TVA

Tennessee Valley Authority, 1101 Market Street, LP 5A, Chattanooga, Tennessee 37402-2801

August 1, 2008

10 CFR 52.79

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D.C. 20555

In the Matter of)
Tennessee Valley Authority)

Docket No. 52-014 and 52-015

BELLEFONTE COMBINED LICENSE APPLICATION – RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION – GROUNDWATER

Reference: Letter from Joseph Sebrosky (NRC) to Andrea L. Sterdis (TVA), Request for Additional Information Letter No. 062 Related to SRP Section 02.04.12 for the Bellefonte Units 3 and 4 Combined License Application, dated July 3, 2008

This letter provides the Tennessee Valley Authority's (TVA) response to the Nuclear Regulatory Commission's (NRC) request for additional information (RAI) items included in the reference letter.

A response to each NRC request in the subject letter is addressed in the enclosure which also identifies any associated changes that will be made in a future revision of the BLN application.

If you should have any questions, please contact Phillip Ray at 1101 Market Street, LP5A, Chattanooga, Tennessee 37402-2801, by telephone at (423) 751-7030, or via email at pmray@tva.gov.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on this 1 day of Aug, 2008.

Jack A. Bailey

Jack A. Bailey
Vice President, Nuclear Generation Development

Enclosure
cc: See Page 2

D085
NRO

cc: (w/Enclosure)

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M.W. Gettler, FP&L
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P. S. Hastings, NuStart
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A.M. Monroe, SCE&G
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L. Reyes, NRC/RII
T. Simms, NRC/HQ

Enclosure
TVA letter dated August 1, 2008
RAI Responses

Responses to NRC Request for Additional Information letter No.062 dated July 3, 2008
(09 pages, including this list)

Subject: Groundwater as discussed in the Final Safety Analysis Report

RAI Number	**Date of TVA Response**
02.04.12-01	This letter – see following pages
02.04.12-02	This letter – see following pages
02.04.12-03	This letter – see following pages
02.04.12-04	This letter – see following pages
02.04.12-05	This letter – see following pages

Associated Additional Attachments / Enclosures	**Pages Included**
Attachment 02.04.12-02A	3 pages
Attachment 02.04.12-02B	3 pages
Attachment 02.04.12-02C	2 pages
Attachment 02.04.12-02D	2 pages
Attachment 02.04.12-03A	3 pages
Attachment 02.04.12-03B	2 pages
Attachment 02.04.12-03C	2 pages

NRC Letter Dated: July 03, 2008

NRC Review of Final Safety Analysis Report

NRC RAI Number: 02.04.12-01

Information provided in the FSAR on private residential water wells across Town Creek is from the 1980's. Specifically, the FSAR states that

> *Private water wells listed in Table 2.4.12-201 were identified during construction of Bellefonte Units 1 and 2, and may have changed since these wells were surveyed. The State of Alabama does not require registration of private water wells; therefore, no records of existing or new private water wells were available.* (FSAR 2.4.12.2.1, p. 2.4-49)

The private residences across Town Creek are the groundwater users closest to the site with the greatest potential to be impacted by any site activities. Provide a description of the efforts undertaken to obtain updated information on these wells. Such information may include, but is not limited to, locations of private homes and other facilities likely to use water, areas served by public water supplies, locations of new wells, well depth, and water use. This issue is associated with Attachment 5, items 2 and 4, of the May 13 -16, 2008, hydrology-related safety site trip report dated June 12, 2008 (ADAMS accession number ML081610308).

BLN RAI ID: 635
BLN RESPONSE:
As no records were available from state or local agencies, visual observations were conducted during the site investigation studies in 2007 by driving past the residences on the public roads. The accessible public roads were driven along the northwest side of Town Creek. Some wells and well house features were identified, but due to lack of access to the private land, no confirmatory observations or measurements were performed. The City of Hollywood underground water supply pipeline markers and water meters were observed along County Road 113 (CR113) northwest of the community; however, none were observed within the community adjacent to Town Creek. No indication of newly installed wells was evident during the drive by survey.
In addition to the drive-by survey, it was noted that no large changes in topography were evident and no large groundwater users had moved into the area since the original 1961 survey. The only potential groundwater users noted would be single-family residential users with no multi-family buildings or commercial land use observed. The homes on the northwest side of Town Creek are outside the incorporated limits of Hollywood, Alabama, and are therefore in the unincorporated land of Jackson County. Building permits for construction of residential dwellings are not required for homes within Jackson County, outside of the incorporated areas; therefore, no public records exist of new home construction. No surface water users were observed in any of the accessible portions of Town Creek downstream of County Road 33 (CR33).

This response is PLANT-SPECIFIC.

ASSOCIATED BLN COL APPLICATION REVISIONS:
No COLA revisions have been identified associated with this response.

ASSOCIATED ATTACHMENTS/ENCLOSURES:

None

NRC Letter Dated: July 03, 2008

NRC Review of Final Safety Analysis Report

NRC RAI Number: 02.04.12-02

Applicant stated at the hydrology site visit the week of May 13, 2008, that the private residential wells across Town Creek from the proposed plant were completed in the Knox Group, and that the Knox Group and Stones River Group are hydraulically isolated from each other. (Such isolation could help to protect the private residential wells if releases occurred at the plant.) The FSAR states that within the Knox Group deposits northwest of the BLN site, large shallow closed depressions in the land surface, or sinkholes, show where significant karst development has occurred. (FSAR 2.5.1.2.2, p. 2.5-35)

Given the potential karst development of the Knox Group and the Stones River Group, provide the technical basis for the assumption that these formations are hydraulically isolated from each other in the area of Town Creek. This issue is associated with Attachment 5, item 8, of the May 13 -16, 2008, hydrology-related safety site trip report dated June 12, 2008 (ADAMS accession number ML081610308).

