[DrCommLANL CZ(SC)+APP]

Zane Spiegel's Draft Comments on the Los Alamos National Laboratory Report

"Analysis of Capture Zones of the Buckman Wellfield

and a

Proposed Horizontal Collector Well North of the Otowi Bridge"

SPECIFIC COMMENTS

PAGE PAR LINE COMMENTS

Cover & p. 1 In title, for **"Capture Zones" read "Zones of Origin"** (see GC(III)).

5 1 3/5, 7 Re "groundwater(s)" in lines 3 & 7, see GC (III)(A).

5 1 6/7 Sentences (A) "The [RG] is subdividing **[gr]** the basin...(Fig. 1)." and (B) the subsequent one, are conceptually incorrect. The first must be made true (and grammatically correct as well) by restating it as "The Rio Grande divides the *surface drainage area* of the Espanola basin into two sub-areas...".

Sentence (B) above ("[G Ws]... predominantly discharge (sic) at the river.") must be restated in conformance with historical facts and correct geohydrological concepts (Spiegel, 1953+; 1957;1962; 1963; 1963a). The most important points in restating the preceding sentence (B) are (1) The Rio Grande does not (and never did or will) act as a simple impermeable barrier --one of many types of boundary conditions (BC), most of which are transformed from standard mathematical terminology (for analogous physical processes) dating back to or before the beginnings of C. XX; (2) much of the ground water east of the river discharged historically to springs along or tributary to Rio Tesuque, Rio Pojoaque/Nambe, and others, which is the reason that the NM State Engineer Office (NMSEO) has required Buckman area wells to acquire affected rights in some of these areas, as well as on the main stream; (3) much of the ground water west of the Rio Grande also discharged historically (and to considerable degree still discharges) not "at the river", but to springs and alluvium in tributaries of the Rio Grande**;** (4) some of the ground-water on both sides of the Rio Grande channel discharges to the floodplain, floodplain drains, or tributary or inner-channel alluvial aquifer elements adjacent to the ever-shifting and aggrading active channel (see Spiegel, 1963, Fig. 28), not to the river itself**,** especially above White Rock Canyon and below Cochiti Dam; (5) none of the streams in the region are "perfectly connected" to any aquifer element; and (6) most of the streams, except the Rio Grande, will probably not have permanent (perennial) flow in the long-term future, and certainly not in the ultimate steady state assumed in the "Zone of Origin" model studies.

5 2 1/2 After the first sentence, insert "The Analysis was based primarily on steady-state models, the May 2002 draft of which had so many omissions and false assumptions that most of our conclusions were useless and highly misleading, both to us and our readers, e.g., (A) the time required to approach a steady state with the total well flux used was not given; (B) the total well flux used in some of our models omitted about half of the real historic well flux (especially values for the LANL wellfield nearest Buckman (1940's-1991), Espanola and Pueblo wells near the Rio Grande, and other community wells and thousands of private wells) for false reasons given elsewhere in our Analysis draft, as the data could have been obtained easily from NMSEO, or estimated from Census 2000 data (Internet); (C) many concepts, terms, and assumptions are false, used incorrectly or in a misleading manner, or too vague to be useful (see Spiegel, 1958, 1961, 1962, 1963, 1963a); (D) many assumptions in our Analysis and preceding reports by LANL and others were inappropriate to the actual geohydrologic system, especially confinement of the regional aquifer and other external and internal BC related to springs, streams, and interbasin flux (NMSEO, 1996); and (E) values of many characteristics we selected were poor choices, based on (albeit, "automatic") fudging to adjust to false inputs, and mostly not verified by sensitivity analyses. Therefore this draft is being withdrawn until further notice."

5 2 1/5 (A) As noted in GC(III)(A) and SC(Cover/p,1), replace the term "capture zones" (line 1) by "*zones of origin*" here, in the report title, and elsewhere. The term "*well-head protection zones*" may be retained, but only with early and repeated emphasis that it pertains only to water quality migration, not "safe yield" or any similar fallacious water-quantity concept.

The initial natural recharge before any wells operated was the "source" of all original natural discharge--subsequent transient well discharges act physically and legally on transient storage in an entire aquifer system (not just the zone of origin) and by diversion of the natural discharge to springs, vegas/cienegas, and streams, All waters in the Rio Grande basin of NM were fully appropriated before LANL or Buckman wellfields existed, and recognized administratively in the Rio Grande basin after 1956, primarily to comply with Compacts.

After long-term flux at a constant rate the aquifer system approaches a new steady state in which sets of streamlines may be identified, some of which define the *zones of origin* for each well or wellfield, but can be predicted properly ONLY IF (1) ALL BASIN WELL FLUX is entered into a model which is (2) BASED ON A REASONABLY ACCURATE CONCEPT OF THE REAL *AQUIFER SYSTEM.*

AS THE PRESENT ANALYSIS DID NOT FULFILL EITHER OF THESE REQUIREMENTS, IT MUST BE REDONE WITH TOTAL WELL FLUX OPERATING ON A PRE-WELL MODEL WHICH HAS BEEN VALIDATED BY USING THE CORRECT

RECHARGE DISTRIBUTION (INCLUDING *INCIDENTAL RECHARGE RELATED TO SURFACE -WATER IRRIGATION)* IN EQUILIBRIUM WITH CORRECT, FULLY DOCUMENTED, ORIGINAL NATURAL DISCHARGE BC, USING ALL OTHER REASONABLY REALISTIC AQUIFER CHARACTERISTICS.

(B) re line 3, For "the wells...water" read "ground water moves to specific wells"

(C) re lines 4/5, For "is the source ...wellfield?" read "are the zones from which contaminants in ground water move to the Buckman wellfield and the new horizontal collector well, respectively?" and delete the next sentence to avoid redundancy.

5 2 6/7 <u>The Analysis needs to be referenced in great detail, or amplified to</u>

explain, with all relevant recent data and valid concepts/terms, complexities of travel of waste liquids or leachates from points of disposal down and laterally through vadose zones, intermediate perched or semi-perched aquifers, to local points of natural discharge to canyon alluvia, springs, or streams, or to entry points or areas at the top (or locally, the water table) of the regional aquifer.

<u>In most places the regional aquifer has no water table because it is saturated to its top and in portions of overlying aquifer elements, therefore is in effect semiconfined by its own individual dipping clay strata or by the overlying saturated beds. (SC (5-4-3)) explains proper use of the term *"water table"* and additional classifications of *aquifer elements.*</u>

5 3 All In view of the enormous number of omissions of well flux, vague statements, errors, misconceptions, and inappropriate terms in the Analysis, the Analysis, all LANL reports cited, and all other LANL and USGS reports since the 1940's need to be reviewed carefully and evaluated for deficiencies in concepts and conclusions, in the light of all the modern information available since 1958, both in New Mexico and, more recently, at other DOE sites.

5 4 all The word "...aquifer.." (line 1)should be clarified: does it mean the entire *aquifer system,* or just one *aquifer element,* the "regional aquifer"? Re line 3, see above comments (5-2-6/7; 5-3-All) in relation to "...species originating at the water table beneath LANL". <u>NOTE AND CORRECT 3 FALSE CONCEPTS, AS FOLLOWS: (1) There is not just one *water table*</u> in the LANL area; they are intangible surfaces, except in some wells, springs, or ponds; (2)the "species" (aqueous contaminants) are not "...originating at the water table..." but "<u>introduced into the shallowest saturated zones at or near waste sites and transmitted laterally to springs and surface waters draining to the RG, or downward to intermediate *leaky perched* or *semiperched aquifers* and thence laterally, or downward to the top of the saturated, *semiconfined*, "regional aquifer";</u> <u>(3) the regional aquifer in the LANL area does not have a continuous "water table" throughout the zone of concern.</u>

Revised models need to <u>consider recent data showing a short time of travel of contaminants down to and through the "regional aquifer", by both vertical and lateral vadose and phreatic flow, through joints in tuff; through coarse Puye Formation and</u>

canyon alluvia; plus canyon base and storm flow, and refer to documents which adequately treat these concepts, e.g., Spiegel. 1958; 1963a; 2000--with appended GSA document listing and describing recent independent major investigations at DOE sites.

Transfer to p. 5, as new par. 5, last two sentences from (15-4-4/8).

6 1 All See previous four and following seven comments, plus GC (II)(D).

Re line 2, "...have analyzed the available hydrogeological information..." is a highly misleading statement, and should be made the WHOLE TRUTH BY ADDING THE FOLLOWING CAVEAT AT THE END OF THE PARAGRAPH:

"(A) Most of the essential available reports on the area were not referenced, and if "analyzed" were either ignored in the Analysis, or their importance was not understood; most previous model studies that were referenced contain serious errors that weren't corrected, despite notes to WQTF, therefore remain in the Analysis;

(B) half the well flux was omitted, despite ready availability in public State files; and

(C) much of the "analysis" resulted in extensive use of false or misleading concepts, terminology, and conclusions. The sum of the above invalidates our Analysis."

6 2 1/2 (A) After "wellfield" insert "and a nearby well for Las Campanas (LC) are" (delete "is"). Add the values of LC withdrawals, and all additional omitted well flux, to the modeled values of SF City Buckman wellfield (see GC(II)(C);

(B) poor editing of bad grammar, here and in numerous other places in Report, should be corrected: especially incorrect uses (and more frequently, omissions) of the definite article "the" (see list at end); (C) delete ", very close to the Rio Grande"; (D) add after the next sentence the exact distances, or a range of distances, from each Buckman well (including the Las Campanas well) to the nearest point of the Rio Grande left bank at normal flow; and (E) for "It" read "The Buckman wellfield".

6 2 4 After "...2000)." insert "The distance from the Las Campanas well to the nearest point of the river is ______meters.".

6 3 5 Missing data are probably available in current NMSEO water-right paper files; also for Espanola municipal wells. Some data for Pueblo and other "unknown" wells might be available from the Legal or Water Rights divisions of NMSEO (GC(II)(D)). If not, missing data and locations of wells must be estimated from Census 2000 data and their effects included in model results.

6 3 8 "Most of the drawdown is observed..." is technically/grammatically incorrect; replace by "The greatest drawdowns are observed at depths of...".

