STATEMENT OF BASIS AND PURPOSE
FOR THE ADOPTION OF THE DENVER BASIN RULES

Colorado Division of Water Resources

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I. Statutory Authority

These rules are promulgated to comply with and implement the requirements of Senate Bill 5 (S.B. 5), passed by the 55th General Assembly and signed by Governor Lamm on June 6, 1985. Section 3 of that bill amended Section 37-90-137 C.R.S., and in subsection (9)(b), the General Assembly required, inter alia, that:

> On or before December 31, 1985, the State Engineer shall promulgate reasonable rules and regulations applying exclusively to the Dawson, Denver, Arapahoe, and Laramie-Fox Hills aquifers to the extent necessary to assure that the withdrawal of ground water from wells described in subsection (4) of this section will not materially affect vested water rights to the flow of any natural stream ...

The statutory bases for the adoption of the proposed Denver Basin Rules are: Section 37-90-137(9)(a), C.R.S., which grants the State Engineer authority to promulgate rules concerning applications for well permits under Section 37-90-137(4); Section 37-90-137(9)(b); and Section 37-80-102 (1)(g), C.R.S. The purpose of these rules, as stated in subsection (9)(b), is to assure that the withdrawal of ground water from wells described in Section 37-90-137(4) and located in the Denver Basin will not materially affect vested water rights to the flow of any natural stream. These rules will also make the State Engineer's consideration of those well permit applications more certain and expeditious and prescribe reasonable criteria for the evaluation of such well permit applications.

II. Hydrologic and Geologic Investigation

In order to draft the rules and regulations, the State Engineer first compiled data and studied the geology and hydrology of the Dawson, Denver, Arapahoe and Laramie-Fox Hills Aquifers. Although previous studies of the Denver Basin had been completed and published by personnel of the State Engineer's office, (Romero, 1976, Ground Water Resources of the Bedrock Aquifers of the Denver Basin; Robson, Romero et al, 1981, Hydrologic Atlas Series For the Dawson, Denver, Arapahoe and Laramie-Fox Hills Aquifers, U.S.G.S. HA-643, HA-646, HA-647 and HA-650), the State Engineer updated and expanded the previous studies of the geology and hydrology of the four

Denver Basin aquifers. The resultant study is the most exhaustive compilation of geologic and hydrologic data on the Denver Basin aquifers completed to date. A summary of this investigation entitled "Geology of the Denver Basin Aquifers" is attached hereto and made part of this statement as Technical Appendix A.

The study first established the existence of the four aquifers as hydrologic units. The State Engineer confirmed a hydrologic separation between the aquifers, rather than just a geologic (age of the formation) or lithologic (type of rock) separation. A hydrologic separation means there is a barrier to the flow of water between adjacent aquifers. The separation means that pumping of a well completed in an aquifer would have little or no impact on an overlying or underlying aquifer. This principle is needed to allow the development of permit conditions to ensure the 100 year life of the aquifer as required in Section 37-90-137(4)(b)(I) C.R.S. Only a hydrologic separation would justify treating and managing each aquifer as a separate unit. If indeed, each aquifer is a separate hydrologic unit, then withdrawals from it must be managed separately from withdrawals from other aquifers. Manmade connections of two hydrologically separate aquifers must be avoided to allow their continued separate management. Furthermore, establishing hydrologic separation is important in determining which aquifers are nontributary. A hydrologic separation allows an upper aquifer in contact with a stream and, thus, tributary to be isolated from lower aquifers which as a result of the separation may be nontributary.

In order to establish and locate the hydrologic separations, the State Engineer reviewed over three thousand geophysical logs obtained from the drilling of water and oil and gas wells. A geophysical log is a log obtained during the construction of a hole revealing the type and character of rock existing at different depths in the hole. Using data from those logs, a series of cross sections were constructed through the Denver Basin. A total of 15 cross sections were constructed, 11 in a east-west orientation and four in a north-south orientation. Approximately 250 logs were utilized in drawing the cross sections. These cross sections established not only the existence of a hydrologic separation between each of the four aquifers on a basin wide basis, but also revealed that the Dawson and Arapahoe aquifers could each be further subdivided into two aquifers. This further subdivision was made possible because of the relatively impermeable shale layer extending throughout much of the areal, or horizontal, extent of those aquifers. These cross sections also provided initial data on the elevations of the tops and bottoms of each aquifer, and the areal extent of each aquifer.

Next the State Engineer supplemented the geologic data developed in the cross sections by reviewing additional geophysical logs located throughout the Basin. Analysis of these geophysical logs provided the basis to map the elevation of the top and bottom of each aquifer throughout the basin and, thus, to calculate the thickness of each aquifer at locations throughout the basin.

