

**GUIDELINES FOR THE ASSESSMENT OF
DRAWDOWN ESTIMATES**

**FOR WATER RIGHT APPLICATION
PROCESSING**

**NEW MEXICO OFFICE OF THE STATE ENGINEER
HYDROLOGY BUREAU REPORT 05-17**

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Introduction

The state engineer cannot grant an application to appropriate groundwater if the proposed appropriation will impair existing water rights (NMSA 1978, Section 72-12-3.E). Likewise, statutes governing changing location of a well (NMSA 1978, Section 72-12-7 and 72-12-23), supplemental wells (NMSA 1978, Section 72-12-24), water-use leasing (NMSA 1978, Section 72-6-5), and ground water storage and recovery (NMSA 1978, Section 72-5A-6) all require that the state engineer make a determination that the proposed action does not impair other water rights before approving an application. The statutes, however, do not define impairment. Impairment may result from the adverse impact created by the action proposed in an application on points of diversion of other groundwater rights (wells). Excessive groundwater-level drawdown at a well may adversely affect or prevent the exercise of the groundwater right(s) associated with the well. Therefore, part of the impairment evaluation involves estimating the drawdown at wells in the proximity of a proposed groundwater diversion.

Guidelines have been developed based on legal, hydrogeologic principles, and agency practice to provide guidance in assessing drawdown estimates for impairment determinations. Analyses of this nature always include uncertainty and data limitations, and accordingly must be applied on a case-by-case basis. Due to these factors, guidelines should include a reasonable level of conservatism, depending on circumstances and available data, to ensure the statutory mandate is met.

Guidelines to assess the impact of drawdown for impairment determinations were first documented in Hydrology Bureau Report 06-01 (Morrison, 2006). Since the release of the 2006 report, improvements to the guidelines have been identified. The purpose of this document is to incorporate these improvements. This document and the procedures herein supersede the 2006 and the October 24, 2016 procedures.

In addition to these drawdown assessment guidelines, basin specific drawdown guidelines have been developed for a number of basins which should supersede these procedures. The procedures in this document should be used where the 2006 guidelines or October 24, 2016 procedures are referenced in basin guidelines.

Drawdown Assessment Guidelines

The Drawdown Assessment guidelines provide a general approach to assess drawdown estimates on wells in the vicinity of a proposed diversion. Data availability and magnitude of drawdown control how the guidelines should be applied. Only a few steps may be necessary to reach a conclusion where drawdowns are de minimis, but additional steps may be necessary where the drawdown effects are larger. A drawdown allowance defines a de minimis drawdown.

An assessment of drawdown begins by identifying the source aquifer, transmissivity (T), storage coefficient (S), and boundary conditions of the source aquifer for a given application. Values of T and S may be obtained from the following sources: hydrologic investigations by the OSE and others, calibrated numerical models, the OSE Hydrology Bureau aquifer test data base (located on the OSE Hydrology Bureau web page), OSE Hydrology Bureau staff, and other sources. The T selected should be appropriate for the water bearing thickness expected to be penetrated by the proposed well.

A Theis analysis is typically performed, although numerical models may be used under the proper conditions, to assess 40-year drawdowns due to the proposed pumping on nearby wells of other ownership, including wells owned by any protestant. The estimated drawdown is compared with a drawdown allowance (see Drawdown Allowance section below). If the predicted drawdown is less than or equal to the drawdown allowance, the impairment analysis in most cases may be concluded. Further work may be conducted for applications which have been protested (see Procedures section). If drawdowns exceed the allowance, an assessment is performed to estimate the 40-year drawdown on these wells due to the use of existing wells along with an assessment to evaluate self-induced drawdown (dynamic drawdown) as nearby wells are cycled on and off. The three drawdown components are summed to obtain the total 40-year drawdown (Figure 1).

Following drawdown estimation, an assessment of adverse impacts to existing nearby wells can be made by evaluating well records to select the amount of water level decline that existing wells may tolerate. As water levels decline, the pumping water level may descend to a level where well operations become uneconomical. Sterrett (2007) indicates (p. 429) that it is impractical to pump a well in an unconfined aquifer at a drawdown that exceeds 67 percent of the water bearing sediments. For administrative purposes, a value of 70 percent of the initial water column is the economical drawdown constraint for wells completed in unconfined and confined aquifers, unless there is information to the contrary (Figure 2).

In addition to the economical drawdown constraint, drawdowns can interfere with the physical production of groundwater. Factors such as the depth and thickness of the water bearing formation along with the pump and screen setting must be taken into account to assess the physical constraint (physical drawdown constraint). See Figure 3 and the Estimations section of this document for further explanation.

