April 1, 2025

UPDATE to U.S. ARMY CORPS OF ENGINEERS' MAY 16, 2005, MEMORANDUM FOR RECORD

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EXECUTIVE SUMMARY

In 1994, the U.S. Army contracted the U.S. Army Corps of Engineers ("ACOE") "to assist in the location, design, and construction" of groundwater monitoring wells on Fort Huachuca.

On May 16, 2005, the U.S. Army Corps of Engineers ("ACOE") produced the MEMORANDUM FOR RECORD after being contracted by Fort Huachuca for "compilation, organization, and analysis" of the groundwater water level data from these monitoring wells.

The May 16, 2005, Memorandum noted as its reason for production:

> "Problem. Groundwater levels are dropping in the Fort Huachuca/Sierra Vista area due to aquifer pumping. Over time, this potentially can have an appreciable effect on groundwater discharge to the San Pedro River. A number of computer models have been developed to simulate groundwater/surface water interrelationships in the upper San Pedro River Basin. However, the accuracy of these models has been limited by the lack of water level data extending from the cone of depression in the Fort Huachuca/Sierra Vista area to the San Pedro River."

The May 16, 2005, Memorandum' analysis and conclusion is based on the well water levels in Fort Huachuca's monitoring wells from April 14, 1995 to April 25, 2005.

The May 16, 2005, Memorandum concluded (***emphasis added***):

> "Conclusion … From analysis of water-level data from 1995-2005, a clear trend has developed. The cone of depression in the Fort Huachuca area is growing, and measured water levels within 2 miles of the river have been declining. If groundwater development in the Fort Huachuca/Sierra Vista continues at present rates, water levels will continue to decline in the region. The extent to which this declining trend in groundwater levels currently extends the San Pedro River itself is uncertain. This is dependent on the hydraulic conductivity of the geologic units located between the wells and the river, and the historical connection between the river and groundwater in this area. However, ***it is likely this decline in water levels currently extends to the river, resulting in a reduction of groundwater discharge to the river when compared to predevelopment conditions***."

Unhappy with the ACOE Memorandum's conclusion, the Army banned the ACOE from further collection and analysis of the data from Fort Huachuca's groundwater monitoring wells.

After the Army removed ACOE, collection of the data was transferred to the U.S. Geological Survey ("USGS") in 2005.

But no further analysis was commissioned by the Army.

No further analysis has been done on the data from Fort Huachuca's groundwater monitoring wells since the May 16, 2005, Memorandum.

This Update compiles and analyzes the monitoring well water level data from Fort Huachuca's groundwater monitoring wells from 1995 to 2025.

In addition to the data from the Base's groundwater monitoring wells, in this Update, we include groundwater well water level data from the USGS' groundwater monitoring well on the San Pedro River at the Charleston Narrows in the San Pedro Riparian National Conservation Area and water level data from the Base's three active groundwater extraction water supply production wells.

The USGS Charleston Narrows monitoring well is located along the same linear transect line as the Base's groundwater monitoring wells.

The analysis of the data from these monitoring wells and production wells are then combined with San Pedro River streamflow data and the conclusions of three studies completed since the May 16, 2005, Memorandum.

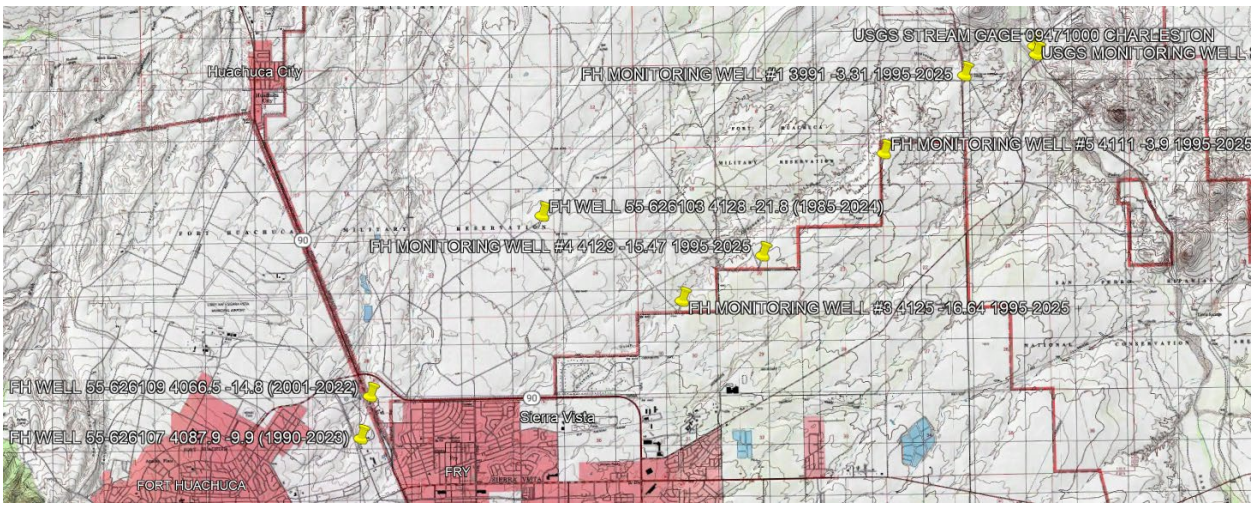
These three studies are "Calculation of Pumping-induced Baseflow and Evapotranspiration Capture Attributable to Fort Huachuca," by GeoSystems Analysis, Inc., in 2010; Simulated Effects of Ground-Water Withdrawals and Artificial Recharge on Discharge to Streams, Springs, and Riparian Vegetation in the Sierra Vista Subwatershed of the Upper San Pedro Basin, Southeastern Arizona, by USGS, in 2014; and, "Evaluation of Impacts of Fort Huachuca Long-term Well Pumping and Recharge on San Pedro River Stream Flow (from 2011 to 2100)," by Integrated Hydro Systems, in 2019.

The May 16, 2005, ACOE Memorandum concludes that "it is ***likely*** that the decline in water levels currently extends to the river, resulting in a reduction of groundwater discharge to the river."

This Update establishes that ***the decline in water levels now undoubtedly extends to the San Pedro River***, and that ***Fort Huachuca-attributable groundwater extraction on-post and off-post is also undoubtedly currently jeopardizing the San Pedro River***.

METHODS AND ANALYSIS

The monitoring wells and gages analyzed in this Update are plotted on Google Earth:



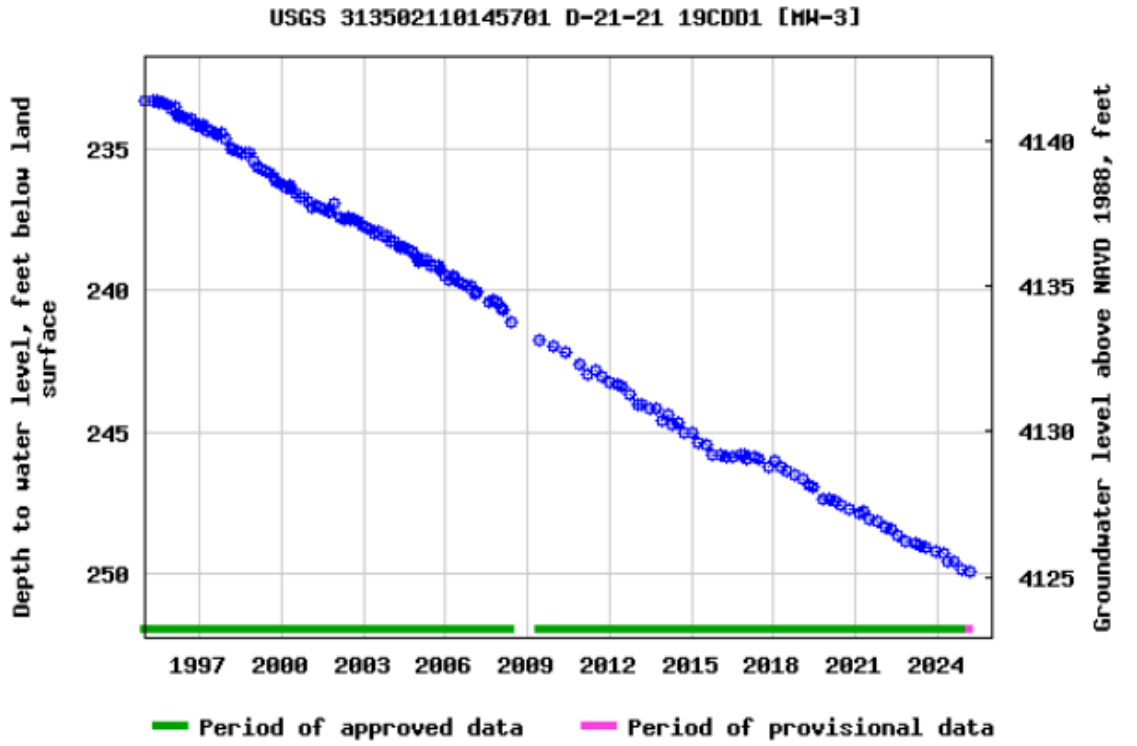
Five groundwater monitoring wells are located in linear transect that extends across Fort Huachuca in a direction from southwest to northeast to the San Pedro River.

Four of the monitoring wells are located on Fort Huachuca. One is located within the San Pedro Riparian National Conservation Area ("SPRNCA") on the San Pedro River at the Charleston Narrows.

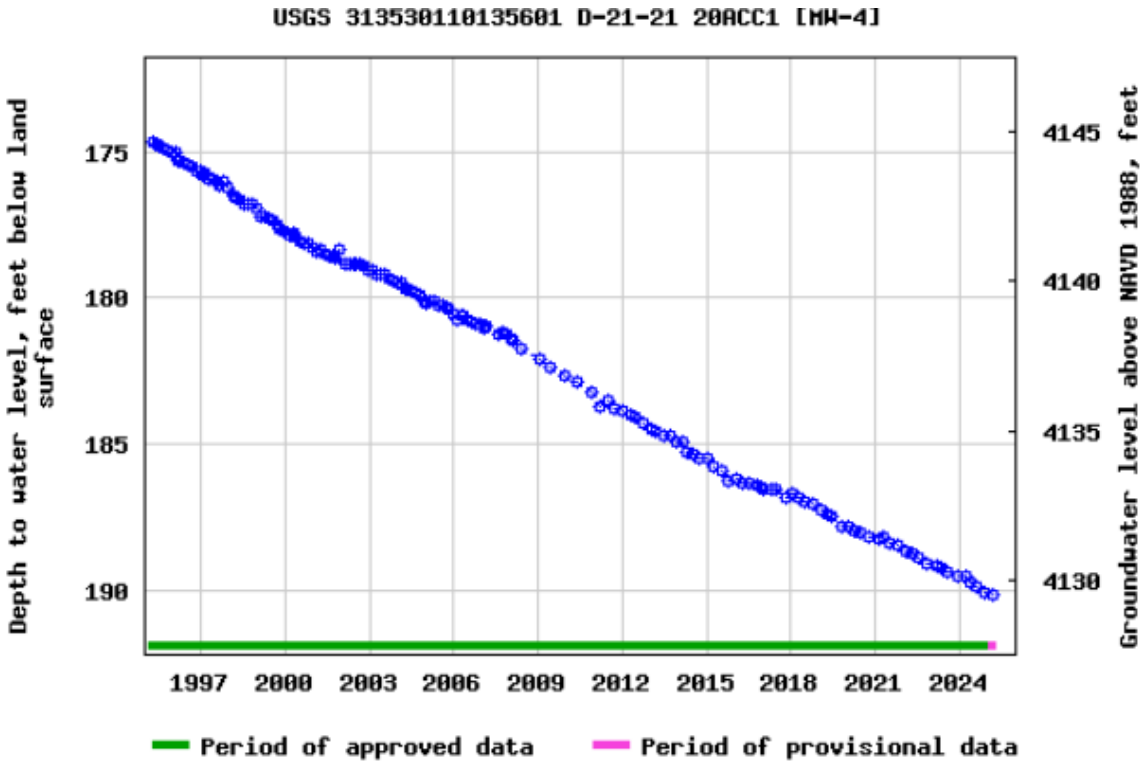
The four monitoring wells on Fort Huachuca extend from the southwest to the northeast, following the subterranean path of underground aquifer water from the Huachuca Mountains downhill to the San Pedro River. They are labeled MW3, MW4, MW5, and MW1 by ACOE in the May 16, 2005, Memorandum.

These four monitoring wells are now labeled USGS 313502110145701 D-21-21 19CDD1 [MW-3], USGS 313530110135601 D-21-21 20ACC1 [MW-4], USGS 313633110122501 D-21-21 16AAD1 [MW-5], and USGS 313721110112401 D-21-21 10ADA1 [MW-1] respectively.

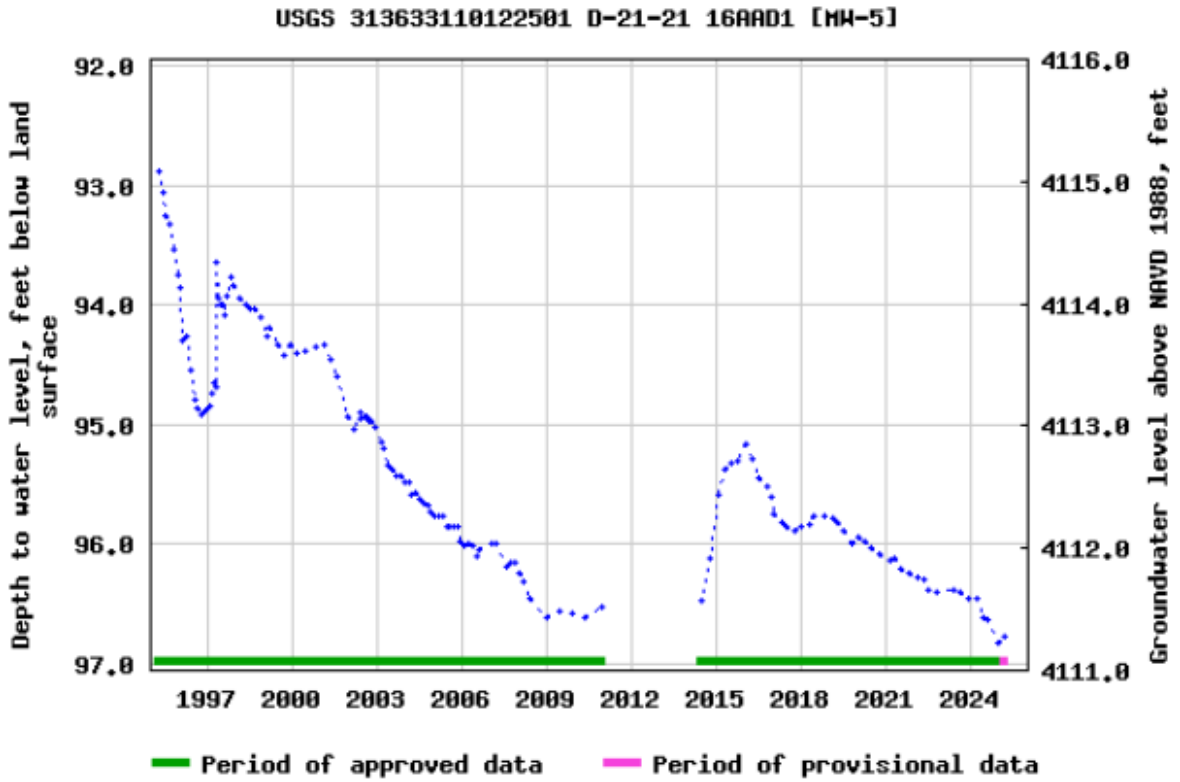
The hydrographs for each of the five monitoring wells follow:



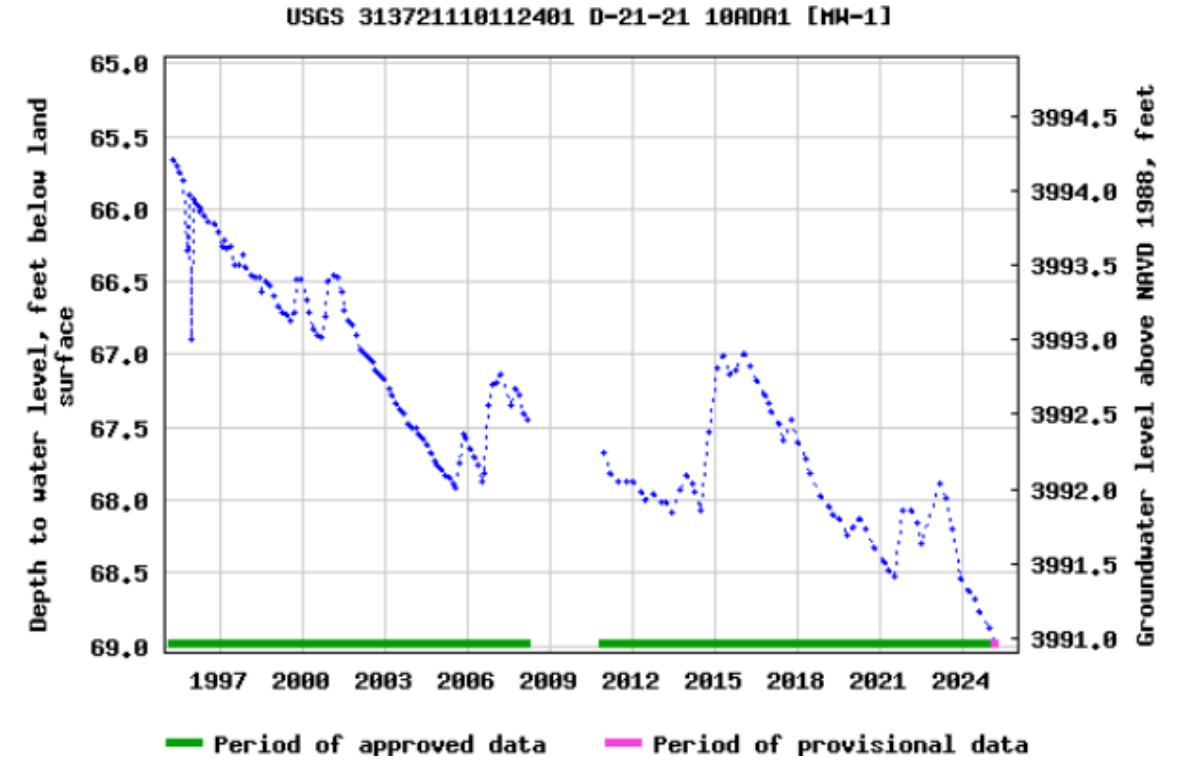
USGS 313502110145701 D-21-21 19CDD1 [MW-3]



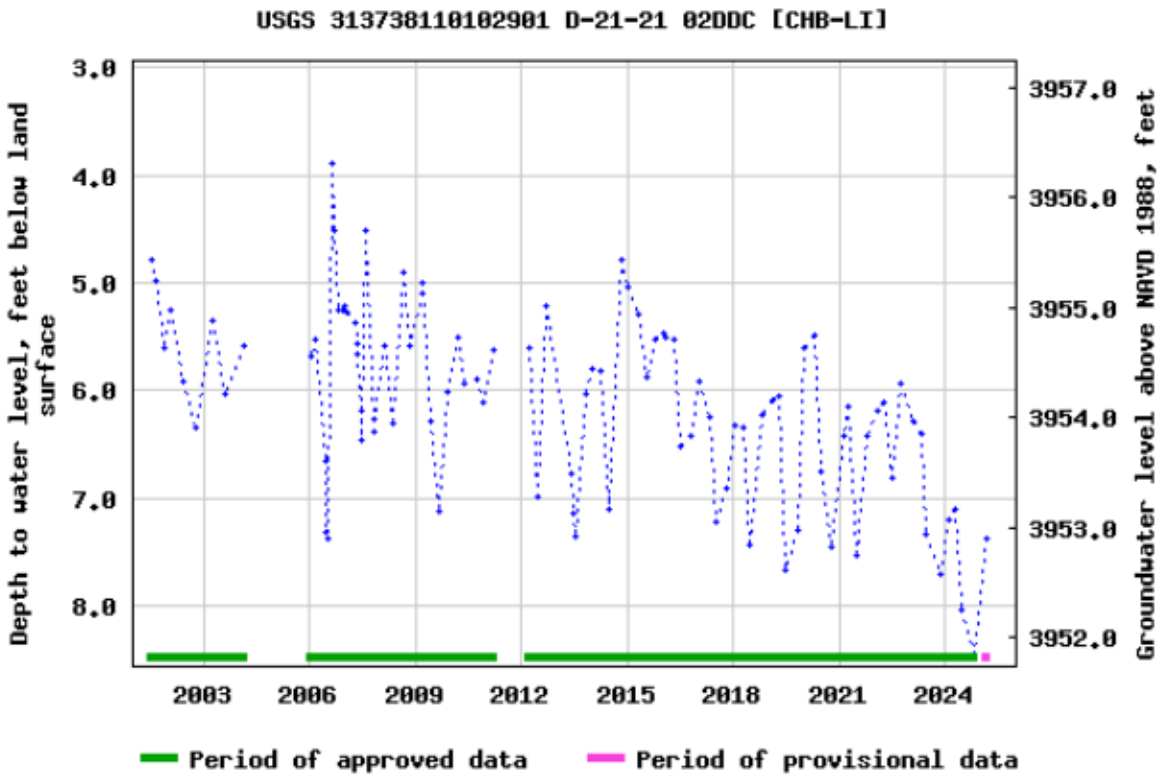
USGS 313530110135601 D-21-21 20ACC1 [MW-4]



USGS 313633110122501 D-21-21 16AAD1 [MW-5]



USGS 313721110112401 D-21-21 10ADA1 [MW-1]



313738110102901

Please note that the hydrographs for all five monitoring wells are similar, reflecting the widespread decline in groundwater well water levels across Fort Huachuca to the San Pedro River.

Gradients of water movement between the monitoring wells are calculated in this Update using the same standard calculations previously used by the ACOE in the May 16, 2005, Memorandum.

These calculations are governed by Darcy's Law, which is an equation that describes the flow of liquid through a porous medium.

In this Update, just as did ACOE in their May 16, 2005, Memorandum, we also assume uniform porosity.

Dividing the difference in monitoring well water level difference by the distance between each adjoining well, the hydraulic gradients are calculated.