In order to locate and map the outcrops, or horizontal limits, of each aquifer, the State Engineer used existing data, data collected from the exhaustive review of geophysical logs and data collected from field investigations. This effort resulted in a refinement of the previous maps locating the outcrops of each aquifer.

Approximately 1,500 of the 3,000 logs reviewed were actually used as data points to construct the Laramie-Fox Hills aquifer maps, while over 1,000 logs were used for the Arapahoe maps. For the Denver aquifer, about 500 data points were used, while about 300 were use for the Dawson maps.

All of the cross sections and aquifer maps were revised by a Geologic Advisory Committee composed of Stanley G. Robson of the United States Geological Survey, Robert M. Kirkham, a geologist employed by the Colorado Mined Land Reclamation Board and W. Curtis Wells, a ground water consultant recommended by the Colorado Ground Water Association. These independent experts advised the State Engineer's staff concerning cross section construction and reviewed the maps for consistency and accuracy.

Finally, as part of the geologic and hydrologic investigation, the State Engineer determined the amount of water available for withdrawal from each aquifer. The amount of water is a function of the areal or horizontal extent of the aquifer, the thickness or vertical extent of saturated material in the aquifer and the specific yield of each aquifer. The mapping of each aquifer had already established the vertical and horizontal dimensions of each aquifer.

In order to determine the volume of saturated material in each aquifer the State Engineer determined the number of feet of material that could contain water, if saturated. The existence of these materials, generally classified as sandstone or siltstone, was determined by a detailed review of the available geophysical logs for each aquifer. After this review, the State Engineer constructed maps showing the thickness of sandstone and siltstone at locations throughout the basin.

The specific yield of an aquifer is a measure of how much water will drain by gravity from a saturated portion of aquifer material. Some of the water will not drain, but will adhere to the aquifer materials, which phenomenon is called specific retention. The determination of specific yield is important because that value is needed to determine how much water may actually be recovered from an aquifer by well pumping. Parameters which affect the value of specific yield for aquifer materials include: the grain size distribution of the particles making up the geologic formation, the cementation of the aquifer materials, the compaction of the formation and the size of the particles. For limestone or fractured rocks the specific yield is a function of the size and interconnection of fractures or solution cavities.

Specific yield is generally determined by the testing of core samples in a laboratory, or by the testing of wells in unconfined aquifers. Existing data for specific yield values in the Denver Basin have been derived principally from the laboratory analysis of core samples. The State Engineer reviewed all available data from the testing of core samples in the Denver Basin. Because the taking of cores is easier and less expensive at exposed outcrops, most of the cores were taken from aquifer materials at the outcrop zones, and thus at, or near, the surface. However, most of the water stored in the Denver Basin is not located at these outcrop zones, but at great depths below the surface. When the aquifer is at significant depths below the land surface, overburden pressure due to the weight of the overlying soil and rock will cause compaction of the aquifer particles resulting in a lower specific yield.

The State Engineer held four meetings with geologists, engineers and ground water consultants in 1984, to discuss issues relating to the Denver Basin Aquifers. During two of those meetings, the appropriate value of specific yield for the Denver Basin Aquifers was discussed at length. The majority of the 30 to 40 professionals who attended the meeting supported the values specified in Rule 6. A summary of the State Engineer's investigation entitled "Specific Yield of the Denver Basin Aquifers" is attached hereto and made a part of this statement as Technical Appendix B.

III. Use of Ground Water Model to Determine Location of Nontributary Ground Water

A. General Discussion of Ground Water Modeling

Soon after the passage of S.B. 5 and prior to finalization of the geologic cross sections and maps, the State Engineer began to evaluate ground water modeling procedures and the constraints of the artificial conditions specified in Section 37-90-103(10.5), C.R.S. to develop a methodology to determine what parts of the Denver Basin Aquifers contained nontributary ground water. The State Engineer decided to use a ground water computer model to evaluate whether the water is nontributary.

Because nontributary ground water is defined in terms of the effect of its withdrawal in the future (in 100 years), the effect cannot be presently measured. To predict the effect of the withdrawal of ground water, experts have devised complex mathematical formulas which, when solved by a computer, can predict the impact of pumping at the end of 100 years. Computers have become a standard tool of analysis to perform the enormous number of calculations which must be done in order to solve those equations.

The definition of nontributary ground water in S.B. 5, Section 37-90-103.5(10.5) C.R.S., assumes that the hydrostatic pressure is not above the top of any of the aquifers. This is an artificial condition that does not exist now and is likely not to occur in the future throughout much of the Denver Basin. This artificially created condition further reinforced the necessity to use a ground water model to predict effects of the withdrawal of ground water.