The most conservative constraint, economical or physical, is the smaller of the two. The total drawdown is compared to the most conservative constraint to determine whether the wells of other ownership are capable of supplying water for a 40-year period from the date of application evaluation. If drawdowns exceed the economical or physical constraint, this may be grounds for impairment unless the drawdowns due to the proposed use are less than or equal to the drawdown allowance, or other options such as deepening the affected well(s) are available. In other words, a proposed well may induce a drawdown up to the most conservative constraint plus the drawdown allowance.

Drawdown Allowance

Preventing any level of new impact on a well is impractical, as this would result in the denial of all applications including those causing relatively small impacts. A drawdown allowance is used to define the relatively small impact due to a proposed diversion that may be allowed to occur on wells in which economical and/or physical constraints are exceeded¹. The drawdown allowance can be used as a screening tool to identify wells that

¹ Wells in which economic and/or physical constraints are exceeded due to total 40-year drawdown are referred to as "critical wells". Wells may become critical due to the use of existing water rights alone or the combined effects of dynamic drawdown, existing uses, and proposed uses if one or more of the drawdown constraints are exceeded.

require additional evaluation.

Recommended drawdown allowances are provided in Table 1. In general, the allowance is based on the magnitude of the current saturated thickness² of the aquifer in the vicinity of an application in relation to the Critical Management Area (CMA) allowances adopted in basin guidelines. Basin guidelines have been developed for several areas of the state, and in those guidelines, CMAs have been identified where there is less than a 40-year life for a regional aquifer. CMAs include those areas in which the majority of the wells are critical. The values in Table 1 should be applied on a case-by-case basis for any type of geologic formation. If multiple applications have been filed in the same area it may be inappropriate to grant a succession of drawdown allowances on a given well.

**TABLE 1
RECOMMENDED DRAWDOWN ALLOWANCES FOR UNCONFINED AND
CONFINED AQUIFERS**

AVERAGE AQUIFER THICKNESS IN THE VICINITY OF A PROPOSED WELL (ft)	TOTAL DRAWDOWN ALLOWANCE OVER 40 YRS (ft)	UNDERGROUND WATER BASIN WITH GUIDELINES
0 - 50	1.0	Curry County, Portales
>50 - 200	2.0	Lea County, Roswell (shallow aquifer), Tularosa (shallow fresh water)
>200	4.0	Mimbres (Deming- Columbus area), Estancia, Animas, Lordsburg

As an example of applying Table 1, well logs in the vicinity of a proposed well indicate an average saturated thickness of 60 feet in fractured rock. Information on the current saturated thickness is unknown, as such, it is appropriate to use well logs to define the saturated thickness. Basin specific guidelines have not been developed for the area in which the proposed well is located. The drawdown allowance is 2.0 feet over 40 years based on Table 1.

Estimations

Drawdown due to Proposed Use (DP)

The Theis equation is typically used to calculate 40-year drawdowns on nearby wells due to the use of a proposed well. Drawdowns calculated by a numerical model may be used, but may not be representative of the actual conditions near a pumping well. This is typically the case if nearby wells are located in the same model cell with the proposed well, or if the numerical model over-simplifies well spacing.

² If data are insufficient to determine the current thickness the thickness may be based on the average water columns obtained from well logs.

The selection of T, S, and boundary conditions should be based on available information and should be reasonable but conservative. If there is uncertainty regarding the aquifer properties or boundary conditions, the Hydrology Bureau should be consulted. If the 40-year drawdowns are less than or equal to the drawdown allowance, no further work to assess impairment is necessary for most applications. Additional work may be conducted if an application is protested.

For applications proposing a change to an existing water right (e.g. to change the point of diversion), the effects due to cessation of the move-from well or wells should be included in the analysis. The net drawdowns are obtained by finding the difference between the move-from and move-to effects. A similar approach may be used to compute the net drawdown for supplemental well applications.

When evaluating a supplemental well application, for a worst case scenario, if no pumping distribution has been provided, assume the entire appropriation is derived from the proposed well if it is capable of yielding this quantity. Information on well capacities for certain casing diameters may be obtained from Sterrett, Table 9.3 (2007). Information on capacities of the water bearing formations may be obtained from well records. This information may be considered to determine if the aquifer is capable of supplying the required amount and whether the well casing is sufficient. If drawdowns exceed the economical or physical drawdown constraint on nearby wells, consider distributing the pumping equally to each well unless available information (such as known well capacities) supports a different proportion. It may be worthwhile to contact the applicant in some cases to obtain information on the pumping distribution. If the applicant is requesting a new supplemental well because wells are failing, a greater percentage of pumping should be assigned to the new well. Keep in mind that requests for new supplemental wells are often made because well yields are inadequate.

