stream and spring flows	PWCC wellfield pumping will lower confined water levels basin-wide. The majority of drawdown has already occurred. Predicted drawdowns at surrounding communities are not large enough to affect aquifer productivity. Water levels near the leasehold have been recovering following the reduction of	No short or long term significant impact

TABLE 23 (Cont.)

Summary of Probable Hydrologic Consequences of the Life-of-Mine Mining Plan for the Kayenta Complex

Probable Hydrologic Consequences	Analysis Results	Significance
Ground Water		
10. (Cont.)	pumping in 2006. No risk of structural damage to the aquifer. Negligible impacts are predicted for streams and springs.	
11. Impact of induced leakage from D-aquifer to N-aquifer	No evidence suggesting impacts to N-aquifer due to leakage from D-aquifer.	No short or long term significant impact
Surface Water		
1. Impact of dams, ponds or impoundments on runoff and channel characteristics	Minor headward aggradation above embankments in stream. Minor incising of streams below dams.	No short or long term significant impact

TABLE 23 (Cont.)

Summary of Probable Hydrologic Consequences of the Life-of-Mine Mining Plan for the Kayenta Complex

Probable Hydrologic Consequences	Analysis Results	Significance
1. (Cont.)	Vegetation encroachment on new channels. Most ponds and dams temporary structures. Small percentage of drainage impounded and structure to be dewatered. Following removal sediment loads will temporarily increase. Channels will reestablish.	
2. Impact of dams, ponds or impoundments on downstream water users	No flood irrigation practice on or downstream of leasehold for several miles. Only 0.7 percent and 2.45 percent of total Dinnebito and Moenkopi watersheds to be dammed through 2018. Record review does not indicate significant impacts have or will occur downstream.	No short or long term significant impacts
3. Impact of dams, ponds or impoundments on stream water quality	Infrequent discharges will meet applicable NPDES effluent limits. Discharge from permanent internal impoundments unlikely.	No short or long term significant impacts

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TABLE 23 (Cont.)

Summary of Probable Hydrologic Consequences of the Life-of-Mine Mining Plan for the Kayenta Complex

Probable Hydrologic Consequences	Analysis Results	Significance
Surface Water		
4. Impact of stream channel diversion on channel characteristics and water quality	Diversion as wide as actual channels. Slopes approximate natural slopes. Energy dissipation when needed. Construction and reclamation will temporarily increase sediment loads. Downstream monitoring shows no effect.	No short or long term significant impacts
5. Effects of culverts at road crossings on stream runoff and water quality	Proper engineering design and use of energy dissipators minimize erosion and allow adequate discharge.	No short or long term significant impacts
6. Removal of pre-existing surface water structures	Three pre-existing surface water structures will be removed by mining. Alternate water supply is being provided until the structures are replaced by permanent impoundments	No short or long term significant impacts
7. Runoff from reclaimed areas to streams	Reshaping of regraded spoils, revegetation and soil reconstruction activities result in localized decreases in peak discharge, runoff volumes, peak sediment concentrations, sediment yield and chemical	No short or long term significant impacts

TABLE 23 (Cont.)

Summary of Probable Hydrologic Consequences of the Life-of-Mine Mining Plan for the Kayenta Complex

Probable Hydrologic Consequences	Analysis Results	Significance
Surface Water 7. (Cont.)	constituents. However, effects will be minor compared to total flow and quality of receiving streams. Original premining conditions will likely be approximated with time following reclamation. Total disturbed area small in comparison to total watersheds.	No short or long term significant impacts
8. Impact of the Reclamation Plan on the Stability of Reclaimed Areas	Development of contour terraces, downdrains and main channels in reclaimed areas with engineering design to insure a controlled drainage development. Sediment yields and flow rates and volumes from reclaimed areas should be lower. Some maintenance may be required, particularly in pre-plan reclaimed areas.	No short or long term significant impacts

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Attachment 3

Revised 2/9/14

PREDICTED EFFECTS OF PUMPING BY PWCC
2014-2044 MINE PLAN REVISION

Prepared for:

Peabody Western Coal Company

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TETRA TECH

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Attachment I

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Introduction

Peabody Western Coal Company (PWCC) submitted a significant permit revision (Life of Mine Plan Revision) proposing to extend coal mining through 2044 at the Kayenta Complex. After cessation of mining, the mine site will be reclaimed, with final bond release projected in 2057. During this period, PWCC will pump groundwater from the N and D aquifers to support mining and reclamation activities. The great majority of the groundwater will be derived from the N aquifer.

Groundwater has been used at the Black Mesa and Kayenta Complexes since 1968 to support mining and reclamation activities, as well as to transport pulverized coal through a coal slurry pipeline at the former Black Mesa mine. At the end of 2005, use of the slurry pipeline ceased, operations at the Black Mesa Complex were suspended, and the rate of groundwater pumping decreased considerably. During this period, the Hopi and Navajo communities have also pumped water from the N aquifer, and to a lesser extent, from the D aquifer.

In order to evaluate the effects of pumping by PWCC, it is necessary to take into account all past pumping, as well as future pumping by PWCC and the tribal communities. This evaluation was achieved using a numerical model of the groundwater system developed by Tetra Tech (Tetra Tech, 2014, in preparation). Because of information collected throughout the N aquifer on the response of the groundwater system to the past pumping, this groundwater model is well-suited to predicting future effects.

This report presents the predicted effects of pumping by PWCC and the communities through 2057, and separates out the effects caused by PWCC.

Simulation Approach

The groundwater model is a non-linear model, in that drawdown in a model cell that is unconfined will reduce the saturated thickness in the cell, and therefore its transmissivity. In addition, if a model cell becomes unsaturated, it is made inactive, at least temporarily. Therefore, predicting the effect of pumping from a well should not be done simply by pumping just that well, unless it is known beforehand that the effect of the pumping will not produce a non-linear effect. The correct way to determine the effects of pumping at the PWCC wellfield is to perform (1) a simulation with all pumping occurring, (2) a second simulation with pumping at the PWCC wellfield removed, and (3) determining the effects of pumping at the wellfield by calculating the differences between the two set of results.

This procedure was followed for these PHC calculations. Two simulations were performed.

1. Community and PWCC – In this simulation, the pumping dataset included pumping rates for the communities, the windmills, and the PWCC wellfield, for stress periods representing 1956 through 2057.
2. Community Only – For this simulation, the wells at the PWCC wellfield were treated as if they were never drilled. This removes the effects of PWCC's pumping, as well as the inter-wellbore

flow. The community and windmill pumping was the same as in the "Community and PWCC" simulation.

From these two simulations, the effects of PWCC's wellfield (Peabody-Only results) can be isolated by evaluating the differences between these two simulations. Pumping at the PWCC wellfield began in 1968; as a result, the two simulations are identical from 1956 through 1967.

Estimated Future Pumping

Peabody Western Coal Company

The model was run, with the following pumping rates projected for the mine wellfield:

a. Actual pumping rates through 2012;
b. 1,500 af/y for 2013 through 2044, during mining; and
c. 600 af/y for 2045 through 2057, during completion of reclamation.

The percent distribution of pumping among the wells in the wellfield is based on the average distribution calculated over the period 2011 and 2012 as listed below according to each well site:

NAV2	56%
NAV3	1%
NAV4	3%
NAV5	10%
NAV6	5%
NAV7	3%
NAV8	21%
NAV9	1%

Tribal Communities

The future pumping from wells supplying the Hopi and Navajo communities was estimated based on future population estimates rates provided by the Tribes. Mr. Michael Foley, on behalf of the Navajo Nation, provided data based on a population estimate for 2010 and projected population growth assuming a growth rate of 2.48 percent. These estimates were reported to be the same as used in the Mid-Demand estimate in the Assessment of Western Navajo and Hopi Water Needs, Alternatives, and Impacts performed by HDR in 2003. The population estimate for the Hopi was derived from a table in Appendix 1 of The Hopi Tribe's Second Amended Statement of Claimant in Civil No. 6417, Superior Court of the State of Arizona In and For the County of Apache, titled "The General Adjudication of All Rights to Use Water in the Little Colorado River System and Source." This table provided average annual population growth rates by area or community that ranged from 1.0% to 5.1% (in Teweom Village near Oraibi), with an average annual growth rate of approximately 1.90%.

The annual pumping based on the population estimates was calculated by multiplying the population by a per capita water use rate of 100 gallons per capita per day (gpcpd). Both the Navajo Nation and Hopi

Tribe estimates of future water use assume a rate of 160 gpcpd, but this usage rate would require development of considerable infrastructure and changes in land use to be achieved. The 2010 average usage was in the range of 50 to 75 gpcpd. Thus a rate is 100 gpcpd is a more reasonable estimate over the timeframe of the prediction.

The population-based pumping is based on pumping centers, not individual wells. Therefore, it was necessary to apply this annual pumping over the wells associated with a pumping center, based on recent pumping information if available, or on equal distribution among the production wells in a pumping center. Both Tribes are planning on population growth in areas not currently supplied with water from production wells. Locations were selected in these areas, and were assumed to be completed in all formations of the N aquifer present at those locations.

For these predictive simulations, the community pumping is simulated through 2012 based on either estimates (for the period prior to collection of community pumping data) or reported annual pumping rates. For 2013 and later, the pumping is based on the projected populations, as described above. Attachment I provides the estimated future pumping rates by well. The locations of these wells are shown on Figure 1.

In addition to the pumping at the communities, the model includes pumping from numerous windmills. The rates of pumping from these low-rate wells were maintained constant through the entire simulation at 0.23 af/y each.

Results

As discussed above, simulation results are available for two simulations: (1) Community and PWCC and (2) Community Only. The differences between these simulations will be termed "PWCC Only"; this term does not apply to a third simulation, but to calculated differences between the two real simulations.

Results are presented in several forms. Water levels calculated by the model are presented in maps for specific times for model layer 3 (representing the lowest formation in the D aquifer, the Entrada sandstone) and for model layer 5 (representing the Navajo sandstone throughout most of the model and the Kayenta and Wingate in the southern part of the model where the Navajo and then the Kayenta thin to zero thickness (i.e., pinch out)). In addition, a map with embedded hydrographs (termed a "hydrographic map" in this report) provides simulated water levels for selected wells that are completed in layer 5 for the entire period of the model.

Maps of simulated drawdown are also presented for the period between 1956 and selected times, for layers 3 and 5. Times of particular interest are:

1. the end of 2005 (when pumping from the PWCC wellfield was significantly reduced);
2. the end of 2044 (the end of mining considered by the Life of Mine Plan Revision); and
3. the end of 2057 (the end of pumping to support reclamation activities).

Drawdown maps are provided for Community-and-PWCC, and PWCC-Only results. The Community-Only simulation was performed solely for the purpose of calculating the PWCC-Only results, and is not presented.

Water Levels

Figure 2a through 2d provides the simulated water levels for layer 3 (representing the D aquifer) and layer 5 (representing the N aquifer) at different times. These results are for the Community-and-PWCC simulation. Figure 2a shows simulated water levels representing the period before there was significant pumping from the aquifer, or at the beginning of 1956 as designated in the model. As would be expected, there are no indications of drawdown occurring at the communities or at the PWCC leasehold. In the N aquifer (represented by Layer 5, Figure 2a-b), the highest water levels are on Shonto Plateau. Water levels are also high in the southeastern part of the model, where the N aquifer comprises the Kayenta and Wingate where the more permeable Navajo sandstone is not present. There is a groundwater divide in the approximate area of Forest Lake. To the northeast, water flows toward Chinle Wash. Discharge of groundwater into Moenkopi Wash has a considerable effect on water levels and directions of flow. In layer 3 (representing the D aquifer, Figure 2a-a), water levels are highest in the southeast, and flow is to the north toward Chinle Wash and to the west. The effects of discharge into several of the washes is apparent in the contour lines which indicate flow to these washes. The calculated drawdown, which is discussed in the next section, is represented by the change from this dataset.

Peabody began pumping from the N and D aquifers in 1968, and was pumping at approximately 4,400 af/y until the end of 2005, when transport of coal through the coal slurry pipeline ended. Beginning in 2006, the rate of pumping from the PWCC decreased markedly, to approximately 1,225 af/y over the period 2006 through 2010 (Macy and others, 2012). Water levels in the vicinity of the leasehold began to recover after this reduction in annual pumping. Thus, the water levels at the end of 2005 represent the greatest effect of PWCC's pumping on water levels near the well field. The simulated water levels at the end of 2005 are shown in Figure 2b. The effect of drawdown in both the D and N aquifers at the PWCC wellfield is apparent (Figures 2b-a and 2b-b, respectively). While there are differences in water levels caused by pumping, the general directions of flow are similar to those in 1956.

For this evaluation, pumping at the leasehold was simulated at a rate of 1,500 af/y until the end of 2044. The rates of pumping at the communities were simulated as described above, and increase as the estimated population increases. Figure 2c shows the simulated water levels at the end of 2044. At this time, water levels at the leasehold are higher than they were in 2005. Water levels in the vicinity of the Hopi communities in the southern part of the groundwater basin (referred to as the Hopi Villages in this report) have declined during this period. Distinct drawdown cones have developed in the southeastern part of the model. In the D aquifer (Figure 2c-a), the drawdown at the PWCC wellfield has decreased as a result of the decreased pumping rate.

A period of 13 years, during which pumping is simulated from the leasehold at 600 af/y, is planned for reclamation activities to be performed and bond release to occur. There is still a cone of depression at the leasehold in 2057, but it is smaller than at the end of 2044 (Figure 2d-a). Water levels have decreased near the Hopi Villages from their levels in 2044.

In summary, the simulated water levels show an increase between 2005 and 2057 in the area around the leasehold. The increase in pumping rate at the communities has resulted in lower water levels in the communities more distant from the leasehold. The general patterns of flow have changed little in the D and N aquifers, except close to the various pumping centers. However, it is difficult to evaluate the details on the water-level maps. The changes in water levels are more apparent in the drawdown maps presented in the next section.

Drawdown

Pumping of groundwater from an aquifer causes water levels to decline as water is removed from storage. This decline is termed "drawdown". Attachment II provides the simulated drawdown for the Community-and-PWCC simulation for selected wells. In this table, values are provided for years in which observations were available during the period 1956 through 2012, and for all years from 2013 through 2057.

Figure 3 shows simulated water levels for the Community-and-PWCC simulation and the Community-Only simulation in selected wells in layer 5 (representing the N aquifer). The time scale ranges from the start of the simulation in 1956 to 2057. Note that the vertical scale is not the same on all the plots, depending on the amount of drawdown that is simulated. The points between 1956 and 2012 represent times where there were water-level measurements. From 2013 to 2057, the points are provided yearly. The difference between the two sets of points (blue for Community and PWCC, and black for Community Only) on each plot is the result of pumping at the PWCC wellfield.

Near the PWCC leasehold, the drawdown caused by PWCC pumping is the greatest. At the two PWCC observation wells near their production wells (NAV3OBS, NAV5R, and NAV6OBS), the effects of changes in pumping rate at the end of 2005 and 2044 are very evident in the blue curves. The black curves show the effect of Tribal pumping alone on water levels at the locations of these wells, causing approximately one hundred feet of drawdown. The diminishing differences between the blue and black curves for these wells show that, while a small amount of residual drawdown remains, water levels have substantially recovered from the effects of pumping at the PWCC wellfield.

At BM3, in the community of Kayenta, approximately 300 feet of drawdown is predicted to occur between the time that the first water level measurements were collected and the end of 2057. There is little difference between the simulated water levels between the Community-and-PWCC and Community-Only simulations, indicating that the impact of PWCC pumping in this well is minimal. There is approximately 200 feet of drawdown at 8T-541 during this time period, nearly all caused by community pumping.

Northeast of the PWCC wellfield, the effects of pumping from the PWCC wellfield are more apparent. At BM2, for example, PWCC pumping had caused approximately 50 feet of drawdown at the end of 2005, and the PWCC-caused drawdown is predicted to decrease to approximately 30 feet in 2057. The model predicts that the total drawdown at BM2 between the mid-1960s and 2057 is approximately 100 feet.

At Forest Lake NTUA-1 (4T-523), the maximum drawdown caused by PWCC pumping between approximately 1980 and 2057 was simulated to be nearly 200 feet, with water levels rebounding from the reduction in PWCC pumping rather quickly. In 2057, the PWCC-caused drawdown in this well is predicted to be approximately 50 feet. Drawdown caused by PWCC pumping should continue to diminish, while community-caused drawdown is predicted to continue increasing.

In the Hopi Village area, the maximum drawdown caused by PWCC pumping is calculated to be 20 to 25 feet, in approximately 2010, for example in the wells at Kykotsmovi.

Near Tuba City, the model predicts 100 to 200 feet of drawdown by 2057, varying by well. The effects of PWCC pumping on the water levels are very small, if present at all. No effects of PWCC pumping are being predicting at the location of the Rare Metals site.

To the northwest of the leasehold about 10 miles, the model predicts small amounts (approximately 10 feet by 2057) of PWCC-caused drawdown (see wells BM4, 2K-301, and 2T-502.

In summary, the model predicts varying amounts of PWCC-caused drawdown in the area, with the differences being a function of the distance from the PWCC-wellfield and whether the location is in the confined or unconfined area. In the confined area, the greatest PWCC-caused drawdown occurred a short time after the end of 2005, when the pumping from the PWCC wellfield was decreased by about 60%.

The maps in Figure 4 and 5 show the simulated drawdown in layers 5 (N aquifer) and 3 (D aquifer), respectively, at different times. The simulated drawdown in layer 5 is shown in Figures 4a through 4c. Each page contains two maps. The upper map shows the drawdown for the Communities-and-PWCC simulation, calculated by subtracting the simulated water levels for a particular time from the pre-production water levels (at the beginning of 1956). The area affected by drawdown is typically called a drawdown cone, even though the area is not necessarily cone-shaped. Separate drawdown cones can be seen the different pumping centers, and several cones have coalesced.

The lower map is the PWCC-Only drawdown which was calculated by subtracting the Community-Only results from the Community-and-PWCC results. This shows only the drawdown cone attributed to pumping at the PWCC wellfield.

The results for the N aquifer at the end of 2005 are presented in Figure 4a. The upper map shows an areally extensive drawdown associated with the PWCC wellfield, and smaller cones of depression around Tuba City/Moenkopi, Shonto and Dennehotso. [There are small areas of drawdown indicated in areas where there is no or limited pumping. These are likely the result of small computational errors with the non-linear model and non-linear boundary conditions.] The difference in the extent of effect (the size of the cone) is largely determined by whether the location is under confined or unconfined conditions. In the central part of the Black Mesa basin, the N aquifer is confined, meaning that the aquifer is overlain by lower permeability rocks and the water levels are higher than the top of the aquifer. In the confined area, water can be released from storage only by expansion of the water or reduction of the pore space in the rocks. The aquifer is unconfined where the water level is below the top of the aquifer. In the unconfined area, water can be released by draining of the rock's pore space. As a result, pumping an amount of water causes greater drawdown in confined areas than in unconfined areas, and the drawdown cones in confined areas are larger than those in unconfined areas.

The lower map in Figure 4a shows the extent of drawdown caused by pumping at the PWCC wellfield, as of the end of 2005. Drawdown is greatest near the wellfield, and extends out beyond the Hopi Villages. "The extent of drawdown" is defined by the one-foot drawdown contour in this discussion. The extent of drawdown from this pumping is very similar to the confined area as portrayed by the USGS in its annual monitoring reports (for example, Macy and others, 2012). One exception is at Rough Rock, which the USGS includes in the unconfined area. Re-examination of the records at this well indicated that the aquifer is confined at this location. The model calculated small amounts of PWCC-caused drawdown between Shonto and Tsegi, and east of Tuba City, that are likely the results of the non-linear model and boundary conditions. Drawdown caused by PWCC beneath the leasehold (Figure 4a-b) is less than that in the Community-and-PWCC simulation (Figure 4a-a), indicative of local community pumping.

Recall that beginning in early 2006, the rate of pumping was significantly decreased, and the simulated PWCC pumping out to 2044 remained less than the pre-2006 rates. As a result, the drawdown at the leasehold due to both Community-and-PWCC pumping has decreased (Figure 4b). The extent of PWCC-caused drawdown has increased slightly. The localized drawdown cones around the communities are more defined than in 2005. Drawdown due to community pumping is predicted to extend over much of the Shonto Plateau.

Figure 4c shows the simulated drawdowns in 2057, at the end of the pumping (at 600 af/y) to support reclamation. Because pumping was occurring at the PWCC wellfield up until 2057, there is still a drawdown cone with slightly over 100 feet of PWCC-caused drawdown in the PWCC wellfield. The PWCC-drawdown at the Hopi Villages has decreased to less than 20 feet. The previously-observed growth of the PWCC extent of drawdown appears to have stopped, or at least greatly slowed.

Figure 5 presents the drawdown predictions for layer 3, which represents the D aquifer. Figures 5a through 5c represents the same years as Figures 4a through 4c did. In 2005 (Figure 5a), drawdown in layer 3 (Entrada sandstone) is simulated to exceed 200 feet in the PWCC leasehold. Several of the PWCC production wells are completed in the D aquifer as well as the N aquifer. [Note: there are very few water-level data in the layer 3 with which to calibrate the model. Well 4T-402 is a well completed in the Dakota, layer 1. Based on a water-level measurement in 2013, the drawdown in layer 1 is believed to be in the range of 10 to 20 feet.] The extent of drawdown caused by PWCC pumping is simulated as extending to the Hopi Villages (Figure 5a-b). There is also drawdown near Polacca and Bacavi caused by local pumping.

The simulated drawdown in layer 3 in 2044 has decreased at the PWCC wellfield, and has increased near the Hopi Villages from both local and PWCC pumping. The predicted extent of drawdown increased slightly between 2005 and 2044. Thirteen years later (2057, Figure 5c), the drawdown caused by PWCC pumping has changed little from the 2044 values, but the effects from community pumping have increased.

Simulated drawdown caused by PWCC pumping near the PWCC wellfield in the N aquifer was greatest at the end of 2005. The simulated pumping in later years was less than in the period before 2006, and water levels near the leasehold have been recovering. The model predicts that community-caused drawdown will prevent the full recovery of water levels at the wellfield. The PWCC-caused drawdown extends throughout the confined zone of the aquifer. The extent of drawdown (defined by the 1-foot contour line) is predicted to expand very slightly by 2044, but its growth is predicted to stop or substantially slow by 2057. The effects of community pumping are predicted to continue to grow as the effects from pre-2005 PWCC pumping continue to diminish.

The amounts of drawdown in the D aquifer are uncertain because of a near-total lack of data with which to calibrate the model to drawdown in the D aquifer. The model simulates more than 200 feet of drawdown in layer 3 at the PWCC wellfield with widespread drawdown from earlier PWCC pumping, and future community pumping. The collection of additional water-level data would be useful for determining the extent of pumping effects in the D aquifer.

Stream and Spring Flow

Simulated streamflows and the amounts of change caused by pumping by PWCC are shown in Figure 6. There are very small changes in the simulated streamflow during the simulations. The flow in Polacca Wash is predicted to be affected the most, with about equal contributions from community and PWCC pumping. At other locations, the simulated streamflows are relatively unaffected. At Laguna Creek and Chinle Wash, the PWCC-induced changes are observable on the plots, but small. Similarly, there is a small effect on the flow at the Moenkopi Wash and Dinnebito Wash gages.

The effects on spring discharge are shown on Figure 7. The largest relative effects are on the discharge at Burro Spring. There are both community and PWCC effects simulated at this location. It is not clear whether there have been observed declines in flow at Burro Spring, because of its low flow and limitations in the precision of the measurements. The model appears to overestimate the effect of pumping at this spring during the calibration period, and the predicted declines may be too high. Continued monitoring with a more precise method is appropriate.

The model predicts that the flow at Pasture Canyon will continue to decrease at increasing rates, due to local pumping. PWCC pumping has no effect on the discharge at Pasture Canyon.

Similarly, the model predicts that the flow from Susunova Spring is likely to decline because of community pumping. The model underpredicts the flow and rate of decline from this spring because of the complex stratigraphy relative to the model layers. Pumping from the PWCC wellfield does not affect this spring.

At the Unnamed Spring near Dinnehotso, the model predicts that neither community nor PWCC pumping will affect flow from this spring.

Effects on Pumping Rates

The model uses the Multinode Well package, which provides a file from which the simulated pumping rates can be extracted. These rates can differ from the input pumping rates if model cells containing pumping wells dry up. [The MNW mode in which the pumping rate is gradually decreased as a result of water-level declines was not used in these simulations.] The simulated pumping rates at the communities and at the PWCC wellfield were compared against the input pumping rates. The only area where these model simulations predict that the aquifer cannot sustain the input pumping rates is at Oraibi. In 2051, the model turns off the well at this location. As water levels recover in response to the cessation of pumping, the model is able to turn the pumping back on again temporarily. This pattern is repeated until the end of the simulation, resulting in an average production rate of about 1/3 that input into the model over the period 2051 through 2057. The production rates at the other communities were not shown to be impacted by this simulation.

Summary and Conclusions

The updated model of the Black Mesa Basin was used to predict the effects of pumping of groundwater from the N and D aquifers at 1,500 af/y through 2044 and at 600 af/y through 2057. Pumping at the communities was assumed to increase in accordance with population estimates provided by the Hopi Tribe and Navajo Nation and a per capita rate of 100 gpcpd. In order to evaluate the effects of pumping by PWCC, the effects of pumping by the communities and by windmills were analyzed separately. Differences between these two simulations indicate the effects of pumping at the PWCC wellfield. The prediction found that in the N aquifer:

a. Throughout most of the confined area, the greatest effect on water levels occurred as the result of pumping at the PWCC wellfield prior to 2006. Because of the lower rate of current and future pumping at the wellfield, the effects of PWCC pumping are diminishing throughout most of the basin.
b. In unconfined areas, the effects of the PWCC pumping are still increasing. The extent of drawdown is primarily determined by the boundary between confined and unconfined conditions in the N aquifer. The simulation predicts that the drawdown extent will slowly increase between 2005 and 2044, but appears to stop expanding between 2044 and 2057.
c. With the reduction of pumping at the PWCC wellfield and increase in pumping rates at the communities, the community pumping will have increasing effect and PWCC will have diminishing effect.
d. The greatest effect on surface water flow is predicted to occur along Polacca Wash, and will be the result of both community and PWCC pumping in approximately equal amounts. Effects on flow in other washes are predicted to be minimal.
e. The greatest effect on spring discharge is predicted to be at Pasture Canyon, solely as the result of local community pumping. The model predicts that the discharge from Burro Spring will decline as a result of both community and PWCC pumping. The model appeared to overpredict the impact of pumping at Burro Spring over the calibration period (through 2012). The precision of the previous discharge measurements makes it difficult to determine

whether any effects have occurred, but the model simulated a noticeable decline over the calibration period.

f. The predictive run did not indicate any limitations on the ability of the numerous community pumping wells to produce the rate of water as provided as model input, except at Oraibi. In 2052, the model began to reduce the rate of pumping from the well there. Simulated water levels near this well indicate that the reduction in pumping from this well is primarily the result of local community pumping, but pumping from the PWCC wellfield also was a contributor. The diminishing effect from pumping at the PWCC wellfield prior to 2006 will decrease the future contribution from the wellfield.

Some of the wells at the PWCC wellfield also produce water from the D aquifer, and some wells near the Hopi Villages also produce water from this aquifer. Because there is very limited monitoring in the D aquifer, the uncertainty in the model with respect to predicting the effects of pumping from the D aquifer is high. The model predicts that drawdown in layer 3 (Entrada sandstone) was greater than 200 feet in 2005, but in the Dakota sandstone at the top of the D aquifer, drawdown was approximately 10 to 20 feet. The approximately 60% reduction in pumping at the PWCC wellfield at the beginning of 2006 is resulting in recovery from the effects of pre-2006 pumping. The increasing pumping from the D aquifer near the Hopi Villages is predicted to cause drawdown to increase throughout the central part of the D aquifer.