BLN RAI ID: 636

BLN RESPONSE:

Groundwater flow in river valleys will normally follow the surface topography prior to discharging to the adjacent river. Although the BLN site is located within a poorly developed, essentially fractured rock, subsurface groundwater system, the groundwater hydraulic characteristics behave similar to a granular groundwater system (Reference 1; Attachment 02.04.12-02A) in that flow within the fracture systems will follow basic hydraulic head principles, modified by being constrained to the fracture flow pathways. Water table groundwater flow in both systems will tend to flow toward the river (or perpendicular to equal contours of surface topography) with discharge to the river (Figure RAI-636-1; Attachment 02.04.12-02C) (Reference 2; Attachment 02.04.12-02B).

The difference between the actual groundwater pathways in a granular media and fractured rock/diffuse flow karst system are generally in the directness of the travel pathways (Figure RAI-636-2; Attachment 02.04.12-02D). In granular systems, the groundwater can travel a much more direct pathway through the subsurface than the potential pathways of the fractured system. However, the hydraulic potential driving the groundwater flow is essentially the same, resulting in groundwater flow moving down gradient via the most open pathway. Therefore, the groundwater movement on either side of the receiving water body would follow the hydraulic potential and discharge to the receiving water body.

The groundwater potentiometric surface (hydraulic head) in the adjacent land being higher than the elevation of the Town Creek Embayment makes the Town Creek Embayment a gaining stream (groundwater discharge to the stream from groundwater). Accordingly, groundwater will tend to discharge to the Town Creek Embayment, both from the BLN site and from the community across Town Creek Embayment. Because Town Creek generally flows into the Tennessee River, the overall topographic gradient would be from Town Creek towards the Tennessee River; therefore, the area wide hydraulic potential would be for groundwater to move from Town Creek to the Tennessee River, or southeast, away from the residential wells. However, since the Stones River Group appears to be less permeable than the Knox Group Formation, the majority of groundwater discharge from the community northwest of the BLN site should be into Town Creek, thus forming a subsurface hydraulic barrier to groundwater flow beneath Town Creek Embayment from the BLN site.

The BLN site overlies the Stones River Group Formation, which lies atop the Knox Group Formation. As illustrated in FSAR Figure 2.5-231, the formation dip direction beneath the site is toward the southeast and away from the residential areas across the Town Creek Embayment. Therefore, bedding plane groundwater transport would generally be hydraulically toward the southeast. Based on the dip of both formations, groundwater flow within these units would be expected to trend from the northwest to the southeast. If vertical transport of groundwater from the Stones River Group into the Knox occurred, it would likely be to a hydraulically down-gradient portion of the aquifer, and unlikely to be penetrated by the wells of the residences on the northwest side of the Town Creek Embayment. Therefore, a release from the BLN site would have little possibility of impacting the private wells on the opposite side of Town Creek.

References:

1. U.S. Environmental Protection Agency, *Ground-Water Monitoring in Karst Terranes, Recommended Protocols & Implicit Assumptions*, EPA / 600 / x-89 / 050, March 1989
2. U.S. Environmental Protection Agency, Handbook, Groundwater, Volume I: Groundwater and Contamination (EPA/625/6-90/016a), September, 1990

This response is PLANT-SPECIFIC.

ASSOCIATED BLN COL APPLICATION REVISIONS:

No COLA revisions have been identified associated with this response.

ASSOCIATED ATTACHMENTS/ENCLOSURES:

Attachment 02.04.12-02A:	U.S. Environmental Protection Agency, *Ground-Water Monitoring in Karst Terranes, Recommended Protocols & Implicit Assumptions*, EPA / 600 / x-89 / 050, March 1989, Cover and page 4
Attachment 02.04.12-02B:	U.S. Environmental Protection Agency, Handbook, Groundwater, Volume I: Groundwater and Contamination (EPA/625/6-90/016a), September, 1990, Cover and page 51
Attachment 02.04.12-02C:	Figure RAI-636-1: Hydraulic Potential for Groundwater Flow Between River Valleys
Attachment 02.04.12-02D:	Figure RAI-636-2: Comparison of Groundwater Flow Between Granular and Fractured Subsurfaces

NRC Letter Dated: July 03, 2008

NRC Review of Final Safety Analysis Report

NRC RAI Number: 02.04.12-03

The FSAR states that:

> During dry periods (July and August, 2006) a groundwater depression was observed adjacent to Town Creek to the northwest of Unit 3. This appears to represent a depletion of the epikarst aquifer and slow drainage into the lower bedrock zone. As precipitation events occur with greater frequency in September and the following fall and winter months, the epikarst aquifer refills and groundwater reestablishes its normal drainage pattern to Town Creek. (FSAR 2.4.12.2.3, p. 2.4-51; Fig. 2.4.12-214)

This interpretation of the groundwater head observations indicates downward movement of groundwater at MW-1212. Discuss why and how such downward movement of groundwater may occur.

This statement from the FSAR implies that the downward movement of groundwater (drainage into the lower bedrock zone) occurs only during relatively dry periods. Provide the technical basis for this conclusion. If the implication was not intended, provide a discussion of the relevance of the downward movement of groundwater at this location to subsurface pathways.

Please provide any other plausible explanations for the groundwater depression.

This issue is associated with Attachment 5, item 8, of the May 13 -16, 2008, hydrology-related safety site trip report dated June 12, 2008 (ADAMS accession number ML081610308).