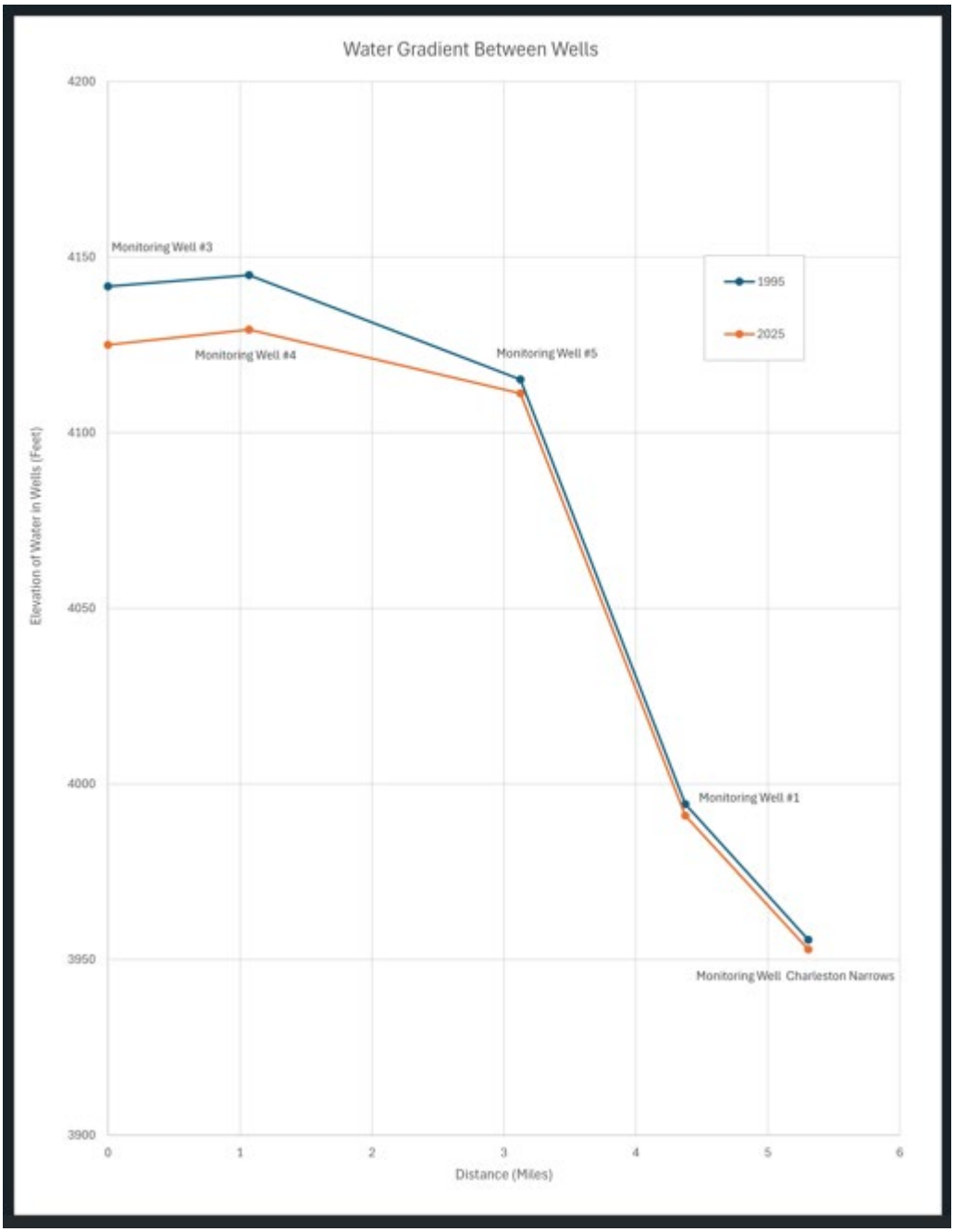
The calculated hydraulic gradients between wells are found in the following table:

	Monitoring Well	Water Elevation (ft)	Elevation Difference	Distance (ft)	Gradient
4/14/1995	3	4141.65			
	4	4144.82	-3.17	5940	-0.00507
	5	4115.13	29.69	10560	0.002734
	1	3994.24	120.89	6600	0.018317
	Charleston Narrows (2001)	3955.6	38.64	4910	0.00787
2/28/2025	3	4125.01			
	4	4129.35	-4.34	5940	-0.00073
	5	4111.23	18.12	10560	0.001716
	1	3990.93	120.3	6600	0.018227
	Charleston Narrows	3952.86	38.07	4910	0.007754

A negative gradient indicates groundwater flow away from the San Pedro River.

A positive gradient indicates groundwater flow in the direction of the San Pedro River.

Plotting the results from these calculations produces a graph of the hydraulic gradient of water movement between the water wells along their transect line towards the San Pedro River:



Between monitoring wells #'s 3 & 4, there is an increasing negative hydraulic gradient since the May 16, 2005, Memorandum.

This means that groundwater between these two wells has been flowing increasingly backwards away from the San Pedro River.

Between monitoring well #4 and the other wells along the transect toward the San Pedro River, wells # 5 and #1, and the USGS Charleston Narrows well at the San Pedro River, the hydraulic gradients are all positive but less positive since 1995.

This means that the reduced groundwater flow towards the San Pedro River noted in the May 16, 2005, Memorandum is continuing.

The narrowing of the hydraulic gradients along the transect gradient line and between these wells, wells # 5 and #1, and the USGS Charleston Narrows well is reflects the lowering of the aquifer water table at the locations of these monitoring wells.

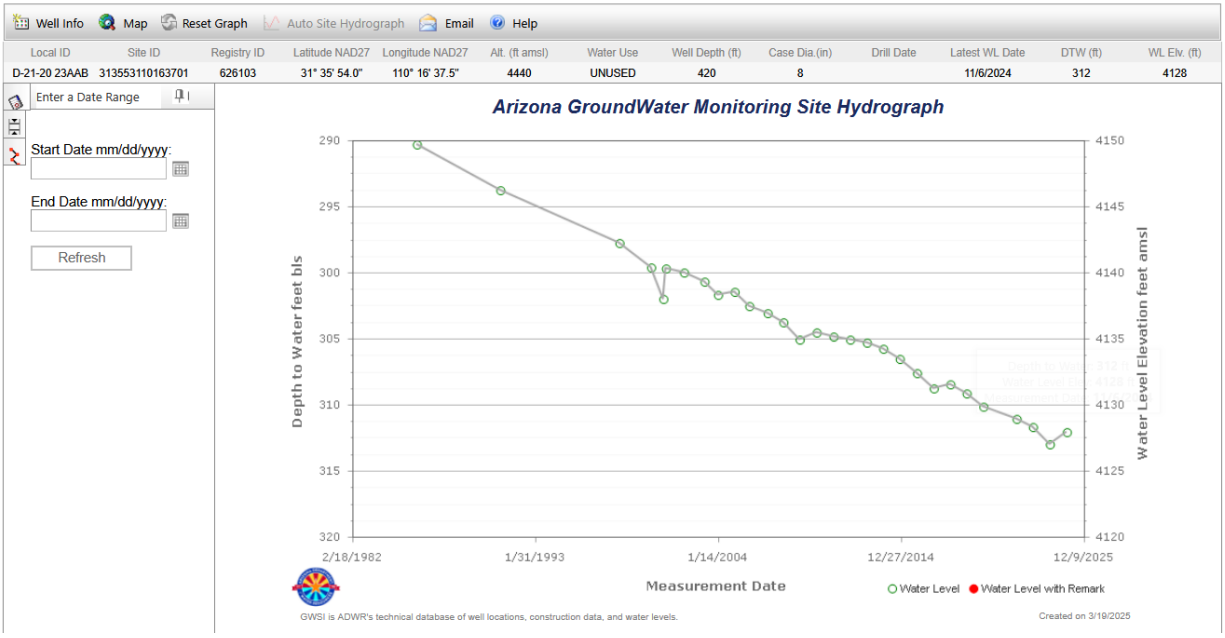
Other well water levels in the area are also diminishing.

Of concern are the dropping water levels in the three groundwater extraction production wells on Fort Huachuca for which data is available online.

