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EFFECTIVE, AFFORDABLE, AND SUSTAINABLE SOLUTIONS FOR LAND & WATER ENVIRONMENT

March 8, 2024

To: Mr. Richard S. Novak, Chair
Sherborn Zoning Board of Appeals
19 Washington Street
Sherborn, MA 01770

Re: Farm Road Homes 40B – Preliminary BoH Questions and Comments Regarding Septic Effluent Impact Analyses (per CLAWE 2-2-2024 update)

Dear Mr. Chair and Board Members:

Creative Land & Water Engineering, LLC (CLAWE) has received and reviewed the comment from Sherborn BoH dated February 15, 2024. This letter provides our responses. To facilitate the review, we will quote the Reviewer's comments first in italics and follow-up with our response in red.

Note: The comments hee are essentially addressed in our response to the BoH comments letter dated February 26, 2024. Therefore, this letter will only provide a brief response for reference and completeness.

Introduction

*After review of the materials submitted by the applicant for the Farm Road Homes project, including the latest updates/revisions of February 2, 2024, the Board of Health has identified a number of questions and concerns regarding aspects of the **septic effluent impact analyses**, which may include:*

- *evaluation of groundwater mounding beneath the soil absorption system,*
- *fate and transport of septic effluent constituents,*
- *water balance of the site,*
- *etc.*

For simplicity and in the spirit of addressing fundamental issues first since they may resolve other issues identified by the BoH, this preliminary memorandum will focus on basic issues of:

- *data sufficiency and appropriateness; and*
- *methodologies applied and/or needed.*

Following the Peer Reviewer's and/or applicant's responses to these concerns, the BoH will share other issues it has identified, if they remain pertinent.

*Note that the BoH's identification of questions and comments about septic effluent impact evaluations has significant overlap with the February 6, 2024 "Review of Predicted K Values" provided by Andrea Stiller of the Groundwater Protection Committee. Those issues are not reiterated in full here so as to not duplicate information. However, **if Ms. Stiller's comments are not being formally reviewed by the Peer Reviewer**, please indicate that to us and the BoH will include additional commentary in its next memorandum.*

These are critical analyses about how an atypically dense and large project may impact groundwater quality, in particular. The BoH has a responsibility to ensure that the analyses are robust so that, if health risks are identified, those risks are appropriately abated per MassHousing's instruction in its Project Eligibility/Site

Approval letter of November 2, 2022:

> *"The Applicant should be prepared to discuss the impact of the Project on water resources and private wells in the area and respond to reasonable request for mitigation."*

Data Sufficiency / Accuracy / Appropriateness

Analytical projections of impacts are sensitive to not only the methods selected but also to the input data used. Proper selection of data is a concern.

A. ***Soil type identification*** *has been oversimplified and is not consistent with Health Agent observations in the field. Photographs and field notes taken by the Health Agent support alternative interpretations.*

   Response: We have reviewed and addressed the data inconsistence with the Board during the March 6, 2024 hearing and documented in our response to BoH letter to ZBA dated February 26, 2024.

B. *Various data provided by CLAWE (12-11-2023) provide useful background information (e.g., Figures 2-5). However, their broad and approximate quality lacks the precision and detail needed for the effluent impact analyses and thus are not substitutes for* ***site-specific data*** *collection.*

   Response: We have reviewed and addressed the data inconsistence with the Board during the March 6, 2024 hearing and documented in our response to BoH letter to ZBA dated February 26, 2024. We also updated our response dated February 2, 2024 to incorporate some latest discussion and more data.

C. *Given the variability in soil/bedrock conditions on the subject property alone ("the site in general has mixed ledge outcrops in the upper hill area and very permeable soil in the lower western part of the land" CLAWE, 2-2-2024), reliance on* ***well drilling logs from neighboring properties*** *is speculative.*

   Response: We have explained the rationale of our data collection and design calculations in our response to BoH letter to ZBA dated February 26, 2024. Applying what data to our design is not speculative but rather based on solid understanding of the site condition and based on groundwater and surficial geology principles.