The particular computer program selected by the State Engineer is described in U.S.G.S. Open File Report 83-875 entitled "A Modular Three-Dimensional Finite-Difference Ground Water Flow Model" by McDonald and Harbaugh (1984). It requires the division of the aquifer being modeled into a number of two dimensional grids or cells. The State Engineer, in modeling the Laramie-Fox Hills aquifer, used 6,731 individual cells, each being one mile square. The Lower Arapahoe, Upper Arapahoe, Denver, Lower Dawson and Upper Dawson aquifers, because of their decreasing areal extent, were divided into fewer cells. Each cell was then assigned the appropriate geological and hydrological values determined by the State Engineer.

The input data for each cell was the elevation of the top and bottom of the aquifer at that location, the number of feet of saturated sands in the aquifer at that location, the hydrostatic pressure at that location, and the hydraulic conductivity. The elevations of the top and bottom of the aquifer had been ascertained by the geologic study discussed previously. Similarly, the number of feet of saturated sands had been determined from a review of the sandstone/siltstone isolith maps developed in the geologic study.

The hydrostatic pressure in the Denver and Arapahoe aquifers was based on U. S. Geological Survey Hydrologic Atlas series HA-646 and HA-647 respectively. In the Dawson aquifer, the State Engineer used previously published material as well as field investigation to construct a map indicating the hydrostatic pressure in that aquifer at different locations. In the Laramie-Fox Hills Aquifer, the State Engineer used a preliminary map developed by Stanley G. Robson of the U.S. Geological Survey to determine the elevation of the potentiometric surface or hydrostatic pressure. However, in S.B. 5, the General Assembly defined nontributary ground water assuming the hydrostatic pressure to be no higher than the top of the Denver Basin aquifers. Thus, if the hydrostatic pressure in a cell was actually higher than the top of the aquifer, it was modeled at the top of aquifer.

Hydraulic conductivity is a measurement of the ability of an aquifer to transmit water. The State Engineer adopted the hydraulic conductivities mapped by Robson, 1983, Hydraulic Characteristics of the Principal Bedrock Aquifers in the Denver Basin, Colorado, HA-659 as input data to the ground water model. The State Engineer further refined that data by reducing the contour interval as mapped by Robson.

The State Engineer, in his geologic investigation, had determined that there are small amounts of "leakage" of water between aquifers, except between the Laramie-Fox Hills and Arapahoe Aquifers which are separated by the nearly impermeable Laramie shale. Thus, the ground water model provided for a small amount of downward "leakage" from the Upper Dawson, Lower Dawson, Denver, and Upper Arapahoe Aquifers. No upward movement of water was modeled because of the assumption, in S.B. 5, that the hydrostatic pressure had been lowered to the top of each aquifer. Without the pressure to force water upward through the confining layer, there would be no upward "leakage."

The classification of individual wells withdrawing ground water as nontributary or tributary requires that the effect of the withdrawal of ground water on the natural surface streams be calculated. To accomplish that, the State Engineer chose to construct a "change" model, or a model that determines the changes in each aquifer as a result of the pumping of a single well at the center of each cell. By calculating the change in gradient or slope of the water table in all the model grids, the effect on the flow of surface streams in hydraulic contact with the aquifer was determined.

In order to calculate the effect of pumping a single well, the change model assumed the initial ground water level to be flat throughout the modeled area. The thickness of the aquifer in each cell was varied to represent the known thickness as determined from the geologic maps.

The equations determine the amount of flow into and out of each cell and the resultant gradient by solving a large number of simultaneous equations. Because the solutions to these equations involve literally thousands of calculations, the use of a large computer is necessary. At the end of each run, the model determines the resulting gradient, or direction of flow, in each cell. The impact on the flow in a surface stream then is determined by the resulting gradient from the stream to the aquifer.

The State Engineer "ran" the model placing a well in the center of a cell. The determination of the resulting flow from the stream to the aquifer allowed the State Engineer to determine whether a well, by itself, would deplete the flow of a natural stream at an annual rate of more than one-tenth of one percent of the annual rate of withdrawal of the well. Data from the over 3,000 model runs were used in constructing the lines defining which water is nontributary.

If the effect is one-tenth of one percent or less, ground water in that cell is considered to be nontributary. If a well caused more than that effect, the ground water in that cell is "not nontributary". The lines defining the location of nontributary ground water were drawn by placing the line between the cells containing nontributary ground water and those containing ground water not found to be nontributary.