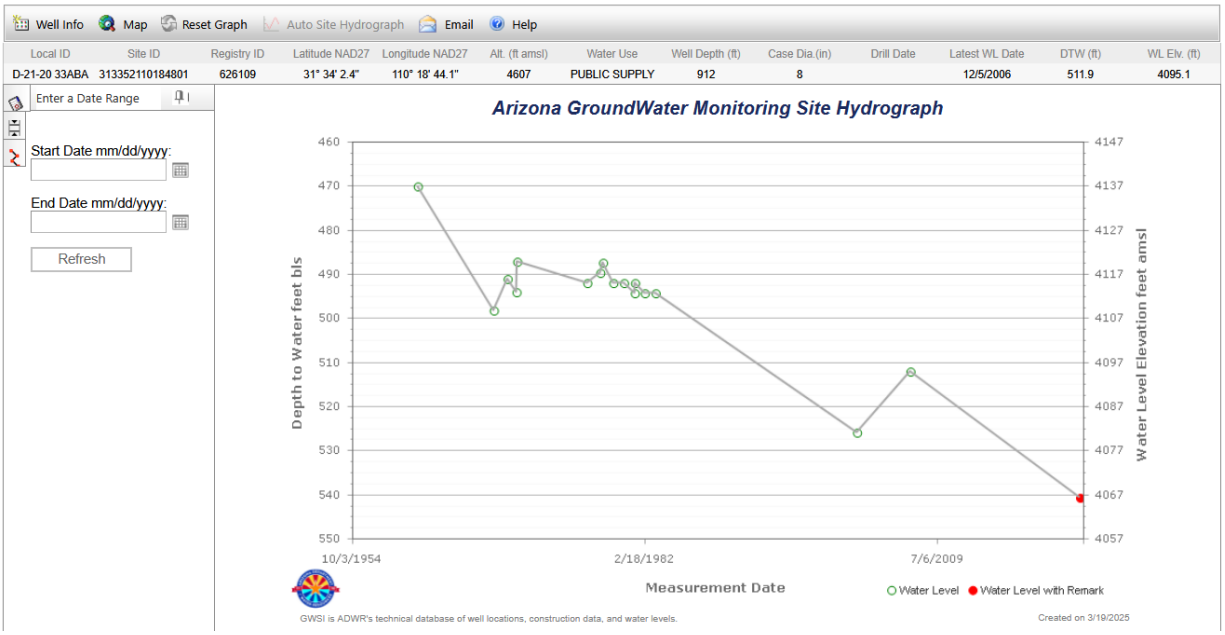
Fort Huachuca registers these three wells as active extraction production wells with the Arizona Department of Water Resources which requires yearly reporting of groundwater levels for extraction production wells. These wells are #'s 55-626107, 55-626109, and 55-626103.

The water levels in these wells have dropped -9.9 feet, -14.8 feet, and -21.8 feet over the last 30, 20 and 40 years respectively.

The hydrographs of these three production wells follow:



https://app.azwater.gov/gwsi/Detail.aspx?SiteID=313553110163701



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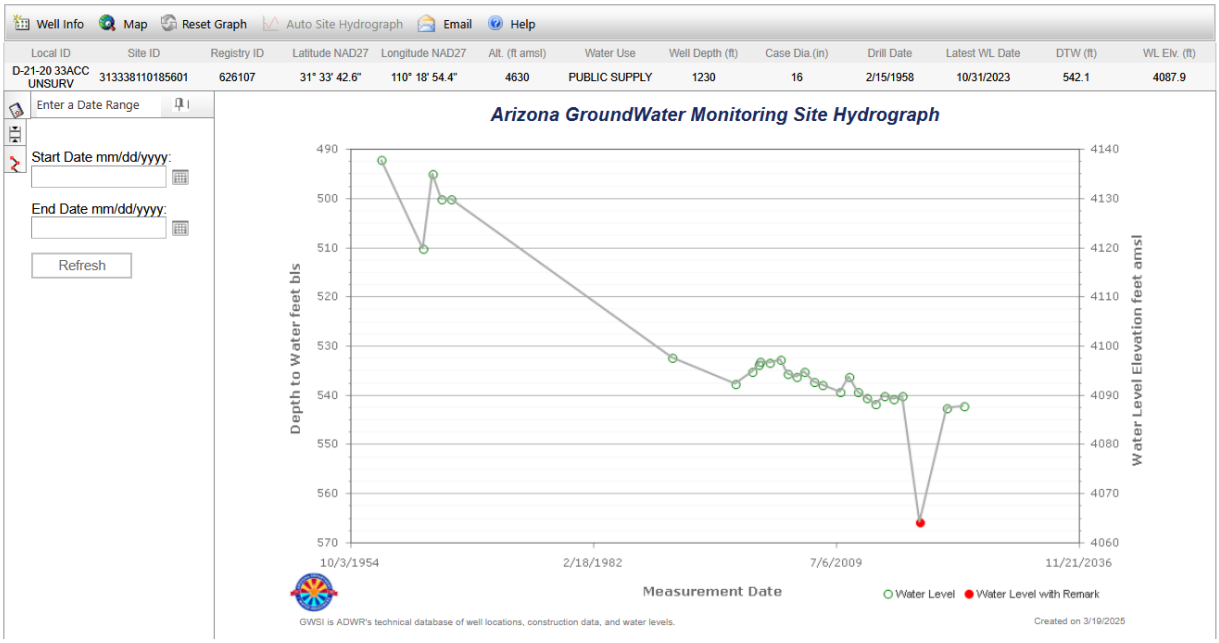
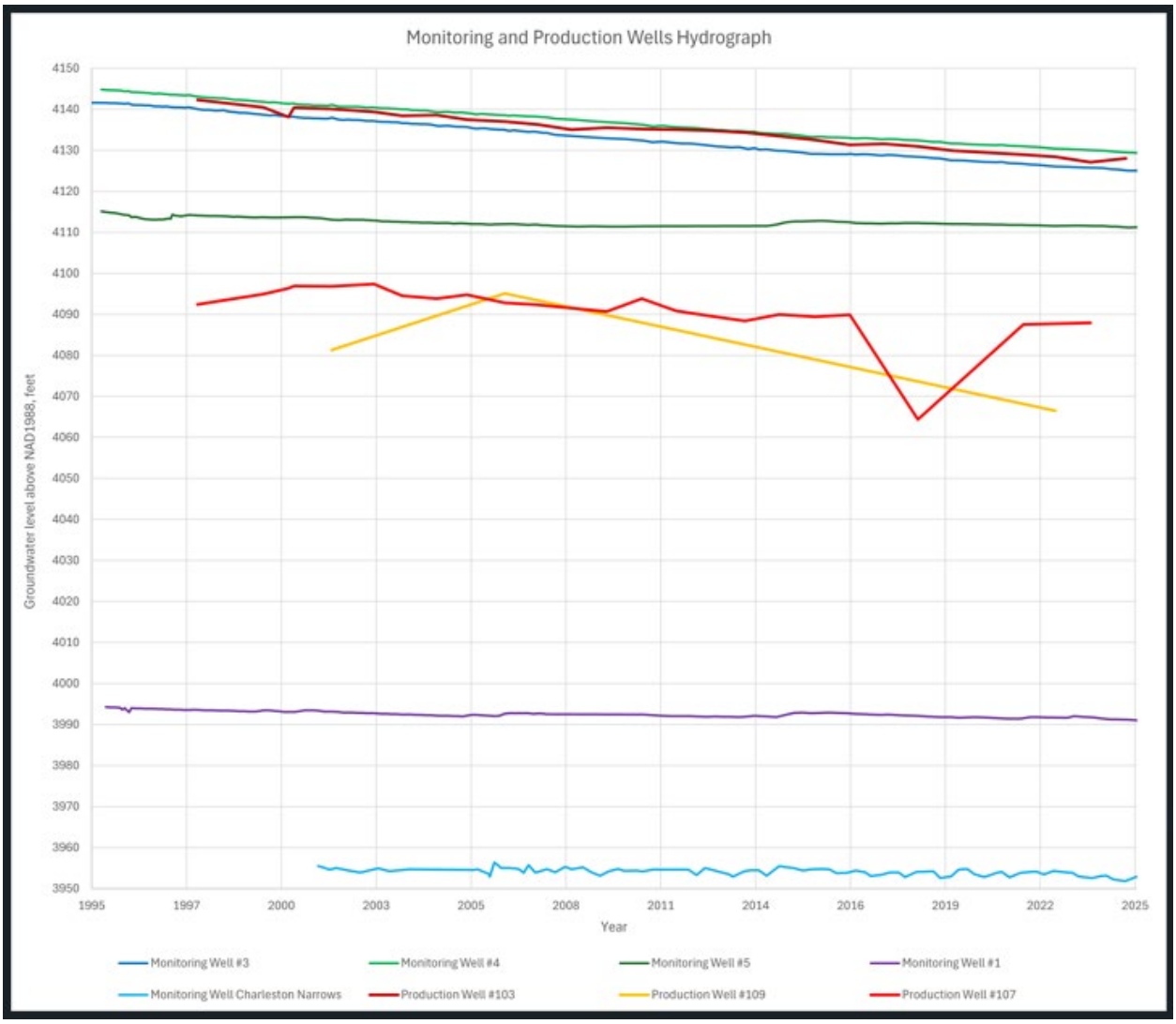


