APPENDIX 3-A

TECHNICAL APPROACH FOR DETERMINING GROUNDWATER ELEVATION MINIMUM THRESHOLD FOR CHRONIC LOWERING OF GROUNDWATER LEVELS IN REPRESENTATIVE MONITORING WELLS

Technical Approach for Determining Groundwater Elevation Minimum Threshold for Chronic Lowering of Groundwater Levels in Representative Monitoring Wells

The general premise for determining Minimum Thresholds for chronic lowering of groundwater levels is that groundwater levels cannot go below a level which prevents overlying groundwater users from meeting their typical water demand. Overlying water demand is determined from land use and by the well use indicated on well driller logs in the vicinity of the RMP.

The saturated thickness of an aquifer is an important factor that can limit well yields. When groundwater levels decline, the saturated thickness of the aquifer decreases. The saturated thickness may decrease to a point at which the aquifer can no longer produce water to the well at the minimum rate of pumping needed to meet typical demands.

The pump rate and aquifer properties control how much saturated aquifer thickness (distance between the bottom of the well and the groundwater level) is needed to meet water demands. Water demands by municipal wells are known as municipal agencies have detailed records of each well's pump capacity and volumes pumped. Private domestic and agricultural well users generally do not have this information, and therefore assumptions are made to estimate their water usage. For domestic use, average rates of 10 gpm were provided by a local pump contractor. For purposes of estimating the minimum saturated thickness (MST) needed, a more conservative rate of 15 gpm was used as this needs more saturated thickness than a well pumping at 10 gpm (i.e. the groundwater level needs to be higher for 15 gpm). For agricultural wells, the estimated capacity provided on the well driller's logs available indicated 250 gpm is typical.

A theoretical MST for each RMP is estimated using a spreadsheet tool developed by the Kansas Geological Survey based on the overlying water demand (Brookfield, 2016). The tool considers well efficiency, nearby pumping wells, and drawdown in the well due to pumping at a given rate. To consider uncertainties in the MST estimation, a 20% safety factor is added to the MST obtained from the spreadsheet tool. It is also assumed that a well pump can be placed no deeper than 20 feet from the bottom of the well to prevent the pump from being damaged by settled sediment in the bottom of the well. This is the typical depth well pumps are set in domestic wells according to a local pump installer. To account for this, a further 20 feet is added to the estimated MST. Figure 1 provides a generalized schematic that illustrates the method described above. The resultant adjusted MST is the minimum thickness of saturated aquifer that is needed for overlying groundwater users to meet their typical demand. In some areas, there may be two overlying uses, such as agricultural and domestic, or municipal and domestic. For these cases, the adjusted MST of the use type that results in the shallowest groundwater level is used.

As a conservative measure, the approach assumes the RMP has a depth equal to the shallowest nearby well screened in the same aquifer as the RMP. This results in a shallower groundwater elevation than if the actual depth of the RMP is used (if it is deeper than nearby wells).