6 3 end Calculations of long-term future drawdowns of the Buckman area wells will probably be significantly affected by the fact that the recent pumping regime of the area cannot be sustained very long without reworking, replacing, or adding wells, for reasons that should be known to the authors, but should be explained to readers, many of whom probably would not be expected to know.

6 4 1/5 Delete first two sentences and update third sentence with test details prior to May 2002, as well did not perform as designed. The many inadequacies of the Analysis appear to be the result of pressure to revise previous conclusions without taking time to read and understand new geohydrologic concepts in reports by NMSEO and cooperators since 1950.

6 5 3/4+ (Also (7-1-all): Model omits half of total basin well flux, including Los Alamos Canyon wellfield, 1940's-1991, invalidating all results. Second sentence ("Our model simulates the pumping for groundwater (sic) supply of Los Alamos county (sic) and LANL (Figure 6).") appears to contradict Analysis Fig. 1, related text, and the rest of the Analysis, which consistently states in numerous places that both types of models extended over a very large area (nearly all of the Espanola basin) far beyond the local wellfields, and beyond the Rio Grande and Rio Chama.

Re the end of (6-5) and top of page 7, if the authors in truth did not know

["... whether there is additional groundwater (sic) discharge in the basin..."], it was their duty, as scientists in public employment, to search for all available data on all additional wells, plus springs, in the Espanola basin which could reasonably be expected to affect the results of their model studies (this means ALL wells and springs in the basin). Such data are readily available in public files, much of it available almost instantly by Internet, telephone, or Fax, from State agencies, such as records for (A) locations and flux of Espanola public supply wells (plus a well in the immediate Buckman wellfield area, privately owned by Las Campanas and "wheeled" to it, but not included in Buckman wellfield flux records; (B) several community supply wells near the Rio Grande and its tributaries, including Los Alamos Canyon wellfield, 1940's-1991; and (C) Pueblo well yields and locations, which can be estimated from old USBIA reports and/or Census (2000) data , plus thousands of private wells in NMSEO partial records (also see GC(II)(C)); .

If these well flux were indeed omitted from previous modeling, all such studies should be revised immediately with "reasonably ascertainable" data on amounts and location of these additional withdrawals, plus new BC and other assumptions. These new data alone should greatly increase the eastward hydraulic gradients and greatly reduce the travel time of contaminants. Most of the other changes in assumptions recommended herein should, in the aggregate, also produce large increases in easterly fluid gradient and decreases in travel time.

The Analysis, if it had intended to show the correct zones of origin for each of Santa Fe's Buckman wellfield and Collector Well system, separately and/or together, has been programmed inconsistently (using some additional wellfields, but omitting many more, for no reason other than the falsely alleged "...lack of information about the well locations and their rates..."), since records for most of the additional flux is readily available in Santa Fe or Espanola, or could be estimated from Census 2000 records.

7 2 3/8 Reread and memorize previous comment; revise Analysis.

7 3 1 What are the context and implications of the phrase "...available surface water for groundwater (sic) recharge?" (A) ***(reduction of natural discharge)* to RG and its tributaries?** (B) water available for ***(induced recharge)*** **caused by wells?** ; (C) surface water possibly available for acquisition by municipalities or others for ***artificial recharge*** by spreading or direct injection; (D) ***(incidental recharge)*** related to existing or augmented waters spread for irrigation from surface waters (perennial or flood); or (E) all of the above? Wherever types "(A)" to "(D") sources are included or implied in the term "recharge", they should be differentiated from natural recharge by the appropriate terminology above (see Spiegel, 1962, 1963, 1963a). Also, see detailed comments on Fig. 13-14, related text, and the following statement.

Water "available" in the future will also be determined by (F) reduced surplus available from Colorado, after possible source reductions due to climate change and probable increased withdrawals/evapotranspiration (ET)in Colorado; and (G) reduced flow due to increasing competitive NM demands and ET in reservoirs, and increased ET upstream of reservoirs in NM (see Spiegel, 1963a; USCE, 1947; Shoshoni Prod., 1978) for illustrations of these concepts.

7 4 1,2 Sources of "available...data" for Fig. 7/8 (and all others) should be given in related text, such as this paragraph, and on Figures and/or in their captions.

7 4 3/4 Sentences 2 and 3 are too vague to be understood by most readers. Do they mean (A) that "...ground water tends to discharge to springs and streams in areas of the lowest elevation, which are the Rio Grande and its tributaries", as stated in many previous USGS and NMSEO publications and memoranda on the Rio Grande basin?, (B) by "middle parts of the basin", in the east-west direction?, (C) both of the above, or (D) other meanings?

7 4 4/7, 9+ The statement including the words "...high hydraulic heads...are due to higher precipitation along the mountain ranges." IS NOT THE WHOLE TRUTH. The heads would be higher away from the river even if precipitation and recharge were uniform (Spiegel, 1962, a NMSEO report distributed to all NM universities and major libraries, including LANL; Spiegel, 2001-2, various reports to SFWQTF and LANL) gives generalized models intended to educate the public on basic features of NM *aquifer systems*, with examples applicable to the Espanola basin and other parts of the Rio Grande, based on 1951-3 field studies (Spiegel and Baldwin, 1963). Revise subject statement, on the basis of these works and intuition (see SC (SGE) and Appendix A.).

Obviously, if recharge is not areally uniform, but is higher along the lateral margins (whether due to higher precipitation there, or simply because of more efficient recharge by channeling of runoff into sandy stream alluvium and underlying aquifer elements, or to *incidental recharge* by\` irrigation with surface runoff from adjacent areas of low infiltration capacity and/or transmissivity (see SC (7-5/6)) then the heads there will be even higher--"the whole truth". The vertically downward- and upward- hydraulic gradients, respectively, in the lateral margins and axis of the modeled basin segment are also observable in various examples in Spiegel (1962), and even in the special case (Analysis Fig. 13) of these more appropriate examples,, or a simplified single-valley aquifer strip modified from it (see SC (F-13)).

7 4 6/7 (1) After "zone" insert, "as noted in several previous publications by USGS, including Theis, 1942; Spiegel, 1963, Fig. 28 and related text and plates; Hearne, 1985; etc.". (2) In next sentence read "These observations are...

7 5/6+ all Both need explanation (better, partial deletion) of non-relevant items, e.g., (1) Jemez River drainage shown in Fig. 9(a)--see previous SC for non-relevance and recommendations for deletion, and (2) re (7-5-2/3) "...precipitation rates increase...to the west...", since the area of western uplands with surface and subsurface drainage to the Rio Grande is substantially less and has lower altitude and average precipitation than the eastern ranges and uplands, which include peaks and cirques above 3960 m which were glaciated prior to 10,000 years BP.

The Analysis fails to mention that the vast eastern uplands contain large areas of old and young moraines, and old periglacial(?) outwash fans and related upland deposits of very durable quartzite boulders which have resisted erosion and preserved permeable uplands which extend far west of source peaks and foothill ridges, areas extensively irrigated by traditional Hispanic communities for centuries, using numerous acequias and storage basins which, along with field watering, provide recharge to numerous mesa-top aquifers perched or semiperched on less permeable rocks of Precambrian to upper Tertiary ages.

Most valleys incised into the eastern piedmont uplands have also been irrigated for centuries by acequia systems constructed and used by traditional communities, both Native American and Hispanic. Two of the systems have been supplemented by storage and release of mountain runoff from reservoirs constructed in the past century (Santa Cruz and Nambe Falls) to acequias and downstream channels.

Like the mesa-top irrigation systems noted in the previous paragraph, the valley irrigation systems have been providing significant *incidental recharge* to underlying aquifers, which include valley terraces, channel alluvium, and underlying strata of the lower and middle parts of the Santa Fe Group, which are generally more transmissive than their equivalents under the mesa-top beds farther upstream. In the past much of the irrigation water that incidentally recharged underlying aquifer systems has reappeared downstream as supplemental water for springs, many of which supplied acequias farther downstream in their respective tributaries of the Rio Grande (see Spiegel and Baldwin, 1963, for details of such features along Rio Tesuque, Santa Fe River, Arroyo Hondo, and Canada de los Alamos; CES, 2000-2, for recent status of these systems, in response to long-term well withdrawals throughout the basin.

All Analysis and previous models should be reviewed to determine the degree of error produced by apparent failure to take into account aforementioned centuries of *incidental recharge* related to surface-water irrigation, especially in the eastern uplands of the Espanola basin. Appropriate corrections of models and conclusions should be made and summarized in a revised Analysis.

Re par. 6-end and top of p. 8: Great age of deeper waters, and "colder climate" during the known ice age at that time are common knowledge by most geologists, which should be noted (if this reference is retained, summarize Anderholm's evidence for low temperature, or other useful recent (if any) information).

8 2 2/9 (+ Fig. 13) Most statements in lines 3-9 are (1)presented in illogical order, like many other Analysis paragraphs, and (2) incomplete, therefore false (not the whole truth, because the most obvious properties of the Espanola basin--its several asymmetries with respect to the Rio Grande--were omitted from Analysis Fig. 13 and its text discussion). The deferred caveats (real properties of the aquifer system) should have been presented first, with emphasis on the omitted asymmetry.

Delete Fig. 13 and related text because they have no useful purpose and it shows only symmetrical aquifer strips, a factor not mentioned by the authors, whereas Espanola basin is highly asymmetrical in all respects, which immediately negates any possibility that a vertical "groundwater (sic)divide" exists below the RG.

If a schematic diagram had been believed necessary, a closer approximation to truth than Fig. 13 should have been used, based on externally observable asymmetries (e.g., very unequal widths of the (corrected) west and east drainage areas; geologic structure; stratigraphy; and geomorphic factors that cause asymmetric areal recharge). A more appropriate alternative to Fig. 13, based on an infinite -strip aquifer system of *mutually leaky aquifers* separated by *aquitards,* could easily be developed from BVP in Spiegel (1962, 1963a) to represent an asymmetric pair of hydraulically-connected half strips.

Analysis Fig. 14 and related text, including paragraph (8-2-all), should also be deleted because of their numerous gross deficiencies. Substantial revisions based on abundant field evidence and true concepts of geohydrology might be acceptable.