The State Engineer's modeling techniques were reviewed and approved by a panel of outside experts consisting of Stanley G. Robson of the United States Geological Survey, Dr. David McWhorter of Colorado State University, and Steven P. Larson of S.S. Papadapulos and Associates, Inc.

A detailed report on the ground water modeling techniques used by the State Engineer entitled "Denver Basin Ground Water Model Report" is attached hereto and made a part of this Statement as Technical Appendix C.

In order to determine the depletion to natural streams, it was necessary for the State Engineer to determine the location of natural streams and their alluviums which are in contact with the Denver Basin Aquifers. The State Engineer conducted field investigations and relied upon numerous published reports to map these natural streams. A summary of this investigation, entitled "Report on Natural Stream Investigation, Denver Basin," is attached hereto and made a part of this Statement as Technical Appendix D.

B. Discussion of Evidence Presented at Rulemaking Hearing

A number of geologists testified during the hearing that the Denver Basin Aquifers are comprised of a series of lenticular sand and shale lenses that vary in areal extent. Except for the shale and clay layers that separate the six aquifers, the other clay or shale lenses are discontinuous and there is hydraulic connection between sand lenses. There was also testimony that the normal well construction procedure is to gravel pack and use perforated casing so as to produce water from each sand lens encountered in a well.

As wells are drilled and pumped, water levels will decline. The objective of the ground water model is to accurately predict when and where those declines will occur and how this will affect natural stream flows. For a constant rate of pumping, the rate of water table decline will vary depending on whether the zone being desaturated is permeable sandstones and siltstones or less permeable shales and clays.

The modeling approach used by the State Engineer considers the total thickness of the aquifer and recognizes that there are both permeable sandstones and siltstones and less permeable shales and clays. This approach more closely represents the physical system than the approaches proposed by Centennial Investment and Development Corporation (Centennial), Park Funding Corporation, or Castle Pines Land Company (Castle Pines), Robinson Brick Company (Robinson), Elysian Corporation (Elysian), Woodfield Properties, Inc. (Woodfield) and Alpert Companies (Alpert), et al. In addition, the use of weighted values for both specific yield and hydraulic conductivity in the model will allow the calculation of cones of depression due to pumping which will closely approximate the cones that are expected to occur in nature.

The development of models considering only the thickness of water yielding sandstones and siltstones and lumping the sandstones into one water yielding bed does not represent the actual conditions in the aquifer. Because the thickness of the aquifer is minimized and because the value of specific yield used in the model is the value for only water yielding materials, the model computed drawdowns are biased and will not represent actual drawdowns. Since the drawdowns are not properly computed (less than what would be expected in the aquifer), then the gradients which are used to compute the inpact on the stream would also be too low and the resultant calculations would not accurately compute the impact on the stream.

The use of a change model as proposed by the State Engineer is appropriate because the objective is to determine what impact will occur on natural streams due to pumping at a proposed well site. The change model predicts the declines in water table due to pumping of a single well after 100 years of continuous pumping. The impact on a natural stream due to a well pumping can be calculated as a function of the water table declines at the end of 100 years. Several parties during the hearing supported the use of a change model.

One cannot calibrate a ground water model for the artificial conditions imposed by Senate Bill 5. Throughout most of the aquifers, artesian conditions now exist and it is not likely that piezometric heads will be simultaneously lowered throughout the aquifers to the elevation of the top of the aquifers.

The State Engineer, in evaluating the appropriate grid size, number of time steps, and the value for the time step multiplier, compared model results with a known analytic solution which computes stream depletions due to well pumping. For these sensitivity analyses the aquifer was assumed to be homogeneous and isotropic and the stream was assumed to be of infinite length. Evaluation of the sensitivity of these parameters against a known analytic solution where the other input data is similar to known Denver Basin Aquifer values is more dependable than using hypothetical values where there is neither a calibrated model or a known analytic solution for comparison.

Water table declines due to pumping increase and spread out areally with time. To determine whether ground water is nontributary pursuant to 37-90-103(10.5), C.R.S., it is necessary to determine whether pumping will affect stream flows in excess of 0.1 percent at the end of 100 years of continuous pumping. The impact of pumping on stream flows will be minimal during the early pumping periods and the rate of change in the impact will increase as pumping continues. For the particular circumstances dictated by the nontributary definition, the impact and rate of change in impact on the stream will be increasing most rapidly at the end of the 100 years.

The finite difference model which approximates the differential equation representing ground water flow needs to have the time step size and time step multiplier selected to provide the maximum sensitivity during the period of most rapid change in computed stream impact. Selection of number of time steps or a time step multiplier which results in a very large time interval for the last time step should be avoided to improve the reliability of model results.