https://app.azwater.gov/gwsi/Detail.aspx?SiteID=313338110185601

The hydrographs documenting the dropping of the water levels in these extraction production wells are consistent in form with the negative gradients between Fort Huachuca monitoring wells #'s 3 and 4 where water is flowing backwards away from the San Pedro River toward the west and towards the Base's extraction production wells.

The following is a summary graph showing the lowering of the water levels in all of the wells studied for this analysis over more than two decades:



Correspondingly, the Base's deficit groundwater pumping on-post and off-post continues to grow.

In fiscal year 2020, on-post Fort Huachuca extraction production wells withdrew an unmitigated total of 996.47 acre feet of groundwater.

In fiscal years 2023 and 2024, Fort Huachuca withdrew an unmitigated total of 1388.1 and 1451.1 acre-feet respectively as the Base-attributable population on-post and off-post has continued to grow even before the recent new expansions.

In 2014, USGS published Simulated Effects of Ground-Water Withdrawals and Artificial Recharge on Discharge to Streams, Springs, and Riparian Vegetation in the Sierra Vista Subwatershed of the Upper San Pedro Basin, Southeastern Arizona, ("USGS (2014)").

USGS (2014) establishes, by geographic location, the percentage of a groundwater well's extracted water that is water captured or denied the San Pedro River.

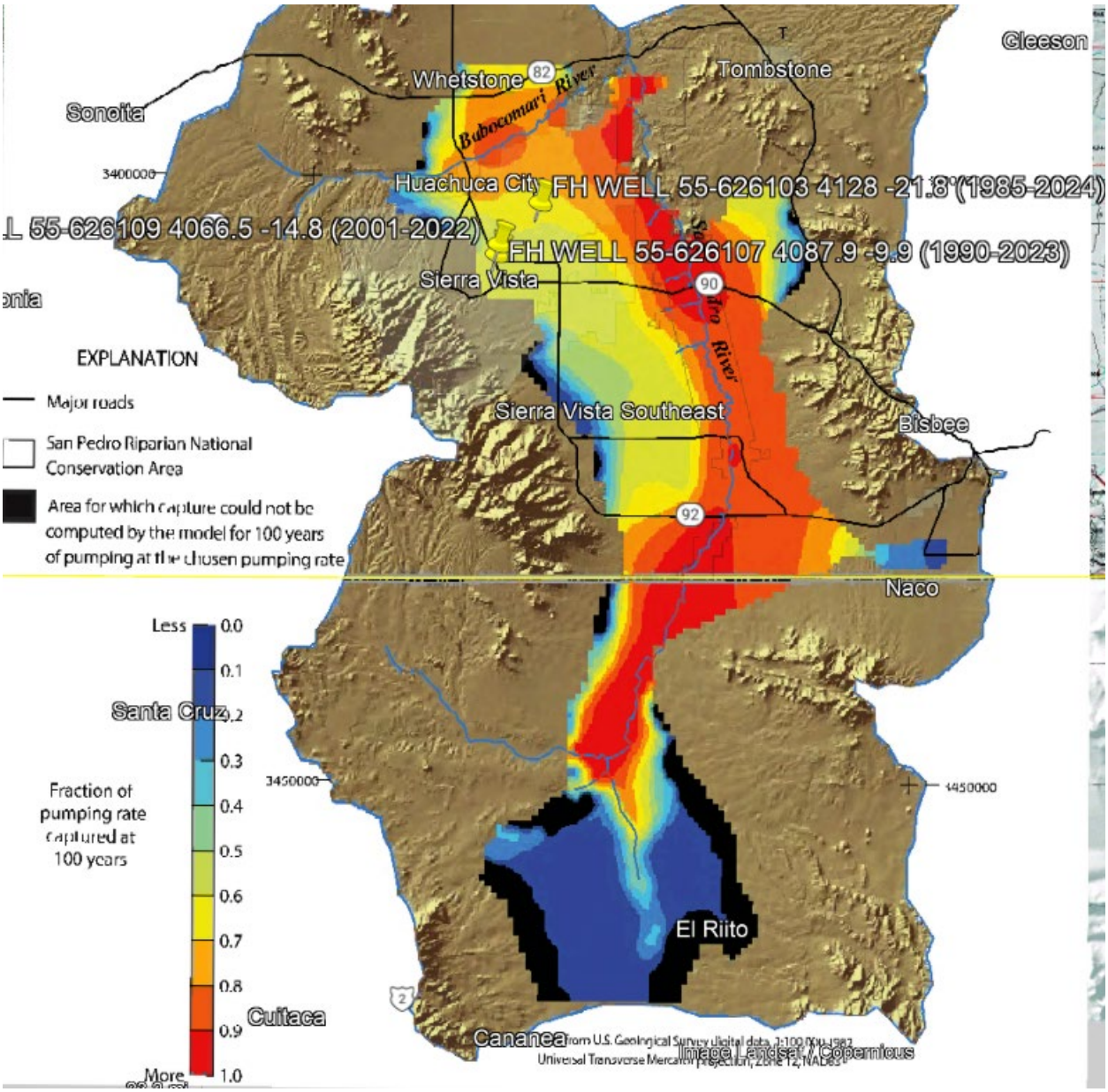
Consistent with USGS (2014), up to 10% of the groundwater currently being extracted from Fort Huachuca's extraction production wells #'s 55-626107 and #55-626109 is water captured or denied from the San Pedro River.

From Fort Huachuca's extraction production well #55-626103, between 10% and 20% of the groundwater currently being extracted is water captured or denied from the San Pedro River.

USGS (2014) predicts that by the year 2100, approximately 50% - 60% of the water withdrawn by Fort Huachuca's extraction production wells #55-626107 and #55-626109 will be water captured or denied from the San Pedro River.

For Fort Huachuca's extraction production well #55-626103, by the year 2100, approximately 60%-70% of the water withdrawn will be water captured or denied from the San Pedro River.

Superimposing Fort Huachuca's three extraction production wells on the year 2100 capture map from USGS (2014) illustrates that by the year 2100, 50% - 60% of the water withdrawn by #55-626107 and #55-626109 and 60%-70% of the water withdrawn by #55-626103 will be water captured or denied from the San Pedro River.