Supplementary detailed comments on Fig. 14 and related text (covering most of the other defects in the original Analysis not mentioned above) are presented in SC (TF-14) and Appendix A herein, for educational purposes. Analytical concepts and field and history study might also be useful in correctly evaluating previous models and in developing new numerical geohydrology models, along with explanations and examples of logical terminology used herein for *mutually leaky multilayer aquifer systems* (see Spiegel (1962).

Re lines 5/6, a river or equivalent drain prevents cross flow in underlying *aquifer elements* only (1) if the river fully penetrates the *aquifer system*, or

(2) in a steady state aquifer system that is symmetrical with respect to the river, both externally and internally. Neither requisite occurs in the Analysis area.

8 2 11/16 These six lines and related Fig. 14 should be deleted, or substantially revised to reflect correct concepts, terminology, and definitions of terms, in accordance with the changes in Fig. 14 shown in Appendix A herein, and the following specific criticisms of the authors' ignorance of basic mathematical physics applied to ground-water hydraulics. [Fig. 14, unlike Fig. 13 and related text, does portray the Rio

Grande valley as being asymmetric (slightly wider to the east of the river), but it more realistically should have been drawn in proportion to its actual asymmetry, and the inner river valley should have been identified in all the land surface profiles (a-d).]

Re (8-2-11/13) and Fig. 14(b), the Figure is misleading and the text statement is false ("If the well pumping...is much less than the amount of water recharged to the east (b), there could be no pumped water coming from the river or western part of the aquifer.) The physical reality, established by Newton's Conservation of Mass and Theis (1935, 1941), and (recognizing that there are no truly confined aquifers) extended to mutually leaky aquifers by Spiegel (1962) and Hantush (19--), is that all wells and wellfields withdraw water from *aquifer system storativity*, plus *induced recharge* from connected streams.

THINK CLEARLY; Water recharged areally or at lateral aquifer-system margins under pre-development quasi-steady conditions was originally destined for natural discharge areas. Introduction of well flux, whether by isolated wells, wellfields, well clusters (or lines of wells parallel to a river or line of springs, a geometry more easily depicted, proven analytically, and visualized by readers) takes water from transient storage in the stressed and connected aquifer elements, but does not usually change the amount of areal or lateral inflow (the authors' "recharge").

The physical reality (TRUTH) is that well flux from any aquifer element lowers water-levels and takes water from nearby transient storage to produce *drawdown cones* that cause *induced leakage* (to stressed aquifer elements) from transient storage in overlying aquifer elements, which in turn, first, *reduce natural discharges* from the aquifer system to connected tributaries and the main river, and second, may eventually reverse outflow so that the streams provide *induced recharge* to connected aquifer elements (Spiegel, 1957, 1977/8, 1998; Cooper et al., 1977; Bredehoeft, 1997).

All *drawdown cones* in the stressed and overlying aquifer elements of mutually leaky aquifer systems (the Espanola basin case), regardless of flux quantity, expand in all directions to all the external boundaries of the aquifer system (since none of the streams are fully penetrating, even if they have "perfect connection"--which they do not) until a steady state is reached in infinite time,

It is essential to note that, regardless of the rate of well flux, (contrary to the authors' statement in (8-2-11/13). quoted below, the effects of well *drawdown cones* on an *aquifer-connected stream* (whether by initial *reduction of natural discharge* to the stream or by later *induced recharge* to aquifer elements) are delayed by water taken from *transient storage* in (not from "recharge") the aquifer system, so the "...amount of water recharged to [the aquifer from] the east (b), ..." cannot prevent "...pumped water [from] coming from the river or the western portion of the aquifer."(8-2-11/13). The authors' quoted false conclusion is probably based on a combination of congenital misinformation (metaphorically, i. e., the university is analogous to the womb) on aquifer concepts and the false Analysis assumption that rivers have "perfect connection" with each and every water-producing stratum in the regional aquifer, which amounts to the false assumption that the rivers have full penetration of the aquifer system, rather than true assumption of zero penetration.

8 3 1 Explain "groundwater (sic) inverse model".

8 5 1-2+ (A) For "...top model boundary..." read "...upper boundary surface of the model..."; for "bottom" read "base" (B) in line 3 (top of p. 9) for "no" read "small". or a calculated value, as all hydraulic effects of wells extend to all model limits by the time a steady state is reached.

9 2 7 <u>List uncertainties/estimate ranges of assumptions and likely effects.</u>

9 3 var. See SC (SGE). Meaning of "structured" (line 2)?

9 4 all (A) What errors of assumption, especially in BC, did the authors find in cited previous models (or any others not cited), and (B) which ones were corrected in the Analysis models and previous LANL models ? (C) If none, why not?.

9 5 10/12 <u>List all these "key assumptions", with evidence. We already know that numerous assumptions in these early models were grossly in error (NMSEO, 1996; Spiegel, 2001, various in 2000-2002)</u> but readers deserve the right to receive information sufficient to evaluate their adequacy independently (also, see previous and next comments).

9 5 12/13 (Also next paragraph, top of p. 10). Justify in detail how the "automated calibration" is "fully objective", in view of the gross deficiencies in the authors' subjective assumptions (largely undocumented and highly "caveated") of boundary conditions, aquifer margins, recharge processes and distribution, well flux, aquifer-element confinement, etc. (in contrast to well-documented previous comments in geology literature, most of which could be readily confirmed by anyone who has had and/or would take the time to acquire detailed field and historical knowledge of the geomorphology, hydrology, and use of the Analysis domain).

10 2,3 1/4 Did the coupled model incorporate corrections to the deficiencies of older models? If so, list corrections, and if not, identify all reasons from the following list: because the authors (A) did not read highly pertinent early and recent non-LANL reports on the area (B) did not personally verify field and published evidence of geomorphic, historical, and recent conditions in the boundary margins and along the Rio Grande and its tributaries (USCE, 1947; Spiegel, 1958, 1961, 1963a); (C) were not sufficiently familiar with Boundary Value Problems (BVP) and associated BC which are the foundations of numerical analysis (Birkhoff/Varga, var.; Spiegel, 1962, 1998); (D) were directed by superiors to avoid one or more of the above; or (E) several of the above (if (D) and/or (E) is chosen, specify which ones apply).

Re (10-3-l/2), <u>"...entire</u> [regional?]<u> aquifer is simulated as confined." (line 2), this statement, if actually followed, makes all LANL model studies using a "confined" regional aquifer property a contradiction, for under this "gi" model assumption, there can be no hydrodynamic connection between the "..complex regional aquifer..." (line 1) and overlying aquifer elements and rivers.</u> Perhaps use "semiconfined" BC?

In addition, other authors' statements appear to (a) contradict other Analysis assumptions about the relationship of the Rio Grande and tributaries to underlying *aquifer elements (e.g., "perfect hydrodynamic connection"* in SC (10-5-22)), and (b) conflict with the general knowledge now correctly recognized by the hydrology profession--that there are no widespread impermeable strata in nature, therefore that confinement throughout is impossible. (See "Pinder fallacy" at end of SC(8-2-11/16).

The broad areas of contact of the Rio Grande and tributary alluvial deposits with various successive layers of the dipping Santa Fe Group beds over the entire Espanola basin guarantee interchange of waters among these *aquifer elements*, and is part of or supplementary to the interaction between the Collector well and Buckman wellfield and irresponsibly omitted wells and wellfields.

The unsupported allegations "confined" (line 2) and "...little effect..." (line 3) must be replaced by "mutually leaky (semiconfined) conditions" and "substantial regional effects", respectively, unless conditions can be proven "confined".

10 3 8,9 Re Analysis item (2), there is no elevation in north-central New Mexico below which "essentially no recharge occurs", Small unit recharge is offset by the large area of lowlands (see Fig. 10 and Spiegel (1963a). Snowmelt and monsoon runoff are rapidly absorbed by all of the many sandy arroyos (not just "focused along the streams" (lines 14/15) that traverse all areas). Most low areas also have *incidental recharge* which must be included in *total recharge per unit area.*

(A) Plains in southern Espanola basin provide significant recharge because of their large area and effective absorption of runoff from adjacent ridges and mountain foothills (Spiegel, 1963, Fig. 31; Table 8; p. 143-46, 151-53); (B) before wells were constructed for livestock use, many springs were supported by recharge to shallow aquifers in low areas (Spiegel (1954), NMBM GW Rept. 4); (C) long-term records of precipitation and well water levels (Spiegel, 1958, 1963a; 2000-2, var.); and (D) reliable and consistent oral traditions (personal comm. to this reviewer, 1949-1957) in various parts of NM indicate that although many years do not have much recharge or even soil moisture, occasional wet years provided sufficient recharge to support many permanent springs, EVEN IN AREAS WITH AVERAGE PRECIPITATION AS LOW AS 8 INCHES PER YEAR AND ELEVATIONS BELOW 5,500 FEET.

Apart from the adverse impact of the untenable assumptions and/or alleged "fully objective" estimation (SC (9-5-end)) of regional parameters used in the Analysis model, the small areas of contaminant "sources" that are admitted to supply contaminants to the main aquifer elements in this model, and the large areas in which this and other LANL studies (especially ongoing studies of specific mesa waste sites) have grossly underestimated the natural recharge to be "zero" or in "relatively small amounts", are not credible. Those short-term studies should be withdrawn immediately, with appropriate public notice and apology.

10 4 1/5 (A) In line 1, for "bottom" read "base"; and

(B) re "...defined as no-flow.", (1) although data and water-level plots and contours in Mourant (1980) suggest "no flow" out of Ancha and basal Tesuque formations along the southeastern boundary, there is significant historical discharge south (locally from the Ancha, based on historical and water rights records (CES, 2000).

These discharges, which include several developed and undeveloped springs in the San Marcos Arroyo drainage area, at or near the southern Analysis boundary, as well as larger internal springs to the northwest, are all very important locally, as they have old priorities (Spiegel, 1963, text + var. Figures and Plates; Spiegel, 1975; Spiegel, 2000-2, var.), were not mentioned in the Analysis or previous works cited. NMSEO (1996) corrects some, but not all, of the false BC that affect these springs;

(2) farther east, near the southern boundary of the Analysis domain, *induced inflow from a strip* of deeper aquifers is probably a better choice of BC than "no-flow", based on data from 1969-70 studies by AMREP and its consultants, the NMSEO/SF County hydrologist, and later monitored wells in the Eldorado area (see JSAI, 2001, but carefully evaluate their "model validation" allegations, many of which have the same types of deficiencies as the LANl Analysis).