Drawdown due to Existing Water Rights (DE)

Numerical groundwater models or the Theis equation may be used to estimate 40-year drawdowns due to the use of existing water rights. Calculations should be performed to assess the impacts of diverting the full amount of permitted, licensed, adjudicated or declared rights. The amount associated with the use of domestic wells (wells permitted under NMSA 1978, Section 72-12-1) should be included in the analysis.

Dynamic Drawdown (DD)

The dynamic drawdown represents the self-induced drawdown inside the casing of a well as the pump is cycled on and off. In some situations dynamic drawdown can be a significant portion of the total drawdown in a well. The procedure to estimate the dynamic drawdown depends on data availability. The options for estimating the dynamic drawdown in the order of preference follow.

1. The dynamic drawdown may be measured directly by obtaining the water level when the well is pumping. This information may have been reported on a well record filed for the well in the section for additional statements. Aquifer tests also provide this information. Corrections to observed drawdowns may be necessary if the operational flow of the well is different from the amount permitted, licensed, adjudicated or declared. Corrections may be made by assuming drawdown is

proportional to the pumping rate. The flow rate Q should represent the permitted diversion in gpm at 60 percent production time ($Q_{\text{gpm at 60 \%}} = 1.03 \times Q_{\text{af/yr}}$).

2. The dynamic drawdown may be estimated if the specific capacity (SC) is available for the well. The specific capacity is the yield of well per unit of drawdown. The dynamic drawdown is equal to the flow rate Q in gallons per minute (gpm) divided by the SC in gpm/ft ($DD = Q/SC$). The flow rate Q should represent the permitted diversion in gpm at 60 percent production time ($Q_{\text{gpm at 60 \%}} = 1.03 \times Q_{\text{af/yr}}$).
3. The Theis equation and well efficiency may be used to compute the dynamic drawdown. A radius of 0.50 feet and 60 percent of a day (864 minutes) for time should be used unless there is information to the contrary. The flow rate Q should represent the permitted diversion in gpm at 60 percent production time ($Q_{\text{gpm at 60 \%}} = 1.03 \times Q_{\text{af/yr}}$). The drawdown computed represents the water level decline in the aquifer adjacent to the well. To obtain the drawdown inside the casing (dynamic drawdown), the drawdown obtained from the Theis equation should be divided by a well efficiency of 70 percent (0.70) unless there is information to the contrary.
4. It will be unnecessary to determine the dynamic drawdown for domestic wells if a minimum water column of 20 feet is assumed as the column required for operation (see Physical Drawdown Constraint section), unless data availability allows the estimation of dynamic drawdown and other components affecting the lowest practical pumping level (LPPL).

Total Drawdown (DT)

The estimated 40-year drawdowns due to the proposed use (DP), existing wells (DE), and self-induced dynamic drawdown (DD) are summed to obtain DT (Figure 1). The drawdown due to the use of existing wells represents the long-term average while the dynamic drawdown represents the instantaneous drawdown as pumps are turned on. Summing the two drawdowns together will produce some double accounting of drawdown, since drawdowns are computed twice for the same well, once in the existing well calculation and again in the dynamic drawdown calculation. However, the over-estimation is probably offset by under-estimating the dynamic drawdown by assuming 70 percent efficiency. Lower efficiencies in some wells are expected, especially in older wells.

Water Column (WC)

The water column is the difference between the depth to the non-pumping water level (static water level) and depth to the base of the well screen, or production zone, whichever is higher in the well column. In the absence of well screen and production zone information, the total well depth may be used as the base of the water column. The initial water column, based on well records, is used for the economical drawdown constraint assessment while the current water column is used for the physical drawdown constraint evaluation. The initial water column was selected for the economical constraint to preserve the economic viability of the well as originally drilled. Using the current water level was necessary for the physical constraint so the dewatering occurring in the past would not be assumed to be available for the future. Water levels reported on well records

may be updated using available water level data in surrounding wells to obtain the current water column. In the absence of field data to project the current water level, a model or water level reported in the well record may be used.

Economical Drawdown Constraint (EDC)

The economical drawdown constraint is calculated based on the percent of initial water column that can be lost before the well loses economical viability. In the absence of more reliable data, a value of 70 percent of the initial water column may be assumed as the economical drawdown constraint (Figure 2).

Physical Drawdown Constraint (PDC)

Physical hardship is the loss of the required well yield due to excessive water level decline. The physical drawdown constraint is the difference between the depth to the current static water level (or depth to the potentiometric surface) and depth to the LPPL. The LPPL depends on the availability of well completion information such as the depth and thickness of the water bearing zone or confining unit, pump setting, and screen setting.