D. *Two* ***soil samples*** *were collected from shallow depths for lab analysis pursuant to establishing hydraulic conductivity. At this site, effluent from the soil absorption system will be migrating through to deeper soils that are different and less permeable (e.g., glacial till, as observed in test pits). Lab analysis of soil samples is not sufficient unless the subsurface is fairly homogeneous, such as the sandy, stratified drift deposits at The Fields at Sherborn.*

   Response: We have address this issue in detail in the response to the BoH letter to ZBA dated February 26, 2024, the two soil samples are merely part of the confirmation and verification to address the BoH Agent's different field notes from the design engineer, which confirmed the correct classification of the soil in the required depth by DEP Title 5 and BoH bylaw even we do not have to comply with the bylaw.

E. *What on-site soil evaluation confirmed that soils in the proposed SAS area have a **soil depth** up to 50 feet? This leads to a claim that an estimate of 25 feet to the aquifer base is conservative. (CLAWE, 12-11-2023)*

Response: This is just a read of the MGIS surficial geological map data in this area not just the SAS and as a reference. We used a data more inline with the soil testing and well drilling logs in the same geological formation as we explained in the response to the BoH letter to ZBA dated February 26, 2024 The soil in this area did show a consistent 17-25 ft of unconsolidated soils and consistent in surficial geologic point of view.

F. ***High groundwater** is claimed to be based on "the dry test pit bottom" or "the observed water tables in the two wet wells". High groundwater means the historic high and thus shall be based either on redoximorphic evidence (i.e., mottles, which are the primary determinant if present) or observed groundwater adjusted using the Frimpter method and long-term data from comparison USGS wells. References to individual or short-term observations are inappropriate for establishing expectations of high groundwater conditions.*

Response: We have addressed this issue in our response to the BoH letter to ZBA dated February 26, 2024. The design used different groundwater from both reality and Regulatory perspective to show that the groundwater mounding is conservatively calculated to assume a safe groundwater separation for wastewater effluent treatment.

Methodologies

Associated with several of the items below are comparisons with The Fields at Sherborn's effluent impact analyses. This is because it was a key prior project in Sherborn for which these sorts of analyses were performed. Overall, those analyses were more detailed and were vetted extensively across a range of participating technical representatives: consultants acting on behalf of the project applicant (CLAWE and Hydrogeocycle); staff from the peer reviewing firm Beta Groups; Sherborn's hydrogeology advisors (Nobis); and Sherborn authorities. Furthermore, Farm Road Homes shares some characteristics of that earlier project.

G. *Groundwater mounding analyses are sensitive to not only soil types but also their distribution in the soil column. **Bore hole permeability testing** is considered a more accurate technique for measuring hydraulic conductivity for a heterogeneous soil profile, such as is found in the area of the soil absorption system. Appendix C (CLAWE 12-11- 2023) mentions this method but it does not seem to have been applied.*

Response: We have addressed this issue in our response to the BoH letter to ZBA dated February 26, 2024. It is not possible to test the right condition as BoH required historic high groundwater conditions in real life. We used holistic approach from all aspects of soil evaluation, and available research for standard hydrogeological practice to determine the proper and conservative parameters for our analysis.

H. *How was **groundwater slope (flow direction)** determined? Did the evaluations distinguish between wet and dry seasons?*

Response: We have addressed this issue in our response to the BoH letter to ZBA dated February 26, 2024. As we monitored with the BoH Agent, the site has fairly weather ledge interface with the unconsolidated soil. The ground water flow direction was determined based on the observable and abutting wetland conditions. We do not see anything onsite will significantly change the groundwater flow directions during wet or dry seasons as demonstrated in widely accepted Frimpter method, which will not change flow direction and only depth of groundwater for wet or dry seasons. .

I. *For comparison, groundwater contour studies for The Fields at Sherborn involved at least a dozen **monitoring points**. What accounts for the different level of technical input for this similarly scaled project?*

Response: We have addressed this issue in our response to the BoH letter to ZBA dated February 26, 2024. Our groundwater flow was based on more than 40 soil test pits and a dozen of monitoring wells installed per BoH standards.

J. *Groundwater **mounding** results obtained using the Hantush method are "considered by experts to be a simplified version of the actual site conditions. The Hantush method can be limited by its assumptions … A common numerical method is to model site conditions using computer simulations. MODFLOW is the most widely used among the many programs that exist. While numerical modeling can provide a more accurate representation of site conditions, it also requires the user to have considerable training in order to develop the model and run simulations and interpret the results." (Minnesota Stormwater Manual)*

Response: As an expert in both surface water and groundwater study for many years, I know both Hantush and Modflow are numerical models. The right use of either one can provide needed design calculations in compliance with DEP Title 5 requirements as shown in DEP guidance for the design of much larger Groundwater discharge permit septic systems.