These facts may not be important to the hydrodynamics of the northern part of the Espanola basin, but (in addition to scientific integrity) because Analysis models, details, and conclusions might be used in future studies by LANL and/or others, the whole truth should be included in all LANL model or other geohydrologic studies in the Espanola basin.

(C) Re lines 2/3, and Analysis Figs. 1, 21, 23, & 25; based on 1949 traverses by Zane Spiegel during USGS-LANL Valles Caldera drilling and aquifer/stream studies--one of our early geohydrologic "contributions to science"--delete from the Analysis domain the Valle Grande/Valle Toledo drainage basins and their eastern and northern mountain rims, which drain to "(Jemez canyon)" and the Abiquiu Reservoir areas, respectively.

The bedrock complex forming the caldera rim (mostly lava and intrusive rocks of the rim of Valles Caldera) probably justifies the assumption that a ground-water divide closely corresponds to and descends from the topographic divide on the rim rocks (possibly with a valid vertical no-flow BC surface, with certain qualifications, OR with a similar surface having an "induced inflow" BC, allowing drainage from storage in an adjoining strip with aquifer coefficients appropriate to the fractured bedrock aquifer on both sides of the rim crest (see SC (13-1-1/2; F-21).

Whether or not the authors agree that the above suggestions are correct interpretations of reality, E-W geologic and hydraulic conductivity sections across the caldera rim (possibly along the Cuba gas pipeline route) and N-S sections from Tchicoma Peak to the vicinity of Abiquiu would be useful to help explain the western part of the profile in Fig. 25.

10 4 3/8 (A) (Also see Analysis Fig. 1 and all others showing model domain.). At the end of the sentence in lines 3/4, delete the period and insert ", and along the topographic divide at the heads of Rio Ojo Caliente and its tributaries.".

(B) Re lines 5/6, contrary to "There is (sic) no data...interbasin fluxes (sic).", there are ample data available to approximate some of the"interbasin fluxes(sic).", e.g., in 2002 studies for Taos County, and in older reconnaissance files related to the declaration of RGUWB (NMSEO, 1956) in Taos and Rio Arriba counties. The "no-flow" designations of exterior boundaries in Analysis (10-4) do not note that natural subsurface inflow from the north occurs in the area described in (A) above, and that data in the works cited at the beginning of this paragraph (B) indicate that under long-term operation of all the current and future real wells, especially by the omitted past, present, and future flux in the northern part of the Espanola basin, additional inflow may be induced into the Rio Ojo Caliente sub-basin of the Analysis domain.

In addition to exterior boundary inflow/outflow, there are large interior sinks (springs, spring-fed streams, and vegas/cienegas) not noted specifically in the text or Figures. Flux from most of them will decline with time, eventually to zero, because of diversion of all physically available water by the real total and future flux (most of which was omitted from Analysis and preceding LANL models) if they are included in the "tributaries" of the Rio Grande that are alleged to have a "constant head" BC.

Maps and hydrographs of declining historical and future flows in such areas should be prepared and used as part of the verification of the nonsteady phase of the Analysis model and to permit public verification of the Analysis assumptions and results. If such flow data were not prepared, they need to be added, with limits set at the times the flows reach zero, at which time the BC will change to the "no-flow" type. Some springs have already dried, others reduced to half their original flow.

10 5 all Re lines1/2 , assumptions of "fixed head" and "...perfect hydrodynamic connection", see SC (5-1-6/7) and other review comments; neither assumption made in the Analysis was true historically, which means that neither of these two factors that are important in assessing the validity of the model's design characteristic is likely to be true for the tributary streams in the future, which will probably all be dry most of the time, especially in the steady state. Some alternative values of channel lining or alluvium vertical anisotropy should have been tested to quantify statements in the next Analysis paragraph (11-01). Also note (and test), re lines 2/4, that the channel lining effect is likely to be different in gaining reaches and times than during channel losses.

Re lines 4/5, historical stage data for the Rio Grande at Otowi are readily available from USGS, and would also help select a reasonable value for the future steady-state river stage. A "dry" future for most reaches of all tributaries is far more likely than any other assumption.

11 1 all EVEN A ROUGH GUESS AT MORE LIKELY VALUES WOULD REDUCE THE PROBABLE MAGNITUDE OF ERROR. Sensitivity analyses in some doubtful cases would help resolve any doubts about choices.

11 2 all See other SC, especially re Analysis Fig. 6 and 18. Important data omitted invalidate most model results. LAC wellfield & other data are easily obtained.

11 3 all Re line 3, insert "usually" at end of line; re line 4,; re lines 4/5, for "...groundwater (sic) recharge..." read "...*induced recharge...",* and for "...significantly increased ..." read "...caused..." (see GC (III)(B)) and SC (Fig. 14));

re line 7/9, after "Although", insert "usually" OR for "high rates" read "higher rates than a vertical well at the same site"; for "...virtually direct pumping of..." read "proximity to"; and add after end of sentence "However, compared to direct diversion of related surface water, they substantially remove suspended solids and associated contaminants."

11 3 11/12 Revise to note that " it is physically impossible for tubes in alluvium to take water from overlying or adjacent surface waters without drawing in some water from the alluvium and other related aquifer elements also."

11 3 12/15 Search literature for typical values in other semi-arid valleys with rivers usually carrying high sediment loads.

11 3 end Revise last sentence, using available data.

11 4 all At end---note that authors' "projected rate" might not be sustainable by the pilot installation, or adequate for needs, requiring additional collector wells.

12 1 1/8 (also Fig. 19) See GC and previous SC comments on undocumented and/or obviously false inputs of "available" data which invalidate the "comparison" graphs and conclusions, confirmed by the following additional details:

(a) Re line 3, types/locations of "available flux" not defined or specified--what are they?; re lines 5-7 and Fig. 19(a), dates of flux measurements and simulation periods are required, along with a map showing all gages/reaches represented by the six sets of bar graphs--when and where are they?.

(b) Re Fig. 19(a)"Discharge" values used might not include all (if any) of the real values of evapotranspiration (*ET) and incidental evapotranspiration (iET)* in ground-water discharge areas: Give details! (e.g., ET from Rio Grande floodplains; iET incidental to natural phreatophyte and soil evaporation, acequia leakage, and crop use related to irrigation diversions of spring-fed flows in Chama valley and lesser tributary valleys). Data, sources of data, and map locations are not given in the Analysis, therefore the total of iET and net lateral ground-water flux can not be verified. Unlikely assumptions on *lateral or induced lateral inflow*, and, particularly, absence of discussion of irrigation and associated iET and localized areal recharge in the Chama River drainages and eastern foothills/valleys discredit model results.

(c) Re lines 7/8 and Fig. 19(a): (A) as the stream reaches gaged or estimated receive flows from large areas, real ground-water outflows vary little over short periods, which, along with (B) large errors in estimates of ground-water flux (see preceding Comment (b) above), may account for the apparent close agreement of estimated and simulated ground-water flux values, NOT "...figure demonstrates that our model matches the measurements reasonably well and without bias."

Errors inherent in gaging and the many cases of bias in model parameters make Fig. 19(a) a farce, as is Fig.19(b), as explained below.

12 2 1,2 + Fig. 19(b). (a) Two maps are needed, one for "P-d" wells, another for "transient" wells showing locations and identifications of all wells for which head measurements were used in Fig. 19(b), with accompanying table of remarks on

conditions at or near wells (wells in use, dates of measurements, screened intervals, etc.)

(b) Text and figure deceit: As with 3D color presentations (see SC (F-21, 23) and related text, vs. SC(F-7, 8) many things can be done with 2D graphs to fool inexperienced eyes into believing an author's questionable allegations minimizing departures of model results from measured values, e.g.,

(1) "...discrepancies...shown in Fig. 19 are largely due to heterogeneities within the aquifer that are unaccounted for in this model.", and

(2) (from SC (12-1-7/8)) "...figure [19] demonstrates that our model matches the measurements reasonably well and without bias."

Examine the following five possible choices in plotting the data represented in Analysis Fig. 19(b): (1) compress graph scales so that large differences appear to be small ones; (2) use different scales in the x/y directions; (3) omit scale lines in one or both directions in graph interior space to make it difficult to visually estimate or measure departures of data along respective axes from a theoretical or "ideal" curve; (4) print the given curve as a wide line; (5) instead of small dots for data pairs, use large dots or squares (or, as in Fig. 19(b), diamonds oriented with their diagonals parallel to the x/y axes) as each of these techniques take up (cumulatively) some of the spaces between data points and the given curve, thus reducing the apparent departures of data from the "Perfect fit" line.

BY STRANGE COINCIDENCE, ALL FIVE (5) OF THE ABOVE GRAPH CHOICES WERE APPLIED IN FIG. 19(b). Whether intentional or not, the five graph choices, listed above and used in Analysis Fig. 19(b), tend to deceive readers (and authors?) by diverting attention away from the fact that most of the points depart significantly from the "Perfect fit" line. Careful visual evaluation of the cited Figure, facilitated by use of a scale or marks on a paper edge, will show the opposite of the authors' claim quoted in the preceding comment (SC (12-1-7/8)).

In fact the plotted data "points" (blue "Pre-development" data diamonds), which represent steady-state heads, most of which were probably measured with considerable accuracy, depart from "Perfect fit" by as much as 30-150 m (~98 to ~492 ft), which hardly agrees with the authors' claim (SC (12-1-7/8)), quoted again here, that "...figure [19] demonstrates that our model matches the measurements reasonably well and without bias." The falsity of the authors' conclusion above will be obvious if the data represented in Analysis Fig. 19(b) are replotted as two separate page-size graphs, with other changes noted below:

(1,2,3) Graph Scales, re (1)and (2), absolute and relative sizes, respectively, and re (3) interior scale lines. (A) Pre-development (P-d) data: Replot (P-d) data on a separate graph, as the data used for this model run cover a much wider range than the transient data, therefore required compressed head scales to fit the small space used. The new graph of (P-d) data should (a) utilize an entire page, with the scale values and explanation printed within the graph, rather than utilizing valuable space outside it, (b) have equal dimensions for the x and y axes, (c) show guide lines vertically as well as horizontally, to facilitate comparison of distances of data points from the "Perfect fit" line, and (c) limit scale ranges to 1600-2600 m (3 high-value data sets can be plotted outside the upper limits of the graph).