For instance, Centennial, in its localized model, used a time step multiplier of two which resulted in a final time step of 45 years. Similarly, Castle Pines, in its Denver Aquifer model, used a multiplier of 1.4 with a resulting final time step of 20.6 years. In contrast, the State Engineer's model used 20 time steps with a multiplier of 1.01, resulting in a final time step of 5.5 years.

Testimony during the hearing revealed the uniform one mile grid size used by the State Engineer was selected after considering both one-half mile and one mile grid sizes and comparing model results with the idealized aquifer analytic solution described above. The model results showed only limited sensitivity to grid size and the use of a one mile spacing versus a half mile spacing would move the 0.1 percent line slightly closer to the stream, resulting in a larger area of nontributary ground water. Considering the discretization of input data describing the aquifer parameters, the selection of the one mile grid size is reasonable.

There was considerable evidence presented on the proper conductance value to model the flow of ground water between the stream alluvium and underlying bedrock aquifer. Conductance as used by the McDonald-Harbaugh model is the product of the area of connection of the alluvium to the underlying bedrock multiplied by the appropriate K/M ratio. The K/M ratio used by the State Engineer (1×10^{-5} per day) was based on the maximum rate of recharge from the alluvium to the bedrock aquifer of 0.133 $ft.^3$/second per square mile determined by Robson in Staff Exhibit 10 and an independent analyses of flow from the Lower Dawson Aquifer into Cherry Creek. Colorado Springs suggested that a higher value of K/M, such as 1×10^{-2} or 1×10^{-3} per day, was proper. The use of a higher value would increase flow across the alluvium-bedrock interface and result in the calculations of higher stream depletions. The use of this higher value was challenged at length by Woodmoor Water & Sanitation District in cross-examination.

In contrast, Centennial assumed in its model that all flow between alluvium and bedrock was in a purely vertical direction. This results in a much lower value for conductance across that interface, and, thus, much lower stream depletions are calculated. The assumption of only vertical flow from the alluvium to the aquifer (or vice-versa) was not supported by evidence and is not considered to be realistic.

Testimony presented on behalf of Castle Pines, Robinson, Elysian and Woodfield, and Alpert suggested the use of a conductance value (8×10^{-5} per day) that was only slightly larger than that used by the State Engineer.

Considering all of the conflicting testimony presented advocating the use of values both higher and lower than those used in the ground water model by the Staff, the State Engineer found that the conductance value used by Staff of 1×10^{-5} per day is reasonable and appropriate in these circumstances.

Centennial agreed with the location of stream alluvium but in its modeling of the impact of pumping on stream depletions it reduced the area of contact between the alluvium and the bedrock aquifers significantly for the Arapahoe and Denver Aquifers. Testimony was that the reduction in contact area was due to use of water level projections from monitoring wells. That evidence was not conclusive to show that there was no connection between the water levels in the alluvium and the water table or piezometric head in the uppermost sand or siltstone member of the respective aquifer.

IV. Explanation of Basis and Purpose of Specific Rules

Rule 3:

Rule 3 sets forth the scope and purpose of the Denver Basin Rules. Rule 3.A. has been amended to clarify that the rules do not apply to wells that are located within a designated ground water basin or that meet the requirements of Section 37-92-602, C.R.S. Rule 3.D. has been added in response to numerous comments that the State Engineer should clarify the relationship between existing water court decrees and these rules.

Rule 4:

Rule 4, by reference to certain figures, defines the six aquifers. The basis for the rule is the geologic investigation done by the State Engineer and described above. The purpose is to define with certainty the boundaries of each aquifer. This will enable the public to determine the location of aquifer boundaries. The determination of aquifer boundaries will also expedite the processing of permits and provide data needed to assure that wells are constructed in only one aquifer, thus supporting aquifer management objectives.

The figures from the Denver Basin Atlas series referred to in Rule 4 locate the bases and the tops of the Lower Dawson, Denver, Upper Arapahoe, Lower Arapahoe, and Laramie-Fox Hills Aquifers. In mapping all of the aquifers, the State Engineer did not map the top of the aquifer where that aquifer outcrops/subcrops at the land surface.

Park Funding Corporation noted in its presentation at the rulemaking hearing that the Office of the State Engineer's selection of boundaries, or "picks," for the top and bottom of the Lower Dawson Aquifer have changed over time. The State Engineer acknowledges that the identification of the boundaries of the Lower Dawson Aquifer has changed over time as more and better data have become available. However, the State Engineer believes that his current picks for the top and bottom of the Lower Dawson Aquifer, as described in Rule 4.A.3., are the proper picks based on all data presently available.