K. *The Hazen method for estimating **hydraulic conductivity** is not typically used. Additionally, is Wang's method for estimating permeability from percolation rates suitable to determining mounding? Percolation rate testing focuses on the immediate movement of effluent from the bottom of the soil absorption system into adjacent soils, whereas mounding is about the potential raising of the groundwater table beneath the soil absorption system, which is a deeper condition and one to be viewed over the long-term.*

Response: We have addressed this issue in our response to the BoH letter to ZBA dated February 26, 2024. Field methodology is all approximate way to apply Darcy's Law for groundwater movement while more accurate laboratory methods can only approximate the field soil condition. It does require professional training and experience to determine a proper safe parameter to use. As we explained in our response, the hydraulic conductivity used in the analysis is very consistent with the soil we observed at the site and confirmed in different aspect views of study method. Hazen method is just one of the method for conforming the parameters but not the only one.

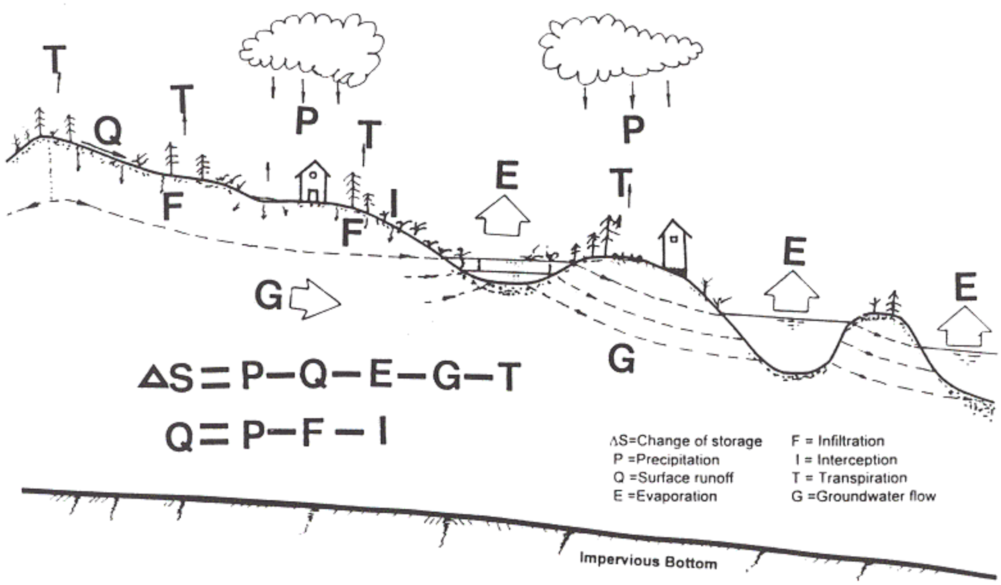
L. ***Mounding** beneath The Fields at Sherborn soil absorption system was predicted to have a maximum height of 0.81 feet (CLAWE), with relatively homogeneous sandy soils over the depth. Maximum*

mounding heights beneath Farm Road Homes soil adsorption system are predicted to be 0.91 feet for L1 and L2, and 0.81 feet for L3 (CLAWE).
Might these values change significantly with bore hole testing and/or adjustments for the heterogeneous soil profile?

Response: We have addressed this issue in our response to the BoH letter to ZBA dated February 26, 2024. We demonstrated that the groundwater mounding height will not impact the septic system design even if the mounding height is 4 times of the calculated value or 4 ft in height. The abutters consultant calculated his mounding height less than 2 ft using extreme conservative assumptions in aquifer depth and hydraulic conductivity.

M. *How has the **water budget** for the site been determined?*

Response: Water budget is a hydrology analysis illustrated in the following diagram. In a simple word, the water budget we are trying to calculate for the concern of nitrogen loading is the long term groundwater recharge volume, as G in the diagram. We attached the detailed description to this letter for our calculations. Please note, DEP is in the process updating their stormwater management regulations requiring more groundwater recharge, which is more in line with our analysis in the past 30 years that we always provided more groundwater recharge than currently required by DEP based on our more detailed hydrology analysis.