BLN RAI ID: 637

BLN RESPONSE:

The explanation provided in the FSAR was not intended to imply that the apparent downward movement of groundwater in the vicinity of MW-1212 only occurred during dry periods, only that the phenomenon was more apparent in gauged water levels during these times.

An additional plausible explanation of the groundwater depression is a rise in reservoir level during the monitoring time period. If the river or creek stage (level) rises, with no additional precipitation input to the adjoining land, then surface water will begin recharging the groundwater aquifer along the shores of the river or creek, setting up a reverse groundwater flow (Reference 1, page 6). If the subsurface surrounding the river or creek has a high permeability (sand, gravel, etc.), this reverse flow equalizes rapidly to form a new, stable phreatic surface; however, if the subsurface is of low permeability, the equalization time may be very long, resulting in a much slower recharge and stabilization of the aquifer phreatic surface. If an adjacent monitoring well, located within this zone of influence, is gauged prior to equalization of groundwater levels to the new river stage, then the groundwater level in the monitoring well will be lower than the current river stage for that day, thus showing an apparent "depression" of the groundwater potentiometric surface at that monitoring well (Figure RAI-637-1).

The surface water elevation in Town Creek (measured at monitoring point SW-4) was compared to the groundwater elevations from monitoring wells MW-1212a and MW-1212b (Figure RAI-637-2). Data shows that in July, 2006, the surface water level in Town Creek was approximately 1 ft. higher than the groundwater elevation in monitoring well MW-1212b, completed in the bedrock, while at the same time only a few inches higher than the groundwater elevation in monitoring well MW-1212a, completed in the soil. This seems to support that the groundwater flow direction is reversed from Town Creek towards the site. Groundwater levels in the near shore soils equilibrated to the higher Town Creek surface water elevation faster than the deeper bedrock, thus downward movement of groundwater from the soils into the bedrock is apparent in areas near shore due to the longer lag time for equilibration to the surface water elevations in the bedrock than in the surficial soils. This relationship holds, to a lesser degree, through August, 2006, after which groundwater levels rise well above the influence of Town Creek and normal groundwater flow directions (towards Town Creek) are resumed.

In the context of the conceptual model, the groundwater "depression" which appears in the drier periods is removed from the conceptual model analysis as it would represent a slowing or perturbation of the transport time and distance; therefore, producing a less conservative analysis. Following the same reasoning, groundwater flows of water drawn into the deeper bedrock would also follow a longer pathway and therefore result in a less conservative analysis.

References:

1. U.S. Geological Survey, *Analytical Solutions and Computer Programs for Hydraulic Interaction of Stream-Aquifer Systems*, Open File Report 98-415A, 1998

This response is PLANT-SPECIFIC.

ASSOCIATED BLN COL APPLICATION REVISIONS:

COLA Part 2, FSAR, Chapter 2, Subsection 2.4.12.2.3, last paragraph, will be revised from:

> During dry periods (July and August, 2006) a groundwater depression was observed adjacent to Town Creek to the northwest of Unit 3. This appears to represent a depletion of the epikarst aquifer and slow drainage into the lower bedrock zone. As precipitation events occur with greater frequency in September and the following fall and winter months, the epikarst aquifer refills and groundwater reestablishes its normal drainage pattern to Town Creek.

To read:

> During the monitored dry periods (July and August, 2006) an apparent groundwater depression was observed adjacent to Town Creek to the northwest of Unit 3. This appears to represent a depletion of the epikarst aquifer combined with higher water levels in Town Creek causing a reversal in groundwater flow in the near shore soils. Groundwater elevation in the near shore soils equilibrates faster to the higher Town Creek water level than the less permeable bedrock underling the surface soils. This results in slow drainage into the lower near shore bedrock zone; however, the bedrock wells (MW-1212b and MW-1212c) do not equilibrate rapidly (due to the lower permeability) and thus show an apparent groundwater "depression". As precipitation events occur with greater frequency in September and the following fall and winter months, the epikarst aquifer refills, near shore groundwater levels rise above the Town Creek surface, and groundwater reestablishes its normal drainage pattern to Town Creek.

ASSOCIATED ATTACHMENTS/ENCLOSURES:

Attachment 02.04.12-03A:	U.S. Geological Survey, *Analytical Solutions and Computer Programs for Hydraulic Interaction of Stream-Aquifer Systems*, Open File Report 98-415A, 1998, Cover and page 6
Attachment 02.04.12-03B:	Figure RAI-637-1: Groundwater Potentiometric Surface Response to Rising Water Levels in Nearby Creeks
Attachment 02.04.12-03C:	Figure RAI-637-2: Water Level Comparison of SW-4 to MW-1212a and MW-1212b

Enclosure
TVA letter dated August 1, 2008
RAI Responses

NRC Letter Dated: July 03, 2008

NRC Review of Final Safety Analysis Report

NRC RAI Number: 02.04.12-04

From an examination of the pumping test and borehole packer test reports, it appears that the pumping test assumed a 14 ft. saturated thickness and the packer tests used 10 ft. intervals in computing hydraulic conductivity values from transmissivity estimates. It is not clear from the pumping test and borehole packer test reports whether the tests were interpreted in a manner consistent with the fractured flow observed at the site. If flow is primarily through fractures, then these hydraulic conductivity values may not be representative of the fracture permeability, and groundwater velocities based on them may underestimate the true velocities. In the pumping test report, increased head during the later part of the pumping test were attributed to a precipitation event. A rapid head response to precipitation appears consistent with high-velocity fracture flow. Provide the technical basis for interpreting the pumping test and borehole packer test results in the fractured flow geologic setting.