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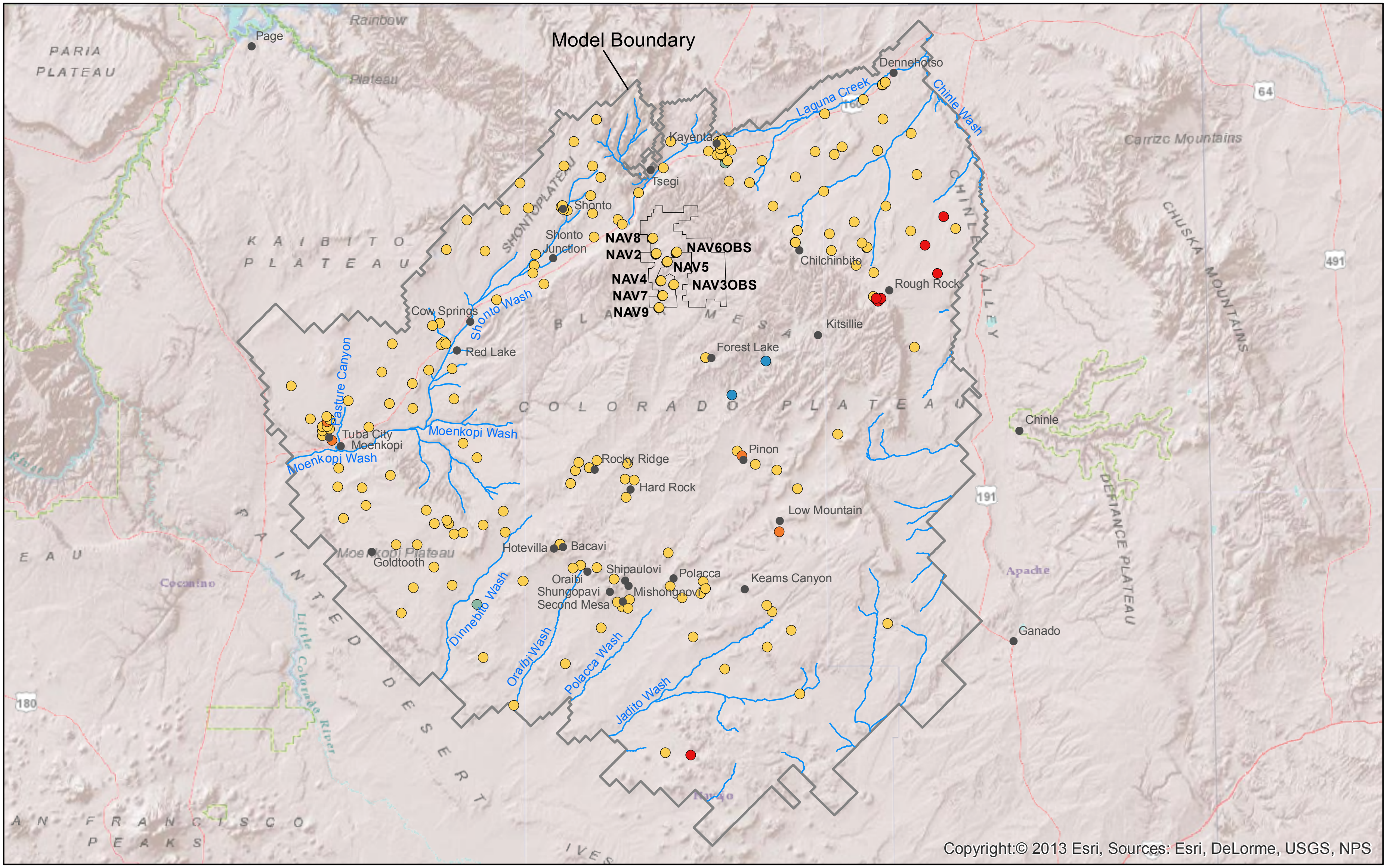
FIGURES



Model Layer & Stratigraphic Units

- 1 - Dakota
- 3 - Entrada
- 4 - Carmel
- 5 - Navajo, Kayenta, & Wingate
- 6 - Kayenta & Wingate
- 7 - Wingate

N

0 5 10 20 30 40
SCALE IN MILES

TITLE:
Locations of Production Wells and Windmills

TETRA TECH

APPROVED	RW	FIGURE
DRAFTED	LD	1
PROJECT#	117-2608008	
DATE	2-10-14	

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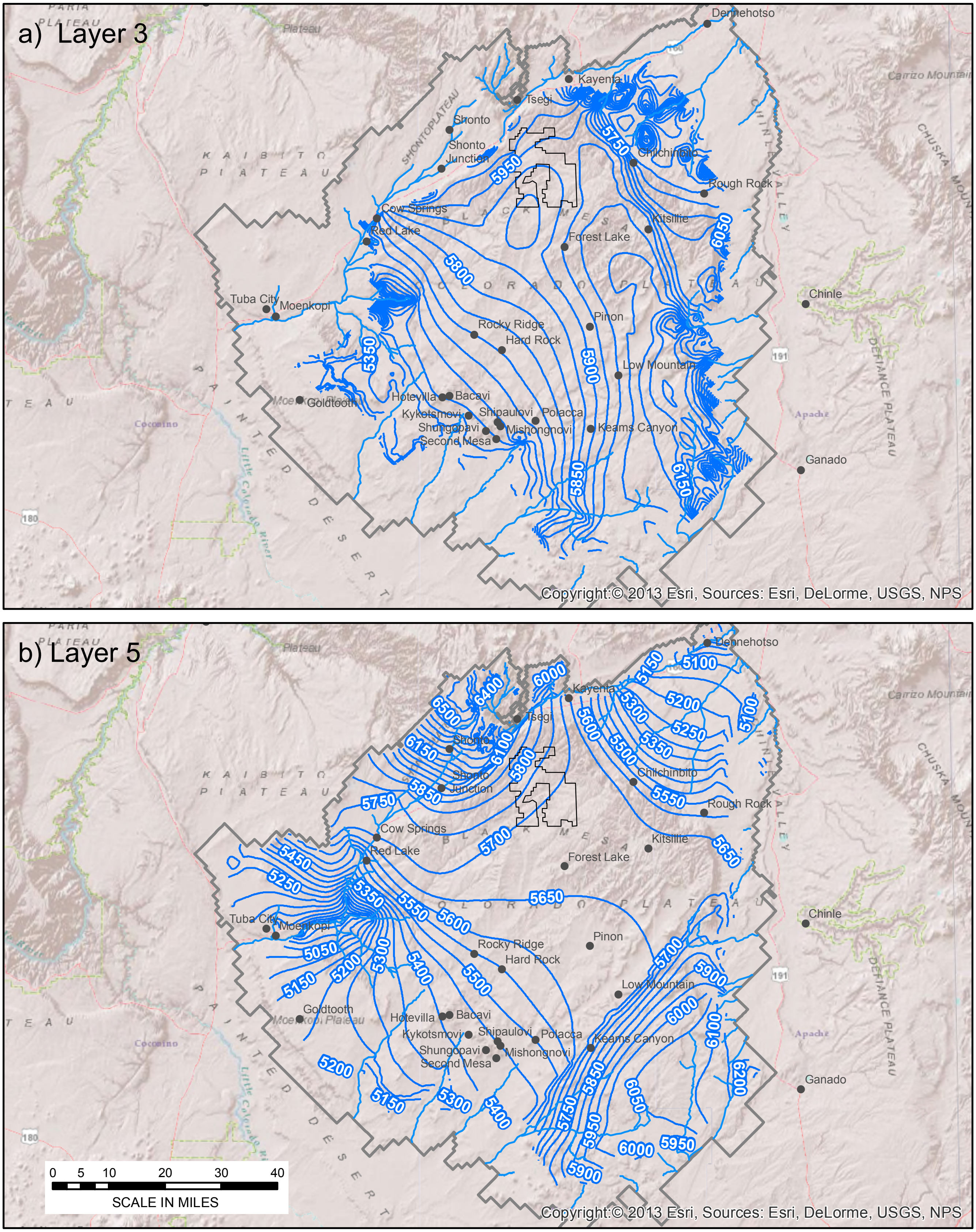


Legend

Water Level Elevation (ft)
Contour interval is 50 feet.

N

TITLE:

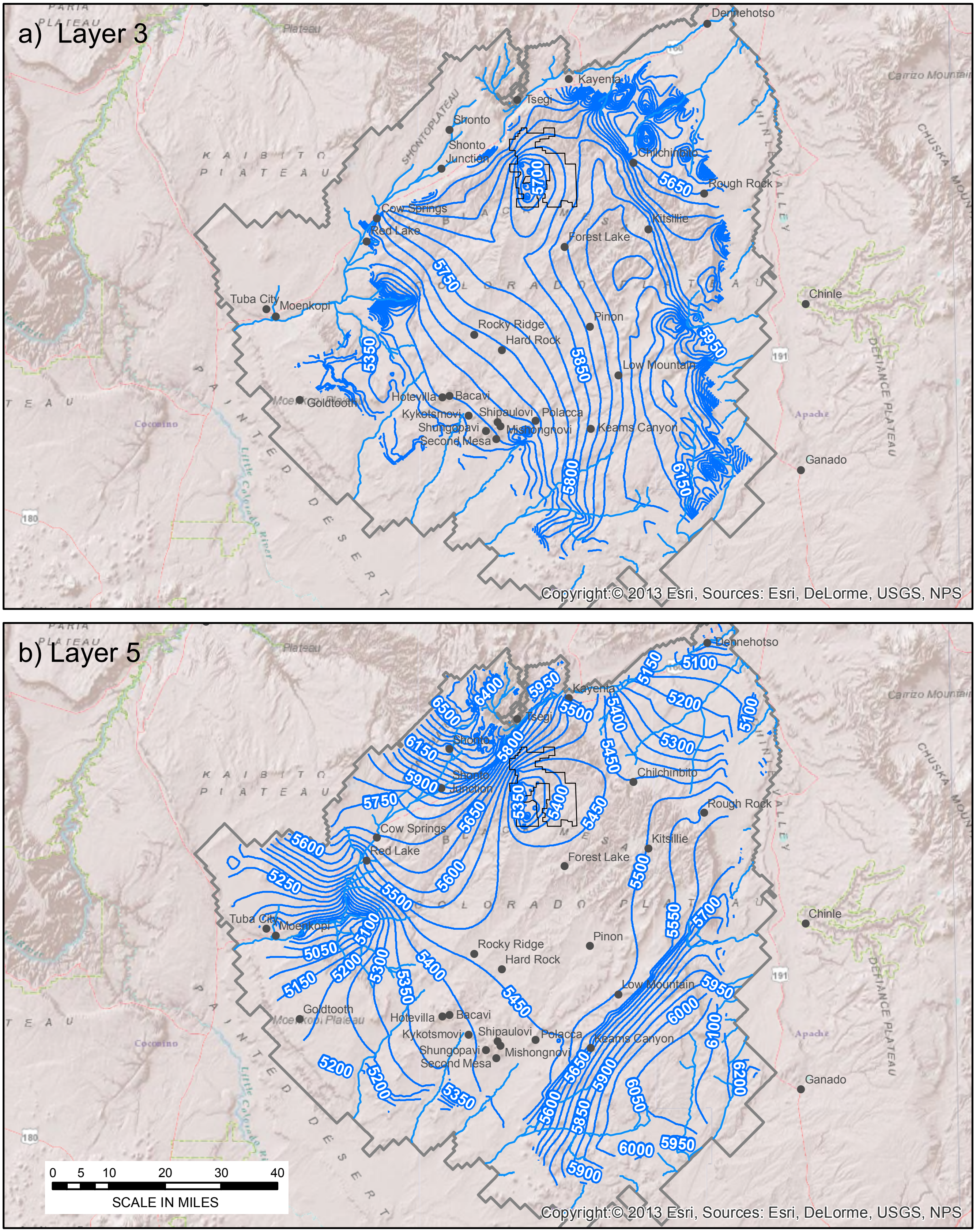
Simulated Water Levels in Layers 3 and 5
1956

TETRA TECH

APPROVED	RW
DRAFTED	LD
PROJECT#	117-2608008
DATE	2-6-14

FIGURE 2a

T:\PEABODY\GIS\PHC Report 2014\mxd\Fig_2a_Hds_1956.mxd



Legend

Water Level Elevation (ft)
Contour interval is 50 feet.

N

TITLE:

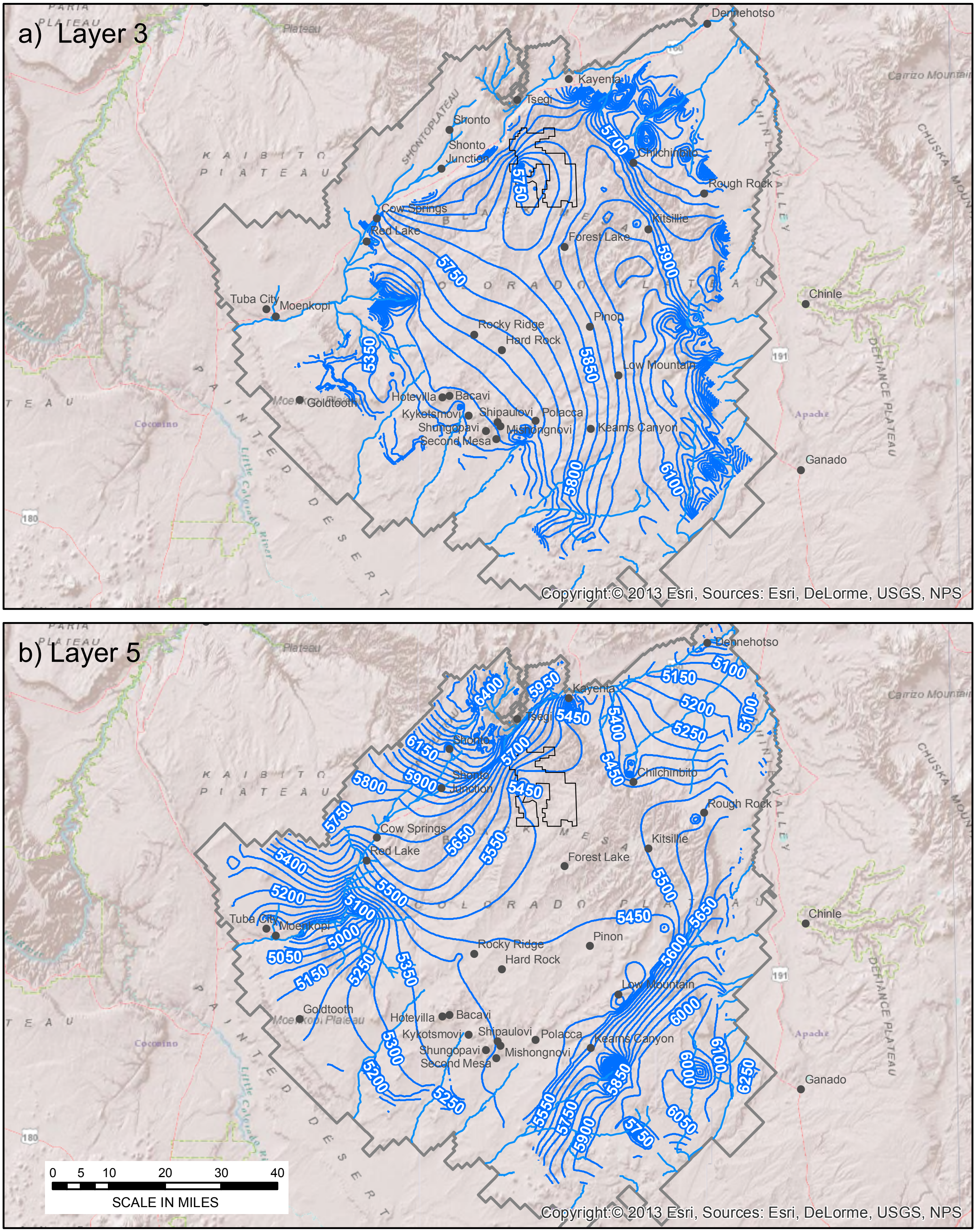
Simulated Water Levels in Layers 3 and 5
2005

TETRA TECH

APPROVED	RW
DRAFTED	LD
PROJECT#	117-2608008
DATE	2-6-14

FIGURE
2b

T:\PEABODY\GIS\PHC Report 2014\mxd\Fig_2b_Hds_2005.mxd



Legend

Water Level Elevation (ft) Contour interval is 50 feet.

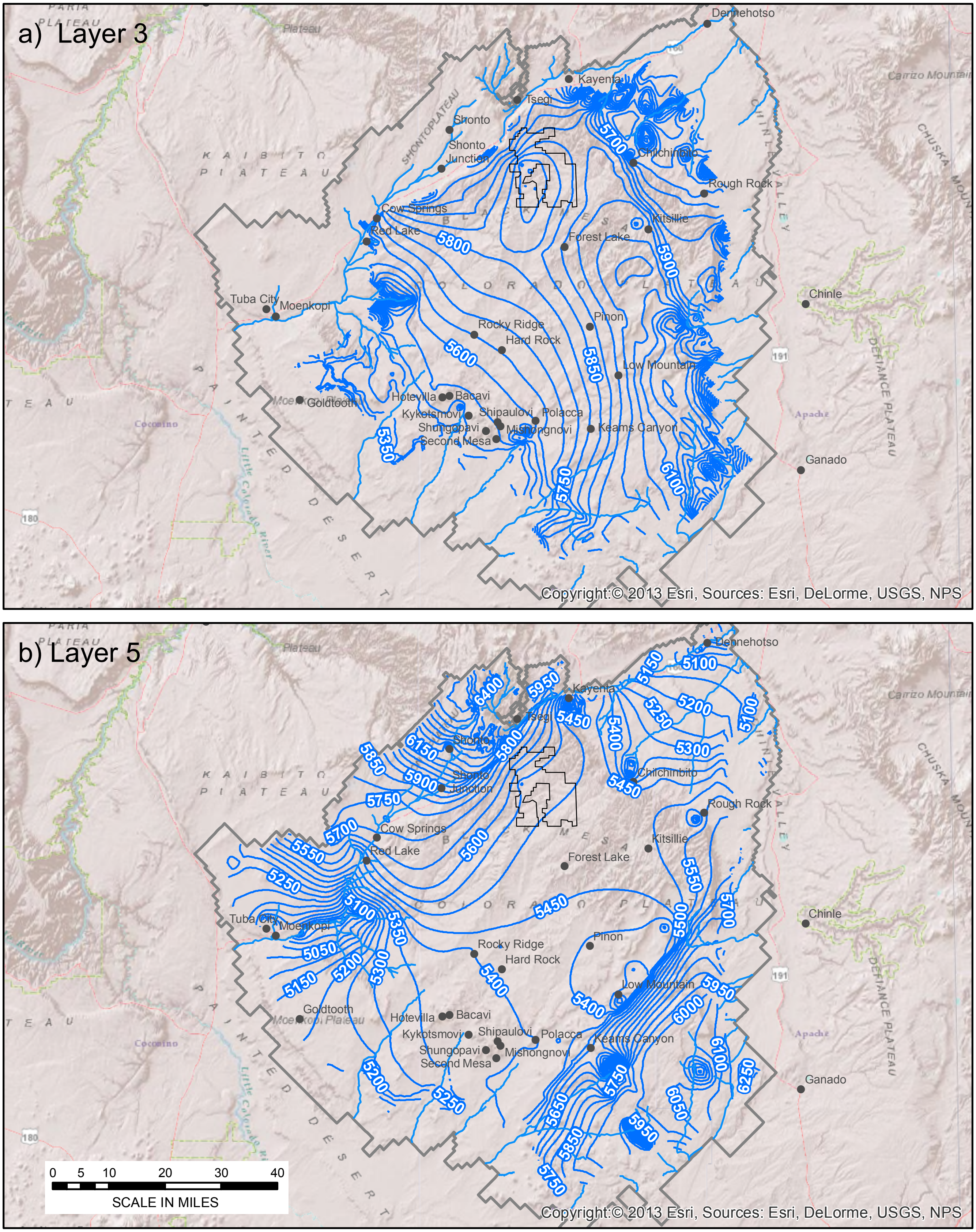
N

TITLE: **Simulated Water Levels in Layers 3 and 5 2044**

TETRA TECH

APPROVED	RW	FIGURE	
DRAFTED	LD	2c	
PROJECT#	117-2608008		
DATE	2-6-14		

T:\PEABODY\GIS\PHC Report 2014\mxd\Fig_2c_Hds_2044.mxd



Legend

Water Level Elevation (ft)
Contour interval is 50 feet.

N

TITLE:

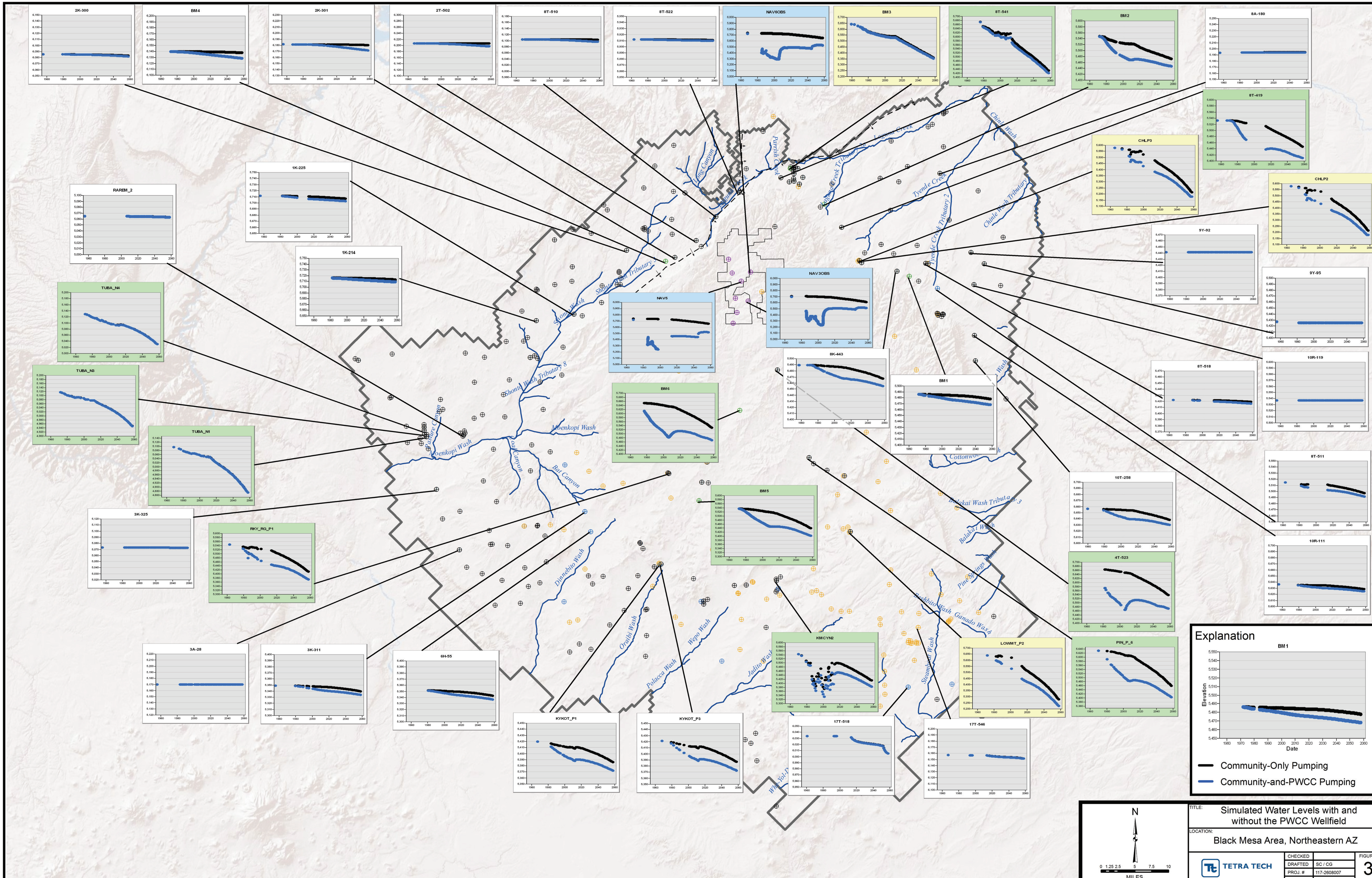
Simulated Water Levels in Layers 3 and 5
2057

TETRA TECH

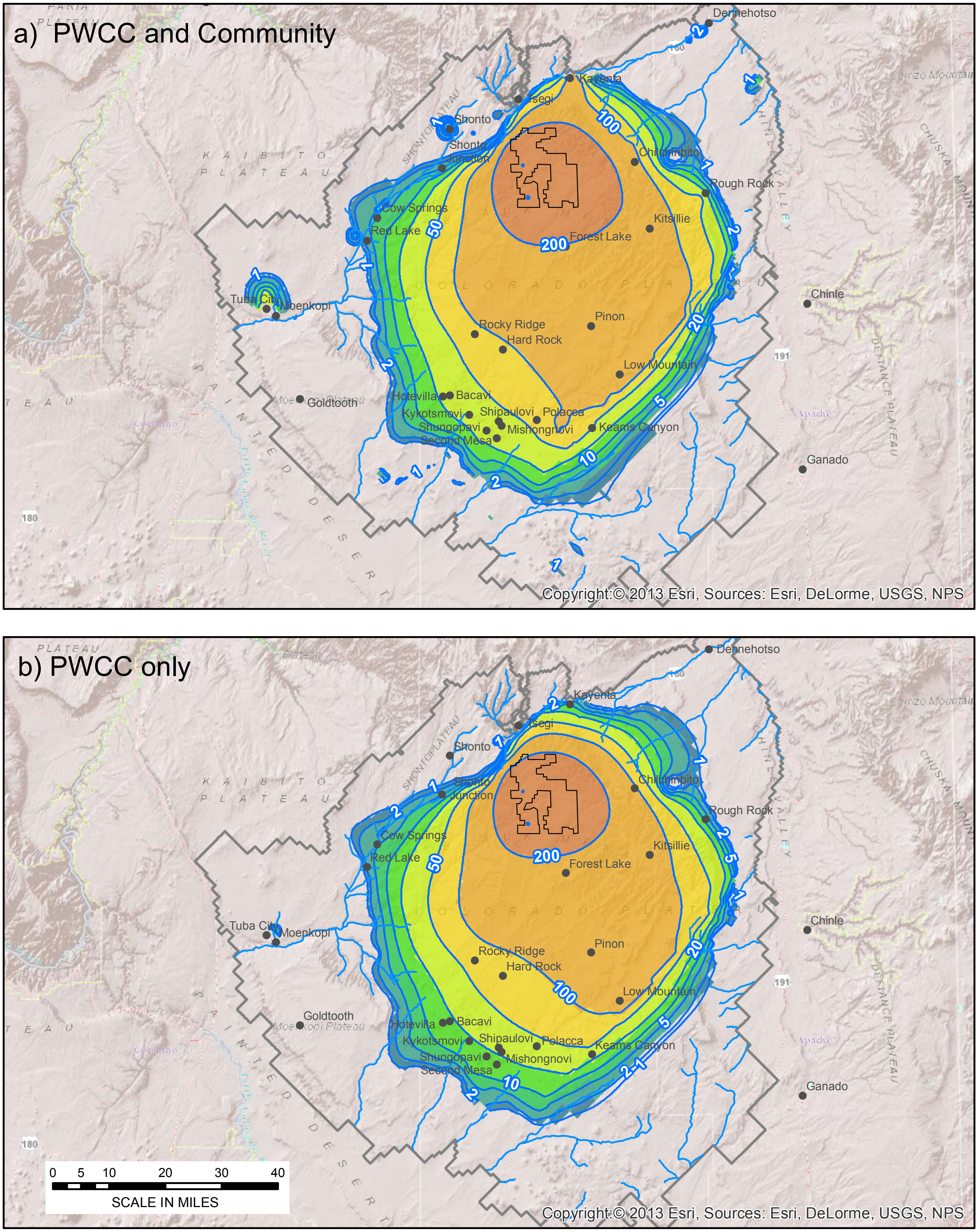
APPROVED	RW
DRAFTED	LD
PROJECT#	117-2608008
DATE	2-6-14

FIGURE
2d

T:\PEABODY\GIS\PHC Report 2014\mxd\Fig_2d_Hds_2057.mxd



2K-300
BM4
2K-301
2T-502
8T-510
8T-522
NAV6OBS
BM3
8T-541
BM2
8A-180
8T-419
CHLP3
CHLP2
1K-225
RAREM_2
1K-214
NAV5
NAV3OBS
9Y-92
9Y-95
TUBA_N4
TUBA_N3
TUBA_N1
8K-443
BM6
BM1
8T-518
10R-119
8T-511
10T-258
BM5
3K-325
RKY_RG_P1
4T-523
10R-111
3A-28
3K-311
6H-55
KMCYN2
LOWMT_P2
PIN_P_6
KYKOT_P1
KYKOT_P3
17T-518
17T-546
Moenkopi Wash
Dinnebito Wash
Oraibi Wash
Polacca Wash
Wepo Wash
Jadito Wash
Chinle Wash
Laguna Creek
Tyende Creek
Pine Springs Wash
Ganado Wash
Balakai Wash
Cottonwood Wash
Bai Canyon
Long Canyon
Explanation
BM1
Elevation
Date
Community-Only Pumping
Community-and-PWCC Pumping
N
0 1.25 2.5 5 7.5 10
MILES
TITLE:
Simulated Water Levels with and without the PWCC Wellfield
LOCATION:
Black Mesa Area, Northeastern AZ
TETRA TECH
CHECKED
DRAFTED SC / CG
PROJ. # 117-2608007
DATE 02/06/2014
FIGURE
3



Drawdown (ft)

- 501 - 1000
- 201 - 500
- 101 - 200
- 51 - 100
- 21 - 50
- 11 - 20
- 6 - 10
- 3 - 5
- 2
- 1

N

TITLE:

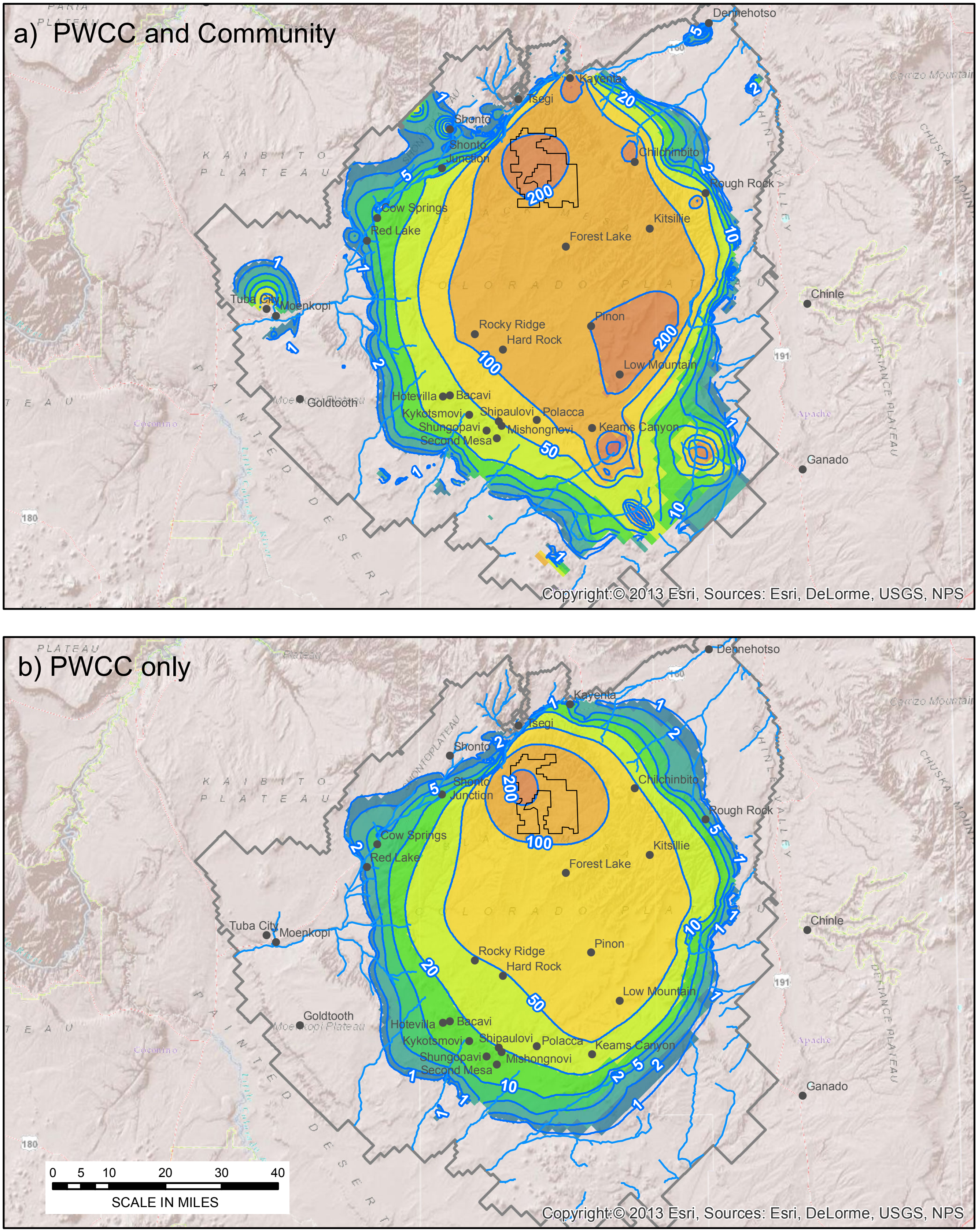
Simulated Drawdown in Layer 5
2005

TETRA TECH

APPROVED	RW
DRAFTED	LD
PROJECT#	117-2608008
DATE	2-6-14

FIGURE 4a

T:\PEABODY\GIS\PHC Report 2014\mxd\Fig_4a_Ddn_L5_2005.mxd



Drawdown (ft)

- 501 - 1000
- 201 - 500
- 101 - 200
- 51 - 100
- 21 - 50
- 11 - 20
- 6 - 10
- 3 - 5
- 2
- 1

N

TITLE:

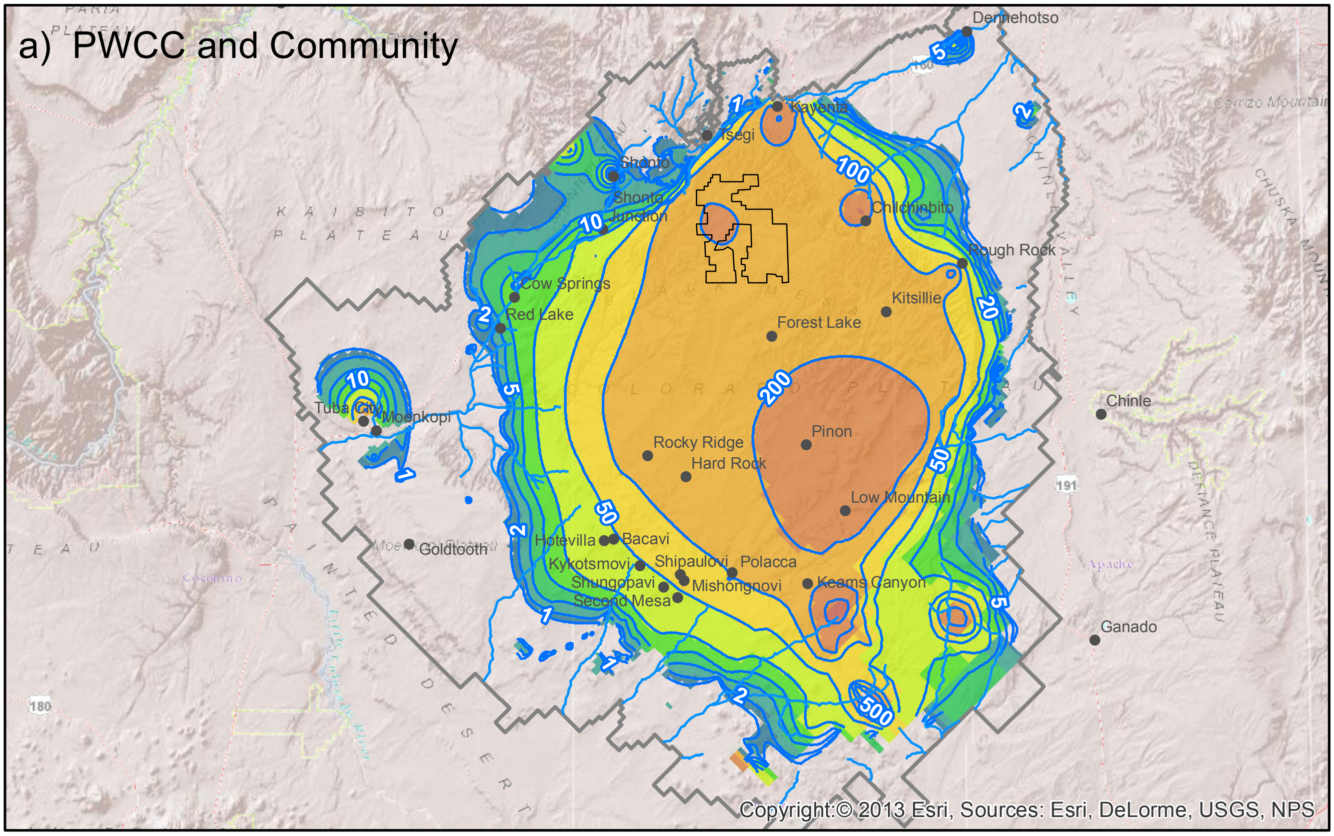
Simulated Drawdown in Layer 5
2044

TETRA TECH

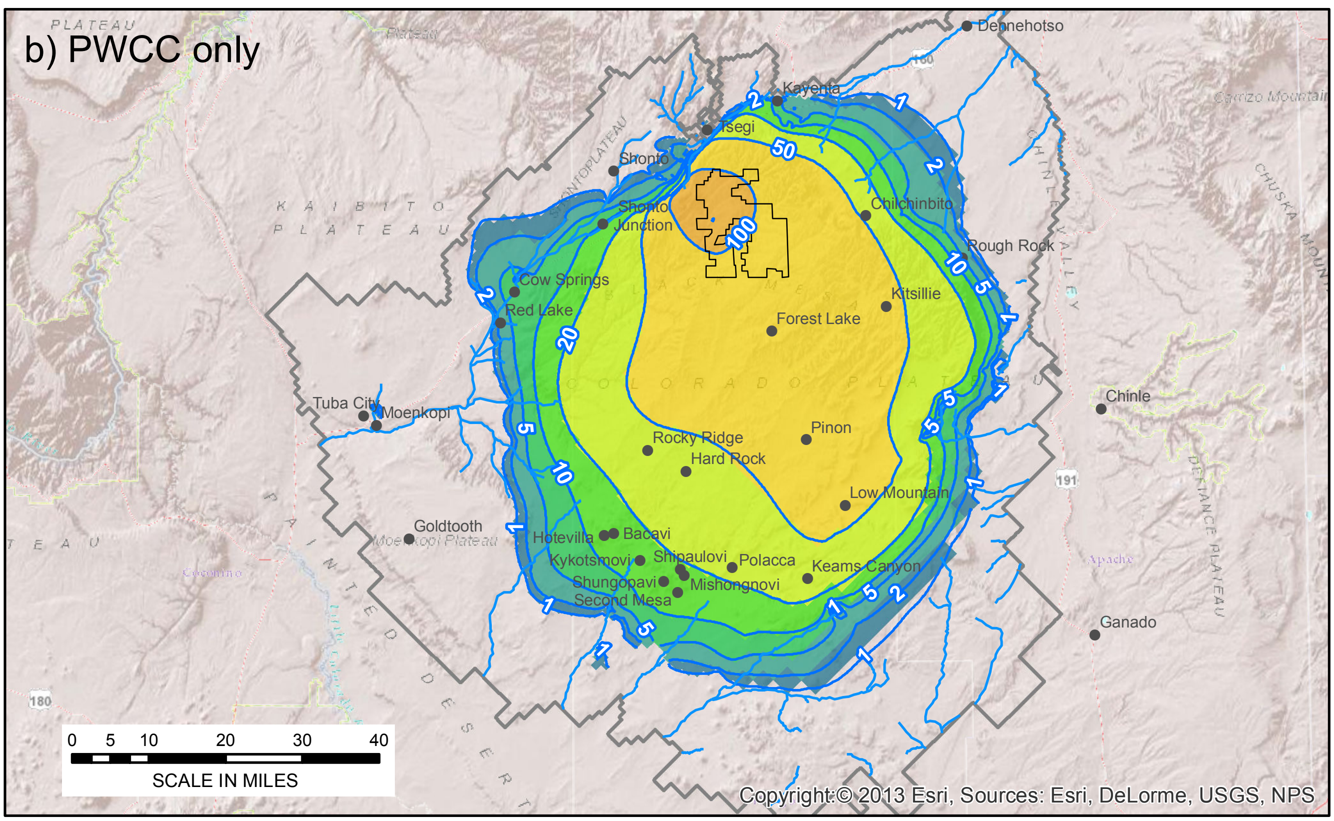
APPROVED	RW	FIGURE
DRAFTED	LD	4b
PROJECT#	117-2608008	
DATE	2-6-14	

T:\PEABODY\GIS\PHC Report 2014\mxd\Fig_4b_Ddn_L5_2044.mxd

a) PWCC and Community



b) PWCC only



Drawdown (ft)

- 501 - 1000
- 201 - 500
- 101 - 200
- 51 - 100
- 21 - 50
- 11 - 20
- 6 - 10
- 3 - 5
- 2
- 1

N

TITLE:

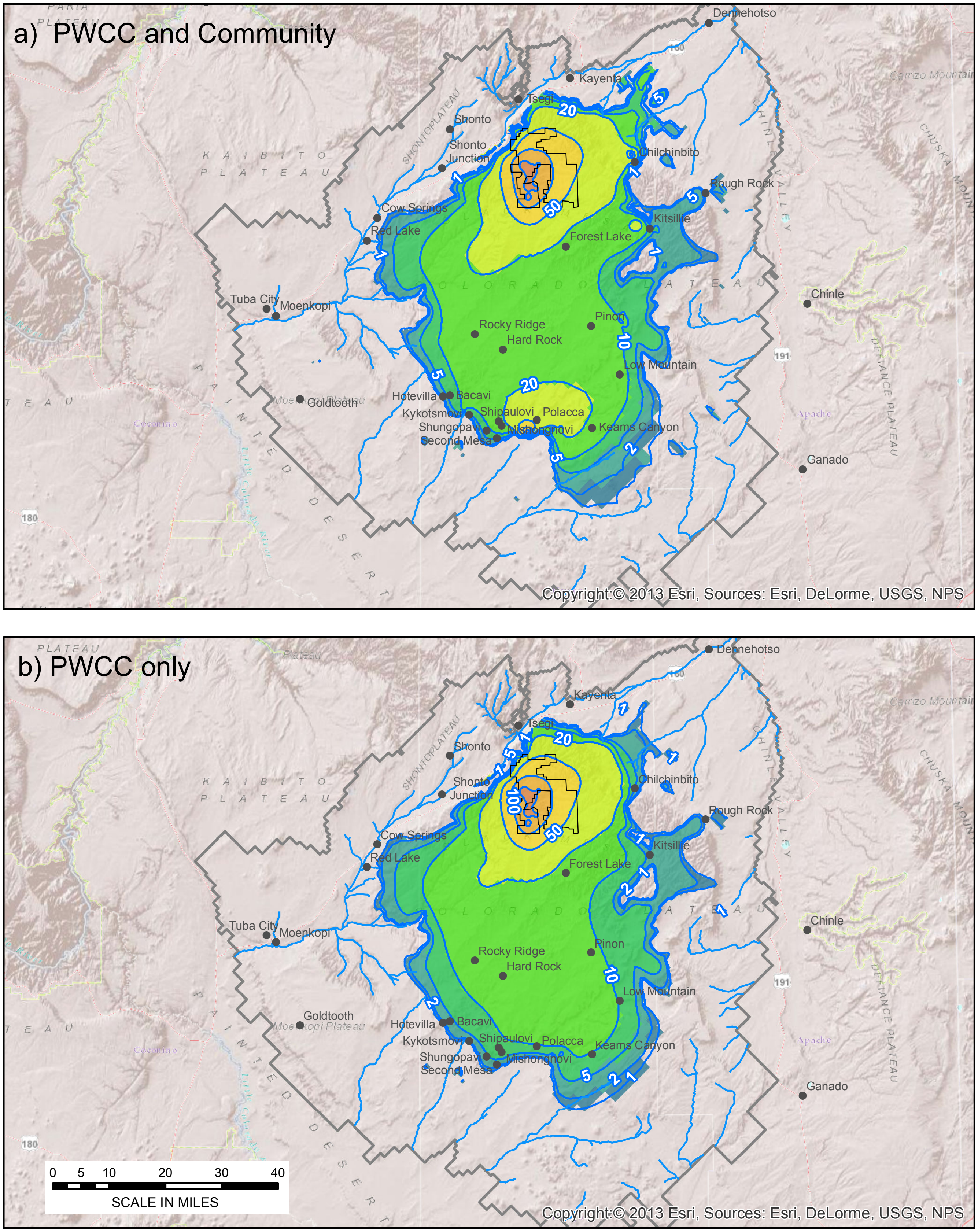
Simulated Drawdown in Layer 5
2057

TETRA TECH

APPROVED	RW
DRAFTED	LD
PROJECT#	117-2608008
DATE	2-6-14

FIGURE 4c

T:\PEABODY\GIS\PHC Report 2014\mxd\Fig 4c Ddn L5 2057.mxd



Drawdown (ft)

- 501 - 1000
- 201 - 500
- 101 - 200
- 51 - 100
- 21 - 50
- 11 - 20
- 6 - 10
- 3 - 5
- 2
- 1

N

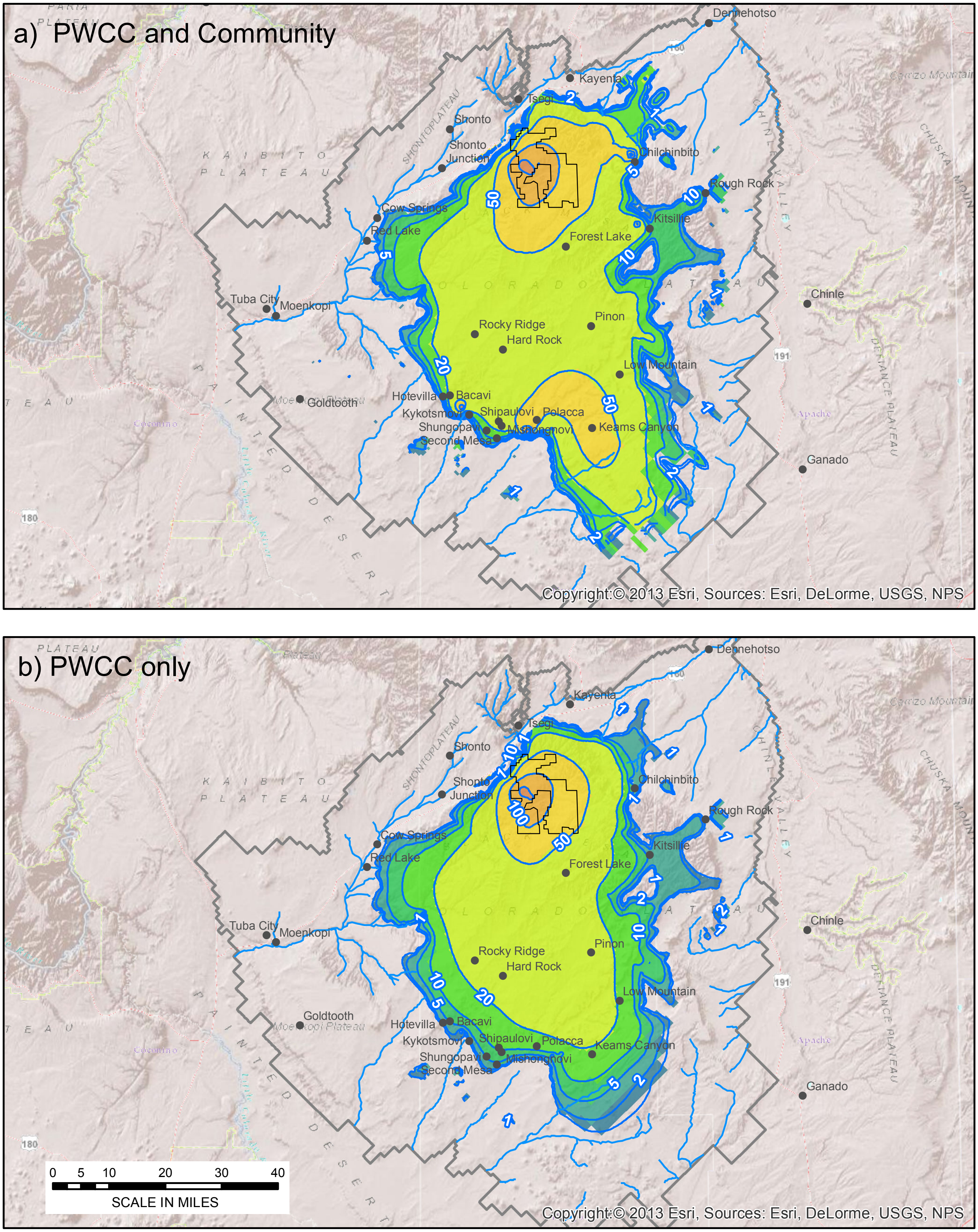
TITLE:

Simulated Drawdown in Layer 3
2005

TETRA TECH

APPROVED	RW	FIGURE
DRAFTED	LD	5a
PROJECT#	117-2608008	
DATE	2-6-14	

T:\PEABODY\GIS\PHC Report 2014\mxd\Fig_5a_Ddn_L3_2005.mxd



T:\PEABODY\GIS\PHC Report 2014\mxd\Fig_5b_Ddn_L3_2044.mxd

Drawdown (ft)

- 501 - 1000
- 201 - 500
- 101 - 200
- 51 - 100
- 21 - 50
- 11 - 20
- 6 - 10
- 3 - 5
- 2
- 1

N

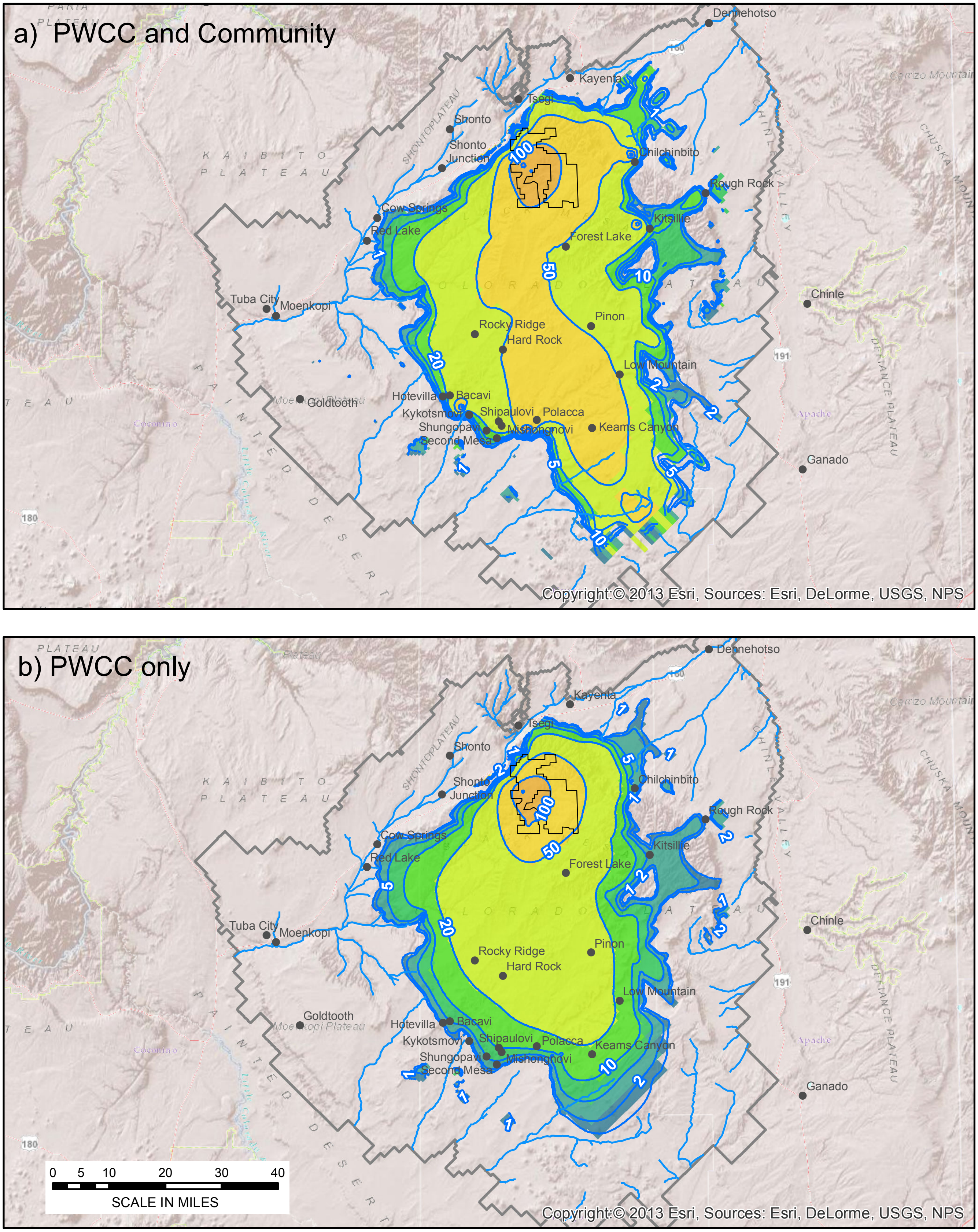
TITLE:

Simulated Drawdown in Layer 3
2044

TETRA TECH

APPROVED	RW
DRAFTED	LD
PROJECT#	117-2608008
DATE	2-6-14

FIGURE
5b



Drawdown (ft)

- 501 - 1000
- 201 - 500
- 101 - 200
- 51 - 100
- 21 - 50
- 11 - 20
- 6 - 10
- 3 - 5
- 2
- 1

N

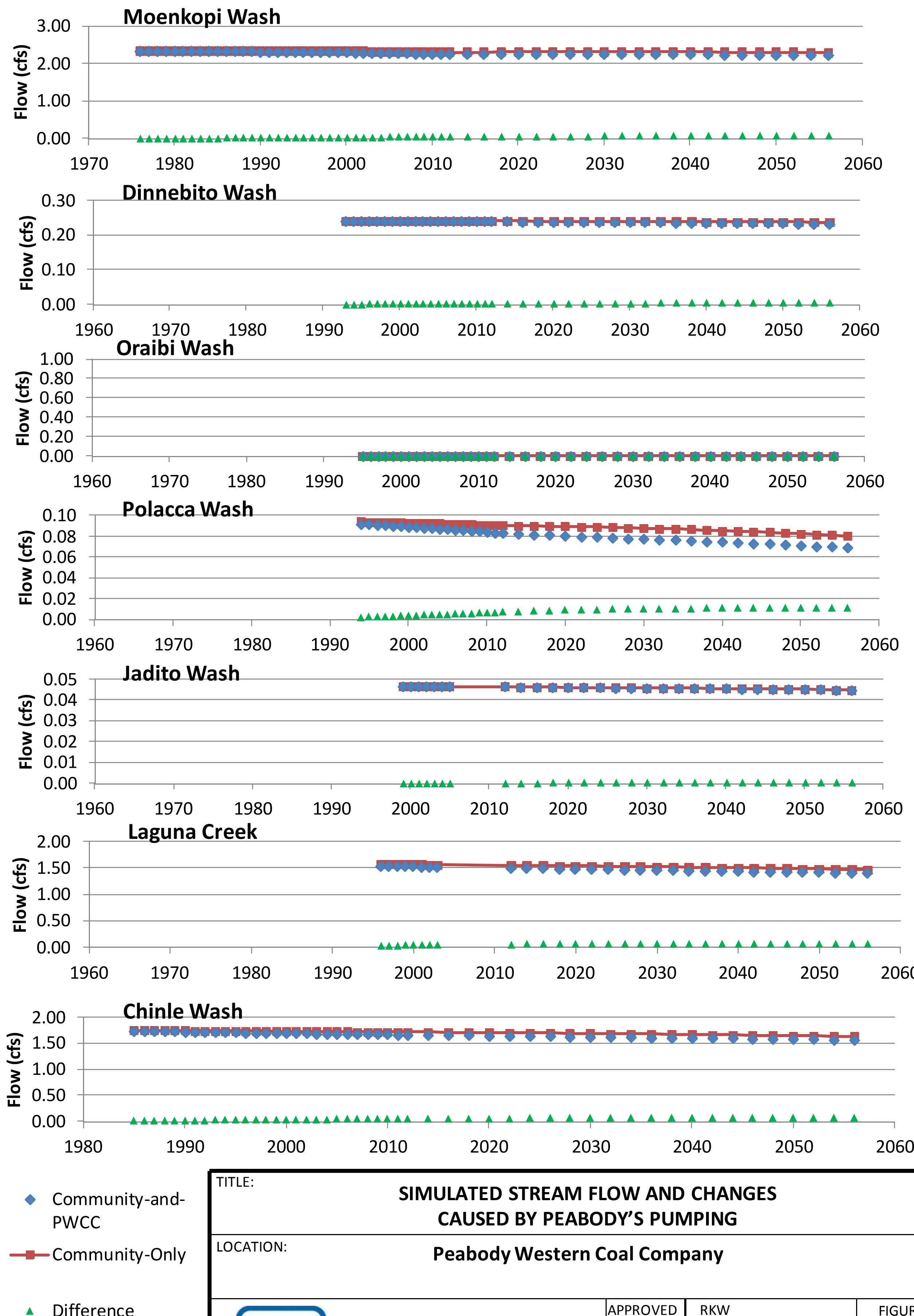
TITLE:

Simulated Drawdown in Layer 3
2057

TETRA TECH

APPROVED	RW	FIGURE
DRAFTED	LD	5c
PROJECT#	117-2608008	
DATE	2-6-14	

T:\PEABODY\GIS\PHC Report 2014\mxd\Fig_5c_Ddn_L5_2057.mxd

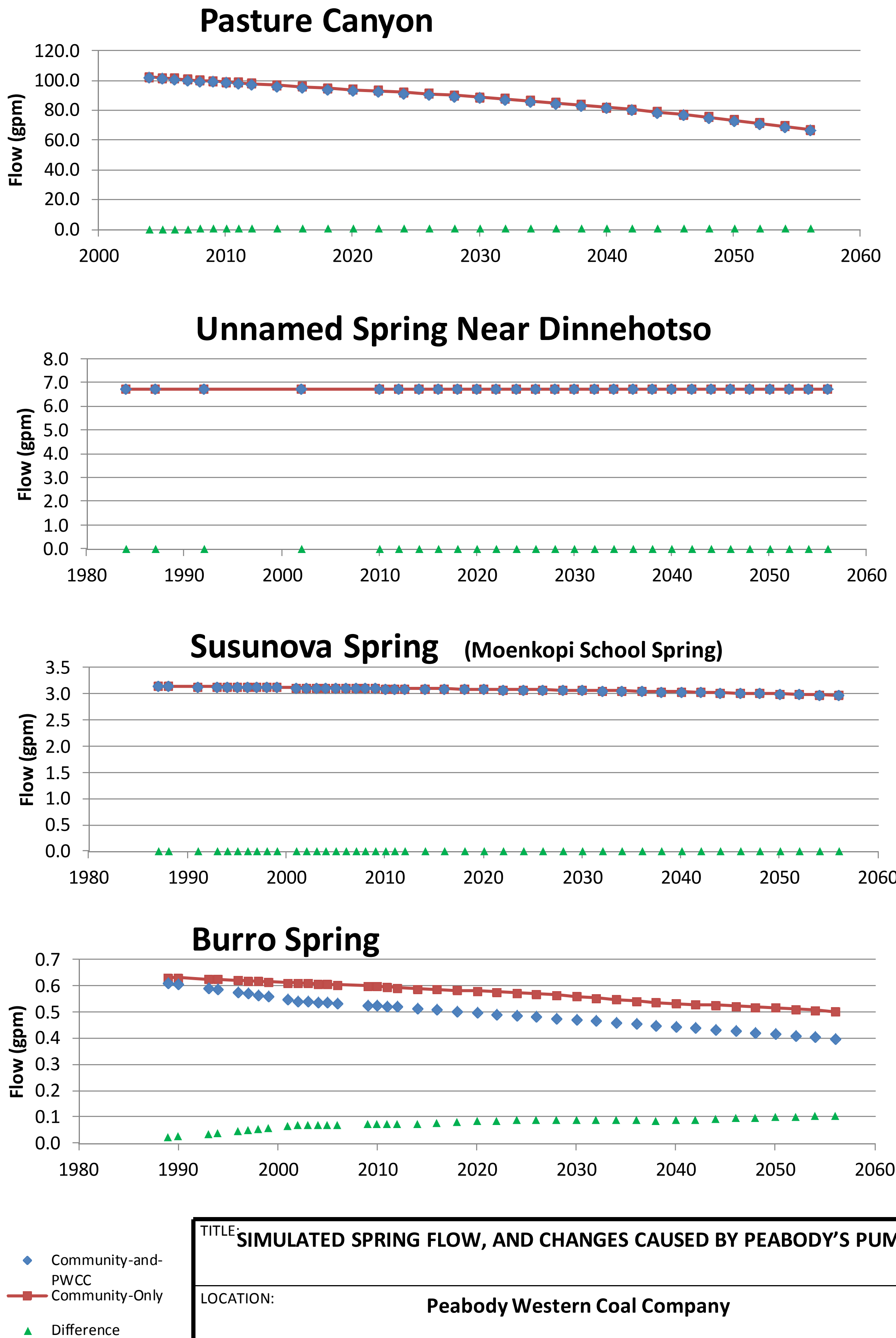


TITLE: SIMULATED STREAM FLOW AND CHANGES CAUSED BY PEABODY'S PUMPING

LOCATION: Peabody Western Coal Company

TETRA TECH

APPROVED	RKW	FIGURE
DRAFTED	CG	6
PROJECT #	117-2608007	
DATE	02-07-2014	



TITLE: SIMULATED SPRING FLOW, AND CHANGES CAUSED BY PEABODY'S PUMPING				
LOCATION: Peabody Western Coal Company				
TETRA TECH	APPROVED	RKW	FIGURE	
	DRAFTED	CG	7	
	PROJECT #	117-2608007		
	DATE	02-07-2014		

ATTACHMENT I

Annual Rates of Community and PWCC pumping

ANNUAL RATES OF COMMUNITY AND PWCC PUMPING (af/y)

WELL NAME	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1K-228	16.25	17.6	18.96	20.31	21.66	23.02	24.37	25.73	27.08	28.44	29.79	31.14	32.5	33.85	35.21	36.56	37.92	39.27	40.62	41.98	43.33	44.69	46.04	47.4	48.75
3K-252	0	0	0	0	0	0	0	139.26	139.26	139.26	139.26	139.26	139.26	139.26	139.26	139.26	139.26	139.26	139.26	139.26	139.26	139.26	139.26	139.26	139.26
3K-318-1	139.26	139.26	139.26	139.26	139.26	139.26	139.26	139.26	139.26	139.26	139.26	139.26	139.26	139.26	139.26	139.26	139.26	139.26	139.26	139.26	139.26	139.26	139.26	139.26	139.26
3K-318-2	139.26	139.26	139.26	139.26	139.26	139.26	139.26	139.26	139.26	139.26	139.26	139.26	139.26	139.26	139.26	139.26	139.26	139.26	139.26	139.26	139.26	139.26	139.26	139.26	139.26
3P-350	0	0	0	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	57.94	57.94
3T-222	0	0	0	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	57.94	57.94
3T-322-1	67.6	67.6	67.6	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	57.94	57.94
3T-322-2	67.6	67.6	67.6	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	57.94	57.94
3T-333	67.6	67.6	67.6	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	0	0
3T-507	0	0	0	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	57.94	57.94
4T-523	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.94
6K-312	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8A-295	12.39	16.53	20.66	24.79	28.92	33.05	37.18	26.81	29.11	37.17	83.22	84.23	107.7	122.5	143.5	165.5	145.2	251.9	254.1	237.4	256.3	250	217.4	236.4	214.7
8K-416	12.39	16.53	20.66	24.79	28.92	33.05	37.18	26.81	29.11	37.17	83.22	84.23	107.7	122.5	143.5	165.5	145.2	251.9	254.1	237.4	256.3	250	217.4	236.4	214.7
BACAVI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CHILCHINBITO_NTUA1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	33.8	7.17	33.8	6.49	67.6	60.84	60.84	40.56
CHILCHINBITO_NTUA2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40.56
CHLCHN_PM2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	70.96	67.58	69.61	0	0	0	0
CHLCHN_PM3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COTTONWD3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COTTONWOOD_NTUA_N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COTTONWOOD_NTUA_S	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DENNEHOTSO_NTUA1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DENNEHOTSO_NTUA2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DENNHOTS_PM1_BIA	10	10.6	11.2	11.8	12.4	13	13.6	14.2	14.8	15.4	16	16.6	17.2	17.8	18.4	19	19.6	20.2	20.8	21.4	22	22.6	23.2	24	25
DENNHOTS_PM2_BIA	0	0	0	0	0	0	0	0	29.15	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
HARD_ROCK_NTUA1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HARD_ROCK_NTUA2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HOPI_CIVIC_CENTER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8.28	8.28	8.28
HOPI_CULTURAL_CENTER	0	0	0	0	0	0	0	0	0	0	0	0	0	1.68	2	3	4.2	5.5	7	8.5	10	11.5	13	14.5	16
HOPI_HIGH_SCH_1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HOPI_HIGH_SCH_2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HOPI_HIGH_SCH_3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HOTEVILLA_PM1	0	10.98	12.2	13.42	14.64	15.86	17.08	18.3	19.52	20.75	21.97	23.19	24.41	25.63	26.85	28.07	29.29	30.51	31.73	32.95	34.17	35.39	36.61	37.83	39.05
HOTEVILLA_PM2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10.98	16.47	21.97
KAYENTA_NTUA1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	250	217.4	236.4	214.7
KAYENTA_NTUA2	12.39	16.53	20.66	24.79	28.92	33.05	37.18	26.81	29.11	37.17	83.22	84.23	107.7	122.5	143.5	165.5	145.2	251.9	254.1	237.4	256.3	250	217.4	236.4	214.7
KAYENTA_NTUA3	0	0	0	0	0	0	0	26.81	29.11	37.17	83.22	84.23	107.7	122.5	143.5	165.5	145.2	251.9	254.1	237.4	256.3	250	217.4	236.4	214.7
KAYENTA_NTUA4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	250	217.4	236.4	214.7
KAYENTA_NTUA5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	217.4	236.4	214.7
KAYENTA_NTUA6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	217.4	236.4	214.7
KAYENTA_NTUA7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	217.4	236.4	214.7
KEAMS_CYN1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13.23	16.07	18.91	21.74	24.58	27.42	30.26	33.09	35.93	38.77	41.6
KEAMS_CYN2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13.23	16.07	18.91	21.74	24.58	27.42	30.26	33.09	35.93	38.77	41.6
KEAMS_CYN3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13.23	18.2	23.16	28.13	33.09
KITSILLIE_NTUA1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
KITSILLIE_NTUA2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
KYKOTSMOVI_PM1	0	0	0	0	0	0	0	0	0	0	0	8.28	9.74	11.2	12.66	14.12	15.58	17.05	18.51	19.97	21.43	22.89	24.35	25.81	27.28
KYKOTSMOVI_PM2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	40	50	60
KYKOTSMOVI_PM3	0	0	0	0	0	0	0	0	0	0	0	0	8.28	9.83	11.38	12.93	14.49	16.04	17.59	19.15	20.7	22.25	23.8	25.36	26.91
LOW_MTN_PM2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9.8	12.25	14.7	17.15	19.6	22.05	24.5	26.95	29.4
MISHONGNOVI_1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MOENKOPI_1	67.6	67.6	67.6	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	57.94	57.94
MOENKOPI_2	67.6	67.6	67.6	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	57.94	57.94
MOENKOPI_3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NAV2	0	0	0	0	0	0	0	0	0	0	0	0	594.1	83.9	625.5	1443.5	1917.24	2135.52	2546.41	2214.25	2606.22	2472.07	2259.87	2422.06	2552.83
NAV3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NAV3OBS	0	0	0	0	0	0	0	0	0	0	0	0	142.9	398.8	406.8	1115.74	2341.64	1534.4	2111.53	1962.18	2516.34	2578.85	1719.23	1999.69	1959.14
NAV4	0	0	0	0	0	0	0	0	0	0	0	0	168.9	100.6	282.3	1073.17	2346.71	2371.38	2515.66	2462.95	2636.97	2545.73	1662.13	2099.03	2044.97
NAV5	0	0	0	0	0	0	0	0	0	0	0	0	153.9	79.5	665.1	1432.35	2458.89	2188.91	1975.36	1823.98	1830.06	1849.32	1240.76	1634.76	1689.83
NAV6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NAV6OBS	0	0	0	0	0	0	0	0	0	0	0	0	143.2	77.3	526.9	1359.03	2410.57	1068.77	1281.31	1093.78	1741.87	1699.29	1389.44	1458.03	1335.38
NAV7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	967.4	2601.49	2509.58	2449.77	2801.52	2669.74	1884.8	2208.17	2069.97
NAV8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	320.32
NAV9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ORAIBI_2	0	0	8.28	9.23	10.19	11.14	12.1	13.05	14.01	14.97	15.92	16.88	17.83	18.79	19.74	20.7	21.65	22.61	23.57	24.52	25.48	26.43	27.39	28.34	29.3
PINON_3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PINON_4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PINON_NTUA1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PINON_NTUA2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

ANNUAL RATES OF COMMUNITY AND PWCC PUMPING (af/y)

WELL NAME	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
PINON_NTUA3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PINON_PHS1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14.36
PINON_PM_6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14.36	17.44	20.52	23.6	26.67	29.75	32.83	35.91	38.99	42.07	45.14
POLACCA_PDC_2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLACCA_USPHS_5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLACCA_USPHS_6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RED_LAKE_NTUA1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13.54	20.31	27.08
RED_LAKE_PM2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RED_LK_PM1	0	13.54	15.04	16.55	18.05	19.56	21.06	22.57	24.07	25.58	27.08	28.59	30.09	31.6	33.1	34.6	36.11	37.61	39.12	40.62	42.13	43.63	45.14	46.64	48.15
RGH_RK_PM4	0	0	0	0	0	0	0	9.54	10.6	11.78	13.09	14.55	16.16	17.96	19.95	22.17	24.64	27.37	30.42	31.63	30.28	23.79	26.36	26.36	26.36
RGH_RK_PM5	0	0	0	0	0	0	0	0	10.6	11.78	13.09	14.55	16.16	17.96	19.95	22.17	24.64	27.37	30.42	31.63	30.28	23.79	26.36	26.36	26.36
ROCKY_RIDGE_PM1	0	0	0	0	0	0	0	8.45	9.65	10.86	12.07	13.27	14.48	15.69	16.9	18.1	19.31	20.52	21.72	22.93	24.14	25.35	26.55	27.76	28.97
ROCKY_RIDGE_PM2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8.45	11.61	14.78	17.95	21.12
ROUGH_ROCK_NTUA1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ROUGH_ROCK_NTUA2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ROUGH_ROCK_PM7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ROUGHROCK_PM3_BIA	0	0	0	6.26	6.95	7.73	8.59	9.54	10.6	11.78	13.09	14.55	16.16	17.96	19.95	22.17	24.64	27.37	30.42	31.63	30.28	23.79	26.36	26.36	26.36
ROUGHROCK_PM6_BIA	0	0	0	0	0	0	0	0	10.6	11.78	13.09	14.55	16.16	17.96	19.95	22.17	24.64	27.37	30.42	31.63	30.28	23.79	26.36	26.36	26.36
SALINA_TP2	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79
SEC_MESA_DY_SCH_1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.67	4.52	5.37	6.22	7.06	7.91	8.76	9.61	10.46	11.31
SEC_MESA_DY_SCH_2	0	0	3.67	4.1	4.52	4.94	5.37	5.79	6.22	6.64	7.06	7.49	7.91	8.34	8.76	9.18	9.61	10.03	10.46	10.88	11.31	11.73	12.15	12.58	13
SECOND_MESA_PD&C1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SECOND_MESA_PM2	0	0	0	0	0	0	0	0	0	0	0	0	3.67	4.36	5.05	5.74	6.43	7.12	7.81	8.5	9.18	9.87	10.56	11.25	11.94
SECOND_MESASCH_PHS1_BIA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHIPAULOVI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.38	4.1	4.82	5.55	6.27	7	7.72	8.45	9.17	9.89	10.62
SHIPAULOVI#2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHONTO_JN_NTUA1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.7	4.05	5.4
SHONTO_JN_NTUA2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHONTO_NTUA1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHONTO_PM2	0	0	0	0	0	39.43	44.57	49.72	54.86	60.01	65.15	70.29	75.44	80.58	85.72	90.87	96.01	101.16	106.3	111.44	116.59	121.73	126.87	132.02	137.16
SHONTO_PM3	0	0	0	0	0	0	39.43	44.81	50.19	55.56	60.94	66.32	71.7	77.07	82.45	87.83	93.21	98.58	103.96	109.34	114.72	120.09	125.47	130.85	136.23
SHONTO_PM4	0	0	0	0	0	0	0	0	39.43	45.35	51.26	57.18	63.09	69.01	74.92	80.84	86.75	92.67	98.58	104.5	110.41	116.33	122.24	128.16	134.08
SHUNGOPAVI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10.14	12.9	15.67	18.43	21.2	23.96	26.73	29.49
SHUNGOPOVI_1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TALAHOGAN	0	0	0	0	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79
TUBA_CITY_NTUA1	0	0	0	0	0	0	0	0	0	0	0	0	0	80.19	100.23	125.29	156.62	195.78	244.72	343.42	436.04	515.41	493.5	608.43	591.53
TUBA_CITY_NTUA2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TUBA_CITY_NTUA3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	125.29	156.62	195.78	244.72	343.42	436.04	515.41	493.5	608.43	591.53
TUBA_CITY_NTUA4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	125.29	156.62	195.78	244.72	343.42	436.04	515.41	493.5	608.43	591.53
TUBA_CITY_NTUA5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TUBA_CITY_NTUA6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TURQUOISE_TRAIL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WELL__30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COAL_CREEK_MESA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
INSCRIPTION_HOUSE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
JEDDITO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STEAMBOAT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TACHEE_BLUE_GAP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEESTOH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WHIPPORWILL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WHITE_CONE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lower_Moenkopi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rural_Moenkopi_District	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper_Rural_Moenkopi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lower_Rural_Moenkopi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Howell_Mesa_East	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Side_Rock_Well	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Central_Dinnebito	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper_Dinnebito	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Central_Rural_Dinnebito	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lower_Dinnebito	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper_Rural_Oraibi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lower_Oraibi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper_Rural_Polacca	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spider_Mound	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lower_Rural_Jadito	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper_Rural_Jadito	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

ANNUAL RATES OF COMMU

WELL NAME	1981	1982	1983	1984	1985	1985.49	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1K-228	50.1	51.46	52.81	54.17	55.52	55.52	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3K-252	139.26	139.26	139.26	360	128.44	128.44	281.35	198.17	244.66	185.94	242.21	193.28	112.54	144.34	166.36	210.4	193.51	212.76	243.15	236.06	185.4	178.28	150.15	136.18	136.18
3K-318-1	139.26	139.26	139.26	360	128.44	128.44	548.03	366.99	398.79	455.06	352.31	296.03	249.55	271.57	254.44	168.81	275.91	294.48	347.16	283.34	208.7	196.01	176.52	169.26	56.19
3K-318-2	139.26	139.26	139.26	360	128.44	128.44	128.44	129.66	134.56	154.13	254.44	75.84	31.8	0	22.01	85.63	113.81	59.1	135.76	136.1	160.75	146.33	129.68	20.48	20.48
3P-350	57.94	57.94	57.94	57.94	57.94	57.94	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3T-222	57.94	57.94	57.94	57.94	57.94	57.94	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3T-322-1	57.94	57.94	57.94	57.94	57.94	57.94	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3T-322-2	57.94	57.94	57.94	57.94	57.94	57.94	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3T-333	0	0	0	183.49	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3T-507	57.94	57.94	57.94	57.94	57.94	57.94	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4T-523	3.4	4.85	6.31	7.77	19.26	19.26	31.09	34.13	53.39	38.18	43.24	38.54	32.46	38.11	35.8	33.5	37.49	28.37	44.58	36.81	43.23	36.88	33.3	35.34	35.34
6K-312	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8A-295	195.8	212	217.4	276.46	423.26	423.26	337.63	232.42	212.85	217.74	185.94	171.26	154.13	110.09	122.33	127.22	131.71	111.78	107.05	118.87	116.85	108.34	127.65	74.34	101.3
8K-416	195.8	212	217.4	276.46	102.75	102.75	39.14	41.59	70.95	78.29	73.39	85.63	119.88	117.43	139.45	122.33	139.14	125.97	138.8	136.77	140.82	120.73	71.8	79.13	79.13
BACAVI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14.67	78.29	61.8	72.27	64.84	74.3	72.61	85.14	70.72	73.96	73.96
CHILCHINBITO_NTUA1	36.05	34.92	34.92	46.48	53.82	53.82	53.82	48.93	48.93	56.27	61.33	54.59	45.75	46.99	22.84	13.71	18.91	54.37	29.38	116.85	86.12	69.03	81.66	5.3	76.32
CHILCHINBITO_NTUA2	36.05	34.92	34.92	46.48	53.82	53.82	51.37	51.37	51.37	53.82	59.36	59.74	72.81	80	111.08	117.53	117.86	47.28	75.65	45.93	41.2	66.93	64.5	34.56	37
CHLCHN_PM2	0	0	0	44.6	59.47	59.47	16.55	18.92	26.69	25.68	23.65	0	0	0	0	0	0	11.03	11.31	11.6	11.9	12.2	12.52	12.84	13.17
CHLCHN_PM3	0	0	0	139.45	24.46	24.46	17.12	19.57	19.57	24.46	24.46	24.46	26.91	22.01	24.46	17.12	14.52	12.83	13.51	22.96	26.34	21.98	13.95	13.28	13.28
COTTONWD3	0	0	0	44.6	41.22	41.22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COTTONWOOD_NTUA_N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	70.95	0	0	0	0	0	0	0	0
COTTONWOOD_NTUA_S	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	31.8	0	0	0	0	0	0	0	0
DENNEHOTSO_NTUA1	0	0	0	100.36	100.03	100.03	94.96	107.65	99.35	86.85	86.19	72.87	97.9	64.61	77.01	37.02	66.19	52.68	35.12	113.47	54.71	65.68	52.89	55.02	52.54
DENNEHOTSO_NTUA2	0	0	0	0	0	0	0	0	0	0	0	0	17.87	56.65	39.65	97.16	78.69	72.95	98.27	54.37	61.46	67.47	82.3	84.82	88.65
DENNHOTS_PM1_BIA	26	27	28	29	30	30	34.25	46.48	61.16	97.86	51.37	48.93	39.14	53.82	80.73	34.25	27.69	37.82	33.77	36.81	31.07	22.86	22.15	17	17
DENNHOTS_PM2_BIA	30	30	30	30	30	30	48.93	31.8	34.25	36.69	31.8	41.59	61.16	41.59	53.82	61.16	65.85	78.35	34.45	104.35	87.47	75.07	64.67	59.29	59.29
HARD_ROCK_NTUA1	0	0	0	0	0	0	2.44	31.8	58.71	66.05	77.45	64.51	74.42	101.98	114.8	113.61	84.76	87.13	122.93	105.03	152.98	96.15	105.16	62.6	64.77
HARD_ROCK_NTUA2	0	0	0	0	0	0	0	0	0	0	0	0	1.85	2.41	0	0	36.13	59.77	22.63	21.28	74.97	46.87	28.33	62.4	66.62
HOPI_CIVIC_CENTER	8.28	8.28	8.28	8.28	8.28	8.28	8.28	8.28	8.28	8.28	8.28	7.33	7.33	2.44	4.89	4.89	9.46	6.08	5.4	6.75	8.44	6.38	12.36	12.58	12.58
HOPI_CULTURAL_CENTER	17.5	19	20.5	22	23.5	23.5	25.1	26.7	28.3	30	37.84	29.35	29.35	34.25	34.25	29.35	29.72	33.43	33.1	26.34	36.13	32.49	21.11	22.88	22.88
HOPI_HIGH_SCH_1	0	0	0	39.14	0	0	31.8	24.46	29.35	51.37	24.46	31.8	36.69	48.93	29.35	29.35	30.39	25.67	34.11	14.18	8.78	38.97	54.27	41.53	41.53
HOPI_HIGH_SCH_2	0	0	0	18.34	0	0	12.23	22.01	0	2.44	14.67	19.57	24.46	29.35	14.67	2.44	21.61	20.94	24.99	43.23	60.45	97.67	116.61	90.33	90.33
HOPI_HIGH_SCH_3	0	0	0	18.34	0	0	9.78	14.67	31.8	22.01	7.33	0	12.23	29.35	17.12	29.35	8.78	18.57	6.08	18.57	59.77	35.36	0	98.2	98.2
HOTEVILLA_PM1	40.28	41.5	42.72	44.03	45.16	45.16	4.89	41.59	48.93	73.39	70.95	78.29	95.41	107.65	66.05	44.03	41.88	27.69	19.92	15.87	16.21	18.61	12.43	13.73	13.73
HOTEVILLA_PM2	27.46	32.95	38.44	44.03	49.43	49.43	51.37	41.59	24.46	26.91	12.23	0	0	0	0	0	0	64.33	65.97	67.6	69.37	71.15	72.99	58.12	58.12
KAYENTA_NTUA1	195.8	212	217.4	217.7	225.08	225.08	198.17	298.48	293.59	249.55	201.55	221.32	293.69	233.9	147.69	235.91	232.34	130.69	263.08	258.01	276.25	408.97	67.88	87.89	87.66
KAYENTA_NTUA2	195.8	212	217.4	217.7	225.08	225.08	198.17	300.93	293.59	251.99	196.48	99.91	211.73	232.26	58.11	196.68	153.66	228.97	285.36	215.12	188.44	39.01	44.68	34.08	34.11
KAYENTA_NTUA3	195.8	212	217.4	217.7	225.08	225.08	198.17	300.93	291.14	249.55	229.77	208.32	283.17	225.24	237.48	172.19	261.72	263.41	265.1	219.51	223.9	259.63	290.46	285.5	285.36
KAYENTA_NTUA4	195.8	212	217.4	217.7	225.08	225.08	198.17	300.93	293.59	249.55	290.65	152.2	168.52	107.48	153.9	307.48	383.98	472.12	333.66	422.81	361.35	9.42	32.39	335.97	128.76
KAYENTA_NTUA5	195.8	212	217.4	217.7	225.08	225.08	200.62	298.48	293.59	249.55	775.57	306.89	389.33	779.59	526.84	545.37	303.6	123.26	336.7	346.15	513.99	461.24	569.48	391.58	390.59
KAYENTA_NTUA6	195.8	212	217.4	217.7	227.53	227.53	198.17	300.93	291.14	249.55	322.8	232.7	140.95	92.49	336.33	84.4	221.87	339.74	193.17	240.79	323.53	302.99	292.19	192.08	219.38
KAYENTA_NTUA7	195.8	212	217.4	217.7	225.08	225.08	198.17	300.93	293.59	249.55	278.8	269.51	236.44	198.69	160.35	163.86	178.65	272.19	145.89	0	179.32	351.79	282.29	261.96	261.3
KEAMS_CYN1	44.44	47.28	50.11	52.95	55.79	55.79	0	0	0	0	0	0	0	0	0	0	0	5.57	5.71	5.86	6.01	6.16	6.32	6.48	6.65
KEAMS_CYN2	44.44	47.28	50.11	37.92	129.66	129.66	127.22	166.36	132.11	159.02	110.09	210.4	122.33	114.99	132.11	139.45	71.26	88.14	136.1	99.62	133.73	72.94	74.82	76.75	78.74
KEAMS_CYN3	38.06	38.06	38.06	37.92	41.59	41.59	90.52	88.07	88.07	127.22	105.2	95.41	41.59	36.69	58.71	34.25	34.45	77.67	134.07	160.41	182.7	213.13	93.28	68.04	68.04
KITSILLIE_NTUA1	0	0	0	11.15	22.3	22.3	29.06	24.67	24.33	25	35.14	25.33	19.35	19.59	18.49	15.78	21.95	28.03	8.44	11.14	2.7	6.42	6.18	105.59	10.06
KITSILLIE_NTUA2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5.4	37.49	27.69	66.19	44.85	42.86	44.74	44.74
KYKOTSMOVI_PM1	28.74	30.2	31.66	34.25	48.93	48.93	127.22	139.45	146.79	88.07	78.29	100.31	48.93	0	0	0	0	0	0	0	0	0	0	0	0
KYKOTSMOVI_PM2	70	80	90	100	85.63	85.63	63.61	56.27	61.16	100.31	144.34	107.65	97.86	95.41	90.52	88.07	137.45	86.12	80.04	75.65	65.52	49.51	51.91	59.99	59.99
KYKOTSMOVI_PM3	28.46	30.02	31.57	33.12	53.82	53.82	0	0	0	0	9.78	2.44	105.2	127.22	132.11	141.9	142.18	133.73	127.99	162.78	162.1	162.71	162.51	150.11	150.11
LOW_MTN_PM2	31.85	34.3	36.75	39.2	0	0	0	0	22.01	31.8	26.91	29.35	19.57	0	0	0	0	0	0	0	0	0	0	0	0
MISHONGNOVI_1	0	0	0	0	7.33	7.33	4.05	4.39	5.74	9.46	10.47	12.23	12.23	14.67	14.67	19.57	19.92	19.59	20.6	23.64	20.26	18.54	19.45	67.15	67.15
MOENKOPI_1	57.94	57.94	57.94	57.94	57.94	57.94	57.94	57.94	57.94	57.94	57.94	24.46	127.22	97.86	97.86	78.29	130.86	120.73	129.17	121.74	115.16	144.2	149.59	21.22	82.93
MOENKOPI_2	57.94	57.94	57.94	57.94	57.94	57.94	57.94	57.94	57.94	57.94	57.94	22.01	127.22	97.86	97.86	78.29	130.86	120.73	129.17	121.74	115.16	144.2	149.59	21.22	82.93
MOENKOPI_3	0	0	0	0	0	0	0	0	0	0	0	0	0	97.86	97.86	78.29	88.07	33.18	34.28	35.41	36.56	37.73	38.93	40.15	41.4
NAV2	2294.34	2516.67	2028.75	2602.84	2803.6	2530.15	2579.05	2389.39	2442.07	395.07	574.53	1219.81	716.6	1638.6	2036.02	1932.81	2175.02	2026.6	2165.39	2312.84	2421.15	2353.92	2336.49	2030	2092.48
NAV3	0	0	0	0	2514.55	102.87	2133.39	1583.66	2543.37	1718.08	2226.18	706.71	481.47	724.93	931.12	998.21	63.61	1252.9	1666.15	1551.43	2360.32	2515.25	2201.58	2458.3	2616.54
NAV3OBS	2164.92	2363.61	1747.61	1400.93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NAV4	2144.98	2350.77	2509.92	2330.15	2313.95	349.62	2593.48	2438.99	2651.53	2338.57	2284.33	2786.35	2639.28	2418.6	2625.36	2287.57	2192.15	2784.4	2727.18	2739.79	2675.74	2526.06	2482.16	2241.09	1116.08
NAV5	1295.84	1464.79	1721.6	1419.51	1676.05	69.75	1588.4	1077.19	1406.4	1164.43	1121.15	1756.06	1937.28	1900.53	1950.44	2194.6	2038.01	2175.2	1858.19	1854.59	1220.63	1601.59	1436.68	1382.13	1434.37
NAV6	0	0	0	0	1097.55	144.77	1702.74	1565.15	761.72	1078.71	492.11	1944.31	2091.81	1898.64	1900.23	2086.94	1979.29	1749.7	1854.93	1839.47	1846.55	1880.75	1827.19	1873.1	1997.12
NAV6OBS	1490.81	2199.05	1703.01	1638.81	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NAV7	2570.74	3071.84	2653.52	1396.87	2555.25	152.54	2203.37	1740.69	1693.85	1081.88	1411.4	1448.2	1521.74	1458.04	1488.36	1761.55	1783.57	1515	1231.72	1653.4	1549.77	1166.24	2077.73	2074.06	2044.43
NAV8	1583.73	2064.23	1689.16	1033.97	360.58	230.27	977.74	482.75	831.09	2147.18	2295.42	2218.27	2352.87	1355.73	1855.61	1967.06	1568.27	1700.4	1468.89	1513.84	1676.39	1770.45	1855.85	1385.16	1001.72
NAV9	0	0	1000.18	2279.47	104.96	0	1358.52	1669.02	1483.31	1747.07	1195.92	1518.45	1158.19	1119.42	995.19	1443.49	1142.56	751.1	647.52	751.33	1420.17	1494.81	1460.87	1571.22	2462.34
ORAIBI_2	30.25	31.21	32.17	33.12	34.08	34.08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PINON_3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	26.59	27.27	27.96	28.68	29.41	30.17	30.95	31.75
PINON_4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PINON_NTUA1	0	0	0	75.84	39.14	39.14	29.35	41.59	58.71	80.73	184.34	69.66	166.14	126.25	112.23	169.64	210.73	205.33	220.52	272.19	257.33	275.17	302.86	305.85	305.85
PINON_NTUA2	0	0	0	78.29	39.14	39.14	29.35	41.59	58.71	83.18	50.96	171.79	124.8	183.49	240.74	233.59	320.15	259.7	310.02	292.79	304.61	340.55	349.43	251.45	251.45

