

ONE-PAGE PLACE ASSESSMENT: FLAGSTAFF, ARIZONA

LOCATED IN THE RIO DE FLAG SUBWATERSHED WITHIN THE LOWER COLORADO WATERSHED

CLIMATE		AVERAGE HIGH & LOW TEMPERATURES ¹											1893 – 2012
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
° F HIGH	42.2	44.8	50.2	58.5	68.0	78.0	81.6	79.1	73.5	63.4	51.6	43.4	61.2
° F LOW	15.3	18.0	22.4	28.0	34.3	41.8	50.9	49.8	41.9	31.5	22.5	16.6	31.1
° C HIGH	5.7	7.1	10.1	14.7	20.0	25.6	27.6	26.2	23.1	17.4	10.9	6.3	16.2
° C LOW	-9.3	-7.8	-5.3	-2.2	1.3	5.4	10.5	9.9	5.5	-0.3	-5.3	-8.6	-0.5
RECORD HIGH ¹	99° F	37.2° C	July 28, 1898				RECORD LOW ¹	-30° F	-34.4° C	January 22, 1937			

SUN		MAR 21 JUN 21 SEP 21 DEC 21					
LATITUDE	35.2°	DEGREES N or S of DUE EAST THE SUN RISES ²		0°	30°N	0°	28°S
		DEGREES N or S of DUE WEST THE SUN SETS ²		0°	30°N	0°	28°S
ELEVATION	6,911 FT 2,107 m	SOLAR-NOON ALTITUDE ANGLE (ABOVE HORIZON) ^{a,2,3}		55°	78°	55°	31°
		SOLAR-NOON WINTER-SOLSTICE SHADOW RATIO ^b		1 : 1.64	...AND AZIMUTH ^c		0°
		9AM & 3PM WINTER-SOLSTICE SHADOW RATIO ^{b,2}		1 : 3.16	...AND AZIMUTH ^{c,2}		43°

WIND		PREVAILING WIND DIRECTION (FROM WHERE) ^{d,4} & AVERAGE SPEED ^{d,5}											MAX SPEED ^{d,6}		
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	MPH	km/h
	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	74	119
MPH	6.2	7.1	7.1	8.9	8.0	7.8	5.6	4.4	5.4	5.8	6.2	6.6	6.6		
km/h	10	11	11	14	13	13	9	7	9	9	10	11	11		

WATER		AVERAGE PRECIPITATION (GAIN) ¹											1893 – 2012
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
INCHES	2.07	2.01	2.03	1.25	0.62	0.44	2.47	2.73	1.91	1.49	1.60	2.03	20.65
mm	52.6	51.1	51.6	31.8	15.7	11.2	62.7	69.3	48.5	37.8	40.6	51.6	524.5
		AVERAGE PAN EVAPORATION (POTENTIAL LOSS) ^{e,7}											1909 – 2005
INCHES	0.00	0.00	0.00	0.00	5.86	7.37	6.03	4.91	3.35	0.00	0.00	0.00	27.52
mm	0.0	0.0	0.0	0.0	148.8	187.2	153.2	124.7	85.1	0.0	0.0	0.0	699.0
WETTEST YEAR'S RAIN ¹	36.59 INCHES	929 mm	1965	DRIEST YEAR'S RAIN ¹	9.90 INCHES	251 mm	1942	LONGEST PERIOD WITH NO MEASURABLE PRECIPITATION ⁸	99 DAYS: September 24 – December 31, 1999	RAINFALL INCOME ^f	931 GPCD	3,523 lpcd	
AREA ^{g,9}	63.87 SQ MILES	165.4 km ²	POPULATION ^{g,9}	67,468	2012 est.	UTILITY-WATER USE ^{h,10}	56 GPCD	212 lpcd					
HISTORICAL	1,227 FT	374.1 m	1954	DEPTH TO GROUNDWATER ^{i,10}	1,297 FT	395.4 m	2012	CURRENT					
CURRENT GROUNDWATER EXTRACTION		>	NATURAL GROUNDWATER RECHARGE ^{i,11}										

WATERGY		%	OF MUNICIPAL ELECTRICITY USED TO MOVE & TREAT WATER ^{k,12}											49.8%
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TOTEM SPECIES		FISH:	Little Colorado spinedace (<i>Lepidomeda vittata</i>)	MAMMAL:	Pronghorn (<i>Antilocapra americana</i>)	
PLANT:		Ponderosa pine (<i>Pinus ponderosa</i>)	BIRD:	Mexican spotted owl (<i>Strix occidentalis</i>)	REPTILE:	Short-horned lizard (<i>Phrynosoma hernandesi</i>)
AMPHIBIAN:		Northern leopard frog (<i>Lithobates pipiens</i>)	MEGAFAUNA:	Mexican grey wolf (<i>Canis lupus baileyi</i>)	13	

FOR MORE INFORMATION & HOW TO APPLY IT

1. For more CLIMATE information, see the introduction, chapters 1, 2, & 4, and appendix 5 of *Rainwater Harvesting for Drylands and Beyond (RWHDB), Volume 1, 2nd Edition*
2. For more SUN information, see chapters 2 & 4 and appendices 5 & 7
3. For more WIND information, see chapters 2 & 4 and appendices 5 & 9
4. For more WATER information, see the introduction, chapters 1–4, and appendices 1–5
5. For more WATERGY information, see chapters 2 & 4 and appendix 9
6. For more TOTEM SPECIES information: the ethics, principles, and strategies throughout *RWHDB* help us shift from a negative to a positive impact on these species and their habitats and ecosystems, on which our quality of life also depends.