For non-domestic wells in an unconfined aquifer, the LPPL may be assumed at 40 feet above the top of the well screen or pump whichever is highest in the column, unless this assumption is unreasonable (Figure 3). The LPPL may also be assumed to be 60 feet above the base of the water column, if the screen interval or pump setting is unknown, unless this assumption is unreasonable. The LPPL for non-domestic wells in a confined aquifer may be assumed at the base of the upper confining unit unless this assumption is unreasonable (Sterrett, 2007). If the total drawdown extends below the LPPL that well becomes a critical well.

Due to the relatively low volume of water produced by domestic wells, and other construction factors, some wells may be constructed with pumps set within the screen interval or close to the bottom of the well. The LPPL is typically assumed to be 20 feet above the base of the water column for domestic wells unless a different value is supported. At least 20 feet may be necessary to maintain submerged conditions, to allow a pump setting above the bottom to avoid sediment problems, and to allow for dynamic drawdown and other components (length of pump and net positive suction head).

Procedures

The list below provides a general description of the steps that may be required.

1. Select the source aquifer, T, S, and boundary conditions.
2. Estimate the current average saturated thickness of the source aquifer in the vicinity of the application and determine the drawdown allowance using Table 1. If the current thickness is unknown the thickness may be estimated based on a model or well records which show the saturated thickness encountered.
3. Using the Theis equation, determine the location of the 40-year contour interval of drawdown corresponding to the drawdown allowance. The Hydrology Bureau has developed a computer program to make this determination.

4. If no wells are identified in which the 40-year drawdown due to the proposed diversion (DP) is greater than the drawdown allowance, no further analysis is necessary (but Procedure Nos. 5 through 13 may be conducted if the application is protested).

For all wells in which 40-year drawdown due to the proposed diversion (DP) is greater than the drawdown allowance and for all wells owned by the protestant(s) regardless of their location, proceed with the following steps.

5. Estimate the 40-year drawdown due to the proposed diversion (DP) on wells within the radius of the contour interval that corresponds to the drawdown allowance. In addition, determine the 40-year drawdown due to the proposed diversion (DP) on wells owned by the protestants regardless of their location.
6. Estimate the 40-year drawdown due to existing water rights (DE).
7. Estimate the dynamic drawdown (DD) for each non-domestic well.
8. Add the results from steps 5, 6, and 7 to obtain the total drawdown (DT) for each non-domestic well considered in the analysis ($DT = DP + DE + DD$).
9. For domestic wells, add results from steps 5 and 6 to obtain the total drawdown ($DT = DP + DE$) if it is assumed that domestic wells require a minimum column of 20 feet for operation. For some cases, including an estimate of the dynamic drawdown in the calculation of total drawdown ($DT = DP + DE + DD$) may be appropriate if the sufficient information is available to estimate the dynamic drawdown for a domestic well.
10. Multiply the initial water column by 0.70 to obtain the economical drawdown constraint (EDC) for each well considered in the analysis.
11. Estimate the depth to the LPPL for each well considered in the analysis.
12. Subtract the depth to the current water level (WL) from the depth to the LPPL to obtain the physical drawdown constraint (PDC) for each well considered in the analysis ($PDC = LPPL - WL$).
13. If DT exceeds the economical (EDC) or physical drawdown constraint (PDC) on any well considered in the analysis, then the well is predicted to have less than a 40-year life and is classified a critical well. Since it has already been established that the drawdown due to the proposed well(s) exceeds the drawdown allowance for wells considered in this analysis, proceed to the Application of Results by Decision-Makers section. If no wells are identified where DT exceeds a drawdown constraint, no additional evaluation is necessary.

Application of Results by Decision-Makers

Although the use of a proposed well may cause drawdowns that exceed an economical or physical constraint plus the drawdown allowance, water right decision-makers may weigh other circumstances before rendering a decision. Several considerations are provided below that may influence decision-making.

One consideration is whether the nearby critical well is reasonably completed. This determination is made by considering the average water columns for wells of the same use (domestic or non-domestic) completed in the preceding 10-year period in the vicinity of a proposed well, unless some other time period is more appropriate. Critical wells that have water columns greater than or equal to 40 percent of the average may be considered reasonably completed. For example, for wells of a certain type of use with an average water column of 100 feet, the water column of a well with 40 feet or more would be considered reasonably completed. Excessive impact on a critical well that is not reasonably completed may not be grounds for impairment.

The presence of a reasonably completed critical well in which the drawdown allowance is exceeded may be considered grounds for impairment. However, before this finding can be rendered, additional factors should be considered such as whether the affected well can be deepened or replaced, and well age. The following guidelines are provided:

1. Reasonably completed critical wells which are 40 years or less in age should not be expected to be deepened or replaced by the well owner because agency basin guidelines attempt to preserve water for 40 years for these wells. Drawdowns on these wells which exceed the allowance may constitute grounds for impairment.
2. If a reasonably completed critical well is more than 40 years in age and can be deepened into the same source as the original well, drawdowns that exceed the drawdown allowance may not be grounds for impairment.
3. If a reasonably completed critical well is more than 40 years in age but cannot be deepened, drawdowns that exceed the drawdown allowance may be grounds for impairment.
4. The decision that a critical well can be deepened or replaced should be based on evidence that deeper wells in the same source exist in the area and are capable of producing the quantity and quality of water sufficient to fulfill the water right.