ANNUAL RATES OF COMMU

WELL NAME	1981	1982	1983	1984	1985	1985.49	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
PINON_NTUA3	0	0	0	75.84	36.69	36.69	26.91	44.03	56.27	80.73	28.95	166.6	154.85	155.61	193.18	171.36	282.66	420.79	412.68	357.63	414.03	388.77	441.86	510.75	510.75
PINON_PHS1	25.14	35.91	46.68	57.46	68.23	68.23	0	0	0	0	0	0	0	0	0	0	0	3.38	3.47	3.56	3.65	3.74	3.84	3.94	4.04
PINON_PM_6	48.22	51.3	54.38	57.46	119.29	119.29	126.05	105.43	105.2	127.4	119.97	102.75	111.45	114.99	114.99	0	0	0	0	0	0	57.72	59.21	0	0
POLACCA_PDC_2	0	0	0	100	100	100	117.43	127.22	114.99	105.2	100.31	100.31	100.31	112.54	139.45	134.56	135.08	135.08	135.08	135.08	135.08	124.78	135.08	163.88	168.13
POLACCA_USPHS_5	0	0	0	100	100	100	0	0	163.92	283.8	88.07	88.07	88.07	88.07	88.07	330.29	259.7	227.28	244.5	270.17	311.37	295.06	342.57	251.11	294.21
POLACCA_USPHS_6	0	0	0	100	100	100	0	0	92.97	0	12.23	12.23	12.23	12.23	12.23	12.23	35.8	8.78	7.77	11.14	7.77	27.74	28.45	0.02	0.02
RED_LAKE_NTUA1	33.85	40.62	47.4	68.94	69.95	69.95	73.33	101.72	131.79	145.99	150.08	154	150.24	92.05	163.68	163.25	164.46	186.42	188.1	195.2	197.22	210.87	153.62	173.45	173.58
RED_LAKE_PM2	0	0	0	40	80	80	73.39	0	0	12.23	0	0	0	0	0	0	0	0	0	0	0	9.09	9.38	9.67	9.97
RED_LK_PM1	49.65	51.16	52.66	54.17	55.67	55.67	0	0	39.14	39.14	31.8	29.35	24.46	22.01	58.71	58.71	17.22	19.25	21.28	25.67	27.02	21.17	21.61	28.35	28.35
RGH_RK_PM4	29.06	33.12	35.82	41.59	34.47	34.47	0	0	0	0	0	0	0	0	0	0	0	7.89	8.06	8.24	8.42	8.62	8.81	9.02	9.23
RGH_RK_PM5	29.06	33.12	35.82	44.03	41.59	41.59	41.59	26.91	0	39.14	44.03	73.39	78.29	53.82	4.89	41.59	41.2	38.16	38.5	44.58	30.73	40.63	51.6	36.22	36.22
ROCKY_RIDGE_PM1	30.18	31.38	32.59	33.8	95	95	19.57	22.01	0	4.89	19.57	12.23	12.23	9.78	2.44	4.89	3.38	0.68	0.68	1.01	0.03	31.5	32.31	33.14	34
ROCKY_RIDGE_PM2	24.29	27.46	30.63	34.25	95	95	22.01	26.91	39.14	34.25	29.35	31.8	29.35	39.14	46.48	41.59	65.52	37.49	33.1	37.15	46.27	37.22	46.67	38.73	38.73
ROUGH_ROCK_NTUA1	0	0	0	30.75	42.24	42.24	32.44	37.84	42.58	41.9	40.55	56.27	56.27	58.71	61.16	46.48	34.11	54.03	53.02	41.54	44.58	57.51	51.06	27.25	22.19
ROUGH_ROCK_NTUA2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40.86	167.84	39.51	33.43	35.12	38.74	55.79	0	0
ROUGH_ROCK_PM7	0	0	0	0	17.12	17.12	19.57	7.33	9.78	19.57	14.67	19.57	19.57	17.12	17.12	2.44	18.57	10.13	15.87	18.24	19.59	24.65	7.53	19.66	13.52
ROUGHROCK_PM3_BIA	29.06	33.12	35.82	41.59	17.12	17.12	7.33	17.12	9.78	9.78	2.44	2.44	0	0	0	7.33	13.85	9.79	13.17	24.32	21.61	14.39	27.66	19.75	19.75
ROUGHROCK_PM6_BIA	29.06	33.12	35.82	41.59	53.82	53.82	63.61	63.61	80.73	85.63	75.84	97.86	75.84	124.77	68.5	61.16	59.44	40.86	38.84	29.72	39.17	37.05	26.48	40.28	40.28
SALINA_TP2	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79
SEC_MESA_DY_SCH_1	12.15	13	13.85	14.7	15.55	15.55	0	0	0	0	0	0	0	0	0	0	2.36	2.7	2.03	3.04	2.7	1.18	4.46	1.6	1.65
SEC_MESA_DY_SCH_2	13.43	13.85	14.27	14.7	15.12	15.12	0	0	0	0	0	0	0	0	0	0	0	0.68	7.09	18.91	18.91	17.49	17.76	17.73	17.73
SECOND_MESA_PD&C1	0	0	0	30.07	66.23	66.23	36.16	34.8	31.09	28.72	32.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SECOND_MESA_PM2	12.63	13.32	14.01	14.7	56.27	56.27	34.25	34.25	29.35	26.91	29.35	61.16	19.57	19.57	29.35	24.46	0	0	0	0	0	0	0	0	0
SECOND_MESASCH_PHS1_BIA	0	0	0	0	0	0	0	2.44	2.44	2.44	2.44	2.44	2.44	2.44	2.44	2.44	0	0	0	0	0	0	0	0	0
SHIPAULOVI	11.34	12.07	12.79	13.52	14.24	14.24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHIPAULOVI#2	0	0	0	7.09	26.91	26.91	61.16	62.51	60.15	62.51	76.71	85.63	92.97	95.41	92.97	92.97	137.45	123.6	107.39	80.71	79.7	69.64	68.96	62.7	62.7
SHONTO_JN_NTUA1	6.76	8.11	9.46	7.33	12.16	12.16	0	44.03	44.03	46.48	52.02	80.84	77.58	178.46	163.08	111.13	100.64	114.15	105.03	219.85	141.84	129.24	175.27	182.17	182.03
SHONTO_JN_NTUA2	0	0	0	7.33	61.16	61.16	48.93	41.59	41.59	48.93	47.03	39.53	56.53	43.17	43.35	38.31	69.57	72.61	81.73	55.38	54.03	78.58	98.21	64.04	58.89
SHONTO_NTUA1	0	0	0	54.4	56.77	56.77	63.87	74.34	21.96	60.49	60.47	56.04	60.27	58.1	48.73	53.84	56.06	47.95	48.63	55.38	56.4	61.02	59.37	397.62	68.16
SHONTO_PM2	142.31	147.45	152.59	157.74	162.88	162.88	149.24	349.86	291.14	274.01	330.29	322.95	310.71	433.04	244.66	200.62	315.08	253.28	285.7	221.54	290.77	251.8	315.42	274.92	295.19
SHONTO_PM3	141.6	146.98	152.36	157.74	163.11	163.11	193.28	112.54	92.97	166.36	61.16	95.41	127.22	222.64	171.26	198.17	236.06	215.46	145.89	104.35	90.17	181.79	201.17	127.52	163.92
SHONTO_PM4	139.99	145.91	151.82	157.74	163.65	163.65	163.92	227.53	188.38	234.87	203.06	168.81	193.28	112.54	176.15	173.7	94.9	68.89	34.45	78.69	99.96	102.56	116.58	140.04	140.04
SHUNGOPAVI	32.26	35.03	37.79	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHUNGOPOVI_1	0	0	0	40.55	37.51	37.51	41.56	44.27	50.35	65.22	63.87	63.61	61.16	63.61	70.95	66.05	74.97	76.66	84.76	94.56	71.59	100.5	113.5	117.92	117.92
TALAHOGAN	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79
TUBA_CITY_NTUA1	595.58	542.85	542.85	489.32	620.3	620.3	615	620.3	653	678.5	427.2	328.24	279.89	277.55	424.82	490.27	482.92	472.45	461.99	535.94	609.56	657.76	456.45	396.36	396.36
TUBA_CITY_NTUA2	0	0	0	0	0	0	0	0	0	0	209.25	331.27	376.64	381.27	358.23	345.06	418.76	379.92	470.09	465.03	494.07	496.77	496.8	538.69	538.69
TUBA_CITY_NTUA3	595.58	542.85	542.85	381.66	620.3	620.3	615	620.3	653	678.5	145.36	410.42	365.56	296.6	272.82	347.66	394.44	252.94	432.61	150.62	593.69	516.15	550.63	360.79	360.79
TUBA_CITY_NTUA4	595.58	542.85	542.85	244.66	620.3	620.3	615	620.3	653	678.5	0.95	358.75	412.38	534.15	393.31	443.69	465.36	530.54	568.7	532.23	663.6	552.49	565.26	484.93	484.93
TUBA_CITY_NTUA5	0	0	0	489.32	620.3	620.3	615	620.3	653	678.5	515.29	785.43	574.79	724.43	879.2	593.33	599.43	642.32	653.47	730.13	595.38	522.1	397.11	454.04	454.04
TUBA_CITY_NTUA6	0	0	0	0	0	0	0	0	0	0	187.99	390.57	899.53	1022.64	1028.06	970.12	1029	923.97	701.76	531.55	613.95	797.09	1993.46	210.16	210.16
TURQUOISE_TRAIL	0	0	0	0	0	0	0	0	0	0	0	0	0	4.89	0	0	0	5.19	5.32	5.46	5.6	5.74	5.89	6.04	6.2
WELL__30	0	0	0	0	0.79	0.79	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COAL_CREEK_MESA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
INSCRIPTION_HOUSE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
JEDDITO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STEAMBOAT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TACHEE_BLUE_GAP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEESTOH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WHIPPORWILL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WHITE_CONE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lower_Moenkopi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rural_Moenkopi_District	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper_Rural_Moenkopi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lower_Rural_Moenkopi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Howell_Mesa_East	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Side_Rock_Well	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Central_Dinnebito	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper_Dinnebito	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Central_Rural_Dinnebito	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lower_Dinnebito	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper_Rural_Oraibi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lower_Oraibi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper_Rural_Polacca	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spider_Mound	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lower_Rural_Jadito	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper_Rural_Jadito	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

ANNUAL RATES OF COMMU

WELL NAME	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
1K-228	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3K-252	135.08	143.71	161.74	132.56	107.62	99.66	123.36	90.42	236.81	242.68	248.7	254.87	261.19	267.66	274.3	281.1	288.08	295.22	302.54	310.04	317.73	325.61	333.69	341.96	350.44
3K-318-1	140.25	151.32	162.32	151.07	129.49	153.85	134.97	114.4	299.61	307.04	314.65	322.46	330.45	338.65	347.05	355.65	364.48	373.51	382.78	392.27	402	411.97	422.18	432.65	443.38
3K-318-2	74.09	25.53	59.61	44.92	36.6	22.21	13.37	19.74	51.7	52.98	54.29	55.64	57.02	58.43	59.88	61.37	62.89	64.45	66.05	67.69	69.37	71.09	72.85	74.66	76.51
3P-350	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3T-222	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3T-322-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3T-322-2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3T-333	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3T-507	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4T-523	33.69	48.34	35.58	34.34	42.08	68.79	52.19	42.13	201.26	206.25	211.37	216.61	221.98	227.49	233.13	238.91	244.83	250.91	257.13	263.51	270.04	276.74	283.6	290.63	297.84
6K-312	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8A-295	50.38	63.19	96.82	120.26	65.38	39.73	38.68	46.93	113.66	116.48	119.36	122.32	125.36	128.47	131.65	134.92	138.26	141.69	145.21	148.81	152.5	156.28	160.16	164.13	168.2
8K-416	87.19	80.33	69.93	12.63	65.47	66.02	52.09	59.91	145.09	148.69	152.38	156.16	160.03	164	168.07	172.23	176.51	180.88	185.37	189.97	194.68	199.5	204.45	209.52	214.72
BACAVI	72.62	63.49	85.42	79.96	83.41	82.62	79.79	89.52	31.8	32.53	33.27	34.04	34.82	35.62	36.44	37.28	38.13	39.01	39.91	40.82	41.76	42.72	43.7	44.71	45.74
CHILCHINBITO_NTUA1	110.56	59.36	123.35	156.29	131.82	135.13	76.91	124.46	239.23	245.16	251.24	257.47	263.86	270.4	277.11	283.98	291.03	298.24	305.64	313.22	320.99	328.95	337.1	345.47	354.03
CHILCHINBITO_NTUA2	55.43	100.54	1.11	89.08	89.01	79.03	131.01	108.24	208.05	213.21	218.5	223.92	229.47	235.16	241	246.97	253.1	259.37	265.81	272.4	279.15	286.08	293.17	300.44	307.89
CHLCHN_PM2	13.51	13.87	14.23	14.6	14.6	14.6	15.8	16.22	31.18	31.95	32.74	33.55	34.39	35.24	36.11	37.01	37.93	38.87	39.83	40.82	41.83	42.87	43.93	45.02	46.14
CHLCHN_PM3	6.95	7.73	7.74	9.69	11.14	7.13	9.63	10.1	19.41	19.9	20.39	20.89	21.41	21.94	22.49	23.05	23.62	24.2	24.8	25.42	26.05	26.69	27.36	28.03	28.73
COTTONWD3	0	0	0	0	0	0	0	0	202.97	208	213.16	218.45	223.87	229.42	235.11	240.94	246.91	253.04	259.31	265.74	272.33	279.09	286.01	293.1	300.37
COTTONWOOD_NTUA_N	0	0	0	0	0	0	0	0	202.97	208	213.16	218.45	223.87	229.42	235.11	240.94	246.91	253.04	259.31	265.74	272.33	279.09	286.01	293.1	300.37
COTTONWOOD_NTUA_S	0	0	0	0	0	0	0	0	202.97	208	213.16	218.45	223.87	229.42	235.11	240.94	246.91	253.04	259.31	265.74	272.33	279.09	286.01	293.1	300.37
DENNEHOTSO_NTUA1	58.45	152.01	90.04	81.99	25.76	65.97	65.17	52.4	65.78	67.41	69.08	70.8	72.55	74.35	76.19	78.08	80.02	82.01	84.04	86.12	88.26	90.45	92.69	94.99	97.35
DENNEHOTSO_NTUA2	91.48	36.44	70.16	59.15	123.92	91.17	94.89	103.53	129.96	133.19	136.49	139.88	143.34	146.9	150.54	154.28	158.1	162.02	166.04	170.16	174.38	178.7	183.14	187.68	192.33
DENNHOTS_PM1_BIA	11.65	92.74	11.64	40.36	24.21	0.02	0.01	107.65	135.14	138.49	141.92	145.44	149.05	152.75	156.53	160.42	164.39	168.47	172.65	176.93	181.32	185.82	190.42	195.15	199.99
DENNHOTS_PM2_BIA	56.51	74.2	46.89	39.78	35.12	39.36	42.82	100.45	126.1	129.23	132.43	135.71	139.08	142.53	146.06	149.69	153.4	157.2	161.1	165.1	169.19	173.39	177.69	182.09	186.61
HARD_ROCK_NTUA1	117.11	149.42	36.08	92.51	41.71	36.87	131.48	66.45	185.9	190.51	195.24	200.08	205.04	210.13	215.34	220.68	226.15	231.76	237.51	243.4	249.43	255.62	261.96	268.45	275.11
HARD_ROCK_NTUA2	3.66	6.49	112.38	60.95	126.26	122.3	37.96	90.65	253.6	259.89	266.34	272.94	279.71	286.65	293.76	301.04	308.51	316.16	324	332.04	340.27	348.71	357.36	366.22	375.3
HOPI_CIVIC_CENTER	12.49	110.85	12.2	7.91	7.17	10.22	5.95	5.96	2.12	2.17	2.22	2.27	2.32	2.37	2.43	2.48	2.54	2.6	2.66	2.72	2.78	2.84	2.91	2.98	3.05
HOPI_CULTURAL_CENTER	19.25	20.66	22.17	19.95	22.97	22.03	24.41	18.94	6.73	6.88	7.04	7.2	7.37	7.54	7.71	7.89	8.07	8.25	8.44	8.64	8.84	9.04	9.25	9.46	9.68
HOPI_HIGH_SCH_1	121.8	71.27	3.86	34.97	13.82	13.35	1.45	13.41	4.76	4.87	4.98	5.1	5.22	5.34	5.46	5.58	5.71	5.84	5.98	6.12	6.26	6.4	6.55	6.7	6.85
HOPI_HIGH_SCH_2	10.75	35.45	76.57	57.93	48.82	44.01	56.91	70.17	24.92	25.5	26.08	26.68	27.29	27.92	28.56	29.22	29.89	30.58	31.28	32	32.74	33.49	34.26	35.05	35.85
HOPI_HIGH_SCH_3	0.01	0	0	0	0	0.01	0	51.13	18.16	18.58	19	19.44	19.89	20.35	20.81	21.29	21.78	22.28	22.79	23.32	23.85	24.4	24.96	25.54	26.12
HOTEVILLA_PM1	13.4	12.26	9.32	3.72	3.72	0	40.74	41.83	14.86	15.2	15.55	15.91	16.27	16.64	17.03	17.42	17.82	18.23	18.65	19.08	19.51	19.96	20.42	20.89	21.37
HOTEVILLA_PM2	63.26	65.12	35.84	72.66	65.53	75.52	82.74	94.56	33.59	34.36	35.15	35.96	36.78	37.63	38.49	39.38	40.28	41.21	42.15	43.12	44.11	45.13	46.17	47.23	48.31
KAYENTA_NTUA1	0	281.18	0	0	19.77	20.26	73.18	36.95	89.49	91.71	93.98	96.31	98.7	101.15	103.66	106.23	108.86	111.56	114.33	117.16	120.07	123.05	126.1	129.22	132.43
KAYENTA_NTUA2	0	234.11	0	0	0	0.81	0.09	0.44	1.07	1.09	1.12	1.15	1.18	1.2	1.23	1.26	1.3	1.33	1.36	1.4	1.43	1.47	1.5	1.54	1.58
KAYENTA_NTUA3	342.43	287.8	254.19	267.13	216.11	246.91	175.95	208.54	505.05	517.58	530.41	543.57	557.05	570.86	585.02	599.53	614.39	629.63	645.25	661.25	677.65	694.45	711.68	729.33	747.41
KAYENTA_NTUA4	344.39	349.32	385.32	596.43	107.28	108.07	108.07	105.55	255.63	261.96	268.46	275.12	281.94	288.93	296.1	303.44	310.97	318.68	326.58	334.68	342.98	351.49	360.21	369.14	378.29
KAYENTA_NTUA5	491.53	509.38	535.52	21.13	668.06	450	362.36	483.18	1170.18	1199.2	1228.94	1259.42	1290.66	1322.66	1355.47	1389.08	1423.53	1458.84	1495.01	1532.09	1570.09	1609.02	1648.93	1689.82	1731.73
KAYENTA_NTUA6	252.37	273.26	77.48	2.97	241.4	424.17	97.73	249.12	603.33	618.29	633.62	649.34	665.44	681.95	698.86	716.19	733.95	752.15	770.81	789.92	809.51	829.59	850.16	871.25	892.85
KAYENTA_NTUA7	268.94	280.1	403.43	268.52	238.08	279.49	252.58	251.36	608.75	623.85	639.32	655.18	671.43	688.08	705.14	722.63	740.55	758.92	777.74	797.02	816.79	837.05	857.81	879.08	900.88
KEAMS_CYN1	6.82	7	7.19	7.37	7.37	7.37	7.98	8.19	2.91	2.98	3.04	3.11	3.19	3.26	3.33	3.41	3.49	3.57	3.65	3.73	3.82	3.91	4	4.09	4.18
KEAMS_CYN2	155.23	8.59	138.63	128.43	128.54	0	134.62	64.81	23.02	23.55	24.09	24.64	25.21	25.79	26.38	26.99	27.61	28.24	28.89	29.56	30.24	30.93	31.64	32.37	33.11
KEAMS_CYN3	50.59	46.41	70.38	65.2	6.22	0	64.84	34.21	12.15	12.43	12.72	13.01	13.31	13.61	13.93	14.25	14.57	14.91	15.25	15.6	15.96	16.33	16.7	17.09	17.48
KITSILLIE_NTUA1	8.14	28.31	8.13	29.81	29.81	0	32.24	33.1	21.67	22.21	22.76	23.32	23.9	24.49	25.1	25.72	26.36	27.01	27.68	28.37	29.07	29.79	30.53	31.29	32.07
KITSILLIE_NTUA2	77.56	44.95	60	46.45	70.27	71.26	71.19	49.74	32.56	33.37	34.2	35.05	35.91	36.8	37.72	38.65	39.61	40.59	41.6	42.63	43.69	44.77	45.88	47.02	48.19
KYKOTSMOVI_PM1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
KYKOTSMOVI_PM2	66.79	37.45	86.12	1.23	0.82	59.92	79.4	54.77	19.45	19.9	20.36	20.83	21.3	21.79	22.29	22.81	23.33	23.87	24.42	24.98	25.55	26.14	26.74	27.35	27.98
KYKOTSMOVI_PM3	129.53	75.24	129.62	69.27	139.47	157.94	146.6	173.53	61.63	63.05	64.5	65.98	67.5	69.05	70.64	72.26	73.92	75.62	77.36	79.14	80.96	82.82	84.72	86.67	88.66
LOW_MTN_PM2	0	0	0	0	0	0	0	0	321.84	329.82	338	346.38	354.98	363.78	372.8	382.05	391.52	401.23	411.18	421.38	431.83	442.54	453.51	464.76	476.29
MISHONGNOVI_1	0.07	0	15.81	19.83	21.28	20.11	17.51	12.83	4.56	4.66	4.77	4.88	4.99	5.11	5.22	5.34	5.47	5.59	5.72	5.85	5.99	6.12	6.26	6.41	6.55
MOENKOPI_1	226.73	142.5	210.77	158.77	134.41	138.34	147.15	141.07	73.23	75.41	77.65	79.96	82.33	84.78	87.3	89.89	92.56	95.31	98.15	101.06	104.06	107.16	110.34	113.62	116.99
MOENKOPI_2	226.73	142.5	210.77	158.77	134.41	138.34	147.15	140.72	73.05	75.22	77.46	79.76	82.13	84.57	87.08	89.67	92.33	95.08	97.9	100.81	103.81	106.89	110.07	113.34	116.7
MOENKOPI_3	42.67	43.97	45.29	46.64	46.64	46.64	50.82	52.26	27.13	27.94	28.77	29.62	30.5	31.41	32.34	33.3	34.29	35.31	36.36	37.44	38.55	39.7	40.88	42.09	43.34
NAV2	2104.11	1377.04	2480.17	2816.14	2609.01	2298.31	2327.62	2327.62	2824.78	2824.78	2824.78	2824.78	2824.78	2824.78	2824.78	2824.78	2824.78	2824.78	2824.78	2824.78	2824.78	2824.78	2824.78	2824.78	2824.78
NAV3	2497.08	95.45	31.78	38.03	43.3	43.14	50.59	50.59	61.4	61.4	61.4	61.4	61.4	61.4	61.4	61.4	61.4	61.4	61.4	61.4	61.4	61.4	61.4	61.4	61.4
NAV3OBS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NAV4	756.69	206.55	120.88	82.06	103.82	88.81	121.02	121.02	146.87	146.87	146.87	146.87	146.87	146.87	146.87	146.87	146.87	146.87	146.87	146.87	146.87	146.87	146.87	146.87	146.87
NAV5	1446.64	223.37	504.94	368.75	583.13	389.4	415.97	415.97	504.82	504.82	504.82	504.82	504.82	504.82	504.82	504.82	504.82	504.82	504.82	504.82	504.82	504.82	504.82	504.82	504.82
NAV6	1920.66	818.89	37.34	30.86	68.76	60.95	204.37	204.37	248.02	248.02	248.02	248.02	248.02	248.02	248.02	248.02	248.02	248.02	248.02	248.02	248.02	248.02	248.02	248.02	248.02
NAV6OBS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NAV7	2541.27	187.71	99.77	99.41	122.46	127.52	128.01	128.01	155.35	155.35	155.35	155.35	155.35	155.35	155.35	155.35	155.35	155.35	155.35	155.35	155.35	155.35	155.35	155.35	155.35
NAV8	1537.85	1040.21	646.21	610.4	1143.57	886.2	869.61	869.61	1055.35	1055.35	1055.35	1055.35	1055.35	1055.35	1055.35	1055.35	1055.35	1055.35	1055.35	1055.35	1055.35	1055.35	1055.35	1055.35	1055.35
NAV9	2336.31	108.22	38.35	39.82	35.84	61.53	57.03	57.03	69.21	69.21	69.21	69.21	69.21	69.21	69.21	69.21	69.21	69.21	69.21	69.21	69.21	69.21	69.21	69.21	69.21
ORAIBI_2	0	0	0	0	0	0	0	0	216.9	223.09	229.45	235.99	242.72	249.65	256.77	264.09	271.62	279.36	287.33	295.53	303.95	312.62	321.54	330.71	340.14
PINON_3	32.58	33.43	34.31	35.21	35.21	35.21	38.08	39.09	39.15	40.13	41.12	42.14	43.19	44.26	45.35	46.48	47.63	48.81	50.02	51.26	52.54	53.84	55.17	56.54	57.94
PINON_4	0.86	0	50.35	0	28.97	0	5.92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PINON_NTUA1	342.92	224.13	339.16	236.04	399.61	78.44	454.02	319.35	319.88	327.81	335.94	344.27	352.81	361.56	370.52	379.71	389.13	398.78	408.67	418.81	429.19	439.84	450.74	461.92	473.38
PINON_NTUA2	266.97	187.92	304.9	197.91	290.08	916.24	277.81	508.5	509.34	521.97	534.91	548.18	561.77	575.71	589.98	604.62	619.61	634.98	650.72	666.86	683.4	700.35	717.72	735.52	753.76