(1, 2, 3)(B) Transient (T) head data: Replot these data on a separate full-page graph, with both x and y scales expanded (and equal), as the range of heads is only half (1500 m to 2100 m) that of the (P-d) data, and many of the data points overlap in the original Analysis graph. (The case of plots of "Transient" (green diamonds in Fig. 19(b)) as Simulated head vs. Measured head is even worse, despite the apparent "better fit", because here the measured heads (horizontal axis) are the result of REAL well flux, whereas the simulated heads (vertical axis) reflect only the well flux input to the model, which is only about half the real flux which caused the measured heads (see GC (II)(C) and related (SC)).)

(4, 5) In both new data plots, (4) draw the "Perfect fit" line as a thin black line; (5) use small black dots for data points (color is not necessary with two separate graphs).

(A basic misconception about numerical models is that every model has a unique combination of aquifer parameters that gives an objective approximation to a "Perfect fit", whereas in fact, there are many possible combinations that give what may be considered an "acceptable" fit by modelers, and this decision is highly subjective, as is obvious in the subject Analysis. Therefore the Analysis model "calibration" generated false ("automatically fudged") aquifer parameters, which apparently misled the authors. "Automatic fudging" of aquifer parameters is as erroneous and unethical as the "hands-on" type.)

---

12 2 2 Re Fig. 20, delete the balance of sentence on this line and insert "...inaccurate values of natural discharge were used in initial calibration, and large quantities of real well flux near the Buckman area (former Los Alamos Canyon wellfield, 1940's-1991, and many other wells near rivers (SC (5-2), (6-2,5+), (11-2)), totaling an amount equal to or greater than the values used, were omitted knowingly from other calibration runs, which completely invalidated calibrations and all conclusions from modeling based on it.

The Analysis, especially input BC, recharge (distribution and total), and other assumptions, SHALL be redone, with due care that "calibrations" do not produce matching based on fudged aquifer characteristics." (see GC and other SC).

12 2 end For "...discrepancy." read "...discrepancy, but does not resolve the basic problem that the well flux input to the model calibration may have been only about half the real flux . As we have not provided maps and flux data on the wells that caused the measured transient heads in Analysis Fig. 19(b), this phase of the Analysis must be redone. THEREFORE, COMPREHENSIVE REVISION OF THE MODEL, AS WELL AS FOR THE TRANSIENT PORTION OF FIG. 19(b), IS NEEDED.

13 1 1,2; F.21. (A) Re "...simulated pre-development (steady-state) heads...", the simulation in Fig. 21must have required use of most assumptions that have been shown

herein to be erroneous or poor choices, which had to have resulted in false "inverse estimates of model parameters...". Therefore the simulation must be redone, using realistic values of BC, areal recharge distribution, and revised (and more detailed) natural discharges at external and internal springs (NEW Fig. **21R**). Prepare NEW Fig. **21A (simulated pre-development steady-state heads, a large-scale portion of NEW Fig. 21R) at the same scale as NEW Fig. 22R.** Revised head contours should have 1 m interval (2D-B/W) at full page size or larger, with N-S orientation, with western drainage areas deleted.

(B) Conform the caption of NEW Fig. **21R** with the text language. Explain in detail how the NEW simulation takes into account (if it does) field water-levels and their dates, and show locations of data points and/or areas used as controls on simulation, and credit all data sources (in text and on NEW Fig. 21A or its caption).

13 1 2,3 For "Figure 22....heads." read **"NEW Figure 22R, a (2D-B/W) larger-scale map of a part of the Analysis domain simulated present transient head drawdowns [**reviewer's insertions underlined**] ,** as the difference between (1) NEW Fig. 21**A**, "Simulated pre-development steady-state heads" (the portion of the Analysis domain in **NEW Fig. 21R** which corresponds to Analysis Fig. 22] and (2) NEW Fig. 21**B**, "Simulated present transient heads.".

NEW Fig. 22R Caption: Read 'Simulated present transient head drawdowns [m]." Present each of the two maps (1) NEW Fig. (21A), an enlarged part of Fig. 21R corresponding to Fig. 22 area and (2) Fig. 22R, all revised to the same scale, page-size, and orientation, with data control points, dates of maps, ID of major wellfields, color codes (on maps or in correct captions, etc.

13 2 2 Obviously the future steady state would be reached only after a very long time, but it would be useful for most readers to know when the future system would not only "...start to stabilize..." but reach some large fraction, say 95 percent, of its ultimate effects on the principal rivers and the entire basin. Semi-logarithmic graphs of (percent reductions of total flow of selected river reaches) vs. (logarithms of elapsed time from beginning of basin well flux) would be even more useful.

13 2 3/4 For "some portion" read "most"; after "...drawn from..." read

" ...transient storage in stressed strata and adjoining leaky aquifer elements, and increasing amounts will be diverted from discharge to streams *(diverted natural discharge)*. Where ground-water gradients at streams reverse, some water will be taken from various streams *(induced recharge)*." Because use of the generic term *"recharge"* may mislead, delete ";...afterwards all... will originate from recharge."

As drawdown cones from producing wells expand into areas which contain or receive dilute (i. e., of same density) aqueous contaminants, ground water in transient storage will tend to be diverted in the direction of producing wells (taking with it any introduced contaminants) in any connected aquifer elements. Portions of the aquifer system which contribute water to specific wells and wellfields are called *"zones of origin"* for those wells; they are bounded by sets of streamlines ("stream surfaces" might be an appropriate term). Statements such as "...pumped water will originate from recharge." or the use of the term "capture zone" for "zone of origin" (see GC (Title))are not justifiable, either conceptually or scientifically (an example of the latter is that *areal recharge* might cease due to urban paving and drainage diversions under large areas of an aquifer, but water in transient storage would tend to continue moving in the directions of producing wells).

To prove the above, asking a question is worth a thousand models:

If a very small quantity of concentrated toxic liquid is introduced into a small arc at the edge of a large and deep cylinder-shaped aquifer with no areal recharge or lateral inflow, and an axial fully-penetrating deep well operates at constant positive flux rate, will the water in the zone of origin of water containing the toxic material (A)"originate from recharge"; (B) tend to move with water in transient storage in the direction of the well; (C) both of the above; or (D) none of the above?.

Obviously, the answer is (B); Q.E.D.

13 3 1/2 Replace Fig. 23 (p.d. ss heads) by Fig. 23R, recomputed to reflect field reality, but without Jemez/Abiquiu drainages and collector well flux, drawn to the same scale and style as Fig. 21R, to enable readers to easily compare them.

13 3 2 After "without" insert "(Fig. 24(a))", which should be re-computed as noted above with reference to Fig. 23 (by a revised model which replaces all false assumptions with correct ones, particularly BC and well flux) redrawn as Fig. 22R

("Simulated present transient" drawdowns) and 24(a)R ("Simulated future steady-state" drawdowns), both rotated 90 degrees, and enlarged to the same scale, to fit page size, which would facilitate the accommodation of 1-meter drawdown contours (after adding all real historical well flux and future flux to revised model runs).

After "with" insert "(Fig. 24(b))". The changes suggested, especially contour interval, should result in drawdown maps showing that the water-level declines are basin-wide or nearly so, with imperfect stream-aquifer connections to the deeper production zones of the regional aquifer (at least in the future steady state, which occurs as elapsed time approaches infinity) in large mutually-leaky aquifer systems with large areas of future water-table conditions, not just "...localized decline...in the aquifer", as falsely alleged in Analysis (13-1-4). A summary of suggested changes in Figs. 21-24 is given in (SC (TF)) below.

13 3 6 The effect of the collector well of "...as much as 50 m" on Buckman drawdowns should be explained (i.e., the pathways of transmission of hydraulic effects should be drawn in plan and profile, and all assumptions described and quantified). Prepare large-scale detailed cross-sections to do this, showing stratigraphy, present transient water levels, and future steady-state water levels of (1) the alluvium and river and (2) underlying semiconfined strata down to depths of about 70 m below river level at the collector well. Sections could be labeled (A-A'), extending about 2 km

east and west of the collector well along a line perpendicular to the Rio Grande at the collector well, and (B-B'-B"-C) from the vicinity of the collector well (point B) downstream along the axis of the river to point (B'), thence easterly along the line of four Buckman monitoring nests (SF-5 to SF-2, plus Buckman 1, 7; see Figs. 3 & 5) to B" at Buckman well 7, thence southerly through Buckman wells 3-5 and beyond, to point (C), about 7 km south of Buckman well 5.

Show only the shallow water levels in the monitoring nests, but add notes to section (B-C) for deep monitor-well water levels, and for pumping levels in each of the producing Buckman wells on the section, in order to allow large-scale portrayal of shallow stratigraphic details of the aquifer system elements.

13 5 all Any geologist with even a minimal introduction to ground-water

principles should have been able to predict, on the basis of early reports and USGS-monitored drilling in Jemez Caldera and brief traverses along existing roads and trails that "...very little (if any)...flows to the east..." (lines 2/3), obviating the cost, first, including the area in the Analysis model, and now, removing it (see previous SC).

13 6 3/5 Before "reservoir..." insert " ...importation; delta/floodplain evapotranspiration; and...". After "...infiltration (..." add "transfers of irrigation rights; ...". After "reservoir..." insert "...and diversion dam...". At end, add "These model factors can be changed in the future to update model predictions."

14 1 1 (A) Explain "concentration of 1.0..."; where contaminants were (and are) distributed areally ; pathways to buried regional aquifer; and times required to traverse these pathways vs. time to steady state. Revise model.