Decision-makers may also consider additional information provided by the applicant when making a decision on the application, such as a pumping schedule, a groundwater monitoring plan, or other information. Based on this information, it may be possible to grant conditional approval. Decision makers may consider other physical solutions to remedy impairment. These solutions may include, but not limited to, the connection of the affected party to the applicant's water system or replacement of impaired wells by the applicant.

Groundwater Leases and Temporary Transfers

The following guidelines are provided:

1. For groundwater leases and temporary transfers, calculations should be performed to assess drawdown due to the use of groundwater. The initial or any renewal term of a lease of water use should not exceed 10 years except as provided in NMSA 1978, Section 72-6-3.C. For a 10-year lease or transfer with no prior authorizations, diversions for modeling should be limited to a 10-year duration.
2. For proposed leases which are being renewed the duration of diversion should include prior authorizations and the proposed lease. As an example, an applicant has been granted one 10-year lease and requests a second 10-year lease. Drawdown calculations should be performed based on a 20-year pumping duration. For prior authorizations and proposed leases, where the combined duration equals or exceeds 40 years, drawdown calculations should assess 40-year effects.
3. Calculations should be performed to determine the maximum drawdown on area wells due to the proposed and prior diversions and the year in which the maximum drawdown occurs for each well. The maximum drawdown represents the greatest drawdown predicted for each well of other ownership. Keep in mind that the maximum drawdown may occur after the end of the pumping duration.
4. The 40-year drawdown allowance should be based on Table 1 and the average aquifer thickness. To obtain the drawdown allowance for other time periods adjustments to the 40-year allowance are necessary. The drawdown allowance for the temporary use of groundwater should be 45 percent of the 40-year allowance for temporary transfers of 5 years or less and 65 percent of the 40-year drawdown allowance for temporary transfers that propose a diversion for a duration greater than 5 years up to 10 years. The percentages are based on the logarithmic relationship of drawdown to pumping time as provided in Figures 4 and 5. The table of values provided in Figure 4 should be used where transfer durations exceed 10 years. Representative transmissivities, storage values, and distances were used to generate Figures 4 and 5. The curve on Figure 4 represents the average of six scenarios (Eric Keyes, OSE, personal communication) and has been normalized to equal 100% at 40 years. In a comparison of the scenarios, the first 10 years showed large variations in the normalized drawdown (Figure 5). There is more certainty of the normalized drawdown after 10 years. Rather than using the precision of the table, the early-time values (45 and 65 percent) were selected as the broader representative average values for those time periods.
5. Special circumstances may be addressed on a case-by-case basis.
6. If no wells are identified in which the maximum drawdown due to the proposed diversion is greater than the drawdown allowance, no further analysis is necessary (but Procedure 7 may be conducted if the application is protested).

For all wells in which the maximum drawdown due to the proposed diversion (DP) is greater than the drawdown allowance associated with the year of maximum effect, and for

all wells owned by the protestant(s), proceed with the step below.

7. Calculations should be performed to determine the total effects in the year of maximum drawdown associated with each well. To obtain the total drawdown for the year of maximum drawdown, the drawdown due to existing rights, the drawdown due to the use of the proposed well, and dynamic drawdown³ should be summed for each well considered in the analysis. If the predicted total drawdown exceeds the economic or physical drawdown constraints and the drawdown allowance for any well, this may be grounds for impairment. However, before a finding of impairment can be made, proceed to the Application of Results by Decision-Makers section.

References

Morrison, Tom, 2006, Guidelines for the Assessment of Drawdown Estimates: New Mexico Office of the State Engineer, Hydrology Bureau Report 06-01.

Morrison, Tom, 2016, Guidelines for the Assessment of Drawdown Estimates: New Mexico Office of the State Engineer, Hydrology Bureau Report 16-03.

Sterrett, R. J., 2007, Groundwater and Wells, Johnson Division, St.Paul, MN.

³ It may be un-necessary to determine the dynamic drawdown for domestic wells where a reservation of 20 feet is assumed, unless data availability allows another approach.