The continuing downward water levels and hydrographic trends of all Fort Huachuca's monitoring wells and extraction production wells are not only the result of Fort Huachuca-attributable growth, but are also the result of the massive historic cumulative unmitigated groundwater pumping deficit accumulated by the Base and by other local groundwater extractors.

The continuing downward water levels and hydrographic trends of all Fort Huachuca's monitoring wells and extraction production wells are consistent with a 2010, report previously covered up by the Army titled, "Calculation of Pumping-induced Baseflow and Evapotranspiration Capture Attributable to Fort Huachuca," Fort Huachuca contractor, GeoSystems Analysis, Inc. ("GeoSystems (2010)").

GeoSystems (2010) documents that Fort Huachuca's attributable, cumulative unmitigated groundwater extraction deficit for 1950-2025 is 400,000 acre-feet:

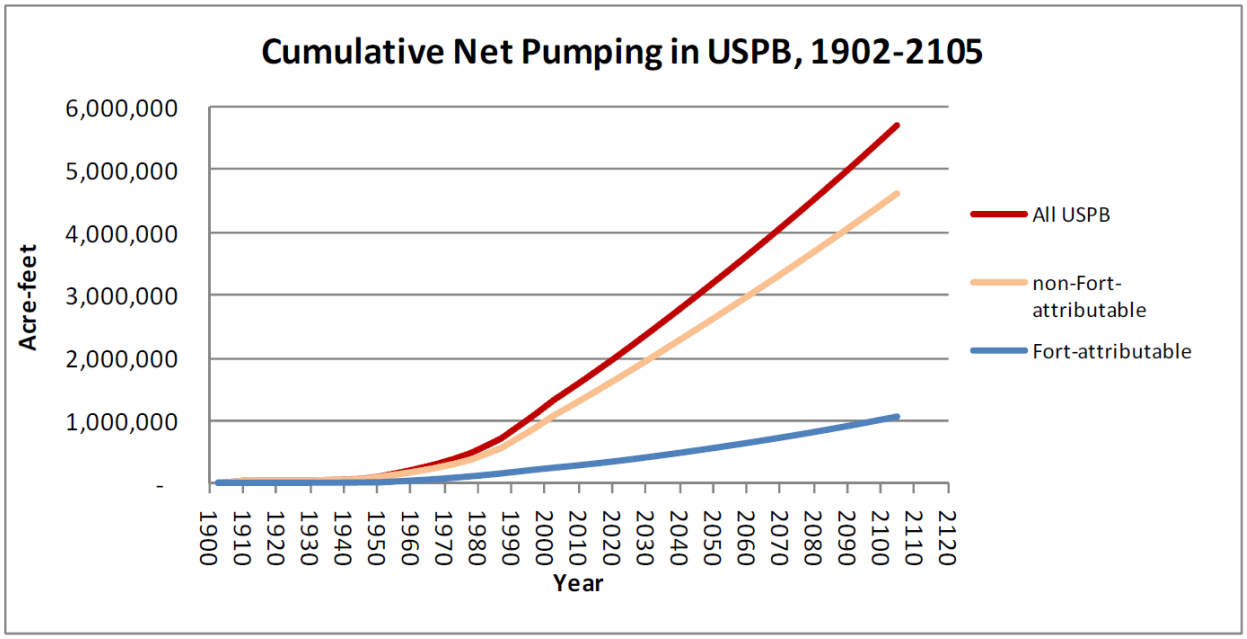


Figure 13. Simulated Cumulative Fort-attributable Pumping in USPB, 1902-2105.

GeoSystems (2010) also finds that (a) Fort-attributable groundwater pumping was already causing harm to the San Pedro River by 2003; and that (b) the harm to the San Pedro River from Fort-attributable groundwater pumping's "peak impacts to simulated baseflow occur in 2050."

The continuing downward water levels and hydrographic trends of all Fort Huachuca's monitoring wells and extraction production wells are also consistent with a 2019, report on Fort Huachuca-attributable groundwater pumping, "Evaluation of Impacts of Fort Huachuca Long-term Well Pumping and Recharge on San Pedro River Stream Flow (from 2011 to 2100)," by Integrated Hydro Systems ("Integrated Hydro (2019)").

Integrated Hydro (2019) finds that "at year 2100 … [d]rawdowns exceed 18 meters in the central high density [Fort Huachuca/Sierra Vista] pumping well area, 2 meters beneath and north of the central Babocomari River, and nearly 2 meters beneath portions of the southern extent of the SPRNCA, south of Lewis Springs."

Integrated Hydro (2019) illustrates its finding of Fort Huachuca-attributable groundwater pumping's diminishing of San Pedro River streamflow:

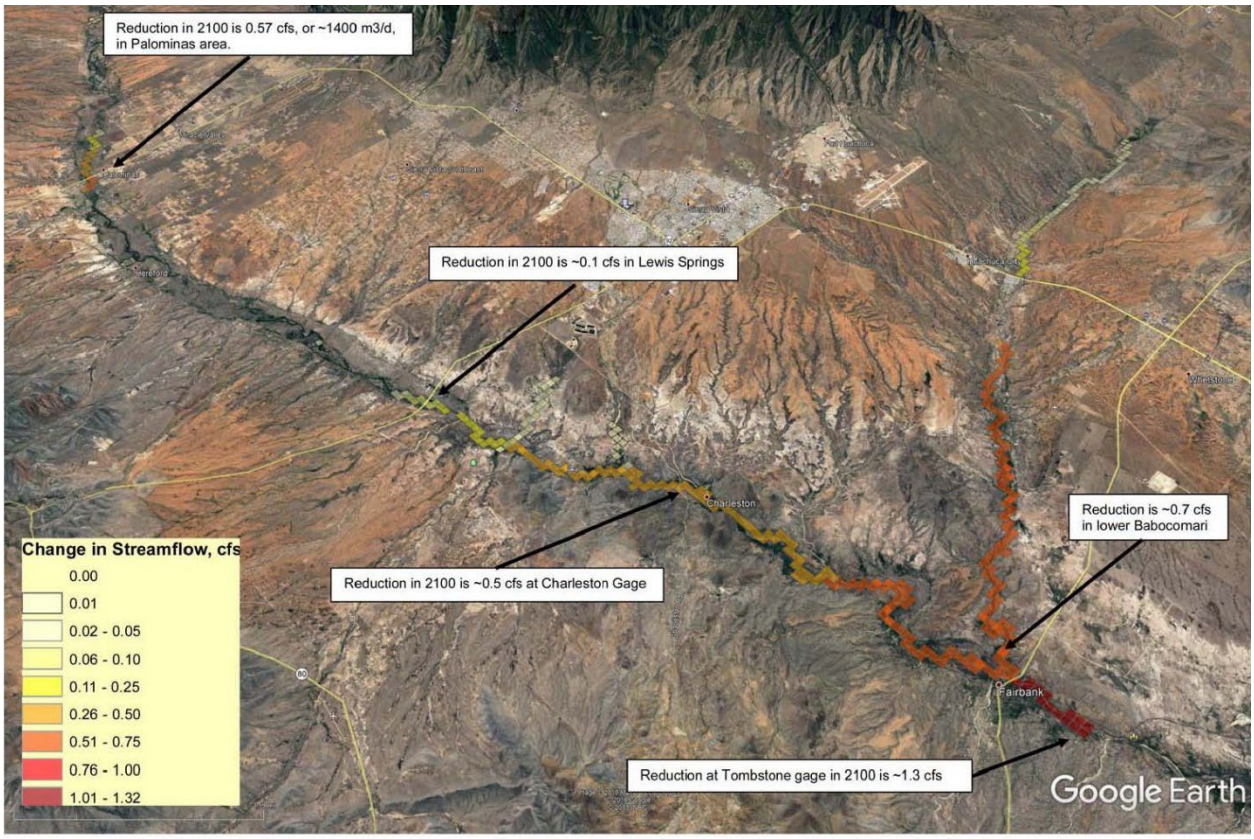


Figure 16. Change in Winter Streamflow (cfs) at Year 2100 due to Fort-Attributable Groundwater Pumping and Recharge (Southern SPRNCA Area). Positive values indicate streamflow decreases, and Negative values indicate streamflow increases. 24