(B) Clarify statement (and previous statements in text) about the "sinks within the model"--which model in Fig. 26, (a) or (b)? Explain why other streams were omitted, and move par. 4 to the end of par. 1, with second caveat first, and concluding with a calculation of storage depletion. Revise model.

(1) Are all sinks assumed to be operating simultaneously, and if not, which are? List operating sinks, or refer to statements elsewhere in Analysis or its revision. (2) If any sinks were omitted list them in a table, with quantities, and an estimate of errors created by total omissions; better yet, revise model and results honestly by including all well flux, stream diversions, and depletions of storage.

14 1 1/4 (A) The second sentence is false (or too vague to be considered "true"), due to the authors' failure to properly distinguish, as noted previously (see (GC), previous (SC), and SC (TF)), (a) the essential difference between a misnomer, "(recharge) capture zone", and the conceptually correct "zone of origin", and (b) the various sub-types that are included in the vague term "recharge" (e.g.,*induced lateral inflow; areal recharge; induced vertical inflow* across aquitards; *diverted natural discharge* (NOT RECHARGE), and *induced river inflow*). A suggested revision

(B)follows, but needs to be preceded by proper definition of "recharge" and identification/definitions of its many sub-concepts (see some listed in (b) above).

(B) For "... 'tag' water recharging from...river,", read "allocate the areas of origin of the ground waters produced by specific wells ("originating" from areas east and west of the Rio Grande, respectively, but in fact diverted from their original destinations *[diverted natural discharge]* to tributaries and main stem of the Rio Grande) vs. (water taken by wells from perennial reaches of tributaries and mainstem of the Rio Grande *(induced river inflow)* (see Fig. 26(a)). [at the time that the system reaches its steady state (?)].

Again, water moving to wells from *"zones of origin"* that is not *"induced river inflow"* is water taken by wells by diverting natural discharge that otherwise would have gone to the rivers, and is neither "diverted areal recharge" nor "diverted lateral inter-element inflow".)

(C) NOTE: Fig. 26(a) shows that parts of the Santa Fe River stream system and some valleys upstream of Buckman are not much farther from the Buckman wellfield than parts of the Pojoaque River stream system, yet appear to have been excluded from consideration in (14-1) and computations itemized in (14-2) of the Analysis. Along with the misrepresentation of the model results in the second sentence of Analysis (14-2), the high probability of (1) future increase in perennial effluent flow of part of the Santa Fe River La Cieneguilla area) and (2) future disappearance of base flow in Tesuque and Nambe tributaries of the Pojoaque River emphasize the need (previously stated) that the "Origin of pumped water" text and Fig. 26 need to be revised and explained in greater detail. The process of computation of the various ratios shown in Fig. 26, and the total ratios given in the text needs to be described in detail, and a map provided which shows in detail which reaches of streams provide the *diverted natural discharge* and which provide *induced river recharge.*

14 2 1/4 For "river recharge" in line 1, read "*(induced recharge from rivers) to (total flux to Buckman wells)...*".

The false second sentence needs to be correctly stated, possibly as "The regions in three shades of blue, representing ratios of (induced recharge from rivers) to (total well flux rate), ranging from very small to 0.20, overlay parts of the domain where reductions in ground-water levels are somewhat less than they would be if there were no reversals of water -level gradients between the rivers and adjoining aquifers. Several shades of green, ranging to yellow, orange, and red, show areas with increasing ratios." See SC(TF-26) and previous SC for some additional reservations about the accuracy of the model representations in Fig. 26. In line 3, for "...capturing water coming..." read "inducing inflow into aquifer elements..." ; in line 4, for "...river." read "...River and other tributaries of the Rio Grande, as in Fig. 26(a)."

14-2-4/6; 14-3-all Values of source waters given appear to be based only on part of the well flux in and near the reduced area shown in Fig. 26(b), and neglects effects on other nearby rivers (see Fig. 26(a)).

(14-1/4) + (13-7) CONCLUSION: THIS SECTION SHOULD BE COMPLETELY REWRITTEN IN CONJUNCTION WITH THE NEXT SECTION, because of errors and high redundancy.

(14 -Title + 5/6) For title "CAPTURE ZONES..." and every other use of term in Analysis, read "ZONES OF ORIGIN..." (ZOO), as noted in GC and previous SC, beginning with SC (5-2-1)).

Summary of 2D model is incomplete and irrelevant, simply because most hydrologists don't understand that 2D representation usually implies that the rivers are both fully penetrating and perfectly connected, which are usually false assumptions.

Delete all except last sentence (duplicates discussion of Fig. 13 & 14, and Analysis (13-7 +); In last sentence, after "we use the", insert "forward". At top of next page (15-1-1/2) combine sentence with first sentence of (15-2-1/2)--NO NEW PARAGRAPH--modified to read "The algorithm allows....flow paths, using the forward particle tracking to identify locations at the *water table* (or top of the saturated zone of the Santa Fe Group/regional aquifer).

15 2 1/2 Re original line 1, see previous comments on use of term *"water table"*--much of the regional aquifer has water levels above its top, therefore has no true water table. Explain, preferably early in the Analysis (at first use of the term "water table"), referring to NEW Fig. 30(a), an E-W geologic section based on well records, showing the land surface, tops of regional aquifer (Santa Fe Group), dates and elevations of initial water levels in all wells, and true water-table elevations, all adjusted to a common "time zero", cross-referenced to this paragraph.

15 2 2 Re second sentence of paragraph, see comments (SC (TF-27-30)) for required revisions of Fig. 27 and other defective diagrams, some of which should be summarized in this section of Analysis text (e.g., show on Fig. 27 all the locations where contaminants are presumed to "enter the water table (sic)".

15 2 3 Be more specific--most readers do not have supernatural powers to read minds of authors: For "...where they exit the aquifer." read "...the wells, wellfields, springs, and contact zones with rivers or subjacent inner valley alluvium by which they discharge from aquifer elements to the Rio Grande and tributaries."

15 2 4 (A) Here, and in all uses elsewhere in Analysis (see SC (SGE), for "..capture zone.." read "..zone of origin (ZOO)...". (B) After "..aquifer.." insert "..system..". (C) Before "...Rio Grande." insert "...El..." .

15 2 5 Re "...wells on Pajarito Plateau...", (A) list all flux (especially SIP wells on Figs. 27, 29, 32 or refer to Tables/Figures containing all needed

information (period of record, annual amounts of flux, average annual flux entered into model for “(ZOO)” or “time of travel (TOT)” maps);

(B) list all well flux in the Espanola basin that was not entered into the model to map “ZOO” or “TOT”, or refer to Tables/Figures with these data and estimates; and

(C) explain why items in (B) were omitted from (A), and consequences of omission.

15 2 7/8 (A) Explain how the Buckman [ZOO] with the collector well (Fig. 29) is allegedly “..similar..” to its zone without the collector (Fig. 27), but allegedly substantially increases drawdowns (up to 50 m) in Buckman wells (see SC (13-3-6)).

[Actually, there is a significantly different reduction in the Buckman ZOO near the collector well (Fig. 29), but since the Rio Grande (Fig. 27) and collector well ZOO (Fig. 29) are aligned into the NE corners of both of these “Planar representations...” , rather than along the Rio Grande itself, these anomalies might be due to defects in modeling (arbitrary limits of ZOO study in this area?). Explain/correct problem.]

(B) The fact that (line 8)“The collector-well [ZOO] is outside LANL boundaries.” is irrelevant. What is relevant, among other factors, is that some waste sites are also “outside LANL boundaries”, according to maps prepared by LANL and made available to this reviewer (Spiegel, 2001). Unfortunately for other readers of this Analysis, the authors have kept that information a secret. along with (until (16-2) “..five water table locations in vicinity of LANL”. While the “outside “ waste sites north of LANL boundaries might not be major ones, their existence should have been acknowledged.

Most of the Analysis domain’s natural recharge, natural discharges, and well discharges, including LANL’s Guaje Canyon, Otowi, and former (1940’s to 1991) Los Alamos Canyon (now San Ildefonso Pueblo) wellfields; other wells for six Pueblos; City of Espanola and other community wells; and thousands of other wells in the Analysis domain are also “...outside LANL boundaries.”, but all of them are highly relevant to LANL’s responsibility to tell the whole truth as soon as possible, instead of hoping that no one will recognize the gross deficiencies in their technical reports. ALL RELEVANT INFORMATION , SUCH AS

(A) THE VAST AMOUNT OF OMITTED BASIN WELL FLUX, WITH DETAILED SOURCE DOCUMENTATION;

(B) DETAILED MAPS AND DATA TABLES OF ALL POINTS, REACHES, AND AREAS OF ALL TYPES OF NATURAL AQUIFER DISCHARGE;

(C) REVISED MAPS AND VALUES OF AREAL AQUIFER RECHARGE, MATCHED TO MEASURED AND ESTIMATED HISTORICAL NATURAL DISCHARGE BY “ZONES OF ORIGIN”;

(D) ACTUAL AREAS AND QUANTITIES OF HAZARDOUS WASTE DEPOSITS IN AND NEAR LANL;

(E) CORRECT ASSUMPTIONS OF ALL MODEL EXTERNAL AND INTERNAL BOUNDARY CONDITIONS; AND MOST IMPORTANT OF ALL,

(F) CORRECT GEOHYDROLOGIC CONCEPTS AND LOGICAL TERMINOLOGY FOR ALL NATURAL AND ANTHROPOGENIC PROCESSES.

15 3 all Figures 30/31 (and their captions) referred to in this paragraph need supplementary information, such as generalized land surface profiles, including indications of the location (thin vertical arrow) and altitude of the normal Rio Grande water surface, and reaches in profiles where the "water table" (sic)[water-level profile] is above (A) the top of the regional aquifer or (B) the land surface.

15 4 3/4 After "...aquifers..." insert "...and associated streamflows..."; delete "an" and for "mechanism,", read "mechanisms, because eastward fluid transport in alluvium and stream channels are much more rapid than in the regional aquifer.

Delete balance of sentence ("...both.....dispersion."); see SC (5-4-3), second paragraph, for additional discussion invalidating deleted processes.

15 4 4/8 The two sentences in these lines should be transferred to the Introduction, as a new paragraph 5 on p. 5.