During the hearing, Blum et al. (Blum) presented evidence that disagreed with the definition of the Lower Dawson Aquifer, as set forth in Rule 4.A.3., in Township 5 South, Ranges 64, 65 and 67 West. After consideration of that evidence, the State Engineer did not modify the picks for the top and bottom of the Lower Dawson Aquifer in that location. The boundaries of that aquifer as identified in Rule 4.A.3. are better when correlated basin-wide than those advanced by Blum. However, the State Engineer added several data points in Township 5 South, Range 65 West which confirm the boundaries as identified by Rule 4.A.3.

During the rulemaking hearing, numerous parties questioned the proposed definition of the Denver Aquifer in Rule 4.A.4., which included, as part of the aquifer, the shale layers separating that aquifer from the Dawson Aquifer above and the Upper Arapahoe Aquifer below. This was inconsistent with the treatment of the shale layer separating the Upper and Lower Dawson Aquifers, the shale layer separating the Upper and Lower Arapahoe Aquifers, and the shale layer separating the Arapahoe Aquifer from the Laramie-Fox Hills Aquifer. None of those shale layers was included in those aquifers. Therefore, Rule 4.A.4. was modified after the hearing to exclude the shale layers at the top and bottom of the Denver Aquifer from the definition of that aquifer.

Woodmoor Water and Sanitation District (Woodmoor) claimed that the outcrop of the Upper Arapahoe Aquifer in El Paso County was incorrectly located by Rule 4.A.6. After reviewing the evidence presented by Woodmoor and the testimony of Staff regarding that pick, the State Engineer concluded that the proposed Rule 4.A.6. correctly identifies the outcrop of the aquifer in that location and did not modify the Rule.

South Adams County Water and Sanitation District presented site specific evidence that showed that refinement of the pick of the top and bottom of the Lower Arapahoe Aquifer in Township 2 South, Range 67 West and Township 3 South, Range 67 West was possible. While this evidence may be used to evaluate individual permit applications in that area, the addition of only three data points did not justify the modification of Rule 4.A.7. which defines the Lower Arapahoe Aquifer.

Rule 4.A.8. defines the Laramie-Fox Hills Aquifer. During the rulemaking hearing, it was noted the base of the Laramie-Fox Hills Aquifer was not mapped in Denver Basin Atlas Number 4, Plate 2, Figure 4.B., in Township 1 South, Range 69 and 70 West; Township 2 South, Range 69 and 70 West; Township 3 South, Range 69 and 70 West; and Township 4 South, Range 69 and 70 West. The base of the aquifer in those townships was not identified because of a lack of data. The producing interval for wells withdrawing nontributary ground water from the Laramie-Fox Hills Aquifer shall be determined on a permit by permit basis.

<u>Rule 5</u>:

Rule 5, by reference to figures from the Denver Basin Atlas series, locates nontributary ground water in the Upper Dawson, Lower Dawson, Denver, Upper Arapahoe, Lower Arapahoe and Laramie-Fox Hills Aquifers. The basis of the rule is the geologic and hydrologic investigations and ground water modeling done by the State Engineer and described above. The rule provides the means to locate nontributary ground water in the Denver Basin Aquifers. The location of nontributary ground water is not shown within the boundaries of any designated ground water basins because the definition of nontributary ground water excludes any ground water within those basins. See Section 37-90-103(10.5), C.R.S.

The map also shows the locations of natural streams and their alluviums within the outcrop/subcrop areas of each aquifer. While the locations of these natural streams are not part of the rule, the lines and areas are included on the maps for informational purposes.

There is disagreement among parties to the rulemaking proceeding as to whether the designation of portions of aquifers as nontributary pursuant to Rule 5 establishes a presumptive aquifer characteristic, subject to rebuttal. After considering the comments of the parties on both sides of the issue, the State Engineer is convinced that S.B. 5 intended the nontributary boundaries for the Denver Basin Aquifers established by these rules to be fixed, at least until and unless modified by the State Engineer in a formal rulemaking proceeding. Therefore, the rule does not provide an opportunity for an applicant to rebut the determination that ground water at a particular location is not nontributary.

Rule 5.A., identifying the location of nontributary ground water in the Upper Dawson Aquifer, was modified after the rulemaking hearing to make the ground water in that aquifer in Section 13, Township 7 South, Range 67 West nontributary. In the proposed rule, that section had erronously been identified as being not nontributary.