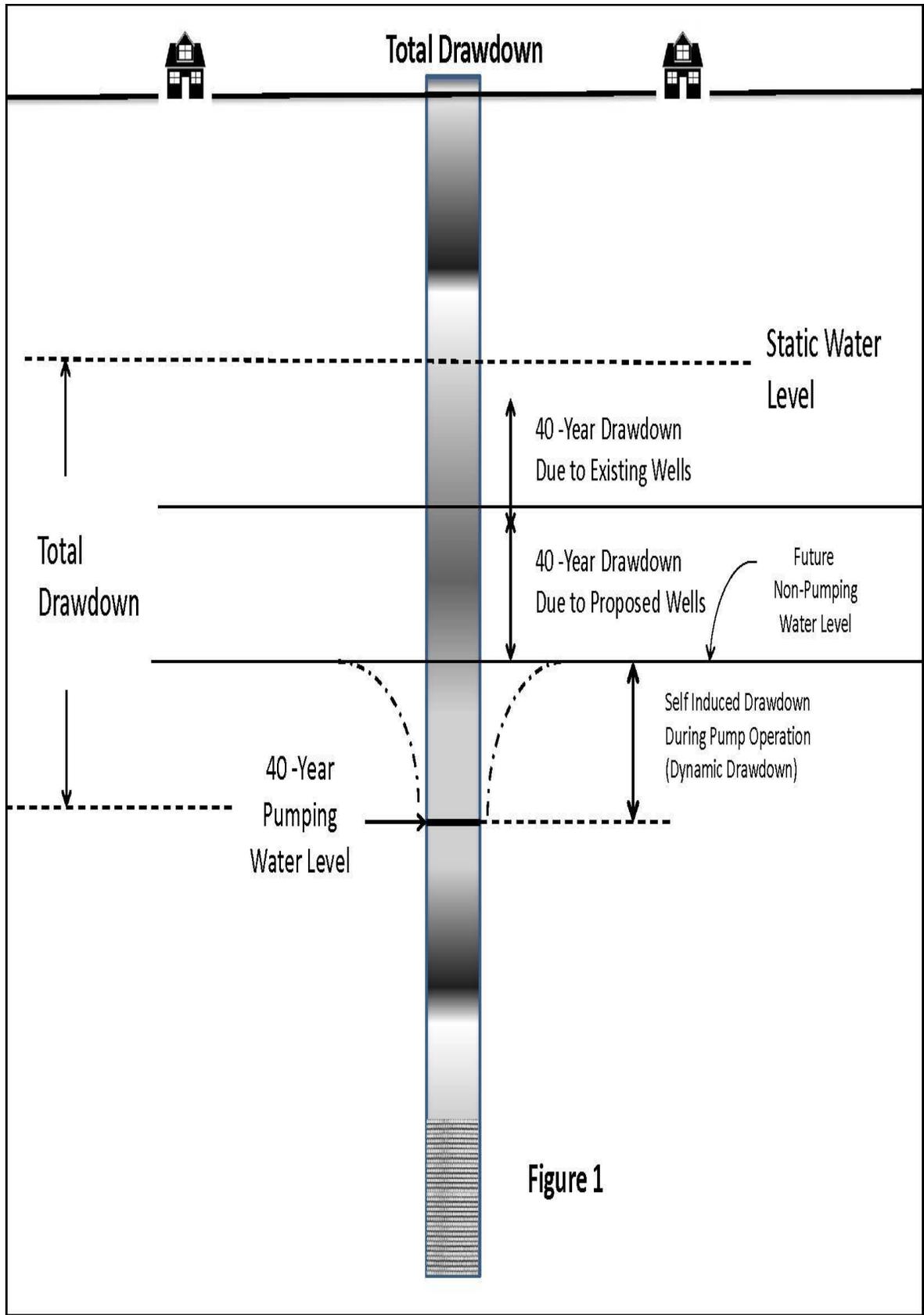


Figure 1

Allowable Economic Drawdown

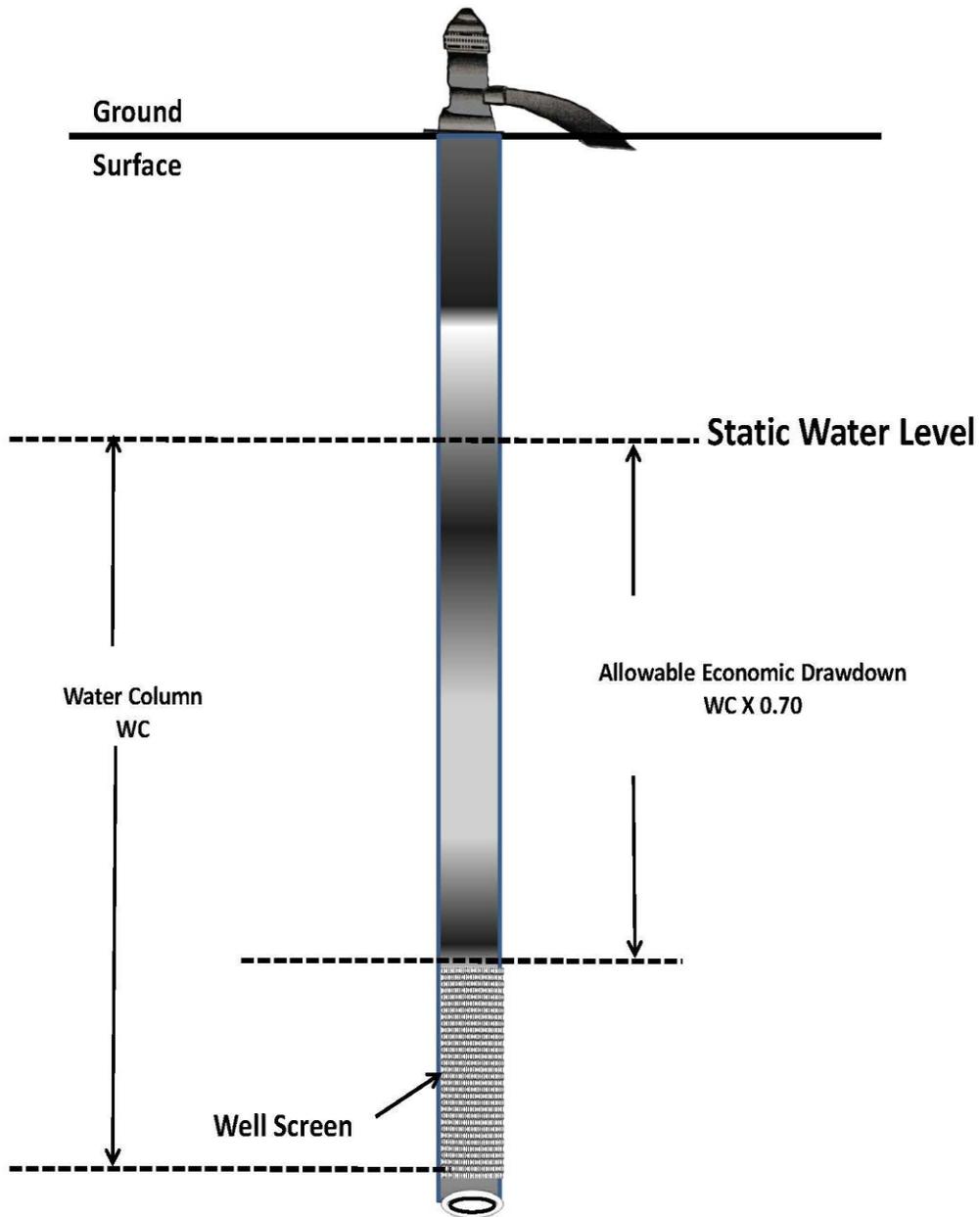


Figure 2