15 5 1/3 For "connection", read "connections"; Delete "...connectivity..." (redundant); after "distribution of..." read "...ground-water discharge to the river and the *induced inflow to the aquifers."*

15 5 4/6 (Restate conceptually correct, and more clearly, as follows: (A)for "...size of [the] Buckman capture zone in the vicinity of [the] Rio Grande..." read "...length of the reaches in which *diverted natural discharge* and *induced diversion* of the Rio Grande occurs (both included in the *zone of origin* for Buckman well flux), both upstream and downstream of the vicinity of the Buckman wellfield."

(B) For last "...capture zones." read "...zones of origin." and add sentence "As less water would be *diverted or induced* from the Rio Grande, especially near the Buckman wellfield, the regional aquifer water-level gradients from the west toward Buckman and LANL wellfields would have to increase in compensation, taking more water from transient storage in the nonsteady transition to a new steady state. No water is taken from areal "recharge", as that water instantly becomes part of aquifer storage, whether or not wells are producing water. The physical reality is that wells first intercept natural discharge destined for rivers, and may eventually induce some loss of upstream flow from them."

15 6 2, 3,4 For "capture zones" in lines 2 and 4, read "zones of origin": in line 3, for "...captured ...west..." read "...diverted from the Rio Grande"; after "...decreases..." insert "all".

15 6 end Add following:

“Wells do not “recharge” after cessation or reduction of production, but

recover i.e., water levels in the well and surrounding aquifer rise, by inflow to the wells of water in transient storage in the entire aquifer. This correct concept can be proven by the following question: ‘What would happen to water levels in a well that has ceased production from an aquifer to which areal and lateral recharge also ceases at the same moment?’ ”

****

The following final sections (pp. 16-18 of the Analysis) are not critiqued here because they depend on highly defective antecedent work:

GROUNDWATER (SIC) TRANSPORT AND DILUTION FACTORS

SENSITIVITY ANALYSES

FINDINGS AND CONCLUSIONS

These sections depend on all the foregoing model design, which include especially model limits and their BC; locations and amounts of natural discharges to the atmosphere, springs, and certain stream reaches (few of which were identified , quantified, or mapped in detail); TOTAL well flux (HALF OF WHICH WAS OMITTED, FOR SPURIOUS REASONS, WHICH ALONE RENDERED THIS STUDY VIRTUALLY USELESS); distribution of areal recharge; basic hydrologic concepts and terminology, all of which have been SHOWN TO BE INCORRECT OR TOO VAGUE AND GENERAL TO BE VALID FOR SOPHISTICATED MODELING AND PUBLIC INFORMATION.

There are virtually no conclusions of the LANL Analysis that could not have been made in conceptually correct form, and with equal or greater accuracy (at miniscule cost compared to that of this “supercomputer model”) on the basis of pre-existing publications and open-file reports and data--especially “reasonably ascertainable” information on locations and historic diversions of water supplies by Espanola, LANL/SIP wellfield in Los Alamos Canyon, other Pueblo and non-pueblo communities, and thousands of private wells--using correct techniques of aquifer head flownet analysis, BVP analysis, and published reports on specific BVP that apply to the Espanola basin. In fact, the same general conclusions, without conceptual errors, of the Analysis were in fact made (2001-2) by the Santa Fe Water Quality Task Force, at little cost to the City or public, other than recording of proceedings and preparation and distribution of meeting minutes (most of the technical documents were produced by several Task Force members at their own cost and distributed at respective meetings). Comments on Tables and Figures (SC (TF)) and spelling and grammar (SC (SGE)) follow.

SPECIFIC COMMENTS (TABLES AND FIGURES)--(SC (TF))

GENERAL: IT IS A BASIC FACT THAT SPRINGS AND SPRING-FED RIVER REACHES ARE THE MOST IMPORTANT HYDROLOGIC FEATURES IN ANY AREA--WHY WERE THEIR EXISTENCE, ELEVATIONS, AND OTHER IMPORTANT DATA

COMPLETELY DISREGARDED, OR INADEQUATELY DOCUMENTED, IN TEXT, TABLES, AND FIGURES OF THIS ANALYSIS?

IDENTIFY ALL SPRINGS ON MAPS WITH NAME AND ELEVATION, AND IN AN "EXPLANATION" BLOCK OR RELATED TABLE, FLOW RANGE, TEMPERATURE, SPECIFIC CONDUCTANCE, AND PRINCIPAL CHARACTERIZING IONS. Also, add "tick" marks along all perennial rivers/reaches to show normal water surface elevations where model is programmed to have constant level, on all maps that show well-water levels or contours, at intervals of 10 meters or less, with thicker ticks at intervals of 50 m (e.g., Figs. 7, 8; Rev. 21, 22, 23, 24(a, b)).

TABLES:

NEW Table _A_. Historic withdrawals from wells in model domain, Espanola basin.

NEW Table_B_. Future annual withdrawals from wells/wellfields in model domain.

FIGURES: <u>[REVIEWER'S NOTE:</u> IN 50 YEARS OF TECHNICAL EDITING FOR USGS, STATE AGENCIES, AND JOURNALS, WE HAVE NEVER SEEN SUCH SLOPPY, MISLEADING, AND INCONSISTENT (WITH TEXT AS WELL AS WITH EACH OTHER) FIGURES, EXPLANATIONS (OR LACK THEREOF) CAPTIONS, AND DISREGARD OF GEOGRAPHY, HISTORIC USE, AND "OUTSIDE" TECHNICAL LITERATURE. IF THIS REPORT HAD BEEN SUBMITTED TO THE REVIEWER IN HIS CAPACITY IN THE PAST DECADE AS ASSOCIATE EDITOR OF A MAJOR HYDROLOGY JOURNAL, IT WOULD HAVE BEEN REJECTED IMMEDIATELY. Editing herein is for public education and appropriate action.

Fig. 2(a)--<u>Renumbered</u>. Lighten photo background to ease view of overprints (use color for contours if needed). Combine overprint items in "Legend" format: (1) add "Buckman wellfield (purple)"; (2) for "...as well as springs," read ""springs (red-tailed circles),"; (3) after "other water supply" read "(present LANL wellfields, green dots; former LANL--now San Ildefonso Pueblo (SIP)--green circles)"

Fig. 2(b)--<u>NEW:</u> Supplementary well-location map for all wells, wellfields, well clusters, and linear groups of wells (see NEW Tables A & B for annual withdrawals).

Fig. 3. Show elevations and temperatures of each spring under ID and elevations of normal Rio Grande water surface (at intervals of 1 or 2 m); refer to text comments in caption; at end of caption, add "(red-tailed circles)".

Fig. 4. Add flux for "previously ignored" wells; note in caption/text; revise model to include all well flux for verification or "adjustment" of aquifer properties.

Fig. 5. Add land-surface elevations and screen depths for each wellhead on graphs.

<u>Caption:</u> (gr/sp) For "Groundwater (sic) water..." read "Ground-water...".

Fig. 6. The reaches for "Discharge to Rio Grande" lines should be stated in the Caption (also see SC 6-5-3-4+), for both pre-development and after (give date ranges and sources for respective values). Add Los Alamos Canyon wellfield data (available in annual LANL water reports to 1991; note that Buckman wellfield also supplies Las Campanas (on ridge north of Cieneguilla); add (on supplementary graphs if needed) Espanola, and Pueblo well data (from water-right filings records or historical and/or legal documents at NMSEO); add all other well flux; add spring flux graph; add reference to Figs. 2 & 3 for well and spring ID and locations, plus spring elevations and temperatures (along with other key indicators of aquifer sources and depths). List sources of data values on Figure or in Caption, as well as in text description.

Fig. 7. Revise west boundary (see text SC); Caption: Add dates and sources of data.

Fig. 8. Revise west boundary; add tick marks for levels of perennial streams at intervals of ten meters; change LA wellfield red dots (six?) to purple circles (San Ildefonso Pueblo (SIP) after 1991). Add Espanola, and all Pueblo wells (both residential supply and irrigation) and revise contours where appropriate.

Caption: In line 1 give year(s) after "present", and references to sources of data (new Table?); after "dots" insert "and circles". Add "See Fig. 6 (revised) and Fig. 9 for data on six former LANL Los Alamos Canyon wells (reverted to SIP in 1992)."

Fig. 9(a). Redraw brown "Ground surface" line (thinner; also in Fig. 9(b)); correct "Valles Grande" change "Water table" to "Water-level profile" (also in Fig. 9(b)).

Fig. 9(b). Identify dot colors under Figure ("Legend" format), or in Caption.

NOTE: "Water table (sic)" profile and isopotentials 6200 to 5700 m do not agree with elevation scale or each other; use thin lines; add key values; identify line of section as "A" to "B"; add a bent leg to Buckman wellfield ("B"---"C") in profile (NEW Fig. 9(c)) and on a supplementary plan (NEW Fig. 9(d)).

Fig. 11. Label "Guaje Canyon" and add symbols for Buckman/Las Campanas wells.
Caption: Note history of LA-1(A&B) wells: they were LANL supply wells only until 1991; SIP will undoubtedly attempt to make full use of the wells in the future.

Fig. 12. Conform sizes and scopes of Fig. 11 & 12, and lighten background photo to facilitate readers' comprehension of geography in relation to sampling points; add "Explanation" block or use Caption. Caption: Add "See Fig. 11 for drainage names."

Fig. 13. DELETE.

THE FOLLOWING INFORMATION IS FOR EDUCATIONAL PURPOSES ONLY:

[Re SC(8-2-2/9)] Some related information in the source textbook (FC , 1979) is not only incorrect, but is not consistent with their own Figure (which by coincidence is correctly drawn, despite FC incorrect source instructions on drawing streamlines, but "divides" are only applicable to steady-state, symmetrical pairs of aquifer strips).