Rule 5.C. was amended after the rulemaking hearing as a result of the exclusion of the shales at the top and bottom of the Denver Aquifer. The exclusion of the shales modified the input into the model and resulted in more ground water being designated as nontributary. Additionally, when the ground water models for the Denver Aquifer were rerun, two river cells omitted in the original model runs were included, which caused the nontributary line to move farther away from Plum Creek and its tributaries.

The City of Arvada presented evidence at the rulemaking hearing showing that the Upper Arapahoe Aquifer was not in hydraulic connection with Big Dry Creek downstream of Standley Lake. As a result of this evidence, the State Engineer remodeled the Arapahoe Aquifer at that location assuming no hydraulic connection between the aquifer and the stream. This resulted in additional ground water being identified as nontributary in Rule 5.D. Also, the inclusion in the model of several streams in El Paso County, omitted in the first model run, caused the ground water in Section 20, Township 10 South, Range 69 West in the Upper Arapahoe Aquifer to be identified as not nontributary. That section had been designated as nontributary in the proposed Rule 5.D.

Rule 5.F., identifying nontributary ground water in the Laramie-Fox Hills Aquifer, was also modified after the rulemaking hearing as a result of the inclusion of several streams in El Paso County in the ground water model. In the rule, as amended, six sections originally designated as nontributary are identified as containing not nontributary ground water. Several streams on the eastern portion of the Laramie Fox-Hills outcrop were also added to the model input for the Laramie-Fox Hills model runs, but did not result in any movement of the line identifying nontributary ground water.

The other geologic evidence presented at the rulemaking hearing, and discussed in connection with Rule 4, _supra_, and Rule 6, _infra_, did not result in the input into the ground water models upon which Rule 5 is based being revised.

Rule 6:

The purpose of this rule is to establish a presumptive specific yield value for each aquifer. For purposes of determining the allowed average annual amount of withdrawal for a well permitted pursuant to Section 37-90-137(4), C.R.S., the rule affords an applicant the opportunity to rebut the presumptive specific yield values by submitting site specific data. Such use of site specific data is not deemed to be a modification of the rule.

Rule 6.A. identifies the specific yield that has been determined for each aquifer. It is based on the investigation done by the State Engineer described in Technical Appendix B. Rule 6.B. provides for the rebuttal of those values upon submittal of site specific data obtained in accordance with the Statewide Nontributary Ground Water Rules, which were the subject of public hearings October 8, 9, and 10, 1985.

The rule provides that, in the absence of statewide rules setting forth procedures for specific yield tests, the State Engineer may consider site specific data on specific yield submitted by an applicant or permittee, and may alter the values set forth in Rule 6.A.

During the rulemaking hearing, Blum presented testimony questioning the specific yield values assigned to the Upper Arapahoe Aquifer, the Lower Arapahoe Aquifer and the Laramie-Fox Hills Aquifer in Rules 6.A.4., 6.A.5. and 6.A.6., respectively. Considering all of the factors affecting specific yield, as summarized in Technical Appendix B attached hereto, the State Engineer did not find that the values assigned to the three aquifers should be modified.

Rule 7:

Rule 7, by reference to figures from the Denver Basin Atlas series, identifies the number of feet of sands or other aquifer material which may be saturated in each of the six aquifers. An applicant or permittee may be required to show that, at the particular location of his well, all of these materials are in fact saturated. The rule is based on the geologic investigation done by the State Engineer. The purpose is to allow determination of the saturated thickness of an aquifer at specific locations for use in the well permitting process. Like specific yield, the number of feet of saturated aquifer materials is an integral part of the determination of the allowed average annual amount of withdrawal of a well permitted pursuant to Section 37-90-137(4), C.R.S.

During the rulemaking hearing both Centennial Investment and Development Corporation, et al. (Centennial) and Woodmoor disagreed with thicknesses of sandstones and siltstones in the Upper Arapahoe Aquifer in El Paso County, as designated in Rule 7.D. To a large extent, these differences result from differing picks for the top of that aquifer in that area. After review of the evidence submitted by Centennial and Woodmoor, the State Engineer found that the proposed identification of the top of the Upper Arapahoe Aquifer was proper, especially when correlated basinwide. See Statement of Basis and Purpose for Rule 4.A.6., supra. Thus, the State Engineer did not alter the thicknesses of sandstones and siltstones in that aquifer.

Centennial also presented evidence questioning the thicknesses of the Denver and Laramie-Fox Hills Aquifers in El Paso County, as described in Rules 7.C. and 7.F. respectively. These differences again seem to be caused by disagreement over the tops and bottoms of those aquifers. The State Engineer reviewed the evidence submitted by Centennial for those aquifers and found the proposed thicknesses, based on the proposed boundaries of the aquifers in Rule 4.A.4. and Rule 4.A.8., to be proper.