HYDROLOGIC CYCLE

N. *Once good hydraulic conductivity values are established, **dispersion analysis** can be performed to evaluate subsurface movement of septic effluent contaminants. For The Fields at Sherborn, Nobis used Domenico dispersion equations and also sought/tested 3- dimensional versions of Domenico. Nobis identified several, including those:*

- *as used for EPA's Raymark Superfund Site (Remedial Investigation Report [TtNUS #N4106], Tetra Tech NUS, Inc., 2005);*
- *in guidance from the State of California; and*
- *developed by Guyonnet and Neville (2004).*

*How does the method used for Farm Road Homes compare with those applied by CLAWE, Hydrogeocycle, Beta Groups, and Nobis for The Fields at Sherborn project? Given similarities in septic system size, soils, and climate, what accounts for the significant differences in **projected nitrogen levels** at identified receptors? Note the following site-specific distances from the downgradient edge of the soil absorption systems to the primary/nearest identified receptor of effluent plumes:*

- *for The Fields at Sherborn, approximately 600 feet to the northern edge of Dirty Meadow Swamp, reached by predicted nitrogen concentrations of 23 to 26 mg/l; and*
- *for Farm Road Homes, approximately 150 feet to the property line to the west[1], reached by predicted nitrogen concentrations of 4 to 7 mg/l.*

Response: As we explained in in our response to the BoH letter to ZBA dated February 26, 2024, the SAS is located in an aera with good large groundwater recharge area plus the additional onsite stormwater recharge, we did demonstrate that the nitrogen level will be much less than 10 mg/l for current drinking water. We do not have an acute location like the Fields, the dispersion model used there to study wells is not necessarily here to show the concentration at the property line, which is not required by Title 5.

Other

Does the Peer Reviewer have access to the functioning versions of the nitrogen loading analysis, water budget, and downgradient receptor spreadsheets (e.g., not just printouts of Appendix G's tables) to be able to review the accuracy of underlying calculations, assumptions, raw data input, etc.?

Response: Each professional can have their little different approach to calculate the water budget and nitrogen concentration in compliance with DEP guidelines. We have provided our input data and the peer review can conduct their assessment which will even be better to confirm our analysis rather than to use our proprietary program.

Feel free to contact us if you have any questions.

Sincerely,

Creative Land & Water Engineering, LLC

By

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User's Guide for the Water Budget Spreadsheet Program

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User's Guide for the Water Budget Spreadsheet Program

1.0 Introduction

The purpose of this program is to calculate a long-term, averaged water budget. It provides essential information for land use changes, specifically from pre-development to post-development conditions. The main input data is from Refs. [1], [2], and [3]. Calculations are based on the hydrologic cycle, which takes into account the change in water storage. The storage change, AS, is equal to the total precipitation, minus the infiltration, interception, evaporation, groundwater flow, and transpiration. For a physical understanding of the hydrological cycle please see Figure 1.