The pumping test report also stated that the test was conducted as a constant-drawdown test. However, the pumping level was not stabilized for several hours after the test began. Describe why the hydraulic conductivity value derived from the test is considered valid in light of this departure from constant-drawdown test conditions.

This issue is associated with Attachment 5, item 12, of the May 13 -16, 2008, hydrology-related safety site trip report dated June 12, 2008 (ADAMS accession number ML081610308).

BLN RAI ID: 638

BLN RESPONSE:

The TVA to NRC letter dated July 23, 2008, documents the actions taken to resolve specific action items associated with the NRC Hydrology Related Site Visit Trip Report. Action Item 3 required TVA to provide a revised porosity analysis. The revised hydraulic conductivity is provided in the second paragraph of the Introduction Section (1.0) of the enclosure to the subject letter, and stated, for conservatism, the highest hydraulic conductivity measured on-site to date (boring B-1046 packer test) would be used in the calculations. Although the pumping test did produce results of the same order of magnitude as the packer test, the higher hydraulic conductivity from the packer test will be used in subsequent calculations for conservatism. The pumping test value will be included as information, but will not be used in final calculations at the BLN. Since BLN is not using pumping test data, a discussion of the constant drawdown test is not provided.

The packer testing was conducted based on locations of actual fracture systems within the boreholes installed during the geotechnical boring program conducted on site during 2006. As the packer tests targeted observed fractured intervals, the results of the packer testing are representative of a fractured flow geologic setting.

This response is PLANT-SPECIFIC

ASSOCIATED BLN COL APPLICATION REVISIONS:

COLA Part 2, FSAR Chapter 2 revisions are addressed in the subject letter and by reference in this response.

ATTACHMENTS/ENCLOSURES:

None

NRC Letter Dated: July 03, 2008

NRC Review of Final Safety Analysis Report

NRC RAI Number: 02.04.12-05

Provide the technical basis for determining porosity (total and effective) and calculating groundwater velocities consistent with the conceptual model of groundwater flow and the occurrence of fracture flow at the site. This issue is associated with Attachment 5, item 11, of the May 13 -16, 2008, hydrology-related safety site trip report dated June 12, 2008 (ADAMS accession number ML081610308).

BLN RAI ID: 639

BLN RESPONSE:

The TVA to NRC letter dated July 23, 2008, documents the actions taken to resolve specific action items associated with the NRC Hydrology Related Site Visit Trip Report. Action Item 3 required TVA to provide a revised porosity analysis. The Porosity Evaluation Section (2.0) of the enclosure to the July 23, 2008, letter provides the technical basis for determining porosity (total and effective) and calculating groundwater velocities consistent with the conceptual model of groundwater flow and the occurrence of fracture flow at the site.

This response is PLANT-SPECIFIC

ASSOCIATED BLN COL APPLICATION REVISIONS:

COLA Part 2, FSAR Chapter 2 revisions are addressed in the subject letter and by reference in this response.

ATTACHMENTS/ENCLOSURES:

None

Attachment 02.04.12-02A
TVA letter dated August 1, 2008
RAI Responses

U.S. Environmental Protection Agency,

Ground-Water Monitoring in Karst Terranes, Recommended Protocols & Implicit Assumptions

EPA / 600 / x-89 / 050

March 1989

United States
Environmental Protection
Agency

Environmental Monitoring
Systems Laboratory
P O Box 93478
Las Vegas NV 89193-3478

EPA/600/X-89/050
March 1989

Research and Development

Ground-Water Monitoring in Karst Terranes

Recommended Protocols & Implicit Assumptions

U.S. Environmental Protection Agency,

Ground-Water Monitoring in Karst Terranes, Recommended Protocols & Implicit Assumptions

EPA / 600 / x-89 / 050

March 1989

Two major types of ground-water flow occur in karst aquifers-- conduit flow and diffuse flow, each of which is an end-member of a continuum. Springs and cave streams in conduit-flow systems are "flashy", as expressed by high ratios between their maximum discharge and base-flow discharge, typically 10:1 to 1000:1. Discharge responds rapidly to rainfall. Flow is generally turbulent. The waters possess low but highly variable hardness; turbidity, discharge, and sometimes temperature also very widely. Where a karst aquifer is less developed and is characterized primarily by diffuse flow, its behavior is less flashy; the ratio between maximum discharge and base-flow discharge of major springs is low (4:1 or less) , and the response of their discharge and water quality to rainfall is slower than in conduit-flow springs. Flow is generally laminar. Hardiness is higher than in conduit-flow springs, but hardness, turbidity, discharge, and temperature have low variability (Quinlan and Ewers, 1985). The variations in and relations among these properties and their variability as a function of aquifer flow, storage, and recharge have been described in a significant paper by Smart and Hobbs (1986).

Two important and seemingly contradictory points need to be made about diffuse flow:

1. Movement of water through most parts of a diffuse-flow aquifer is similar to movement of water through granular aquifers. Darcy's law is operative (Hickey, 1984; Wailer & Howie, 1988).

2. Although water from a diffuse-flow spring may be discharged from an obvious conduit, perhaps 3 m (10 ft) in diameter, the geometry and configuration of the "plumbing system" that feeds it near the orifice is trivial. Wilson and Skiles (1988) and Stone (1989) have published maps of different cave systems with more than 11 km (6.5 mi) of braided passage that feeds diffuse flow springs.