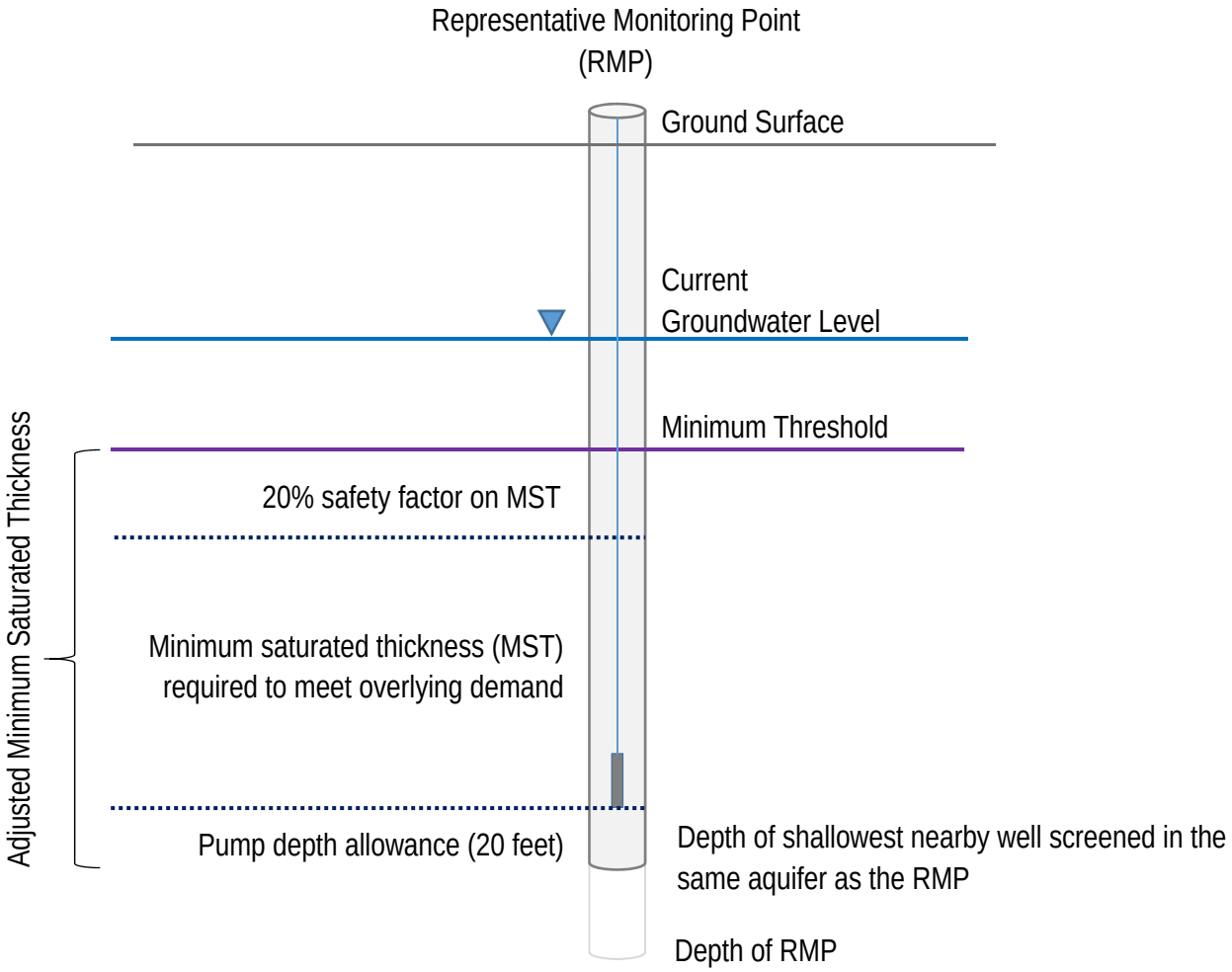

Figure 1. Schematic of Minimum Saturated Thickness Approach

Table 1 summarizes the minimum thresholds for 17 RMPs selected as representative across the Basin. There are five RMPs that had adjusted MSTs that are greater than 30 feet below historic low groundwater levels. For these RMPs, the minimum threshold was raised to 30 feet below historic low groundwater levels. This was done because, although the wells could meet their demand with a much lower groundwater level, having groundwater levels drop to these depths may influence other sustainability indicators. The rationale for selecting a maximum of 30 feet below historic low is that the majority of the RMPs have adjusted MSTs less than 30 feet below historic low levels as shown on Figure 2.

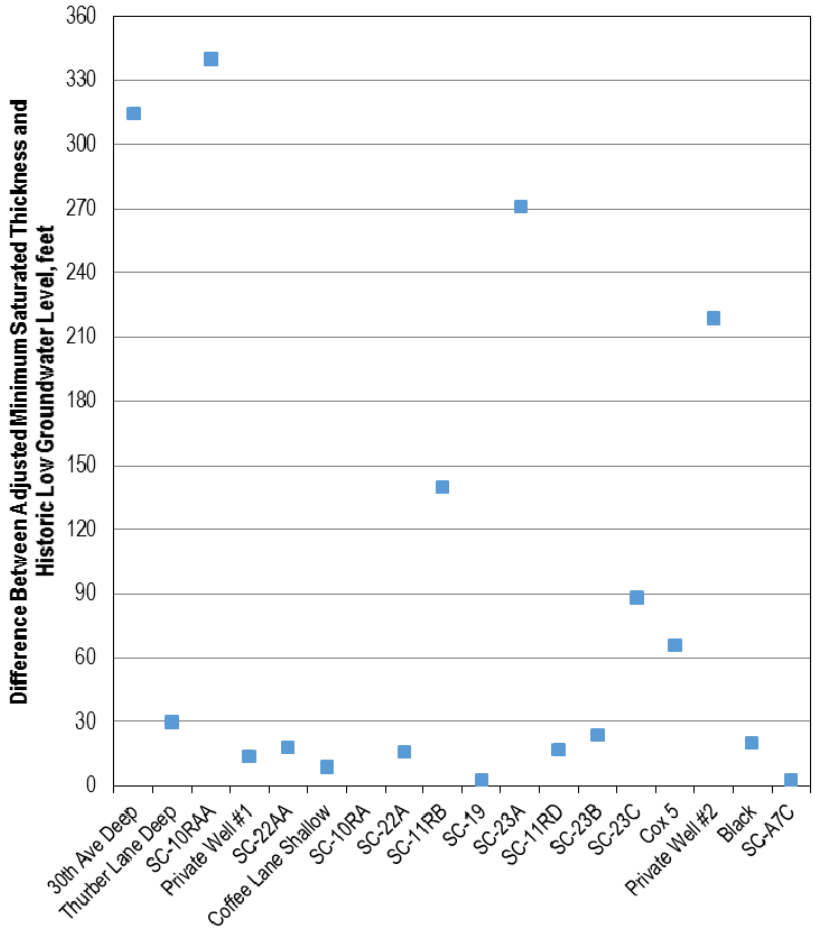

Figure 2. Representative Monitoring Points Difference between Adjusted Minimum Saturated Thickness and Historic Low Groundwater Level

There are four wells where the minimum thresholds were raised to sea level as these are close to protective elevation coastal monitoring wells and having groundwater levels below sea level will make it difficult to achieve protective elevations at the coast. Other reasons for raising elevations from the MST levels are provided in Table 1.