Integrated Hydro (2019) also notes that,

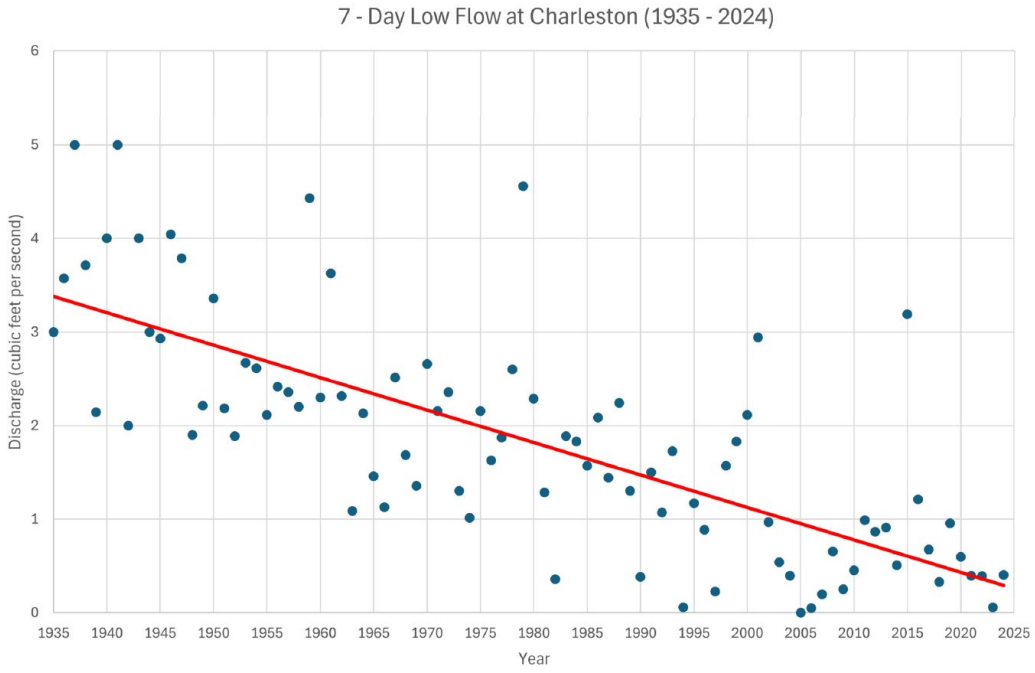
> "[i]f this pumping [Fort Huachuca's massive, negative, unmitigated cumulative groundwater pumping] were considered in this study, the total Fort-Attributable pumping impacts on the San Pedro River baseflow discharge would be much greater than just considering projected impacts from 2011 to 2100."

The continuing downward water levels and hydrographic trends at all Fort Huachuca's monitoring wells and extraction production wells, at the USGS Charleston Narrows monitoring well, and the findings of GeoSystems (2010) and Integrated Hydro (2019) are also consistent with the dramatically declining hydrograph of the USGS Charleston stream gage during the driest times of the year.

During the driest times of the year all stream surface flow comes directly from aquifer water seeping into the river from the riverbanks.

The water moving from the underground aquifer through the riverbanks during the driest times of the year is called baseflow.

The hydrograph of the baseflow of the San Pedro River over the last 90 years follows:



DISCUSSION/CONCLUSION

Using the same methodology as ACOE did in its May 16, 2005, we document in this Update that an increasing amount of groundwater between Fort Huachuca monitoring wells #3 and #4 is moving backward away from the San Pedro River.

At the same time, the hydraulic gradients toward the San Pedro River between monitoring wells, #5, #1, and Charleston Narrows to the east show a small decrease in their gradients.

This means that the flow of groundwater toward the San Pedro River has decreased.

Since the May 16, 2005, Memorandum, essentially the entire aquifer water table under Fort Huachuca has dropped.

These findings are consistent with three studies released since the May 16, 2005, Memorandum, where GeoSystems (2010), USGS (2014) and Integrated Hydro (2019) all document Fort Huachuca's diminishment of San Pedro River baseflow and predict increasing future harm to the San Pedro River.

These findings are consistent with GeoSystems (2010) documentation of Fort Huachuca's massive historic unmitigated 400,000 acre-feet groundwater extraction deficit, as well as that of others.

The change in the hydraulic gradients between 1995 and 2025 along the linear transect line from Fort Huachuca to the San Pedro River is analogous to a situation where a playground slide is lowered by shortening the slide's supporting legs, but with the upper support legs near the top of the slide shortened in larger increments than the lower legs nearer to the bottom of the slide.

The shortening of the supporting slide legs progressively reduces the slope of the slide as well as the downhill velocity of the children using the slide until the slide becomes nonfunctional.

A summary of our Update findings includes:

1. The water levels in all of the monitoring wells along the transect line across Fort Huachuca to the San Pedro River have dropped from 1995 to 2025.;

2. This drop in the monitoring well water levels along the transect line of across Fort Huachuca to the Charleston Narrow monitoring well, combined with the reduction in San Pedro River baseflow at the Charleston streamflow gage, reflects the lowering of the entire underground aquifer water table level under Fort Huachuca.;

3. Increasing negative hydraulic gradients between Fort Huachuca's two westernmost groundwater monitoring wells, #3 & #4, indicate that groundwater is moving toward Fort Huachuca's groundwater extraction production wells instead of moving toward the San Pedro River.;

4. The diminishing hydraulic gradient of groundwater movement towards the San Pedro River along the transect line of Fort Huachuca's monitoring wells has continued diminishing over time since 1995. This indicates that less groundwater is moving underneath Fort Huachuca toward the San Pedro River.;

5. The lowering of the entire aquifer water table level under Fort Huachuca has resulted in the lowering of aquifer water table levels extending to the San Pedro River.;

6. The findings of this Update confirm the findings of GeoSystems (2010) and Integrated Hydro (2019) that (a) Fort Huachuca-attributable unmitigated historically cumulative 400,000 acre-feet of groundwater extraction is already diminishing San Pedro River baseflow, and that (b) current increasing Fort Huachuca-attributable groundwater extraction when combined with the Base's past unmitigated cumulative groundwater extraction deficit will increasingly continue diminishing San Pedro River baseflow into the future.

> When the water table in the aquifer under the San Pedro River falls below the streambed, the San Pedro River will be dry except during runoff events caused by storms. This is exactly what happened to the Santa Cruz River in Tucson.

The May 16, 2005, ACOE Memorandum concludes that "it is ***likely*** that the decline in water levels currently extends to the river, resulting in a reduction of groundwater discharge to the river."

This Update establishes that ***the decline in water levels under Fort Huachuca now <u>undoubtedly</u> extends to the San Pedro River***.

Fort Huachuca is still the largest single groundwater extractor in the Sierra Vista Subwatershed.

With (1) the decline in underground aquifer water levels under Fort Huachuca now extending to the San Pedro River, (2) with Fort Huachuca's unmitigated historically cumulative 400,000 acre-feet of groundwater extraction, (3) with continuing diminishment of San Pedro River baseflow, and (4) with Fort Huachuca's increasing yearly unmitigated groundwater extraction, it is indisputably clear that Fort Huachuca is not only already harming the San Pedro River, but is, by itself, jeopardizing the continued existence of the River.

ADDENDUM:

CHARLESTON STREAM GAGE 7-DAY FLOW WITH 9 POINT MOVING AVERAGE