   The most significant controls on flow-type are the types of recharge and storage, as discussed by Smart & Hobbs (1986). These most influence the degree of variability of water chemistry and the magnitude, timing, and duration of response of springs and wells to storms. For very large ground-water basins there is additional dampening of response to storms as a consequence of their sheer size and the greater time necessary to transmit the storm input to their spring (White, 1988, p. 186-187). Also, individual storms will tend to overlap and seasonal trends will comprise the most obvious part of the annual record.

A quick, inexpensive way to distinguish between a conduit-flow spring and a diffuse-flow spring is to observe its turbidity

Attachment 02.04.12-02B
TVA letter August 1, 2008
RAI Responses

U.S. Environmental Protection Agency Handbook
Groundwater
Volume I: Groundwater and Contamination
(EPA/625/6-90/016a)
September, 1990

United States Environmental Protection Agency

Office of Research and Development
Washington DC 20460

EPA 625/6-90/016a
September 1990

Handbook

Ground Water

Volume I: Ground Water and Contamination

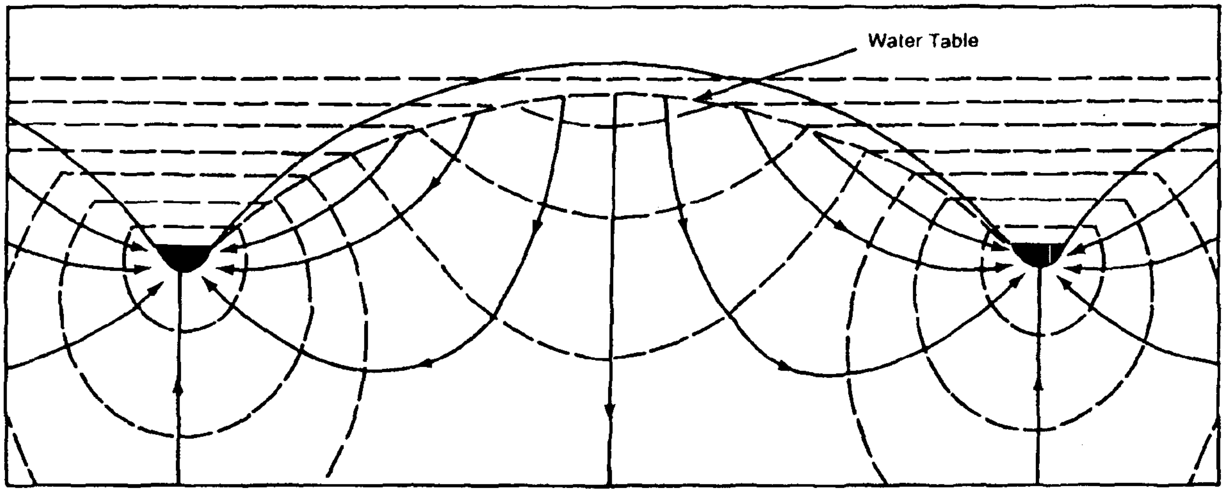


Figure 3-1. Approximate Flow Pattern in Uniformly Permeable Material between the Sources Distributed over the Air-Water Interface and the Valley Sinks (After Hubbert, 1940)

extreme to many miles in the regional case. Individual flow lines are, of course, influenced by the stratigraphy and, in particular, are controlled by hydraulic conductivity.

As water infiltrates a recharge area, the mineral content is relatively low. The quality changes, however, along the flow path and dissolved solids, as well as several other constituents, generally increase with increasing distances traveled in the subsurface. It is for this reason that even nearby streams may be typified by different chemical quality. A stream, seep, or spring in a local discharge area may be less mineralized than that issuing from a regional discharge zone because of the increase in mineralization that takes place along longer flow paths. It must be remembered, however, that other conditions, such as soil type, solubility of the enclosing rocks, surface drainage characteristics, and waste disposal practices, may have a profound effect on water quality at any particular site.

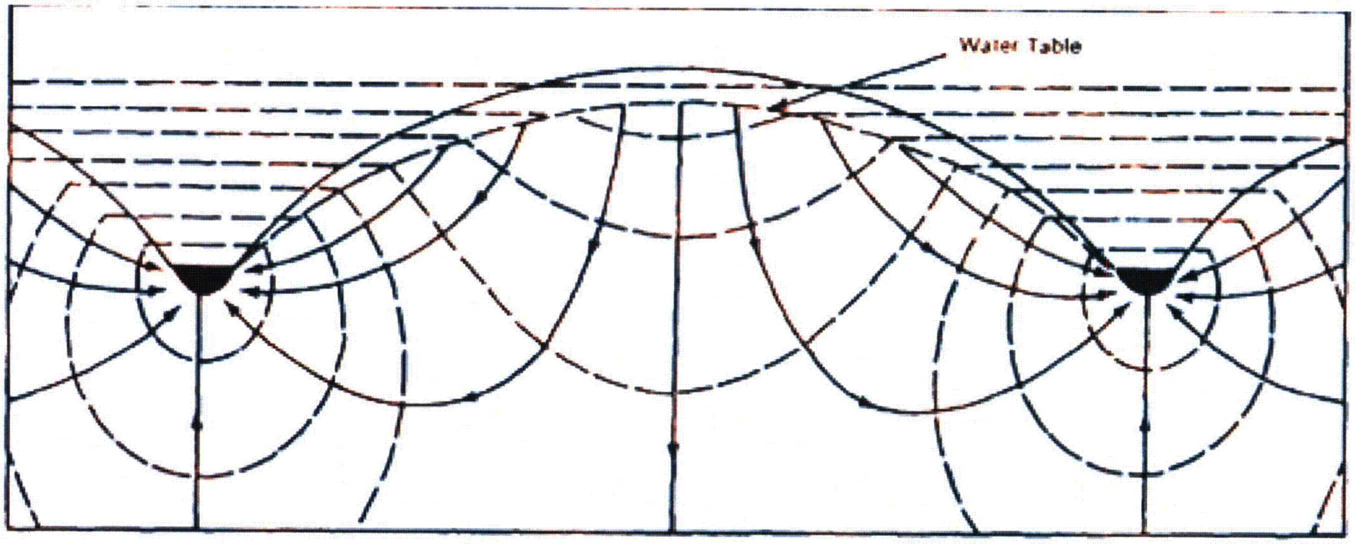
Even streams in close proximity may differ considerably in discharge even though the size of the drainage area and climatic conditions are similar. Figure 3-2 gives the superimposed hydrographs of White River in southwestern South Dakota and the Middle Loup River in northwestern Nebraska, which are good examples. White River has a low discharge throughout most of the year, but from May to September, flash floods are common. The wide extreme in discharge is characteristic of a flashy stream.