References

Brookfield, A. 2016. Minimum Saturated Thickness Calculator, Method Overview and Spreadseet Description. Kansas Geological Survey Open---File Report 2016---3, pp 6.

Table 1. Summary of Representative Monitoring Points with Minimum Threshold Groundwater Elevations

RMP Name	Overlying Demand Type	Aquifer	Minimum Threshold Elevation (feet amsl)	Minimum Saturated Thickness (MST) Assumptions and Adjustments made to Minimum Thresholds (MT)
30th Ave Deep	Municipal	Tu	0	No private wells screened in this very deep aquifer. There are some municipal wells screened in this aquifer > 0.8 mile to the north. Shallowest municipal well depth results in a minimum elevation of -324 ft amsl based on the MST. However, well screens are typically at 200 ft below ground so the MT is adjusted upwards to sea level which is typically above well screens.
Thurber Lane Deep	Private Domestic	Purisima AA/Tu	-10 Upward	Shallowest domestic well depth results in a minimum elevation of -33 ft amsl that still meets demands. Increase the elevation to -10 ft amsl so that there is not such a steep gradient between this RMP and the coast where there are higher protective groundwater elevations.
SC-10RAA	Private Domestic	Purisima AA/Tu	35 30 ft below low	There are no deep domestic wells in the area of this RMP that are screened in the Pur AA/Tu similar to the RMP. They are screened shallower in Pur A/AA and in the alluvium. Even using the shallowest domestic well depth (not screened in the same aquifer), adjusted MST is at -275 ft amsl, MT is therefore set to 30 ft below historic low levels.
Private Well #1	Private Domestic	Purisima AA/Tu	362	Shallowest domestic well depth in same aquifer as RMP.
SC-22AA	Municipal	Purisima AA	0	Shallowest municipal well depth and municipal well MST. The adjusted MST is --3 ft amsl, MT is therefore increased to sea level.
Coffee Lane Shallow	Municipal	Purisima A/AA	27	Shallowest domestic well depth in same aquifer as RMP.
SC-22A	Municipal/Private Domestic	Purisima A	2	Shallowest domestic well depth, adjusted MST at muni well MST is -3 ft amsl. MT set at 2 ft above SC-22AA MT because groundwater levels in SC-22A are typically 2 ft higher than SC-22AA levels, which has a minimum threshold of 0 ft amsl.
SC-11RB	Private Domestic	Purisima BC	120	Not many domestic wells are deep enough in this location to go down through the Purisima DEF and D units into the underlying Purisima BC unit. Shallowest domestic well depth in same aquifer as RMP (555 ft). MT set to 30 ft below historic low because adjusted MST results in > 30 ft below historic low level.
SC-19	Municipal/Private Domestic	Purisima BC	56	Not many private wells nearby. Municipal wells are shallower than private wells with County records. Used shallowest municipal well depth

RMP Name	Overlying Demand Type	Aquifer	Minimum Threshold Elevation (feet amsl)	Minimum Saturated Thickness (MST) Assumptions and Adjustments made to Minimum Thresholds (MT)
				in same aquifer as RMP.
SC-23A	Municipal	Purisima BC	0	No domestic wells at this depth in the area. Shallowest municipal well depth, adjusted MST >30 ft below historic low. Raise MT to sea level 0 ft amsl which is 21 ft below historic low.
SC-11RD	Private Domestic	Purisima DEF	295	Shallowest domestic well depth in same aquifer as RMP.
SC-23B	Small Water System/ Private	Purisima DEF	50	Shallowest domestic well depth results in a minimum elevation of -137 ft amsl that still meets demands. Increase the elevation to 50 ft amsl. Difference in groundwater levels between SC-23B and SC-23A is 50 ft during historic low levels on hydrograph.
SC-23C	Municipal	Purisima F	15	Shallowest domestic well depth results in a minimum elevation of -14 ft amsl that still meets demands. Increase the elevation to 15 ft amsl. This is both 30 ft lower than historic low and equal to the average depth below SC-23B elevation.
CWD-5	Private Domestic	Purisima F	133	Shallowest domestic well depth results in a minimum elevation of 97 ft amsl that still meets demands. Increase the MT elevation to 30 ft below average historic lows.
Private Well #2	Private Domestic	Purisima F	562	Shallowest domestic well depth results in a minimum elevation of 433 ft amsl that still meets demands. Increase the elevation to 562 ft amsl, which is 30 ft below historic lows.
Black	Private Domestic	Purisima F	21	Other domestic wells in the area are screened in both the Aromas and Purisima F, while this RMP is screened in only the Purisima F. The MT is set at a level less than 30 ft below the historic low.
SC-A7C	Ag/Municipal	Aromas	0	Shallowest Ag well depth results in a minimum elevation of --20 ft amsl that still meets demands. MT is therefore set at sea level.