FLAGSTAFF PLACE-ASSESSMENT NOTES

- a. The solar-noon altitude angle (a.k.a., solar-noon elevation angle) refers to the number of degrees the sun is located above the equator-facing horizon at solar noon on the given date. In the northern hemisphere, the equator-facing horizon is to the south. In the southern hemisphere, the equator-facing horizon is to the north.
- b. The solar-noon winter-solstice shadow ratio is the object's height : length of object's shadow cast on December 21 at noon (the longest noontime shadow of the year). The ratio is 1 : x, where $x = 1 \div \tan(90 - (\text{latitude} + 23.44))$.
- c. Azimuth is the angle formed between a reference direction (here, due south) to the point on the horizon directly below a given object. Solar noon is the time on any day when the sun's azimuth is 0°. The 9 am & 3 pm winter-solstice azimuth indicates the sun's deviation, in degrees, east/west of due south at those times (-/+ 3 hours from solar noon) on December 21.
- d. Max wind speed converted from 64 knots to 74 mph (ref. 6).
- e. An evaporation pan holds water whose depth is measured daily as water evaporates. These data allow us to determine evaporation rates at a given location. Compare average rainfall (water gain) to potential water loss via evaporation by looking up pan-evaporation rates for your area. According to one definition, if pan-evaporation rates exceed rainfall rates, you are in a dryland environment. Another definition states that drylands are "land areas where the mean annual precipitation is less than two thirds of potential evapotranspiration (potential evaporation from soil plus transpiration by plants), excluding polar regions and some high mountain areas which meet this criterion but have completely different ecological characteristics" (Greenfacts.org). The higher the ratio of potential evaporation to rainfall, the more important evaporation-reducing strategies such as mulch, windbreaks, shading, and covered water storage become.
Flagstaff data was recorded at Flagstaff's Fort Valley Station (#023160). The annual precipitation is 75% of annual evaporation. According to the first definition, Flagstaff's is a drylands environment; according to the second, it is **not** a drylands environment.
- f. Calculated in situ w/ average rainfall, area, & population
- g. City proper
- h. 2013 residential = 56 gpcd, non-residential = 42 gpcd, total (not including lost & unaccounted-for water (L&U)) = 98 gpcd, total including L&U = 112 gpcd (ref. 10)
- i. Data is from Woody Mtn Well #1 which appears to have the longest period of record. See graph on page 31 of report (ref. 10).
- j. The Little Colorado Plateau Basin and adjacent basins' overall groundwater recharge is more than extracted ... but locally we ... see dropping water tables in some of our wellfields (Lake Mary Wellfield) and so local extraction is greater than recharge (ref. 11)
- k. kWh for Flagstaff water production & treatment in 2013 (19,304,206) ÷ total municipal kWh usage (38,784,590) = 49.8% (ref. 12)

CREDITS: Brad Lancaster, Resource concept | Megan Hartman, Resource creation, secondary research | Rusty Tweed, Willow Bend, Primary research

FLAGSTAFF PLACE-ASSESSMENT REFERENCES

1. Flagstaff Airport station (#023010), wrcc.dri.edu, accessed 5/1/2014
2. Rainwater Harvesting for Drylands & Beyond, Vol 1, or esrl.noaa.gov/gmd/grad/solcalc, accessed xx/xx/20xx
3. RWHDB Vol 1, or Mar 21 = 90–latitude, Jun 21 = 90–(latitude–23.44), Sep 21 = 90–latitude, Dec 21 = 90–(latitude+23.44)
4. Frequency by Direction, Flagstaff AP (KFLG), windhistory.com/station.html?KFLG, accessed 5/2/2014
5. Average Wind Speed, www.wrcc.dri.edu/climatedata/climtables/westwind/#ARIZONA, accessed 5/14/2014
6. Dan Leblanc, National Weather Service Meteorologist at the Flagstaff Office, via phone 5/15/2014
7. Arizona Monthly Average Pan Evaporation, www.wrcc.dri.edu/htmlfiles/westevap.final.html#ARIZONA, accessed 5/1/2014
8. Summary of Historical Hazard Events Impacting Coconino County Communities, page 2, www.flagstaff.az.gov/DocumentCenter/Home/View/1087, accessed 5/12/2014
9. Census.gov, accessed 5/10/2014
10. Report to the Water Commission Year 2013: Water, Wastewater, Reuse and Stormwater Annual Report, via email from Kyle Brown, Project Manager, City of Flagstaff, Stormwater Management Division, 5/1/2014
11. Erin M. Young, R.G., Water Resources Manager, City of Flagstaff, via email, 5/19/2014
12. Tamara H. Lawless, Ph.D., Sustainability Specialist, City of Flagstaff, via email 5/1/2014
13. Selected by Zack Zdinak (www.lifedraw.com/aboutzack.html) and Rick Miller, retired from AZ Game and Fish Dept in Flagstaff