The flow of Middle Loup River is nearly constant, although from late spring to early fall higher flows may occur. These peaks, however, differ considerably from those found in White River because the increase in discharge takes place over a longer interval, the stage does not range widely, and the recession occurs more slowly. The differences in hydrographs of these two nearby rivers is puzzling, until the geology and topography of their respective basins are examined.

White River flows through the Badlands of South Dakota, an area of abrupt changes in relief, steep slopes, little vegetative cover, and rocks that consist largely of silt and clay, both of which may contain an abundance of bentonite. When wet, bentonite, a swelling clay, increases greatly in volume. As a result of these features, rainfall in the White River basin tends to quickly run off and there is little opportunity for infiltration and ground-water recharge to occur. Thus, intense rainstorms cause flash floods, such as those that occurred in June, August, and September.

The Middle Loup basin is carved into the undulating grassland topography of the Sandhills of Nebraska, where surficial materials consist of wind-blown sand. Since the low relief, grass-covered surface promotes infiltration, precipitation is readily absorbed by the underlying sand. As a result, there is very little surface runoff and a great amount of infiltration and ground-water recharge. The ground water slowly migrates to the river channel, thus providing a high sustained flow. In a comparison of the hydrographs of these two rivers, it is evident that the geologic framework of the basin

Figure RAI-636-1
Hydraulic Potential for Groundwater Flow Between River Valleys



Reference 2 (Attachment 02.04.12-02B), Figure 3-1, page 51

Figure RAI-636-1 Hydraulic Potential for Groundwater Flow Between River Valleys

Figure RAI-636-2
Comparison of Groundwater Flow
Between Granular and Fractured Subsurfaces