ANNUAL RATES OF COMMU

WELL NAME	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
PINON_NTUA3	449.58	70.41	390.75	74.15	452.28	28.88	398.81	301.5	302	309.49	317.16	325.03	333.09	341.35	349.81	358.49	367.38	376.49	385.83	395.4	405.2	415.25	425.55	436.1	446.92
PINON_PHS1	0.86	4.25	50.35	4.48	4.48	0	4.85	4.97	4.98	5.1	5.23	5.36	5.49	5.63	5.77	5.91	6.06	6.21	6.36	6.52	6.68	6.85	7.01	7.19	7.37
PINON_PM_6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLACCA_PDC_2	0	177	355.23	486.25	527.84	372.35	380.12	206.98	73.51	75.2	76.93	78.7	80.51	82.36	84.25	86.19	88.17	90.2	92.27	94.39	96.56	98.78	101.05	103.37	105.75
POLACCA_USPHS_5	296.37	286.88	196.58	0	0	0	397.45	408.04	144.93	148.26	151.67	155.15	158.72	162.37	166.1	169.91	173.82	177.81	181.9	186.08	190.36	194.73	199.21	203.79	208.47
POLACCA_USPHS_6	0.46	0	54.92	226.52	106.72	172.24	245.6	159.12	56.52	57.81	59.14	60.5	61.89	63.32	64.77	66.26	67.78	69.34	70.93	72.56	74.23	75.94	77.68	79.47	81.3
RED_LAKE_NTUA1	173.34	178.22	211.68	40.15	177.69	189.58	182.35	169.24	18.48	18.94	19.41	19.89	20.39	20.89	21.41	21.94	22.48	23.04	23.61	24.2	24.8	25.41	26.04	26.69	27.35
RED_LAKE_PM2	10.28	10.59	10.91	60.96	60.96	0	12.24	12.59	1.37	1.41	1.44	1.48	1.52	1.55	1.59	1.63	1.67	1.71	1.76	1.8	1.84	1.89	1.94	1.99	2.03
RED_LK_PM1	21.13	26.12	312.95	7.22	17.56	16.82	17.04	15.83	1.73	1.77	1.82	1.86	1.91	1.95	2	2.05	2.1	2.16	2.21	2.26	2.32	2.38	2.44	2.5	2.56
RGH_RK_PM4	9.45	9.68	9.92	10.16	10.16	10.16	10.95	11.24	13.3	13.63	13.96	14.31	14.66	15.03	15.4	15.78	16.17	16.58	16.99	17.41	17.84	18.28	18.74	19.2	19.68
RGH_RK_PM5	32.56	33.07	33.24	21.98	22.3	14.68	32.85	52.66	62.29	63.84	65.42	67.04	68.71	70.41	72.16	73.94	75.78	77.66	79.58	81.56	83.58	85.65	87.78	89.95	92.18
ROCKY_RIDGE_PM1	34.89	35.8	36.74	1.35	1.35	0	19.28	6.65	18.6	19.07	19.54	20.02	20.52	21.03	21.55	22.08	22.63	23.19	23.77	24.36	24.96	25.58	26.22	26.87	27.53
ROCKY_RIDGE_PM2	21.71	23.38	26.46	5.93	21.52	17.87	60.42	13.58	37.99	38.93	39.9	40.89	41.9	42.94	44.01	45.1	46.22	47.36	48.54	49.74	50.98	52.24	53.53	54.86	56.22
ROUGH_ROCK_NTUA1	48.75	49.92	114.12	52.41	107.24	120.95	140.69	117.04	138.45	141.88	145.4	149.01	152.7	156.49	160.37	164.35	168.42	172.6	176.88	181.27	185.76	190.37	195.09	199.93	204.89
ROUGH_ROCK_NTUA2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ROUGH_ROCK_PM7	20.78	26.06	13.44	5.81	21.22	16.99	6.99	14.34	16.96	17.38	17.81	18.26	18.71	19.17	19.65	20.14	20.64	21.15	21.67	22.21	22.76	23.32	23.9	24.5	25.1
ROUGHROCK_PM3_BIA	23.03	3.94	23.03	0.06	0.01	0.03	18.96	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02
ROUGHROCK_PM6_BIA	40.98	24.18	37.84	31.36	38.38	37.7	23.81	31.69	37.49	38.42	39.37	40.35	41.35	42.37	43.42	44.5	45.6	46.73	47.89	49.08	50.3	51.54	52.82	54.13	55.48
SALINA_TP2	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49
SEC_MESA_DY_SCH_1	1.69	0.38	1.78	1.83	1.83	1.83	1.97	2.03	0.72	0.74	0.75	0.77	0.79	0.81	0.83	0.85	0.86	0.88	0.9	0.93	0.95	0.97	0.99	1.01	1.04
SEC_MESA_DY_SCH_2	14.35	17.93	10.98	21.65	14.49	18.38	25.3	1.99	0.71	0.72	0.74	0.76	0.77	0.79	0.81	0.83	0.85	0.87	0.89	0.91	0.93	0.95	0.97	0.99	1.02
SECOND_MESA_PD&C1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SECOND_MESA_PM2	0	0	0	0	0	0	0	20.11	7.14	7.31	7.47	7.65	7.82	8	8.19	8.37	8.57	8.76	8.96	9.17	9.38	9.6	9.82	10.04	10.27
SECOND_MESASCH_PHS1_BIA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHIPAULOVI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHIPAULOVI#2	61.15	67.65	62.61	68.1	74.12	71.6	68.39	78.12	27.75	28.38	29.04	29.7	30.39	31.09	31.8	32.53	33.28	34.04	34.83	35.63	36.44	37.28	38.14	39.02	39.91
SHONTO_JN_NTUA1	129.52	104.13	169.39	192.97	176.05	173.55	164.59	182.01	215.32	220.66	226.13	231.74	237.49	243.38	249.41	255.6	261.94	268.43	275.09	281.91	288.9	296.07	303.41	310.93	318.65
SHONTO_JN_NTUA2	88.63	115.37	106.69	1.3	12.44	135.08	148.78	104.88	124.07	127.15	130.3	133.54	136.85	140.24	143.72	147.28	150.94	154.68	158.52	162.45	166.48	170.6	174.83	179.17	183.61
SHONTO_NTUA1	58.04	71.54	73.66	91.63	86.92	80.4	63.09	65.26	77.2	79.12	81.08	83.09	85.15	87.26	89.43	91.64	93.92	96.25	98.63	101.08	103.59	106.16	108.79	111.49	114.25
SHONTO_PM2	207.38	336	309.95	252.1	283.41	242.8	276.12	227.23	268.81	275.48	282.31	289.31	296.49	303.84	311.38	319.1	327.01	335.12	343.43	351.95	360.68	369.62	378.79	388.19	397.81
SHONTO_PM3	219.04	111.71	3.32	104.99	164.92	122.86	125.01	116.91	138.31	141.74	145.25	148.85	152.54	156.33	160.2	164.18	168.25	172.42	176.7	181.08	185.57	190.17	194.89	199.72	204.67
SHONTO_PM4	136.6	87.82	107.08	94.82	85.3	65.83	97	70.27	83.13	85.19	87.3	89.47	91.69	93.96	96.29	98.68	101.13	103.64	106.21	108.84	111.54	114.31	117.14	120.04	123.02
SHUNGOPAVI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHUNGOPOVI_1	119.91	128.7	110.03	108.52	33.36	209.79	128.84	109.55	38.91	39.8	40.72	41.65	42.61	43.59	44.59	45.62	46.67	47.74	48.84	49.96	51.11	52.28	53.48	54.71	55.97
TALAHOGAN	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49
TUBA_CITY_NTUA1	499.93	844.46	473.88	186.79	271.4	610.46	372.41	343.02	898.36	920.63	943.47	966.86	990.84	1015.42	1040.6	1066.4	1092.85	1119.95	1147.73	1176.19	1205.36	1235.26	1265.89	1297.28	1329.46
TUBA_CITY_NTUA2	516.5	289.95	562.08	557.52	531.18	538.52	359.79	390.94	1023.86	1049.25	1075.27	1101.94	1129.26	1157.27	1185.97	1215.38	1245.52	1276.41	1308.07	1340.51	1373.75	1407.82	1442.74	1478.51	1515.18
TUBA_CITY_NTUA3	389.77	775.05	455.92	362.09	464.11	307.27	428.87	328.25	859.67	880.99	902.84	925.23	948.18	971.69	995.79	1020.49	1045.79	1071.73	1098.31	1125.55	1153.46	1182.07	1211.38	1241.42	1272.21
TUBA_CITY_NTUA4	312.7	802.98	544.69	386.33	398.26	429.03	534.21	114.4	299.61	307.04	314.65	322.46	330.45	338.65	347.05	355.65	364.48	373.51	382.78	392.27	402	411.97	422.18	432.65	443.38
TUBA_CITY_NTUA5	406.67	1082.29	479.71	761.28	258.99	0	1206.42	19.74	51.7	52.98	54.29	55.64	57.02	58.43	59.88	61.37	62.89	64.45	66.05	67.69	69.37	71.09	72.85	74.66	76.51
TUBA_CITY_NTUA6	1112.64	661.63	724.92	1309.49	1051.98	1122.97	749.77	90.42	236.81	242.68	248.7	254.87	261.19	267.66	274.3	281.1	288.08	295.22	302.54	310.04	317.73	325.61	333.69	341.96	350.44
TURQUOISE_TRAIL	6.36	6.53	6.7	6.88	6.88	6.88	7.44	7.63	11.31	12.15	13.06	14.04	15.08	16.21	17.42	18.72	20.12	21.62	23.23	24.96	26.83	28.83	30.98	33.29	35.78
WELL__30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COAL_CREEK_MESA	0	0	0	0	0	0	0	0	295.17	302.49	309.99	317.68	325.56	333.63	341.91	350.38	359.07	367.98	377.1	386.46	396.04	405.86	415.93	426.24	436.81
INSCRIPTION_HOUSE	0	0	0	0	0	0	0	0	535.22	548.49	562.09	576.03	590.32	604.96	619.96	635.34	651.09	667.24	683.79	700.74	718.12	735.93	754.18	772.89	792.06
JEDDITO	0	0	0	0	0	0	0	0	504.99	517.51	530.35	543.5	556.98	570.79	584.95	599.45	614.32	629.55	645.17	661.17	677.56	694.37	711.59	729.24	747.32
STEAMBOAT	0	0	0	0	0	0	0	0	524.55	537.56	550.89	564.55	578.55	592.9	607.6	622.67	638.11	653.94	670.16	686.78	703.81	721.26	739.15	757.48	776.27
TACHEE_BLUE_GAP	0	0	0	0	0	0	0	0	503.21	515.69	528.48	541.59	555.02	568.78	582.89	597.34	612.16	627.34	642.9	658.84	675.18	691.92	709.08	726.67	744.69
TEESTOH	0	0	0	0	0	0	0	0	396.52	406.36	416.43	426.76	437.35	448.19	459.31	470.7	482.37	494.33	506.59	519.16	532.03	545.23	558.75	572.6	586.8
WHIPPORWILL	0	0	0	0	0	0	0	0	636.57	652.36	668.54	685.11	702.11	719.52	737.36	755.65	774.39	793.59	813.27	833.44	854.11	875.3	897	919.25	942.05
WHITE_CONE	0	0	0	0	0	0	0	0	549.44	563.07	577.03	591.34	606.01	621.04	636.44	652.22	668.4	684.97	701.96	719.37	737.21	755.49	774.23	793.43	813.11
Lower_Moenkopi	0	0	0	0	0	0	0	0	8.3	8.93	9.62	10.35	11.14	12	12.91	13.9	14.96	16.11	17.34	18.66	20.09	21.62	23.28	25.06	26.97
Rural_Moenkopi_District	0	0	0	0	0	0	0	0	12.5	12.82	13.15	13.48	13.83	14.18	14.54	14.91	15.29	15.68	16.08	16.48	16.9	17.33	17.78	18.23	18.69
Upper_Rural_Moenkopi	0	0	0	0	0	0	0	0	12.5	12.82	13.15	13.48	13.83	14.18	14.54	14.91	15.29	15.68	16.08	16.48	16.9	17.33	17.78	18.23	18.69
Lower_Rural_Moenkopi	0	0	0	0	0	0	0	0	12.5	12.82	13.15	13.48	13.83	14.18	14.54	14.91	15.29	15.68	16.08	16.48	16.9	17.33	17.78	18.23	18.69
Howell_Mesa_East	0	0	0	0	0	0	0	0	2.35	2.52	2.72	2.92	3.15	3.39	3.65	3.92	4.22	4.54	4.89	5.26	5.67	6.1	6.56	7.06	7.6
Side_Rock_Well	0	0	0	0	0	0	0	0	2.02	2.18	2.34	2.52	2.7	2.91	3.13	3.36	3.62	3.89	4.18	4.5	4.83	5.2	5.59	6.01	6.46
Central_Dinnebito	0	0	0	0	0	0	0	0	80.64	83.02	85.47	88	90.6	93.27	96.03	98.86	101.78	104.79	107.89	111.07	114.35	117.73	121.21	124.79	128.47
Upper_Dinnebito	0	0	0	0	0	0	0	0	6.68	6.82	6.97	7.12	7.27	7.42	7.57	7.73	7.9	8.06	8.23	8.41	8.58	8.77	8.95	9.14	9.33
Central_Rural_Dinnebito	0	0	0	0	0	0	0	0	4.6	4.69	4.78	4.88	4.97	5.07	5.17	5.27	5.37	5.48	5.58	5.69	5.8	5.91	6.03	6.15	6.27
Lower_Dinnebito	0	0	0	0	0	0	0	0	11.29	11.52	11.75	11.99	12.24	12.49	12.74	13	13.27	13.54	13.82	14.1	14.39	14.68	14.98	15.29	15.6
Upper_Rural_Oraibi	0	0	0	0	0	0	0	0	5.44	5.59	5.75	5.91	6.08	6.25	6.43	6.61	6.8	6.99	7.19	7.39	7.6	7.82	8.04	8.27	8.5
Lower_Oraibi	0	0	0	0	0	0	0	0	12.58	12.93	13.29	13.66	14.04	14.43	14.83	15.24	15.67	16.11	16.55	17.02	17.49	17.98	18.48	18.99	19.52
Upper_Rural_Polacca	0	0	0	0	0	0	0	0	4.77	4.88	4.99	5.11	5.23	5.35	5.48	5.6	5.74	5.87	6.01	6.15	6.29	6.44	6.59	6.74	6.9
Spider_Mound	0	0	0	0	0	0	0	0	19.35	20.23	21.14	22.09	23.08	24.12	25.21	26.34	27.53	28.77	30.06	31.41	32.83	34.31	35.85	37.46	39.15
Lower_Rural_Jadito	0	0	0	0	0	0	0	0	19.34	19.95	20.57	21.21	21.87	22.56	23.26	23.99	24.74	25.51	26.3	27.13	27.97	28.85	29.75	30.67	31.63
Upper_Rural_Jadito	0	0	0	0	0	0	0	0	7.77	8.01	8.26	8.52	8.79	9.06	9.35	9.64	9.94	10.25	10.57	10.9	11.24	11.6	11.96	12.33	12.72

ANNUAL RATES OF COMMU

WELL NAME	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054
1K-228	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3K-252	359.14	368.04	377.17	386.52	396.11	405.93	416	426.32	436.89	447.72	458.83	470.21	481.87	493.82	506.06	518.62	531.48	544.66	558.16	572.01	586.19	600.73	615.63	630.9	646.54
3K-318-1	454.38	465.65	477.2	489.03	501.16	513.59	526.33	539.38	552.76	566.46	580.51	594.91	609.66	624.78	640.28	656.16	672.43	689.1	706.19	723.71	741.66	760.05	778.9	798.21	818.01
3K-318-2	78.4	80.35	82.34	84.38	86.48	88.62	90.82	93.07	95.38	97.74	100.17	102.65	105.2	107.81	110.48	113.22	116.03	118.91	121.86	124.88	127.97	131.15	134.4	137.73	141.15
3P-350	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3T-222	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3T-322-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3T-322-2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3T-333	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3T-507	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4T-523	305.23	312.8	320.56	328.51	336.65	345	353.56	362.33	371.31	380.52	389.96	399.63	409.54	419.69	430.1	440.77	451.7	462.9	474.38	486.15	498.2	510.56	523.22	536.2	549.5
6K-312	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8A-295	172.37	176.64	181.03	185.51	190.12	194.83	199.66	204.61	209.69	214.89	220.22	225.68	231.28	237.01	242.89	248.91	255.09	261.41	267.9	274.54	281.35	288.32	295.48	302.8	310.31
8K-416	220.04	225.5	231.09	236.82	242.7	248.72	254.88	261.21	267.68	274.32	281.13	288.1	295.24	302.56	310.07	317.76	325.64	333.71	341.99	350.47	359.16	368.07	377.2	386.55	396.14
BACAVI	46.79	47.69	48.62	49.56	50.51	51.49	52.49	53.5	54.54	55.59	56.67	57.61	58.56	59.54	60.53	61.53	62.56	63.6	64.65	65.73	66.82	67.67	68.53	69.4	70.28
CHILCHINBITO_NTUA1	362.81	371.81	381.03	390.48	400.16	410.09	420.26	430.68	441.36	452.31	463.53	475.02	486.8	498.87	511.25	523.93	536.92	550.23	563.88	577.86	592.2	606.88	621.93	637.36	653.16
CHILCHINBITO_NTUA2	315.53	323.36	331.37	339.59	348.01	356.64	365.49	374.55	383.84	393.36	403.12	413.11	423.36	433.86	444.62	455.65	466.95	478.53	490.39	502.56	515.02	527.79	540.88	554.29	568.04
CHLCHN_PM2	47.28	48.46	49.66	50.89	52.15	53.44	54.77	56.13	57.52	58.95	60.41	61.91	63.44	65.01	66.63	68.28	69.97	71.71	73.49	75.31	77.18	79.09	81.05	83.06	85.12
CHLCHN_PM3	29.44	30.17	30.92	31.69	32.47	33.28	34.1	34.95	35.82	36.71	37.62	38.55	39.5	40.48	41.49	42.52	43.57	44.65	45.76	46.89	48.06	49.25	50.47	51.72	53
COTTONWD3	307.82	315.45	323.28	331.3	339.51	347.93	356.56	365.4	374.46	383.75	393.27	403.02	413.02	423.26	433.76	444.51	455.54	466.83	478.41	490.28	502.44	514.9	527.67	540.75	554.16
COTTONWOOD_NTUA_N	307.82	315.45	323.28	331.3	339.51	347.93	356.56	365.4	374.46	383.75	393.27	403.02	413.02	423.26	433.76	444.51	455.54	466.83	478.41	490.28	502.44	514.9	527.67	540.75	554.16
COTTONWOOD_NTUA_S	307.82	315.45	323.28	331.3	339.51	347.93	356.56	365.4	374.46	383.75	393.27	403.02	413.02	423.26	433.76	444.51	455.54	466.83	478.41	490.28	502.44	514.9	527.67	540.75	554.16
DENNEHOTSO_NTUA1	99.76	102.23	104.77	107.37	110.03	112.76	115.56	118.42	121.36	124.37	127.45	130.61	133.85	137.17	140.57	144.06	147.63	151.29	155.05	158.89	162.83	166.87	171.01	175.25	179.59
DENNEHOTSO_NTUA2	197.1	201.99	207	212.13	217.39	222.78	228.31	233.97	239.77	245.72	251.81	258.06	264.46	271.02	277.74	284.63	291.69	298.92	306.33	313.93	321.72	329.69	337.87	346.25	354.84
DENNHOTS_PM1_BIA	204.95	210.03	215.24	220.57	226.04	231.65	237.4	243.28	249.32	255.5	261.84	268.33	274.98	281.8	288.79	295.95	303.29	310.82	318.52	326.42	334.52	342.81	351.32	360.03	368.96
DENNHOTS_PM2_BIA	191.24	195.98	200.84	205.82	210.93	216.16	221.52	227.01	232.64	238.41	244.32	250.38	256.59	262.96	269.48	276.16	283.01	290.03	297.22	304.59	312.14	319.89	327.82	335.95	344.28
HARD_ROCK_NTUA1	281.94	288.93	296.09	303.44	310.96	318.67	326.58	334.67	342.97	351.48	360.2	369.13	378.28	387.67	397.28	407.13	417.23	427.58	438.18	449.05	460.18	471.6	483.29	495.28	507.56
HARD_ROCK_NTUA2	384.61	394.15	403.92	413.94	424.21	434.73	445.51	456.56	467.88	479.48	491.38	503.56	516.05	528.85	541.96	555.4	569.18	583.29	597.76	612.58	627.78	643.34	659.3	675.65	692.41
HOPI_CIVIC_CENTER	3.12	3.18	3.24	3.3	3.36	3.43	3.49	3.56	3.63	3.7	3.77	3.84	3.9	3.96	4.03	4.1	4.16	4.23	4.3	4.38	4.45	4.51	4.56	4.62	4.68
HOPI_CULTURAL_CENTER	9.9	10.09	10.29	10.48	10.69	10.89	11.1	11.32	11.54	11.76	11.99	12.19	12.39	12.6	12.81	13.02	13.24	13.46	13.68	13.91	14.14	14.32	14.5	14.68	14.87
HOPI_HIGH_SCH_1	7.01	7.14	7.28	7.42	7.57	7.71	7.86	8.01	8.17	8.33	8.49	8.63	8.77	8.92	9.07	9.22	9.37	9.53	9.68	9.85	10.01	10.14	10.27	10.4	10.53
HOPI_HIGH_SCH_2	36.67	37.38	38.11	38.84	39.6	40.36	41.14	41.94	42.75	43.57	44.42	45.16	45.91	46.67	47.44	48.23	49.03	49.85	50.68	51.52	52.38	53.04	53.71	54.4	55.09
HOPI_HIGH_SCH_3	26.72	27.24	27.77	28.3	28.85	29.41	29.98	30.56	31.15	31.75	32.37	32.9	33.45	34.01	34.57	35.15	35.73	36.32	36.93	37.54	38.16	38.65	39.14	39.64	40.14
HOTEVILLA_PM1	21.86	22.29	22.72	23.16	23.6	24.06	24.53	25	25.48	25.98	26.48	26.92	27.37	27.82	28.28	28.75	29.23	29.72	30.21	30.71	31.22	31.62	32.02	32.43	32.84
HOTEVILLA_PM2	49.42	50.38	51.35	52.35	53.36	54.39	55.44	56.51	57.61	58.72	59.86	60.85	61.86	62.89	63.94	65	66.08	67.18	68.29	69.43	70.58	71.48	72.38	73.3	74.23
KAYENTA_NTUA1	135.71	139.08	142.53	146.06	149.69	153.4	157.2	161.1	165.1	169.19	173.39	177.69	182.09	186.61	191.24	195.98	200.84	205.82	210.93	216.16	221.52	227.01	232.64	238.41	244.32
KAYENTA_NTUA2	1.62	1.66	1.7	1.74	1.78	1.83	1.87	1.92	1.97	2.01	2.06	2.12	2.17	2.22	2.28	2.33	2.39	2.45	2.51	2.57	2.64	2.7	2.77	2.84	2.91
KAYENTA_NTUA3	765.95	784.94	804.41	824.36	844.8	865.76	887.23	909.23	931.78	954.89	978.57	1002.84	1027.71	1053.19	1079.31	1106.08	1133.51	1161.62	1190.43	1219.95	1250.21	1281.21	1312.99	1345.55	1378.92
KAYENTA_NTUA4	387.68	397.29	407.14	417.24	427.59	438.19	449.06	460.2	471.61	483.3	495.29	507.57	520.16	533.06	546.28	559.83	573.71	587.94	602.52	617.46	632.78	648.47	664.55	681.03	697.92
KAYENTA_NTUA5	1774.68	1818.69	1863.79	1910.01	1957.38	2005.93	2055.67	2106.65	2158.9	2212.44	2267.31	2323.54	2381.16	2440.21	2500.73	2562.75	2626.3	2691.44	2758.18	2826.59	2896.69	2968.52	3042.14	3117.59	3194.91
KAYENTA_NTUA6	915	937.69	960.94	984.77	1009.2	1034.22	1059.87	1086.16	1113.09	1140.7	1168.99	1197.98	1227.69	1258.14	1289.34	1321.31	1354.08	1387.66	1422.08	1457.34	1493.49	1530.52	1568.48	1607.38	1647.24
KAYENTA_NTUA7	923.22	946.12	969.58	993.63	1018.27	1043.52	1069.4	1095.92	1123.1	1150.96	1179.5	1208.75	1238.73	1269.45	1300.93	1333.19	1366.26	1400.14	1434.86	1470.45	1506.91	1544.29	1582.58	1621.83	1662.05
KEAMS_CYN1	4.28	4.36	4.45	4.53	4.62	4.71	4.8	4.89	4.99	5.09	5.18	5.27	5.36	5.45	5.54	5.63	5.72	5.82	5.91	6.01	6.11	6.19	6.27	6.35	6.43
KEAMS_CYN2	33.87	34.53	35.2	35.88	36.57	37.28	38	38.73	39.48	40.25	41.02	41.71	42.4	43.1	43.82	44.55	45.29	46.04	46.81	47.58	48.37	48.99	49.61	50.24	50.88
KEAMS_CYN3	17.88	18.23	18.58	18.94	19.3	19.68	20.06	20.45	20.84	21.24	21.65	22.01	22.38	22.75	23.13	23.51	23.91	24.3	24.71	25.12	25.53	25.86	26.19	26.52	26.86
KITSILLIE_NTUA1	32.86	33.68	34.51	35.37	36.25	37.14	38.07	39.01	39.98	40.97	41.98	43.03	44.09	45.19	46.31	47.46	48.63	49.84	51.07	52.34	53.64	54.97	56.33	57.73	59.16
KITSILLIE_NTUA2	49.38	50.61	51.86	53.15	54.47	55.82	57.2	58.62	60.07	61.56	63.09	64.66	66.26	67.9	69.59	71.31	73.08	74.89	76.75	78.65	80.6	82.6	84.65	86.75	88.9
KYKOTSMOVI_PM1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
KYKOTSMOVI_PM2	28.63	29.18	29.74	30.32	30.91	31.5	32.11	32.73	33.37	34.01	34.67	35.25	35.83	36.43	37.03	37.65	38.27	38.91	39.56	40.21	40.88	41.4	41.93	42.46	43
KYKOTSMOVI_PM3	90.7	92.45	94.24	96.06	97.92	99.81	101.74	103.71	105.72	107.76	109.84	111.67	113.53	115.41	117.33	119.28	121.26	123.28	125.32	127.41	129.52	131.17	132.83	134.52	136.23
LOW_MTN_PM2	488.1	500.2	512.61	525.32	538.35	551.7	565.38	579.4	593.77	608.5	623.59	639.05	654.9	671.14	687.79	704.84	722.32	740.24	758.6	777.41	796.69	816.45	836.69	857.44	878.71
MISHONGNOVI_1	6.71	6.84	6.97	7.1	7.24	7.38	7.52	7.67	7.82	7.97	8.12	8.26	8.39	8.53	8.67	8.82	8.97	9.11	9.27	9.42	9.58	9.7	9.82	9.95	10.07
MOENKOPI_1	120.47	123.6	126.8	130.09	133.47	136.93	140.48	144.13	147.87	151.71	155.64	159.23	162.9	166.66	170.5	174.44	178.46	182.57	186.79	191.09	195.5	199.23	203.04	206.91	210.87
MOENKOPI_2	120.17	123.29	126.49	129.77	133.14	136.59	140.14	143.77	147.5	151.33	155.26	158.84	162.5	166.25	170.08	174	178.02	182.12	186.32	190.62	195.01	198.74	202.53	206.4	210.34
MOENKOPI_3	44.63	45.79	46.98	48.19	49.44	50.73	52.04	53.39	54.78	56.2	57.66	58.99	60.35	61.74	63.16	64.62	66.11	67.64	69.2	70.79	72.42	73.81	75.22	76.65	78.12
NAV2	2824.78	2824.78	2824.78	2824.78	2824.78	2824.78	2824.78	2824.78	2824.78	2824.78	2824.78	2824.78	2824.78	2824.78	2824.78	1129.91	1129.91	1129.91	1129.91	1129.91	1129.91	1129.91	1129.91	1129.91	1129.91
NAV3	61.4	61.4	61.4	61.4	61.4	61.4	61.4	61.4	61.4	61.4	61.4	61.4	61.4	61.4	61.4	24.56	24.56	24.56	24.56	24.56	24.56	24.56	24.56	24.56	24.56
NAV3OBS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NAV4	146.87	146.87	146.87	146.87	146.87	146.87	146.87	146.87	146.87	146.87	146.87	146.87	146.87	146.87	146.87	58.75	58.75	58.75	58.75	58.75	58.75	58.75	58.75	58.75	58.75
NAV5	504.82	504.82	504.82	504.82	504.82	504.82	504.82	504.82	504.82	504.82	504.82	504.82	504.82	504.82	504.82	201.93	201.93	201.93	201.93	201.93	201.93	201.93	201.93	201.93	201.93
NAV6	248.02	248.02	248.02	248.02	248.02	248.02	248.02	248.02	248.02	248.02	248.02	248.02	248.02	248.02	248.02	99.21	99.21	99.21	99.21	99.21	99.21	99.21	99.21	99.21	99.21
NAV6OBS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NAV7	155.35	155.35	155.35	155.35	155.35	155.35	155.35	155.35	155.35	155.35	155.35	155.35	155.35	155.35	155.35	62.14	62.14	62.14	62.14	62.14	62.14	62.14	62.14	62.14	62.14
NAV8	1055.35	1055.35	1055.35	1055.35	1055.35	1055.35	1055.35	1055.35	1055.35	1055.35	1055.35	1055.35	1055.35	1055.35	1055.35	422.14	422.14	422.14	422.14	422.14	422.14	422.14	422.14	422.14	422.14
NAV9	69.21	69.21	69.21	69.21	69.21	69.21	69.21	69.21	69.21	69.21	69.21	69.21	69.21	69.21	69.21	27.68	27.68	27.68	27.68	27.68	27.68	27.68	27.68	27.68	27.68
ORAIBI_2	349.84	358.54	367.45	376.59	385.96	395.55	405.39	415.47	425.8	436.39	447.24	457.15	467.27	477.62	488.2	499.01	510.06	521.35	532.9	544.7	556.76	566.95	577.33	587.9	598.66
PINON_3	59.38	60.85	62.36	63.91	65.49	67.12	68.78	70.49	72.24	74.03	75.86	77.75	79.67	81.65	83.67	85.75	87.88	90.06	92.29	94.58	96.92	99.33	101.79	104.31	106.9
PINON_4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PINON_NTUA1	485.12	497.15	509.48	522.11	535.06	548.33	561.93	575.86	590.15	604.78	619.78	635.15	650.9	667.04	683.59	700.54	717.91	735.72	753.96	772.66	791.82	811.46	831.59	852.21	873.34
PINON_NTUA2	772.45	791.61	811.24	831.36	851.98	873.1	894.76	916.95	939.69	962.99	986.87	1011.35	1036.43	1062.13	1088.47	1115.47	1143.13	1171.48	1200.53	1230.31	1260.82	1292.09	1324.13	1356.97	1390.62