Example of Allowable Physical Drawdown Non-Domestic Wells

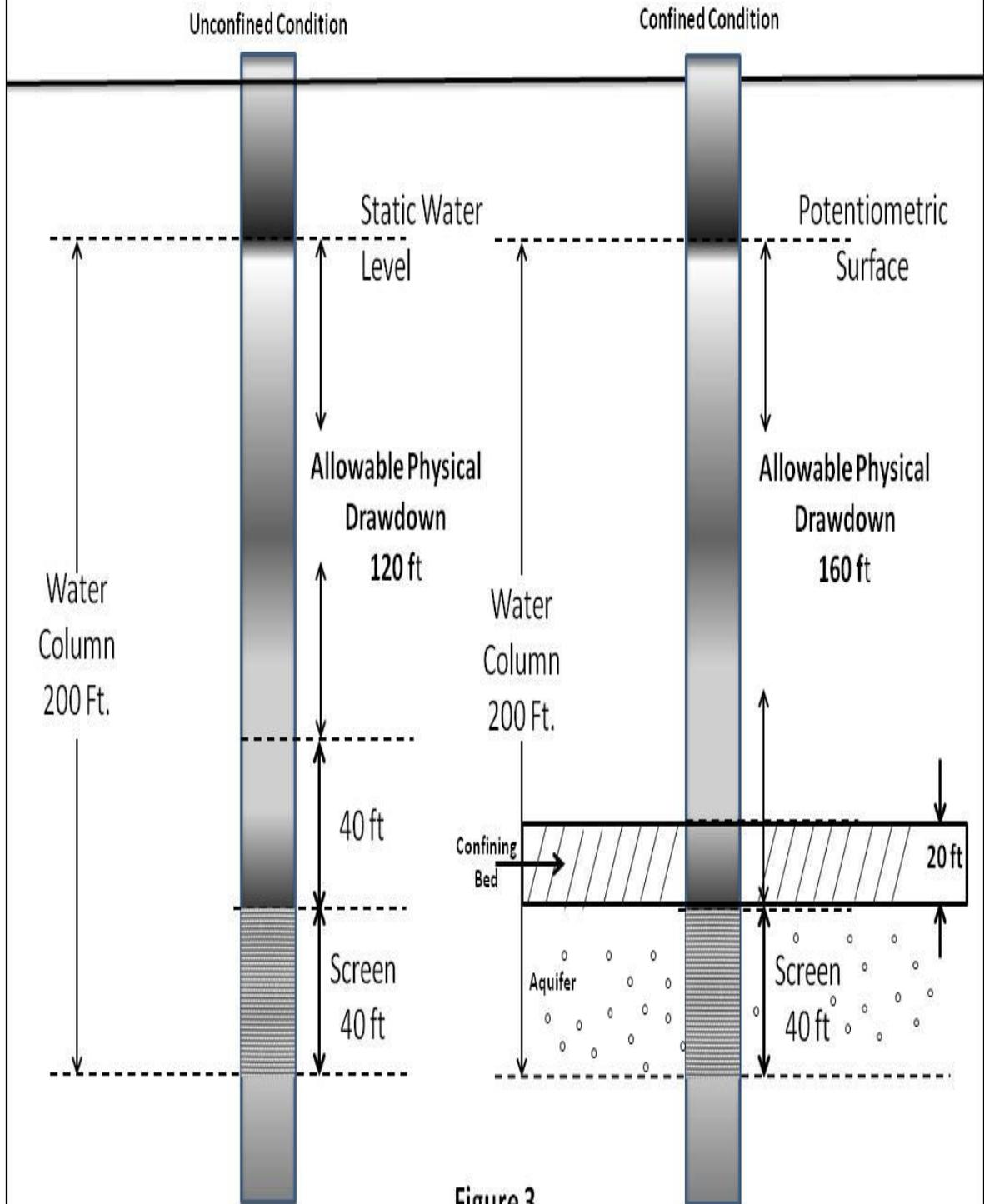


Figure 3

FIGURE 4
REPRESENTATIVE NORMALIZED DRAWDOWN CURVE