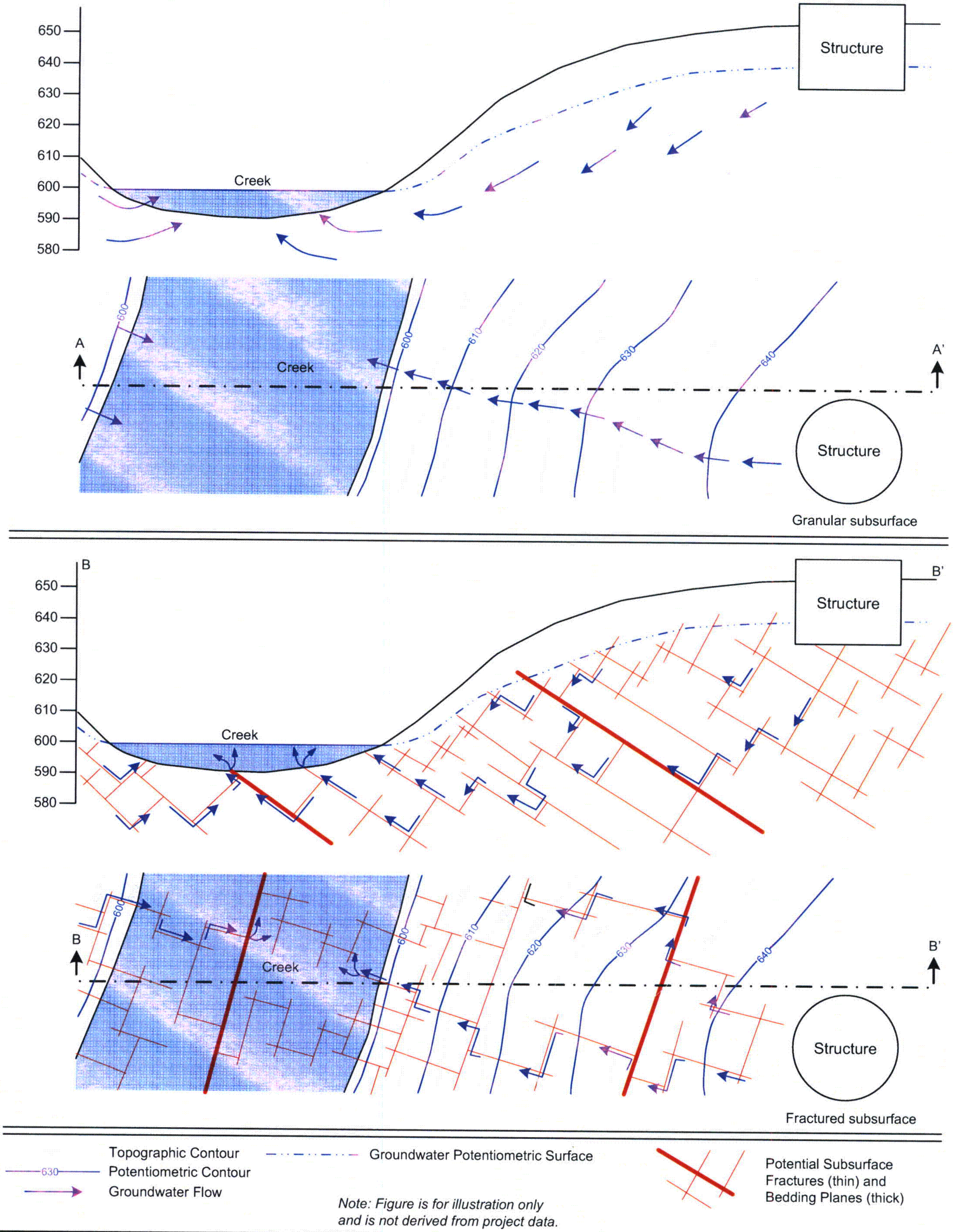


Figure RAI-636-2 Comparison of Groundwater Flow Between Granular and Fractured Subsurfaces

U.S. Geological Survey

Analytical Solutions and Computer Programs for Hydraulic Interaction of Stream-Aquifer Systems

Open File Report 98-415A, 1998

U.S. Department of the Interior
U.S. Geological Survey

Analytical Solutions and Computer Programs for Hydraulic Interaction of Stream-Aquifer Systems

By PAUL M. BARLOW and ALLEN F. MOENCH

Open-File Report 98-415A

A product of the
Ground-Water Resources Program

Marlborough, Massachusetts
1998

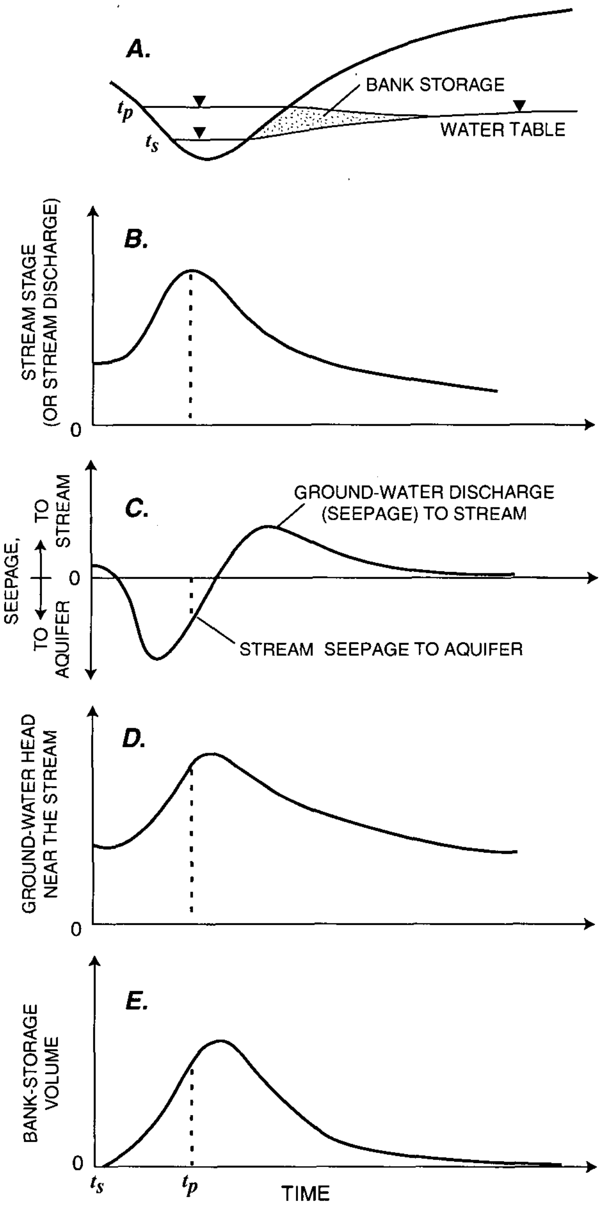


Figure 3. Response of stream-aquifer system to flood wave: (*A*) rise of stream stage and seepage of streamflow into aquifer as bank storage; (*B*) stream-stage hydrograph; (*C*) seepage hydrograph; (*D*) ground-water-head hydrograph; and (*E*) bank-storage-volume hydrograph (t_s, start of flood wave; t_p, time of flood peak). (Adapted from Freeze and Cherry, 1979, p. 227.)