ANNUAL RATES OF COMMU

WELL NAME	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054
PINON_NTUA3	458	469.36	481	492.93	505.15	517.68	530.52	543.68	557.16	570.98	585.14	599.65	614.52	629.76	645.38	661.38	677.79	694.6	711.82	729.47	747.57	766.11	785.1	804.58	824.53
PINON_PHS1	7.55	7.74	7.93	8.13	8.33	8.53	8.75	8.96	9.18	9.41	9.65	9.88	10.13	10.38	10.64	10.9	11.17	11.45	11.73	12.02	12.32	12.63	12.94	13.26	13.59
PINON_PM_6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLACCA_PDC_2	108.18	110.27	112.4	114.58	116.79	119.05	121.35	123.7	126.09	128.53	131.02	133.2	135.41	137.66	139.95	142.27	144.64	147.04	149.48	151.97	154.49	156.45	158.44	160.45	162.49
POLACCA_USPHS_5	213.26	217.39	221.59	225.88	230.25	234.7	239.24	243.86	248.58	253.39	258.29	262.58	266.94	271.38	275.89	280.47	285.13	289.87	294.69	299.59	304.56	308.43	312.35	316.31	320.33
POLACCA_USPHS_6	83.16	84.77	86.41	88.08	89.79	91.52	93.29	95.1	96.94	98.81	100.72	102.4	104.1	105.83	107.59	109.37	111.19	113.04	114.92	116.83	118.77	120.28	121.8	123.35	124.92
RED_LAKE_NTUA1	28.03	28.73	29.44	30.17	30.92	31.68	32.47	33.27	34.1	34.95	35.81	36.7	37.61	38.54	39.5	40.48	41.48	42.51	43.57	44.65	45.75	46.89	48.05	49.24	50.46
RED_LAKE_PM2	2.09	2.14	2.19	2.24	2.3	2.36	2.42	2.48	2.54	2.6	2.66	2.73	2.8	2.87	2.94	3.01	3.09	3.16	3.24	3.32	3.4	3.49	3.57	3.66	3.75
RED_LK_PM1	2.62	2.69	2.75	2.82	2.89	2.96	3.04	3.11	3.19	3.27	3.35	3.43	3.52	3.61	3.69	3.79	3.88	3.98	4.07	4.18	4.28	4.39	4.49	4.61	4.72
RGH_RK_PM4	20.16	20.66	21.18	21.7	22.24	22.79	23.36	23.94	24.53	25.14	25.76	26.4	27.06	27.73	28.41	29.12	29.84	30.58	31.34	32.12	32.91	33.73	34.57	35.42	36.3
RGH_RK_PM5	94.47	96.81	99.21	101.68	104.2	106.78	109.43	112.14	114.92	117.77	120.7	123.69	126.76	129.9	133.12	136.42	139.81	143.27	146.83	150.47	154.2	158.02	161.94	165.96	170.07
ROCKY_RIDGE_PM1	28.21	28.91	29.63	30.37	31.12	31.89	32.68	33.49	34.32	35.17	36.05	36.94	37.86	38.8	39.76	40.74	41.75	42.79	43.85	44.94	46.05	47.2	48.37	49.57	50.79
ROCKY_RIDGE_PM2	57.62	59.05	60.51	62.01	63.55	65.13	66.74	68.4	70.09	71.83	73.61	75.44	77.31	79.23	81.19	83.2	85.27	87.38	89.55	91.77	94.05	96.38	98.77	101.22	103.73
ROUGH_ROCK_NTUA1	209.97	215.17	220.51	225.98	231.58	237.33	243.21	249.24	255.43	261.76	268.25	274.9	281.72	288.71	295.87	303.21	310.73	318.43	326.33	334.42	342.72	351.22	359.93	368.85	378
ROUGH_ROCK_NTUA2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ROUGH_ROCK_PM7	25.73	26.36	27.02	27.69	28.37	29.08	29.8	30.54	31.3	32.07	32.87	33.68	34.52	35.37	36.25	37.15	38.07	39.01	39.98	40.97	41.99	43.03	44.1	45.19	46.31
ROUGHROCK_PM3_BIA	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
ROUGHROCK_PM6_BIA	56.85	58.26	59.71	61.19	62.7	64.26	65.85	67.49	69.16	70.87	72.63	74.43	76.28	78.17	80.11	82.1	84.13	86.22	88.36	90.55	92.79	95.1	97.45	99.87	102.35
SALINA_TP2	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49
SEC_MESA_DY_SCH_1	1.06	1.08	1.1	1.12	1.15	1.17	1.19	1.21	1.24	1.26	1.28	1.31	1.33	1.35	1.37	1.4	1.42	1.44	1.47	1.49	1.52	1.53	1.55	1.57	1.59
SEC_MESA_DY_SCH_2	1.04	1.06	1.08	1.1	1.12	1.14	1.17	1.19	1.21	1.24	1.26	1.28	1.3	1.32	1.35	1.37	1.39	1.41	1.44	1.46	1.49	1.5	1.52	1.54	1.56
SECOND_MESA_PD&C1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SECOND_MESA_PM2	10.51	10.71	10.92	11.13	11.35	11.57	11.79	12.02	12.25	12.49	12.73	12.94	13.16	13.37	13.6	13.82	14.05	14.29	14.52	14.76	15.01	15.2	15.39	15.59	15.79
SECOND_MESASCH_PHS1_BIA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHIPAULOVI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHIPAULOVI#2	40.83	41.62	42.42	43.24	44.08	44.93	45.8	46.69	47.59	48.51	49.45	50.27	51.11	51.96	52.82	53.7	54.59	55.5	56.42	57.36	58.31	59.05	59.8	60.56	61.33
SHONTO_JN_NTUA1	326.55	334.65	342.95	351.45	360.17	369.1	378.25	387.63	397.25	407.1	417.19	427.54	438.14	449.01	460.15	471.56	483.25	495.24	507.52	520.1	533	546.22	559.77	573.65	587.88
SHONTO_JN_NTUA2	188.17	192.83	197.62	202.52	207.54	212.69	217.96	223.37	228.91	234.58	240.4	246.36	252.47	258.73	265.15	271.73	278.46	285.37	292.45	299.7	307.13	314.75	322.56	330.56	338.75
SHONTO_NTUA1	117.08	119.99	122.96	126.01	129.14	132.34	135.62	138.99	142.43	145.97	149.59	153.3	157.1	160.99	164.99	169.08	173.27	177.57	181.97	186.48	191.11	195.85	200.71	205.68	210.78
SHONTO_PM2	407.68	417.79	428.15	438.77	449.65	460.8	472.23	483.94	495.94	508.24	520.85	533.76	547	560.57	574.47	588.71	603.31	618.28	633.61	649.32	665.43	681.93	698.84	716.17	733.93
SHONTO_PM3	209.75	214.95	220.28	225.75	231.34	237.08	242.96	248.99	255.16	261.49	267.98	274.62	281.43	288.41	295.56	302.89	310.41	318.1	325.99	334.08	342.36	350.85	359.55	368.47	377.61
SHONTO_PM4	126.07	129.2	132.4	135.69	139.05	142.5	146.03	149.66	153.37	157.17	161.07	165.06	169.16	173.35	177.65	182.06	186.57	191.2	195.94	200.8	205.78	210.88	216.11	221.47	226.97
SHUNGOPAVI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHUNGOPOVI_1	57.26	58.36	59.49	60.64	61.82	63.01	64.23	65.47	66.74	68.03	69.35	70.5	71.67	72.86	74.07	75.3	76.55	77.82	79.12	80.43	81.77	82.81	83.86	84.92	86
TALAHOGAN	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49
TUBA_CITY_NTUA1	1362.43	1396.22	1430.84	1466.33	1502.69	1539.96	1578.15	1617.29	1657.4	1698.5	1740.62	1783.79	1828.03	1873.36	1919.82	1967.43	2016.23	2066.23	2117.47	2169.98	2223.8	2278.95	2335.47	2393.39	2452.74
TUBA_CITY_NTUA2	1552.76	1591.27	1630.73	1671.17	1712.62	1755.09	1798.62	1843.22	1888.93	1935.78	1983.79	2032.99	2083.4	2135.07	2188.02	2242.28	2297.89	2354.88	2413.28	2473.13	2534.46	2597.32	2661.73	2727.74	2795.39
TUBA_CITY_NTUA3	1303.76	1336.1	1369.23	1403.19	1437.99	1473.65	1510.2	1547.65	1586.03	1625.36	1665.67	1706.98	1749.31	1792.7	1837.16	1882.72	1929.41	1977.26	2026.29	2076.55	2128.05	2180.82	2234.91	2290.33	2347.13
TUBA_CITY_NTUA4	454.38	465.65	477.2	489.03	501.16	513.59	526.33	539.38	552.76	566.46	580.51	594.91	609.66	624.78	640.28	656.16	672.43	689.1	706.19	723.71	741.66	760.05	778.9	798.21	818.01
TUBA_CITY_NTUA5	78.4	80.35	82.34	84.38	86.48	88.62	90.82	93.07	95.38	97.74	100.17	102.65	105.2	107.81	110.48	113.22	116.03	118.91	121.86	124.88	127.97	131.15	134.4	137.73	141.15
TUBA_CITY_NTUA6	359.14	368.04	377.17	386.52	396.11	405.93	416	426.32	436.89	447.72	458.83	470.21	481.87	493.82	506.06	518.62	531.48	544.66	558.16	572.01	586.19	600.73	615.63	630.9	646.54
TURQUOISE_TRAIL	38.45	40.69	43.05	45.56	48.21	51.02	53.99	57.13	60.46	63.98	67.7	71.02	74.49	78.14	81.96	85.97	90.18	94.6	99.23	104.08	109.18	113.63	118.27	123.1	128.12
WELL__30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COAL_CREEK_MESA	447.65	458.75	470.13	481.79	493.73	505.98	518.53	531.39	544.56	558.07	571.91	586.09	600.63	615.52	630.79	646.43	662.46	678.89	695.73	712.98	730.67	748.79	767.36	786.39	805.89
INSCRIPTION_HOUSE	811.7	831.83	852.46	873.6	895.26	917.47	940.22	963.54	987.43	1011.92	1037.02	1062.73	1089.09	1116.1	1143.78	1172.14	1201.21	1231	1261.53	1292.82	1324.88	1357.74	1391.41	1425.92	1461.28
JEDDITO	765.85	784.85	804.31	824.26	844.7	865.65	887.12	909.12	931.66	954.77	978.45	1002.71	1027.58	1053.06	1079.18	1105.94	1133.37	1161.48	1190.28	1219.8	1250.05	1281.05	1312.83	1345.38	1378.75
STEAMBOAT	795.52	815.25	835.46	856.18	877.42	899.18	921.48	944.33	967.75	991.75	1016.34	1041.55	1067.38	1093.85	1120.98	1148.78	1177.27	1206.47	1236.39	1267.05	1298.47	1330.67	1363.67	1397.49	1432.15
TACHEE_BLUE_GAP	763.16	782.08	801.48	821.36	841.73	862.6	883.99	905.92	928.38	951.41	975	999.18	1023.96	1049.36	1075.38	1102.05	1129.38	1157.39	1186.09	1215.51	1245.65	1276.54	1308.2	1340.65	1373.89
TEESTOH	601.36	616.27	631.55	647.22	663.27	679.72	696.57	713.85	731.55	749.7	768.29	787.34	806.87	826.88	847.38	868.4	889.94	912.01	934.62	957.8	981.56	1005.9	1030.85	1056.41	1082.61
WHIPPORWILL	965.41	989.35	1013.89	1039.03	1064.8	1091.21	1118.27	1146	1174.42	1203.55	1233.39	1263.98	1295.33	1327.45	1360.37	1394.11	1428.69	1464.12	1500.43	1537.64	1575.77	1614.85	1654.9	1695.94	1738
WHITE_CONE	833.27	853.94	875.11	896.82	919.06	941.85	965.21	989.15	1013.68	1038.82	1064.58	1090.98	1118.04	1145.76	1174.18	1203.3	1233.14	1263.72	1295.06	1327.18	1360.09	1393.82	1428.39	1463.81	1500.12
Lower_Moenkopi	29.03	30.77	32.61	34.56	36.63	38.82	41.14	43.6	46.21	48.97	51.9	54.5	57.23	60.1	63.11	66.27	69.59	73.08	76.74	80.59	84.63	88.18	91.88	95.74	99.76
Rural_Moenkopi_District	19.17	19.58	20.01	20.44	20.89	21.34	21.81	22.28	22.76	23.26	23.76	24.2	24.64	25.09	25.55	26.01	26.49	26.97	27.46	27.96	28.47	28.86	29.26	29.66	30.06
Upper_Rural_Moenkopi	19.17	19.58	20.01	20.44	20.89	21.34	21.81	22.28	22.76	23.26	23.76	24.2	24.64	25.09	25.55	26.01	26.49	26.97	27.46	27.96	28.47	28.86	29.26	29.66	30.06
Lower_Rural_Moenkopi	19.17	19.58	20.01	20.44	20.89	21.34	21.81	22.28	22.76	23.26	23.76	24.2	24.64	25.09	25.55	26.01	26.49	26.97	27.46	27.96	28.47	28.86	29.26	29.66	30.06
Howell_Mesa_East	8.18	8.67	9.18	9.73	10.31	10.92	11.57	12.26	12.98	13.75	14.57	15.3	16.05	16.85	17.69	18.56	19.49	20.45	21.47	22.53	23.65	24.65	25.69	26.77	27.9
Side_Rock_Well	6.95	7.37	7.81	8.28	8.77	9.3	9.86	10.45	11.07	11.74	12.44	13.07	13.72	14.41	15.13	15.89	16.68	17.52	18.4	19.32	20.29	21.14	22.03	22.95	23.91
Central_Dinnebito	132.27	135.71	139.25	142.88	146.6	150.41	154.33	158.35	162.48	166.71	171.05	175.1	179.24	183.48	187.82	192.27	196.82	201.47	206.24	211.12	216.11	220.42	224.82	229.3	233.88
Upper_Dinnebito	9.53	9.69	9.86	10.03	10.21	10.39	10.57	10.75	10.94	11.13	11.32	11.48	11.64	11.8	11.97	12.13	12.3	12.47	12.65	12.82	13	13.13	13.26	13.39	13.52
Central_Rural_Dinnebito	6.39	6.5	6.62	6.74	6.86	6.98	7.1	7.23	7.36	7.49	7.62	7.73	7.83	7.94	8.05	8.16	8.28	8.39	8.51	8.62	8.74	8.83	8.92	9	9.09
Lower_Dinnebito	15.92	16.19	16.46	16.74	17.02	17.31	17.61	17.91	18.21	18.52	18.83	19.1	19.38	19.66	19.95	20.24	20.53	20.83	21.13	21.44	21.75	21.96	22.18	22.4	22.62
Upper_Rural_Oraibi	8.74	8.95	9.17	9.39	9.62	9.85	10.09	10.33	10.58	10.84	11.1	11.33	11.57	11.81	12.06	12.32	12.58	12.84	13.12	13.39	13.68	13.91	14.16	14.4	14.65
Lower_Oraibi	20.06	20.56	21.06	21.57	22.1	22.64	23.2	23.77	24.35	24.95	25.56	26.11	26.67	27.24	27.82	28.42	29.03	29.66	30.29	30.94	31.61	32.16	32.72	33.29	33.86
Upper_Rural_Polacca	7.06	7.2	7.33	7.47	7.61	7.76	7.9	8.05	8.21	8.36	8.52	8.66	8.81	8.96	9.12	9.27	9.43	9.59	9.75	9.92	10.09	10.22	10.34	10.47	10.61
Spider_Mound	40.91	42.56	44.28	46.07	47.92	49.86	51.87	53.96	56.13	58.4	60.75	62.99	65.31	67.71	70.2	72.79	75.47	78.25	81.13	84.11	87.21	90.01	92.91	95.9	98.99
Lower_Rural_Jadito	32.62	33.49	34.39	35.31	36.25	37.23	38.22	39.25	40.3	41.37	42.48	43.46	44.46	45.49	46.54	47.61	48.71	49.83	50.98	52.15	53.36	54.34	55.35	56.38	57.42
Upper_Rural_Jadito	13.11	13.48	13.86	14.24	14.64	15.05	15.47	15.9	16.34	16.79	17.26	17.67	18.08	18.5	18.93	19.37	19.83	20.29	20.76	21.25	21.75	22.17	22.6	23.03	23.48

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WELL NAME	2055	2056	2057
1K-228	0	0	0
3K-252	662.58	679.01	695.85
3K-318-1	838.3	859.09	880.39
3K-318-2	144.65	148.24	151.91
3P-350	0	0	0
3T-222	0	0	0
3T-322-1	0	0	0
3T-322-2	0	0	0
3T-333	0	0	0
3T-507	0	0	0
4T-523	563.12	577.09	591.4
6K-312	0	0	0
8A-295	318.01	325.9	333.98
8K-416	405.96	416.03	426.35
BACAVI	71.17	72.07	72.99
CHILCHINBITO_NTUA1	669.36	685.96	702.97
CHILCHINBITO_NTUA2	582.13	596.56	611.36
CHLCHN_PM2	87.23	89.4	91.61
CHLCHN_PM3	54.32	55.67	57.05
COTTONWD3	567.91	581.99	596.42
COTTONWOOD_NTUA_N	567.91	581.99	596.42
COTTONWOOD_NTUA_S	567.91	581.99	596.42
DENNEHOTSO_NTUA1	184.05	188.61	193.29
DENNEHOTSO_NTUA2	363.64	372.66	381.9
DENNHOTS_PM1_BIA	378.11	387.49	397.09
DENNHOTS_PM2_BIA	352.82	361.57	370.54
HARD_ROCK_NTUA1	520.15	533.05	546.27
HARD_ROCK_NTUA2	709.58	727.18	745.21
HOPI_CIVIC_CENTER	4.74	4.8	4.86
HOPI_CULTURAL_CENTER	15.06	15.25	15.44
HOPI_HIGH_SCH_1	10.66	10.8	10.93
HOPI_HIGH_SCH_2	55.79	56.49	57.21
HOPI_HIGH_SCH_3	40.65	41.17	41.69
HOTEVILLA_PM1	33.26	33.68	34.11
HOTEVILLA_PM2	75.18	76.13	77.1
KAYENTA_NTUA1	250.38	256.59	262.95
KAYENTA_NTUA2	2.98	3.06	3.13
KAYENTA_NTUA3	1413.11	1448.16	1484.07
KAYENTA_NTUA4	715.23	732.97	751.15
KAYENTA_NTUA5	3274.14	3355.34	3438.55
KAYENTA_NTUA6	1688.09	1729.96	1772.86
KAYENTA_NTUA7	1703.27	1745.51	1788.8
KEAMS_CYN1	6.51	6.59	6.68
KEAMS_CYN2	51.52	52.18	52.84
KEAMS_CYN3	27.2	27.54	27.89
KITSILLIE_NTUA1	60.63	62.13	63.67
KITSILLIE_NTUA2	91.11	93.37	95.68
KYKOTSMOVI_PM1	0	0	0
KYKOTSMOVI_PM2	43.54	44.1	44.66
KYKOTSMOVI_PM3	137.96	139.71	141.48
LOW_MTN_PM2	900.5	922.83	945.72
MISHONGNOVI_1	10.2	10.33	10.46
MOENKOPI_1	214.89	219	223.18
MOENKOPI_2	214.36	218.45	222.62
MOENKOPI_3	79.61	81.13	82.68
NAV2	1129.91	1129.91	1129.91
NAV3	24.56	24.56	24.56
NAV3OBS	0	0	0
NAV4	58.75	58.75	58.75
NAV5	201.93	201.93	201.93
NAV6	99.21	99.21	99.21
NAV6OBS	0	0	0
NAV7	62.14	62.14	62.14
NAV8	422.14	422.14	422.14
NAV9	27.68	27.68	27.68
ORAIBI_2	609.62	620.78	632.15
PINON_3	109.55	112.27	115.05
PINON_4	0	0	0
PINON_NTUA1	895	917.2	939.95
PINON_NTUA2	1425.11	1460.45	1496.67

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WELL NAME	2055	2056	2057
PINON_NTUA3	844.98	865.93	887.41
PINON_PHS1	13.93	14.27	14.63
PINON_PM_6	0	0	0
POLACCA_PDC_2	164.55	166.64	168.76
POLACCA_USPHS_5	324.4	328.52	332.69
POLACCA_USPHS_6	126.5	128.11	129.73
RED_LAKE_NTUA1	51.72	53	54.31
RED_LAKE_PM2	3.85	3.94	4.04
RED_LK_PM1	4.84	4.96	5.08
RGH_RK_PM4	37.2	38.12	39.07
RGH_RK_PM5	174.29	178.61	183.04
ROCKY_RIDGE_PM1	52.05	53.34	54.67
ROCKY_RIDGE_PM2	106.3	108.94	111.64
ROUGH_ROCK_NTUA1	387.37	396.98	406.83
ROUGH_ROCK_NTUA2	0	0	0
ROUGH_ROCK_PM7	47.46	48.64	49.85
ROUGHROCK_PM3_BIA	0.03	0.03	0.03
ROUGHROCK_PM6_BIA	104.89	107.49	110.15
SALINA_TP2	0.49	0.49	0.49
SEC_MESA_DY_SCH_1	1.61	1.63	1.66
SEC_MESA_DY_SCH_2	1.58	1.6	1.62
SECOND_MESA_PD&C1	0	0	0
SECOND_MESA_PM2	15.99	16.19	16.4
SECOND_MESASCH_PHS1_BIA	0	0	0
SHIPAULOVI	0	0	0
SHIPAULOVI#2	62.11	62.89	63.69
SHONTO_JN_NTUA1	602.46	617.4	632.71
SHONTO_JN_NTUA2	347.15	355.76	364.59
SHONTO_NTUA1	216.01	221.37	226.86
SHONTO_PM2	752.13	770.79	789.9
SHONTO_PM3	386.97	396.57	406.41
SHONTO_PM4	232.59	238.36	244.27
SHUNGOPAVI	0	0	0
SHUNGOPOVI_1	87.09	88.2	89.32
TALAHOGAN	0.49	0.49	0.49
TUBA_CITY_NTUA1	2513.57	2575.91	2639.79
TUBA_CITY_NTUA2	2864.72	2935.76	3008.57
TUBA_CITY_NTUA3	2405.34	2464.99	2526.12
TUBA_CITY_NTUA4	838.3	859.09	880.39
TUBA_CITY_NTUA5	144.65	148.24	151.91
TUBA_CITY_NTUA6	662.58	679.01	695.85
TURQUOISE_TRAIL	133.35	138.79	144.45
WELL__30	0	0	0
COAL_CREEK_MESA	825.87	846.36	867.35
INSCRIPTION_HOUSE	1497.52	1534.66	1572.72
JEDDITO	1412.94	1447.98	1483.89
STEAMBOAT	1467.67	1504.07	1541.37
TACHEE_BLUE_GAP	1407.97	1442.88	1478.67
TEESTOH	1109.46	1136.97	1165.17
WHIPPORWILL	1781.1	1825.27	1870.54
WHITE_CONE	1537.32	1575.45	1614.52
Lower_Moenkopi	103.95	108.31	112.86
Rural_Moenkopi_District	30.47	30.89	31.31
Upper_Rural_Moenkopi	30.47	30.89	31.31
Lower_Rural_Moenkopi	30.47	30.89	31.31
Howell_Mesa_East	29.08	30.31	31.59
Side_Rock_Well	24.92	25.96	27.05
Central_Dinnebito	238.54	243.3	248.15
Upper_Dinnebito	13.66	13.79	13.93
Central_Rural_Dinnebito	9.18	9.27	9.36
Lower_Dinnebito	22.84	23.06	23.29
Upper_Rural_Oraibi	14.91	15.17	15.43
Lower_Oraibi	34.45	35.05	35.66
Upper_Rural_Polacca	10.74	10.88	11.01
Spider_Mound	102.18	105.46	108.86
Lower_Rural_Jadito	58.49	59.57	60.68
Upper_Rural_Jadito	23.93	24.4	24.87

ATTACHMENT II

Simulated Drawdowns in Selected Wells in the Confined Area

Annual PWCC Portion of the Drawdown at Community Wells in the Confined Area (ft)

Community Name	Well ID	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
Bacavi	only well																						
Chilchinbito	1																		5.54				
Chilchinbito	2																						
Chilchinbito	PM2										0									8.94			
Chilchinbito	PM3										0									8.94			
Forest Lake	4T-523																						
Hard Rock	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.08	0.23	0.55	1.33	2.93	5.38	8.47	12.00	15.86
Hopi Civic Center	only well	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.08	0.19	0.41	0.76	1.25	1.85
Hopi Cultural Center	only well	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.08	0.19	0.40	0.75	1.23	1.83
Hopi High School	No. 1																						
Hopi High School	No. 2																						
Hopi High School	No. 3																						
Hotevilla	PM1		0																				
Hotevilla	PM2															0						0.48	
Kayenta	1																						2.05
Kayenta	2																						
Kayenta	3																						
Kayenta	4																						2.65
Kayenta	5																						
Kayenta	6																						
Kayenta	7																						
Kayenta	PM2	0																					
Kayenta	PM3	0																					
Keams Canyon	No. 2															0			0.23				
Keams Canyon	No. 3																					1.17	
Kitsillie	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.04	0.07	0.13	0.22	0.32
Kitsillie	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.70	1.60	3.74	8.62	15.85	23.95	32.13	40.28	48.53
Kykotsmovi	PM1												0										
Kykotsmovi	PM2																						
Kykotsmovi	PM3													0									
Low Mountain	PM2																	0.56					
Mishongnovi	only well																						
Pinon	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.18	0.48	1.13	2.69	5.58	9.53	14.11	19.08	24.36
Pinon	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.16	0.44	1.03	2.46	5.15	8.90	13.31	18.15	23.30
Pinon	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.13	0.37	0.88	2.09	4.46	7.88	12.04	16.66	21.64
Pinon	PM6															0.32							
Polacca	PM4											0		0								0.96	
Polacca	PM5																						
Polacca	PM6																						
Rocky Ridge	PM2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04	0.11	0.29	0.68	1.45	2.66	4.29	6.29
Rocky Ridge	PM3	0																					
Rough Rock	1	0																					
Rough Rock	PM3									0													
Rough Rock	PM5									0													
Rough Rock	PM6									0													
Rough Rock	PM7																	0.1					
Second Mesa	No. 1			0																			
Second Mesa	PM2													0									
Shipaulovi	No. 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.04	0.11	0.24	0.46	0.77	1.18
Shungopovi	only well	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.05	0.12	0.27	0.53	0.94	1.48

Annual PWCC Portion of t

Community Name	Well ID	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Bacavi	only well															10.44							
Chilchinbito	1											71.24	73.65	76.53	78.25	80.08	82.14	82.28	84.55	87.4	89.42	91.42	93.53
Chilchinbito	2			25.7																			
Chilchinbito	PM2					50.63	54.85	58.79	62.68	65.63	70.6		73.97	77.1			84.43						
Chilchinbito	PM3					50.63	54.85	58.79	62.68	65.63	70.6		73.97	77.1	79.4	81.27	84.43	86.28	88.04	90.2			
Forest Lake	4T-523					90.8	100.54		113.09	112.91	118.74	121.84	127.46	130.89	132.75	134.91	138.75	141.46	145.31	148.12		151.76	153.54
Hard Rock	2	19.85	23.70	27.39	30.96	34.52	38.23	42.14	46.01	49.39	52.64	55.87	59.02	61.94	64.58	66.99	69.20	71.28	73.34	75.44	77.45	79.37	81.27
Hopi Civic Center	only well	2.55	3.32	4.13	4.96	5.80	6.62	7.48	8.36	9.25	10.11	10.95	11.78	12.59	13.38	14.14	14.86	15.54	16.19	16.82	17.44	18.05	18.64
Hopi Cultural Center	only well	2.54	3.33	4.15	5.00	5.85	6.69	7.56	8.45	9.35	10.21	11.06	11.90	12.72	13.52	14.30	15.04	15.73	16.39	17.04	17.67	18.30	18.91
Hopi High School	No. 1								8.97														
Hopi High School	No. 2							8.69															
Hopi High School	No. 3								10.02			14.13											
Hotevilla	PM1																						
Hotevilla	PM2	1.47																					
Kayenta	1										8.45	8.66		9.79	8.92				12.66	12.88	11.88		
Kayenta	2							1.28			1.46	1.67			2.05				3.11	3.26	3.34		
Kayenta	3							3.58	3.58	3.82	4.43			5.46	5.3				7.56	7.77	7.51		
Kayenta	4							8.43	9.04		10.75				10.87		14.04		15.61	15.72	15.97		
Kayenta	5	4.38						9.73	10.5					14.27	13.72	15.77			17.8	18.07	18.33		
Kayenta	6	4					8.89	9.8	10.56	11.04	12.27	12.67	13.75	14.22	8.08	16.01			17.82	17.97	10.16		
Kayenta	7	1.53					3.6			2.99	4.6			5.04	4.71	6.05			7.33	7.27	6.33		
Kayenta	PM2																						
Kayenta	PM3																						
Keams Canyon	No. 2		4.59			9.2	10.92	12.73		15.56	17.39	18.81	20.38	21.96	24.03	25.57	28.26	29.67	30.96	32.36		33.81	34.91
Keams Canyon	No. 3																						
Kitsillie	1	0.45	0.61	0.78	0.96	1.16	1.37	1.59	1.83	2.06	2.30	2.55	2.80	3.05	3.30	3.55	3.80	4.05	4.29	4.53	4.77	5.01	5.26
Kitsillie	2	55.65	61.42	66.75	71.95	77.66	83.91	89.95	95.04	98.26	102.30	106.55	110.37	113.28	115.76	118.29	120.80	123.39	126.40	129.33	132.04	134.87	137.72
Kykotsmovi	PM1						4.92	5.6	6.29		7.59	8.01	8.76		10.22	10.84	11.91	12.48				14.14	14.6
Kykotsmovi	PM2	1.23																					13.09
Kykotsmovi	PM3		2.36			4.39				7.1			9.07	9.71				12.88					
Low Mountain	PM2					33.76	37.01	41.07	45.16	50.73	54.44		58.55										
Mishongnovi	only well		1.97																				
Pinon	1	29.58	34.40	38.96	43.36	47.82	52.56	57.50	62.15	65.98	69.84	73.72	77.45	80.78	83.72	86.44	88.96	91.38	93.87	96.41	98.79	101.12	103.45
Pinon	2	28.46	33.26	37.80	42.18	46.59	51.26	56.13	60.78	64.66	68.50	72.35	76.08	79.43	82.42	85.16	87.71	90.14	92.62	95.15	97.53	99.86	102.18
Pinon	3	26.72	31.51	36.07	40.44	44.81	49.38	54.17	58.81	62.80	66.65	70.49	74.23	77.62	80.72	83.51	86.11	88.58	91.05	93.59	96.02	98.36	100.67
Pinon	PM6			40.09					62.61	66.18		74.77		83		86.63	91.07	91.82		98.56	101.03		103.46
Polacca	PM4																						
Polacca	PM5									3.05													
Polacca	PM6									3.11													
Rocky Ridge	PM2	8.58	11.07	13.65	16.24	18.83	21.44	24.12	26.88	29.63	32.28	34.85	37.36	39.80	42.13	44.32	46.37	48.28	50.08	51.83	53.52	55.16	56.74
Rocky Ridge	PM3		0.49			0.95	1.15	1.31	1.45	1.57	1.82	1.94	1.99	2.15	2.3	2.42	2.61	2.72	2.84	2.97	3.07	3.19	3.29
Rough Rock	1																						
Rough Rock	PM3																						
Rough Rock	PM5																						
Rough Rock	PM6																						
Rough Rock	PM7																						
Second Mesa	No. 1	1.05																					
Second Mesa	PM2											7.23											
Shipaulovi	No. 2	1.67	2.22	2.82	3.44	4.05	4.65	5.29	5.92	6.57	7.17	7.81	8.43	9.05	9.63	10.24	10.82	11.36	11.89	12.39	12.91	13.43	13.95
Shungopovi	only well	2.17	2.97	3.86	4.81	5.79	6.80	7.82	8.87	9.95	11.03	12.09	13.15	14.18	15.20	16.18	17.13	18.03	18.89	19.71	20.51	21.30	22.08