Rule 8:

In accordance with Section 37-90-137(9)(b), C.R.S., Rule 8 limits the consumption of wells withdrawing nontributary ground water from the Denver Basin Aquifers to 98% of the water pumped. The water relinquished may be released to the uppermost aquifer or a surface stream near the site of use. The rule is promulgated in order to assure that withdrawal of nontributary ground water from the Denver Basin Aquifers will not materially affect vested water rights to the flow of any natural stream. The rule is necessary to replace depletions to the flows of natural streams caused by the withdrawal of nontributary ground water. The pumping of nontributary ground water under existing artesian conditions will affect the flows of natural streams at a rate much greater than one-tenth of one percent within one hundred years. The relinquishment to the tributary system of two percent of the nontributary ground water withdrawn should prevent any material effect on vested water rights. See "Summary of Factors Supporting Two Percent Relinquishment Requirement" attached hereto and made a part of this Statement as Technical Appendix E.

The State Engineer, in the summary attached as Technical Appendix E, has determined that withdrawal of nontributary ground water from the Denver Basin Aquifers will affect the flow of natural streams. This effect will result from withdrawal of nontributary ground water when the hydrostatic pressure is above the top of the aquifer and will continue when the hydrostatic pressure is reduced to the top of the aquifer and below. Presently, the hydrostatic pressure in much of the Denver Basin aquifers is above the top of the aquifers. In this condition, sometimes referred to as a confined or artesian condition, the effects of withdrawing ground water extend for much greater distances than will be the case when the aquifers are unconfined or under water table conditions.

The rule requires an applicant to demonstrate that his use of water will not result in more than 98% consumption of the water. In most instances, the permitted use of water will not result in greater consumption. Most uses, such as irrigation, including lawn and garden irrigation, domestic, stock watering, municipal, and industrial uses are far less than 98% consumptive and a restriction to those uses will suffice. In the few instances where the proposed use has the potential to be greater than 98% consumptive, the applicant must assure the State Engineer that two percent of the water pumped will be relinquished. After a well is in operation, the State Engineer may reasonably require the permittee to demonstrate that this requirement is being met.

No evidence was presented to show that the two percent relinquishment requirement is excessive for any of the Denver Basin Aquifers. Several parties supported the requirement and there was evidence that, in certain aquifers, two percent relinquishment may be insufficient to protect vested water rights from injury., However, Section 37-90-137(9)(b), C.R.S. limits the amount of relinquishment that may be required by these rules to two percent.

Rule 9:

Rule 9 provides for the modification of the elevation of the top or bottom of an aquifer (as determined in Rule 4) and the number of feet of saturated aquifer materials (as determined in Rule 7). The purpose of the rule is to allow the State Engineer, in determining the allowed average annual amount of withdrawal for a well, to consider, without modifying these rules, site specific data which may be more descriptive for a particular location than the presumptive aquifer characteristics established by Rules 4 and 7.

Rule 10:

Numerous parties and one interested person objected to the costs of having to construct two replacement wells to replace a single existing well that withdraws ground water from more than one Denver Basin Aquifer, as defined in these rules. Several factors contributed to their concern. First, in instances where a single existing well withdraws ground water from the Upper Arapahoe Aquifer and Lower Arapahoe Aquifer or from the Upper Dawson Aquifer and Lower Dawson Aquifer, these rules in conjunction with the proposed Statewide Nontributary Ground Water Rules would require the construction of two replacement wells. Second, in the past, there were situations in which the office of the State Engineer concurred in the selection of different aquifer boundaries than those established by these rules for purposes of well construction. Again, in such a case, these rules in conjunction with the proposed Statewide Nontributary Ground Water Rules would require the construction of two replacement wells.

To reduce the costs to well owners who relied upon the then-existing aquifer boundaries in constructing their wells, the State Engineer has determined that they should be allowed to construct a single replacement well that withdraws ground water from the same producing interval as the original well. This will not materially affect vested water rights since the original well already provides an artificial connection between aquifers, so that allowing a single replacement well within 200 feet of the original well location would maintain the status quo. In order not to increase the number of wells acting as conduits between aquifers, this rule does not apply to applications for permits for new wells, additional wells pursuant to Section 10 of S.B. 5, alternative point of diversion wells, or supplemental wells.

Rule 13:

Several parties suggested that Rule 13 be modified to require periodic revision at fixed intervals. The State Engineer thinks that it is more appropriate to undertake revisions as new data indicate that such revisions are necessary.