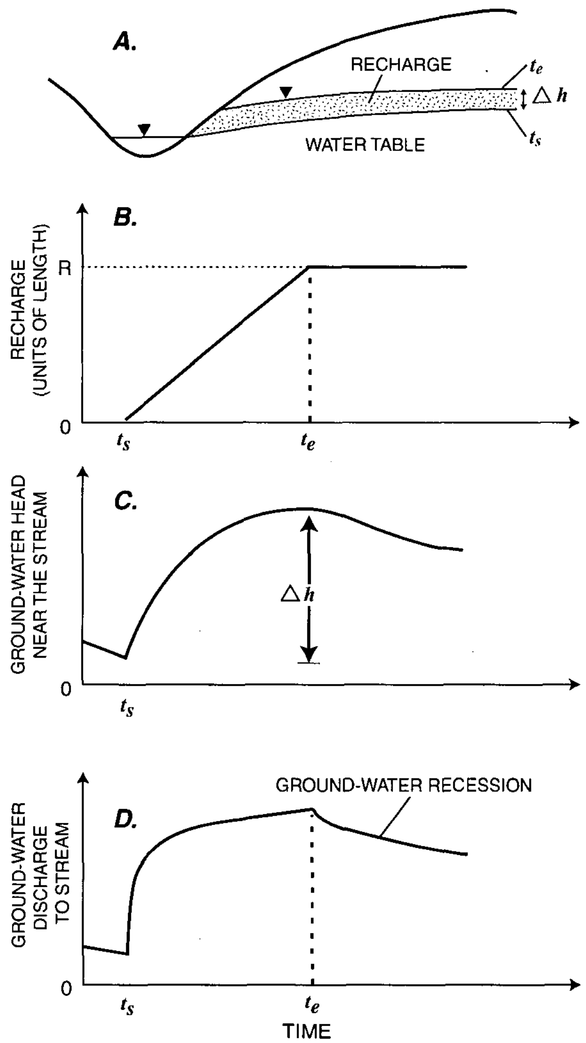


Figure 4. Response of stream-aquifer system to a gradual recharge event: (*A*) rise of water table; (*B*) recharge hydrograph; (*C*) ground-water-head hydrograph; and (*D*) ground-water-discharge hydrograph (t_s, start of recharge; t_e, end of recharge; *R*, total recharge; Δh, maximum rise of water table).

Figure RAI-637-1
Groundwater Potentiometric Surface
Response to Rising Water Levels in Nearby Creeks

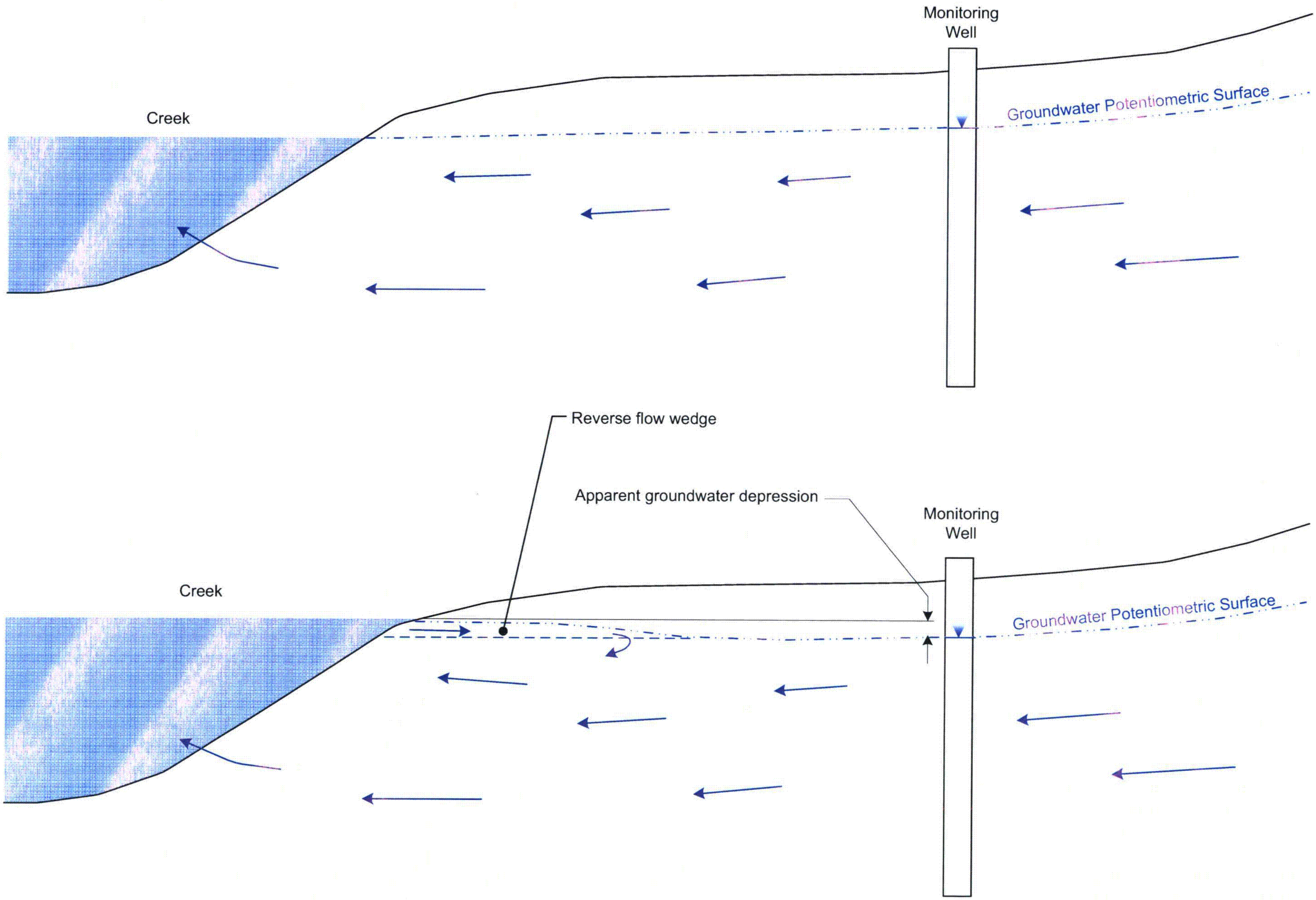


Figure RAI-637-1 Groundwater Potentiometric Surface Response to Rising Water Levels in Nearby Creeks

Figure RAI-637-2
Water Level Comparison of SW-4 to MW-1212a and MW-1212b

Figure RAI-637-2
Water Level Comparison of SW-4 to MW-1212a and MW-1212b