Annual PWCC Portion of t

Community Name	Well ID	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Bacavi	only well														19.34	19.26	19.14	18.99	18.82	18.64	18.45	18.26	18.08
Chilchinbito	1	95.85	97.89	99.68	102.43	104.13									91.65	88.71	86.09	83.75	81.66	79.78	78.07	76.5	75.06
Chilchinbito	2														67.08	65	63.07	61.3	59.71	58.26	56.94	55.73	54.61
Chilchinbito	PM2		99.13												94.09	91.07	88.37	85.96	83.81	81.86	80.1	78.48	76.99
Chilchinbito	PM3	96.47													94.09	91.07	88.37	85.96	83.81	81.86	80.1	78.48	76.99
Forest Lake	4T-523	157.34	163.36					178.93	173.55	164.14	156.5	149.32	144.72	139.71	132.21	128.92	125.99	123.32	120.86	118.56	116.42	114.42	112.55
Hard Rock	2	83.26	85.40	87.64	89.98	92.41	94.91	97.01	97.97	97.83	96.93	95.55	93.89	92.05	90.12	88.19	86.32	84.51	82.78	81.14	79.57	78.07	76.66
Hopi Civic Center	only well	19.23	19.81	20.40	21.00	21.62	22.26	22.91	23.51	24.00	24.33	24.52	24.58	24.54	24.43	24.26	24.05	23.80	23.54	23.27	22.99	22.72	22.45
Hopi Cultural Center	only well	19.51	20.11	20.71	21.32	21.95	22.60	23.26	23.88	24.39	24.75	24.95	25.03	25.00	24.89	24.73	24.52	24.27	24.01	23.74	23.46	23.19	22.92
Hopi High School	No. 1														35.99	35.99	35.88	35.69	35.43	35.12	34.78	34.42	34.04
Hopi High School	No. 2														37.68	37.67	37.54	37.32	37.04	36.71	36.34	35.95	35.55
Hopi High School	No. 3														39.25	39.22	39.08	38.85	38.54	38.19	37.81	37.4	36.97
Hotevilla	PM1														19.53	19.45	19.33	19.18	19.01	18.83	18.64	18.44	18.25
Hotevilla	PM2														19.53	19.45	19.33	19.18	19.01	18.83	18.64	18.45	18.26
Kayenta	1														14.8	14.45	12.92	12.2	11.85	11.41	10.64	10.1	9.1
Kayenta	2														6.85	6.94	6.96	7	6.87	6.77	6.22	5.72	5.66
Kayenta	3														11.36	11.22	10.69	10.37	9.89	9.46	8.61	8.03	7.81
Kayenta	4														16.47	16.05	13.82	12.89	12.81	12.53	11.84	11.25	9.61
Kayenta	5														21.04	20.33	18.85	17.93	17.54	17.13	16.41	15.77	14.83
Kayenta	6														8.55	9.58	7.08	6.42	6.77	6.61	6.47	6.71	6.9
Kayenta	7														9.89	9.36	8.44	8.03	7.43	6.65	6.03	5.72	5.51
Kayenta	PM2														8.59	8.74	8.84	8.9	8.92	8.89	8.77	8.6	8.44
Kayenta	PM3														7.4	7.53	7.64	7.72	7.76	7.76	7.67	7.51	7.35
Keams Canyon	No. 2	36.25	37.63	38.75	40.04	41.34	42.21	44.15	44.55	45.84	47.3	47.95	48.33	48.66	48.66	48.39	48	47.51	46.97	46.4	45.79	45.18	44.56
Keams Canyon	No. 3														50.62	50.29	49.83	49.3	48.71	48.08	47.43	46.77	46.11
Kitsillie	1	5.50	5.73	5.97	6.18	6.41	6.68	6.92	7.18	7.40	7.61	7.81	7.96	8.09	8.21	8.31	8.39	8.45	8.51	8.55	8.58	8.60	8.61
Kitsillie	2	140.94	144.48	148.08	151.70	155.29	158.65	159.17	155.60	150.35	144.89	139.74	134.92	130.47	126.47	122.98	119.90	117.12	114.58	112.23	110.05	108.01	106.11
Kykotsmovi	PM1	15.11	15.73	16.19	16.74	17.29	17.68	18.49	18.67	19.22	19.67	19.97	20.12	20.19	20.16	20.06	19.92	19.76	19.58	19.39	19.19	18.99	18.79
Kykotsmovi	PM2	13.55	14.12												18.28	18.21	18.11	17.98	17.84	17.68	17.52	17.35	17.19
Kykotsmovi	PM3		16.21	16.69	17.25	17.82	18.21		19.23	19.8	20.26	20.57	20.7	20.78	20.72	20.62	20.47	20.29	20.1	19.9	19.69	19.48	19.27
Low Mountain	PM2		90.82												102.33	100.41	98.45	96.51	94.62	92.79	91.03	89.34	87.73
Mishongnovi	only well														19.44	19.4	19.31	19.2	19.06	18.91	18.75	18.59	18.43
Pinon	1	105.97	108.68	111.51	114.43	117.46	120.51	122.63	122.83	121.69	119.73	117.38	114.81	112.16	109.49	106.92	104.51	102.21	100.04	98.00	96.05	94.23	92.49
Pinon	2	104.67	107.33	110.12	113.00	115.99	119.01	121.23	121.68	120.75	118.97	116.76	114.28	111.70	109.08	106.54	104.15	101.86	99.71	97.67	95.72	93.90	92.16
Pinon	3	103.11	105.72	108.46	111.30	114.24	117.21	119.55	120.45	119.86	118.42	116.37	114.08	111.60	109.06	106.58	104.19	101.91	99.75	97.70	95.75	93.90	92.16
Pinon	PM6		109.19	112.49	115.03	118.31	120.65	124.79	125.17	124.88	123.09	120.5	118.3	115.57	110.56	107.93	105.48	103.15	100.97	98.91	96.94	95.11	93.36
Polacca	PM4														36.18	35.88	35.5	35.08	34.63	34.16	33.69	33.21	32.75
Polacca	PM5														0.4	0.42	0.44	0.45	0.47	0.48	0.49	0.51	0.52
Polacca	PM6														0.42	0.43	0.45	0.47	0.49	0.5	0.52	0.53	0.55
Rocky Ridge	PM2	58.30	59.88	61.50	63.16	64.89	66.66	68.46	70.07	71.23	71.88	72.02	71.80	71.19	70.39	69.42	68.34	67.20	66.04	64.88	63.74	62.62	61.53
Rocky Ridge	PM3		3.43	3.52	3.64	3.74	3.83	3.92	4.04	4.18	4.28	4.38	4.43	4.47	4.47	4.44	4.4	4.36	4.33	4.29	4.25	4.22	4.18
Rough Rock	1														26.18	25.62	25.04	24.46	23.91	23.38	22.87	22.41	21.97
Rough Rock	PM3														28.17	27.56	26.94	26.31	25.7	25.12	24.57	24.06	23.58
Rough Rock	PM5														25.75	25.23	24.67	24.1	23.54	23.02	22.51	22.04	21.6
Rough Rock	PM6														21.65	21.22	20.76	20.29	19.82	19.38	18.96	18.57	18.21
Rough Rock	PM7														26.01	25.46	24.89	24.31	23.76	23.23	22.73	22.26	21.82
Second Mesa	No. 1														17.7	17.7	17.65	17.57	17.47	17.36	17.23	17.11	16.98
Second Mesa	PM2														18.55	18.54	18.47	18.37	18.25	18.12	17.98	17.84	17.69
Shipaulovi	No. 2	14.44	14.91	15.39	15.87	16.35	16.86	17.37	17.87	18.31	18.66	18.90	19.05	19.12	19.11	19.09	19.01	18.90	18.77	18.63	18.47	18.32	18.16
Shungopovi	only well	22.84	23.60	24.33	25.06	25.81	26.60	27.35	28.10	28.80	29.39	29.81	30.11	30.27	30.26	30.15	29.97	29.72	29.44	29.13	28.80	28.46	28.12

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Community Name	Well ID	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
Bacavi	only well	17.88	17.69	17.5	17.33	17.16	16.99	16.83	16.68	16.54	16.39	16.26	16.13	16	15.89	15.78	15.67	15.57	15.47	15.37	15.28	15.19	15.11
Chilchinbito	1	73.72	72.48	71.33	70.26	69.27	68.34	67.48	66.67	65.91	65.21	64.55	63.93	63.35	62.81	62.3	61.82	61.37	60.95	60.55	60.17	59.81	59.47
Chilchinbito	2	53.57	52.62	51.73	50.9	50.14	49.43	48.77	48.15	47.58	47.04	46.54	46.08	45.64	45.24	44.85	44.49	44.15	43.83	43.53	43.25	42.98	42.72
Chilchinbito	PM2	75.62	74.34	73.16	72.06	71.04	70.09	69.2	68.37	67.59	66.87	66.19	65.56	64.97	64.41	63.89	63.4	62.94	62.5	62.09	61.71	61.34	60.99
Chilchinbito	PM3	75.62	74.34	73.16	72.06	71.04	70.09	69.2	68.37	67.59	66.87	66.19	65.56	64.97	64.41	63.89	63.4	62.94	62.5	62.09	61.71	61.34	60.99
Forest Lake	4T-523	110.79	109.15	107.6	106.15	104.78	103.5	102.29	101.15	100.07	99.06	98.11	97.21	96.36	95.56	94.81	94.09	93.42	92.77	92.17	91.6	91.05	90.54
Hard Rock	2	75.31	74.04	72.82	71.68	70.59	69.56	68.58	67.66	66.79	65.96	65.18	64.44	63.74	63.07	62.44	61.84	61.28	60.73	60.22	59.73	59.27	58.83
Hopi Civic Center	only well	22.17	21.91	21.65	21.41	21.18	20.96	20.74	20.53	20.34	20.14	19.96	19.78	19.61	19.46	19.31	19.16	19.03	18.90	18.77	18.65	18.53	18.42
Hopi Cultural Center	only well	22.64	22.38	22.12	21.88	21.64	21.42	21.20	20.99	20.79	20.59	20.40	20.22	20.05	19.89	19.73	19.59	19.45	19.32	19.19	19.07	18.95	18.84
Hopi High School	No. 1	33.65	33.26	32.86	32.48	32.09	31.72	31.35	30.99	30.65	30.31	29.98	29.67	29.36	29.07	28.79	28.52	28.26	28.01	27.78	27.55	27.33	27.12
Hopi High School	No. 2	35.13	34.72	34.3	33.89	33.48	33.09	32.7	32.32	31.96	31.6	31.26	30.93	30.61	30.3	30	29.72	29.45	29.19	28.94	28.7	28.47	28.25
Hopi High School	No. 3	36.54	36.1	35.67	35.24	34.82	34.4	34	33.6	33.22	32.85	32.5	32.15	31.82	31.49	31.19	30.89	30.6	30.33	30.07	29.82	29.58	29.35
Hotevilla	PM1	18.05	17.86	17.67	17.49	17.31	17.15	16.98	16.83	16.68	16.53	16.39	16.26	16.14	16.02	15.9	15.8	15.69	15.59	15.49	15.4	15.31	15.22
Hotevilla	PM2	18.06	17.86	17.67	17.49	17.32	17.15	16.99	16.83	16.68	16.54	16.4	16.26	16.14	16.02	15.91	15.8	15.7	15.59	15.49	15.4	15.31	15.23
Kayenta	1	8.02	7.56	6.61	6.78	7.01	6.96	7.22	7.53	7.78	6.38	6.25	6.65	7.05	6.79	4.02	4.22	5.14	5.78	5.93	5.23	5.14	5.23
Kayenta	2	5.67	5.69	5.72	5.75	5.44	4.6	4.25	4.69	4.95	5.1	5.19	5.25	5.3	5.35	5.37	5.38	5.4	5.42	5.43	5.4	5.37	5.29
Kayenta	3	7.57	7.52	7.36	7.45	7.32	6.87	6.83	7.11	7.33	6.74	6.64	6.83	7.06	7.06	6.57	6.64	6.86	7.04	6.66	5.91	5.87	5.48
Kayenta	4	7.98	7.21	5.53	5.75	6.54	6.97	7.21	7.44	7.65	6.76	6.71	7.04	7.39	7.53	6.57	6.16	6.17	6.37	5.74	4.84	4.8	5.07
Kayenta	5	13.86	13.5	12.96	12.99	13.17	13.18	13	12.94	12.91	8.5	8.14	9.21	10.09	10.75	10.8	10.75	10.8	10.99	9.93	8.61	8.81	9.09
Kayenta	6	6.79	6.63	6.52	6.42	6.35	6.31	6.27	6.23	6.2	6.19	6.22	6.27	6.33	6.41	6.5	6.6	6.68	6.75	6.8	6.85	6.91	6.95
Kayenta	7	5.23	4.8	4.26	4.04	4.25	4.29	4.37	4.45	4.53	4.54	4.03	3.79	3.9	3.96	3.95	3.94	3.98	4.03	4.1	4.15	4.2	4.24
Kayenta	PM2	8.3	8.2	8.11	8.05	8	7.84	7.65	7.53	7.48	7.37	7.32	7.33	7.36	7.39	7.37	7.38	7.41	7.45	7.45	7.4	7.1	6.12
Kayenta	PM3	7.23	7.15	7.09	7.04	6.99	6.79	6.52	6.39	6.36	6.34	6.33	6.33	6.35	6.37	6.38	6.39	6.4	6.42	6.43	6.42	6.38	6.12
Keams Canyon	No. 2	43.94	43.33	42.74	42.16	41.59	41.04	40.51	40	39.51	39.04	38.58	38.14	37.72	37.32	36.93	36.56	36.21	35.87	35.55	35.24	34.95	34.66
Keams Canyon	No. 3	45.46	44.81	44.18	43.57	42.97	42.4	41.84	41.31	40.8	40.3	39.83	39.37	38.94	38.52	38.11	37.73	37.36	37.01	36.68	36.36	36.05	35.76
Kitsillie	1	8.62	8.62	8.62	8.61	8.60	8.59	8.58	8.56	8.54	8.52	8.48	8.44	8.40	8.36	8.31	8.26	8.21	8.16	8.11	8.06	8.02	7.97
Kitsillie	2	104.34	102.67	101.11	99.64	98.27	96.98	95.76	94.61	93.54	92.52	91.56	90.66	89.80	89.00	88.24	87.52	86.83	86.19	85.57	84.99	84.43	83.91
Kykotsmovi	PM1	18.58	18.38	18.19	18.01	17.83	17.66	17.5	17.34	17.19	17.04	16.9	16.76	16.64	16.51	16.4	16.29	16.19	16.08	15.98	15.88	15.79	15.71
Kykotsmovi	PM2	17	16.83	16.67	16.52	16.37	16.22	16.08	15.95	15.82	15.69	15.56	15.45	15.33	15.23	15.13	15.04	14.95	14.85	14.76	14.68	14.6	14.52
Kykotsmovi	PM3	19.05	18.85	18.65	18.46	18.27	18.09	17.92	17.76	17.6	17.45	17.3	17.16	17.03	16.9	16.78	16.66	16.56	16.45	16.34	16.24	16.15	16.06
Low Mountain	PM2	86.18	84.71	83.31	81.97	80.71	79.5	78.36	77.27	76.24	75.26	74.33	73.45	72.61	71.81	71.05	70.32	69.63	68.98	68.35	67.76	67.19	66.64
Mishongnovi	only well	18.26	18.1	17.94	17.79	17.63	17.49	17.35	17.2	17.06	16.92	16.79	16.66	16.54	16.42	16.31	16.21	16.11	16.02	15.93	15.85	15.77	15.69
Pinon	1	90.85	89.30	87.82	86.44	85.13	83.89	82.71	81.60	80.56	79.56	78.62	77.73	76.88	76.08	75.32	74.60	73.91	73.26	72.64	72.05	71.49	70.95
Pinon	2	90.52	88.97	87.49	86.11	84.79	83.55	82.37	81.26	80.21	79.21	78.26	77.37	76.52	75.72	74.96	74.23	73.54	72.88	72.26	71.66	71.10	70.56
Pinon	3	90.50	88.93	87.44	86.04	84.72	83.46	82.27	81.14	80.08	79.07	78.10	77.20	76.34	75.52	74.74	74.00	73.30	72.63	71.98	71.37	70.79	70.23
Pinon	PM6	91.71	90.15	88.67	87.28	85.97	84.72	83.55	82.43	81.39	80.39	79.45	78.56	77.71	76.91	76.15	75.43	74.74	74.1	73.48	72.89	72.33	71.79
Polacca	PM4	32.3	31.85	31.42	31.01	30.61	30.23	29.86	29.51	29.17	28.84	28.53	28.23	27.94	27.67	27.41	27.16	26.93	26.71	26.5	26.29	26.1	25.91
Polacca	PM5	0.54	0.55	0.56	0.57	0.59	0.6	0.61	0.63	0.64	0.65	0.66	0.68	0.69	0.7	0.71	0.73	0.74	0.75	0.76	0.77	0.79	0.8
Polacca	PM6	0.56	0.58	0.6	0.61	0.63	0.64	0.66	0.67	0.69	0.7	0.72	0.73	0.74	0.76	0.77	0.79	0.8	0.81	0.83	0.84	0.85	0.87
Rocky Ridge	PM2	60.48	59.47	58.49	57.56	56.67	55.82	55.01	54.23	53.49	52.79	52.12	51.49	50.89	50.31	49.77	49.25	48.76	48.30	47.86	47.44	47.04	46.66
Rocky Ridge	PM3	4.15	4.12	4.1	4.08	4.05	4.04	4.02	4	3.98	3.97	3.95	3.94	3.92	3.91	3.9	3.89	3.89	3.88	3.88	3.87	3.87	3.86
Rough Rock	1	21.56	21.18	20.83	20.49	20.18	19.89	19.61	19.35	19.11	18.88	18.67	18.47	18.28	18.1	17.94	17.78	17.63	17.5	17.37	17.25	17.13	17.02
Rough Rock	PM3	23.13	22.72	22.33	21.96	21.62	21.29	20.99	20.71	20.44	20.19	19.96	19.74	19.53	19.33	19.15	18.98	18.81	18.67	18.52	18.39	18.26	18.14
Rough Rock	PM5	21.19	20.8	20.44	20.1	19.78	19.48	19.2	18.94	18.69	18.46	18.24	18.03	17.84	17.66	17.49	17.33	17.18	17.04	16.91	16.78	16.66	16.55
Rough Rock	PM6	17.86	17.54	17.24	16.96	16.69	16.44	16.21	15.99	15.78	15.59	15.41	15.24	15.09	14.94	14.8	14.67	14.54	14.42	14.31	14.21	14.11	14.02
Rough Rock	PM7	21.41	21.03	20.68	20.34	20.03	19.74	19.46	19.2	18.96	18.73	18.52	18.32	18.13	17.95	17.78	17.63	17.48	17.34	17.22	17.09	16.98	16.87
Second Mesa	No. 1	16.84	16.71	16.58	16.46	16.33	16.21	16.09	15.97	15.85	15.73	15.62	15.5	15.4	15.29	15.2	15.11	15.03	14.96	14.88	14.81	14.74	14.67
Second Mesa	PM2	17.54	17.4	17.25	17.11	16.97	16.84	16.71	16.58	16.45	16.32	16.19	16.07	15.96	15.85	15.75	15.65	15.56	15.48	15.4	15.32	15.24	15.17
Shipaulovi	No. 2	18.00	17.84	17.68	17.54	17.39	17.25	17.11	16.97	16.84	16.70	16.57	16.44	16.32	16.21	16.10	16.00	15.91	15.82	15.74	15.65	15.57	15.50
Shungopovi	only well	27.78	27.44	27.11	26.79	26.47	26.17	25.87	25.58	25.31	25.04	24.78	24.53	24.29	24.06	23.84	23.63	23.43	23.25	23.07	22.89	22.73	22.57

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Community Name	Well ID	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057
Bacavi	only well	15.03	14.96	14.88	14.8	14.71	14.6	14.5	14.38	14.25	14.1	13.95	13.79	13.63	13.47
Chilchinbito	1	59.15	58.79	58.19	57.27	56.12	54.82	53.48	52.15	50.87	49.65	48.49	47.4	42.07	33.58
Chilchinbito	2	42.48	42.24	41.91	41.43	40.78	39.99	39.13	38.24	37.35	36.48	35.65	34.86	33.28	30.7
Chilchinbito	PM2	60.67	60.3	59.68	58.74	57.55	56.21	54.83	53.46	52.14	50.88	49.69	48.57	43.75	36.11
Chilchinbito	PM3	60.67	60.3	59.68	58.74	57.55	56.21	54.83	53.46	52.14	50.88	49.69	48.57	43.75	36.11
Forest Lake	4T-523	90.05	88.72	86.6	84.31	82.09	79.99	78.03	76.2	74.49	72.88	71.36	69.92	68.54	67.22
Hard Rock	2	58.41	57.99	57.49	56.86	56.11	55.26	54.35	53.40	52.43	51.46	50.49	49.54	48.60	47.68
Hopi Civic Center	only well	18.32	18.22	18.11	18.00	17.88	17.74	17.60	17.43	17.25	17.05	16.85	16.63	16.42	16.21
Hopi Cultural Center	only well	18.73	18.63	18.53	18.42	18.29	18.15	18.00	17.83	17.65	17.45	17.24	17.02	16.80	16.58
Hopi High School	No. 1	26.92	26.73	26.54	26.35	26.16	25.96	25.74	25.49	25.23	24.95	24.65	24.34	24.02	23.69
Hopi High School	No. 2	28.04	27.84	27.64	27.44	27.24	27.02	26.79	26.53	26.26	25.96	25.65	25.32	24.98	24.63
Hopi High School	No. 3	29.13	28.92	28.72	28.51	28.3	28.07	27.83	27.56	27.27	26.96	26.63	26.29	25.94	25.57
Hotevilla	PM1	15.14	15.06	14.99	14.91	14.81	14.71	14.61	14.48	14.35	14.2	14.05	13.89	13.72	13.56
Hotevilla	PM2	15.15	15.07	14.99	14.91	14.82	14.71	14.61	14.48	14.35	14.2	14.05	13.89	13.73	13.57
Kayenta	1	5.38	5.58	5.69	4.79	4.7	4.81	5	5.12	5.17	5.34	5.51	5.67	5.77	5.85
Kayenta	2	5.2	5.15	5.13	5.1	5.05	4.97	4.89	4.85	4.83	4.81	4.74	4.67	4.64	4.6
Kayenta	3	5.61	5.98	6.17	5.66	3.41	3.32	3.87	4.25	4.3	4.56	4.34	4.55	4.76	4.24
Kayenta	4	5.33	5.59	5.85	5.98	6.08	6.2	6.33	6.48	6.62	6.75	6.88	6.99	7.08	7.13
Kayenta	5	9.4	9.73	10.04	10.12	10.14	10.25	10.39	10.54	10.68	10.79	10.82	10.52	9.77	9.56
Kayenta	6	7	7.05	7.1	7.17	7.24	7.31	7.39	7.48	7.57	7.67	7.77	7.86	7.95	8.03
Kayenta	7	4.28	4.32	4.37	4.42	4.46	4.51	4.55	4.59	4.63	4.67	4.7	4.73	4.77	4.8
Kayenta	PM2	5.87	6.06	6.22	6.34	6.36	6.35	6.34	6.35	6.37	6.39	6.22	6.07	6.02	6
Kayenta	PM3	5.83	5.7	5.67	5.68	5.67	5.65	5.62	5.6	5.59	5.59	5.51	5.4	5.33	5.3
Keams Canyon	No. 2	34.39	34.13	33.88	33.62	33.35	33.05	32.72	32.36	31.97	31.56	31.13	30.68	30.22	29.75
Keams Canyon	No. 3	35.48	35.21	34.94	34.68	34.39	34.08	33.73	33.35	32.94	32.5	32.05	31.58	31.1	30.61
Kitsillie	1	7.94	7.91	7.89	7.88	7.86	7.84	7.82	7.79	7.76	7.73	7.69	7.65	7.61	7.57
Kitsillie	2	83.41	82.62	81.19	79.37	77.42	75.47	73.59	71.79	70.08	68.47	66.95	65.49	64.07	62.69
Kykotsmovi	PM1	15.63	15.54	15.46	15.38	15.28	15.17	15.07	14.94	14.8	14.65	14.49	14.32	14.15	13.99
Kykotsmovi	PM2	14.45	14.38	14.31	14.23	14.15	14.06	13.97	13.86	13.73	13.6	13.46	13.31	13.16	13.02
Kykotsmovi	PM3	15.97	15.89	15.81	15.72	15.62	15.5	15.4	15.26	15.12	14.96	14.79	14.62	14.44	14.27
Low Mountain	PM2	66.13	65.62	65.06	64.38	63.57	62.64	61.63	60.55	59.44	58.31	57.19	56.04	54.87	53.71
Mishongnovi	only well	15.61	15.54	15.46	15.39	15.31	15.21	15.11	14.98	14.85	14.71	14.56	14.39	14.22	14.05
Pinon	1	70.44	69.90	69.16	68.22	67.11	65.90	64.63	63.34	62.05	60.77	59.52	58.26	56.99	55.75
Pinon	2	70.04	69.50	68.79	67.87	66.79	65.60	64.35	63.07	61.78	60.51	59.26	57.99	56.72	55.47
Pinon	3	69.70	69.16	68.47	67.59	66.53	65.37	64.12	62.84	61.55	60.27	59.00	57.69	56.35	55.05
Pinon	PM6	71.28	70.73	69.95	68.96	67.81	66.56	65.25	63.93	62.62	61.33	60.06	58.79	57.53	56.29
Polacca	PM4	25.74	25.56	25.4	25.23	25.03	24.82	24.58	24.31	24.01	23.7	23.38	23.05	22.7	22.35
Polacca	PM5	0.81	0.38	0.36	0.4	0.44	0.47	0.49	0.51	0.53	0.55	0.56	0.58	0.59	0.6
Polacca	PM6	0.88	0.33	0.3	0.35	0.39	0.43	0.46	0.49	0.51	0.53	0.55	0.57	0.58	0.59
Rocky Ridge	PM2	46.30	45.96	45.62	45.25	44.83	44.36	43.82	43.23	42.61	41.95	41.28	40.59	39.91	39.22
Rocky Ridge	PM3	3.86	3.86	3.85	3.85	3.84	3.83	3.81	3.79	3.76	3.73	3.7	3.67	3.63	3.59
Rough Rock	1	16.92	16.82	16.72	16.61	16.46	16.28	16.06	15.8	15.53	15.24	14.95	14.65	14.36	14.07
Rough Rock	PM3	18.03	17.92	17.81	17.68	17.53	17.33	17.1	16.82	16.53	16.23	15.91	15.59	15.28	14.96
Rough Rock	PM5	16.44	16.34	16.24	16.13	15.99	15.82	15.61	15.37	15.11	14.83	14.55	14.26	13.97	13.68
Rough Rock	PM6	13.93	13.85	13.76	13.67	13.56	13.42	13.25	13.05	12.83	12.6	12.36	12.12	11.88	11.63
Rough Rock	PM7	16.77	16.67	16.57	16.46	16.31	16.13	15.92	15.67	15.4	15.12	14.82	14.53	14.24	13.95
Second Mesa	No. 1	14.6	14.54	14.47	14.4	14.33	14.25	14.15	14.04	13.93	13.8	13.66	13.52	13.36	13.2
Second Mesa	PM2	15.09	15.03	14.96	14.89	14.81	14.72	14.63	14.51	14.39	14.25	14.11	13.96	13.79	13.63
Shipaulovi	No. 2	15.42	15.35	15.28	15.21	15.13	15.04	14.94	14.82	14.69	14.56	14.41	14.25	14.09	13.92
Shungopovi	only well	22.42	22.27	22.13	21.99	21.84	21.68	21.49	21.29	21.06	20.82	20.57	20.30	20.02	19.74