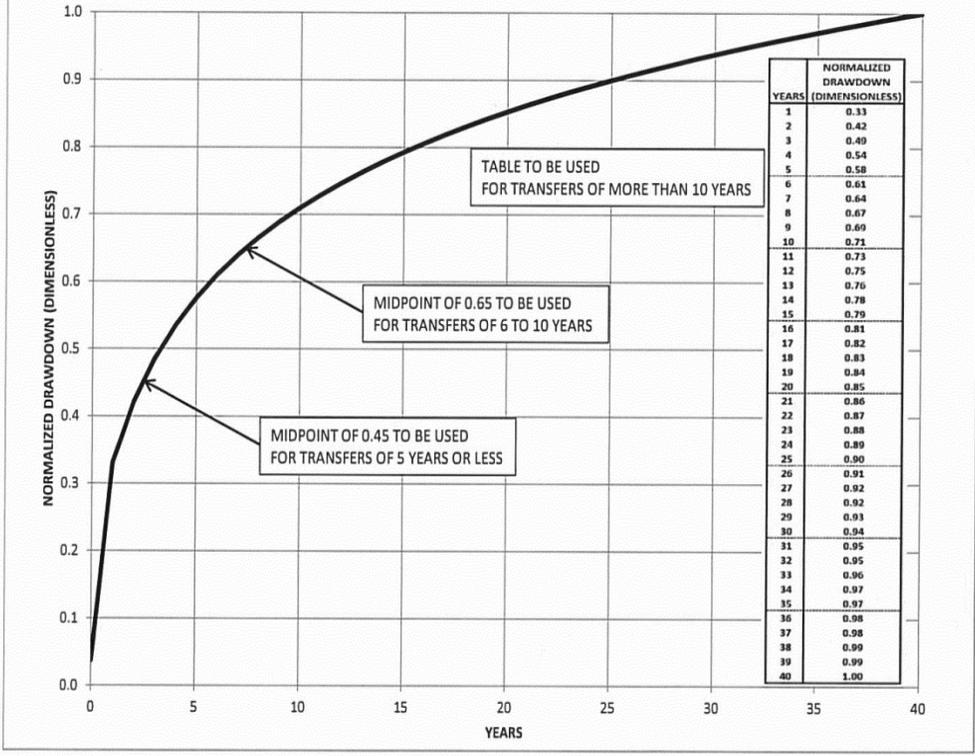


FIGURE 5
COMPARISON OF NORMALIZED DRAWDOWN CURVES WITH VARIATIONS IN THEIS EQUATION PARAMETERS