The cross-section shown might be taken as a section across a model with zero-gradient drainages normal to the page, therefore should be clarified on the figure or in the caption. The adapted figure, if used, should be simplified by using only one "valley" , such as the half-valley from D leftward to E and A, plus the mirror-image half-valley continuing leftward. This would leave room for a 3D sketch, such as Spiegel (1963, Fig. 25), which more closely represents a simple valley drained by a "normal" river (one that slopes downstream). The note "Groundwater (sic) divide", referring to two vertical planes (through points A&B and D&C, respectively) is not advisable because while the term is commonly used for the "ridge-type" feature D&C, it is not normally used for a plane through a river, such as that through A&B. It is recommended that the term be restricted to the "ridge-type" feature D&C only, and even this usage should be clarified by reference to a discussion of intra-basin "ground-water divides" (Spiegel, 1963, p. 151-3; Fig. 31; Pl. 6 &7), which suggests a different term, such as "dividing streamline" or "streamline divide". It should also be noted, both in caption and text (p. 8, par. 2) that such "divides" are not permanent , but are subject to shift by effects of pumping and/or shift of areal recharge pattern (see previous paragraph).

Caption: (A)aquifer is **saturated,** but not to the land surface; (B) after "aquifer" in line 2 add ", with uniform areal recharge" to conform to (8-2-3); (C) FC (1979) has numerous errors, particularly in notes on flow nets (Spiegel, 1981-2, Ohio State U. Syllabi for UG/G courses in Ground Water).

[HINT: "Flowpaths" (sic) are not necessarily normal to equipotentials, as stated in the FC text, although they are correctly shown in Fig. 13, for reasons which every ground-water hydrologist should learn before drawing or using flow-nets.]

Fig. 14. DELETE (SEE REVISED FIG. 14R).

THE FOLLOWING INFORMATION IS FOR EDUCATIONAL PURPOSES ONLY.

Many errors in sketches and caption: (A) river not identified in sketches (b-d); (B) **sketches (a-d) should be reduced to THREE "scenarios" of** water-level profiles at specific valley crossings (show increasing depth and extent as well flux increases from zero (just a special "scenario" in Fig. 17(a), to be re-designated "Scenario I" in the sequence of increasing flux) to successively greater flux (b) through (c); (C) caption is misleading and illogical; **use conceptually correct terms (Spiegel, 1962) to differentiate progressive stages in well diversions from original natural stream flow (GC(III)). All nonsteady stages incidentally deplete storage.**

New Scenarios that should logically be used are:

(a) Scenario I, zero well discharge, Q=0, hence no diversion; (b) Scenario II, well Q sufficiently small that ground water originally flowing to inner valley or river is diverted to well, but river-directed gradient is decreased, not reversed (*diverted natural discharge*); **(c) Scenario III, well Q is large enough to reverse hydraulic gradient from river at section crossing, which causes *induced recharge*** **(water from the river flow to the well).**

Fourth and fifth Scenarios (d, e) could be added in which the River becomes semiperched locally (d) as aquifer levels in a vertically anisotropic aquifer are drawn down sufficiently below the bottom of the fluid channel, and becomes "leaky perched"(e) as aquifer water levels below the river are drawn down sufficiently to dewater upper levels of the uppermost aquifer element. All the above Scenarios were described and illustrated by Spiegel (1962), but simplified by noting that many modern well fields are linear geometrically (like part of the present Buckman wellfield) and can be approximated as a portion of a continuous line sink or drain; revise caption.

(REVISED) Fig. 14R. Conceptual sequence of scenarios I to III (V optional) for wells with different discharges Q_i at a given distance inland from a river (or for lines of wells parallel to a river). (a) $Q=Q_a=0$; (b) $Q=Q_b>0$; (c) $Q=Q_c>>0$; etc. if desired, to (e).

Fig. 16. Invert order of rainfall values to match Fig. 17.

Fig. 18. Revise Figure and model to include ALL well flux in model area (see text comments pertaining to this Figure.)

Fig. 19. Revise Figure/model to include ALL well flux in model area (see SC pertaining to this Figure and required revisions of Fig. 19(b) to two enlarged Figures).

Fig. 20. Show date/times of data on bar graph; show water levels above msl at "zero" drawdown and msl elevation of river at nearest point on day of observation; list wells operating during days that would affect data; add well location map or refer to Fig. 3.

Fig. 21-24. See text comments on needed revisions of Figures (re SC-13).

(NEW) Fig. 21(A) [replacement for Analysis Fig. 21]. EXPLAIN WHY THERE IS NO "REAL" STEADY-STATE HEAD CONTOUR MAP IN THE ANALYSIS, BASED ON HISTORICAL DATA AROUND 1950 (USGS STUDIES AT LOS ALAMOS, SANTA FE, AND POJOAQUE AREAS), NOR ACKNOWLEDGMENT MADE for use of such data for control points?

Revise the original model (see SC (13-1-1/2), especially with respect to previously omitted well flux, revised BC (especially at inflow/outflow borders and at external and internal springs), revised areal distribution and amounts of areal recharge, and revised and more detailed connections with perennial stream reaches.

The new results should be printed in a more useful (2D -B/W)page-size (or larger) format, with N/S orientation and contour interval of 5 m, to facilitate interpretation by readers. If good reason exists, reprint 3D simulation results based on corrected model (with Jemez River and Abiquiu Dam drainages deleted) as Fig. 21(R), but the 3D version serves no apparent useful purpose, other than an illusion of science prowess. (NEW CAPTION): "Figure 21(R). Contour map of simulated pre-development steady-state hydraulic heads [m]).

(NEW)Fig. 21(G)(a). Details in enlarged portion of a vertical cross-section through Rio Grande, channel and floodplain alluvium, tributary alluvium and, upper part of regional aquifer, showing pre-development steady-state head fields at y = -127,000 m (near mouth of Los Alamos Canyon). Rio Grande was a *gaining river* by virtue of natural ground-water inflow that occurred in the Espanola Valley and most other reaches of the Rio Grande in New Mexico prior to 1928, when diversion dams, levees, and riverside drain controls were built by USBR/MRGCD, with encouragement by NM administration, legislature, and agencies (particularly NMSEO).

WATER-LEVEL TYPES: (ADD AT SIDE OF OR UNDER SECTION): Water surface of Rio Grande (solid line); water table in channel and associated alluvium (dotted line); hydraulic head of uppermost beds of Tesuque Fm. (dashed line).

NEW Fig. 26(a). Revise model; REPLACE Fig. 26 with Fig. 26(a), which includes effects of all PRESENT well flux (BUT NOT COLLECTOR)in revised model area (delete Jemez River and Abiquiu Dam tributaries, as noted re previous figures and text), but including the effects of the six San Ildefonso wells at original yields (assuming that they will be restored and used for new economic developments by the Pueblo) that prior to 1992 were used by LANL. Raise wellfield names; after “LANL”, insert “wells”.

Insert vertical black arrows with ID (RG; T/P) to indicate rivers crossed by section.

<u>Caption:</u> “Fig. 26(a). Vertical cross-section through post-development steady-state hydraulic head [m] field at y = - 133,000 m (10 times vertical exaggeration); the flowpaths represent the directions of ground-water movement from the west and east *zones of origin,* in response to all presumed future well flux in the revised model area*.* River abbreviations: RG = Rio Grande; T/P = Tesuque/Pojoaque, followed by elevations of normal water surfaces [m].

<u>NEW</u> Fig. 26(b). See <u>NEW</u> Fig 26(a) for notes to add on (1) revisions of model and their effects, and (2) wellfield and river ID notation, elevations, and arrows. On (a) 3D representation, identify Santa Fe River wellfields; on (b) plan, identify color code, LANL wellfields (qualifying the former LAC field and its probable future Pueblo use); on (c) section, add other notes given above re Fig. 25.

<u>Caption:</u> For “recharge” read *“diverted natural discharge/induced (river) recharge”;* explain in text (p. 14, par. 2), and add an enlargement of a portion of Fig. 26 (c), captioned “Fig. 26 (d) Interrelationships of waters of Rio Grande, channel alluvium aquifer element, and underlying regional aquifer (mutually leaky strata of Tesuque Fm. of Santa Fe Group) along a cross-section at model coordinate y = (same as Fig. 26(c)): Along any given cross-section the aquifer water-level gradient in the channel alluvium may be (1) toward the river (aquifer system discharging to river, but subject to reduction in gradient I*(diverted natural discharge)* by time-dependent effects of well flux anywhere in the aquifer system); (2) zero (no flow to or from river); or (3) away from the river (*induced river recharge* to aquifer system).

APPENDIX SC (SGE) PARTIAL LIST OF SP/GR ERRORS (SGE)

PAGE	PAR	LINE	COMMENTS
5	1	3/5, 7	Re “groundwater(s) (sic)” in lines 3 & 7, see GC (III)(A).

5 1 6/7 Re (A) “The[RG] is subdividing **[gr]** the basin...(Fig. 1).”

5 1 7/8 Re (B) the next sentence “Groundwaters (sic) from both parts of the basin predominantly discharge **[gr]** at the river.”, read “discharge predominantly”.

5 4 1 The word “...aquifer..” should be clarified: does it mean the entire *aquifer system,* or just one *aquifer element,* the “regional aquifer”?

7 4 3/4 Sentences 2 and 3 are too vague to be understood by most readers.

7 4 6/7 For “This observation is...” read “These observations are...”.

7 4 9/10 After “...-sections of...” insert “...the...”; after “...close to...” read “...Buckman, based on present data, ...” .

9 3 4 Grammatical errors (2) here and scattered elsewhere.

9 5 3 (gr) For “...thicker” read “...thicker, because it includes...”.

11 4 all Correct two gr errors.

12 1 5/6 For “...is compared against...”, read “...is compared to...”.

12 1 9 Read “...permeabilities of each of...”.

12 4 5, 7 gr/sp errors.

Table 5; Fig. 5 Caption: (gr/sp) For “Groundwater (sic) water...” read “Ground-water...”; Check all other Figures for similar inconsistency with standard English spelling of similar words.

REVIEWER’S REFERENCES CITED (RRC)

Spiegel (1953+), Numerous reports on Mutual Domestic Water Consumers Association (MDWCA) projects from 1953 to 1957, and other years. (p. 5).

Spiegel (1957), Expert testimony (*City of Albuquerque* vs. *S.E. Reynolds..., 1957)* in defense of the 1956 declaration of the Rio Grande Underground Water Basin (RGUWB). (RRC), p. 2.

Spiegel (1962; 1963, 1963a).

Spiegel, 1962,

TBC.......