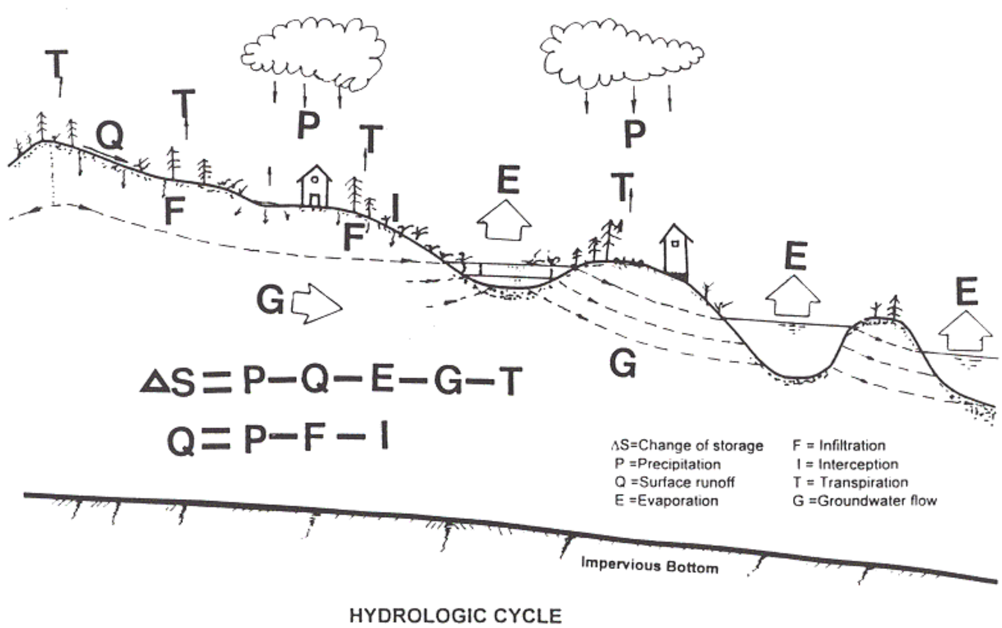

Figure 1

The program itself is written in Quattro Pro. It can be used to evaluate the water budget change from existing land use conditions to developed land use conditions. The program requires several input data including precipitation, land use, and vegetation distribution. The program then calculates the volumes of available water, recharged water, and stormwater runoff. Detailed information will be given in the following sections. For a given water budget, you are allowed to have two types of wetlands at the same time.

2.0 Input Data Description

The following information is required for the water budget calculations: (1) area, (2) percentage of each vegetation, (3) precipitation, (4) snowfall, (5) lake evaporation, and (6) runoff. The area, in acres, is broken down into specific land use types with assigned hydrologic soil groups. Land use types can be impervious (i.e. driveways, roads), lawns, meadows, forests, wetlands, or open water. The forests are further divided into two groups: deciduous and evergreen. The percent vegetation is also an important parameter to include because deciduous trees will have a different interception and transpiration loss than the evergreens. The hydrologic soil groups for area calculations are A,B, C, or D, which are based on the texture of the soil. These soil types are determined using U.S.G.S. SCS soil maps. The remaining four inputs are described below.

2.1 Precipitation

The input data for the average annual precipitation can be found on the U.S.G.S. Hydrologic Atlas#7, Ref. [2]. This is the total precipitation for both rainfall and snowfall and is entered in inches.

2.2 Snowfall

Snowfall data can be located in the Climatic Atlas of the United States, from the Department of Commerce, Ref. [4]. The annual snowfall can be translated into a relative amount of rainfall by assuming the density for new snowfall is equal to 100 kg/m'. From this assumption, every 10 units of snow depth equals 1 unit of water, Ref. [5].

2.3 Lake Evaporation

Average annual lake evaporation (in inches) is determined using the evaporation atlas by the U.S. National Weather Service, Ref. [6].

2.4 Runoff

The runoff of a particular area, given in inches, can be found on the U.S.G.S. map of mean annual runoff for the Northeastern, Southeastern, and Mid-Atlantic United States, Ref. [7].

3.0 Output Data Description

After inputting the above required data, the program calculates the following output: interception, transpiration, available water, recharge, and storm runoff. The calculations for each output are too complex to give here, however each output is be described in this section. The following equation should help relate some of these terms, and others that were given above:

$\Delta S = P - Q - E - G - T$
$Q = P - F - I - M$

where P = precipitation, Q = surface runoff, E = evaporation, G = groundwater flow, T= transpiration, F=infiltration, I = interception, M=man-made recharge (infiltration).

3.1 Interception

This is the amount of precipitation intercepted by grasses, shrubs, and trees. Interception depend on the type of vegetation. Table I lists the interception coefficients, as percentages, for the given type of vegetation and precipitation. As the interception due to trees, leaves, etc., increases the interception coefficient increases. Table 2 gives the average interception in inches with the corresponding interception coefficient for a meadow and lawn.

Table 1. Interception Coefficients.

	Deciduous	Evergreen
Snow	0.1	0.25
Rain	0.15 (with leaves) 0.07 (without leaves)	0.26

Table 2. Average Interception, with corresponding interception coefficient.

	Interception, in	Coefficient
Meadow, Ref. [8]	4.33	0.098
Lawn	4.00	0.091

3.2 Transpiration

Transpiration is the water loss through the leaves of trees. It is the last term of the water storage equation shown above. The amount of water transpired in a given area is dependent on the type of ecosystem. For example, different types of wetlands have different transpiration coefficients. The evapotranspiration coefficients for wetlands used in this program are given in Table 3.

Table 3. Evapotranspiration Coefficients for Wetlands.

Wetland Type	Coefficient
Coastal marsh	3.0
Regular marsh	2.5
Forest	1.8
Pond with leaves	0.8
Open water	1.0

3.3 Available Water

The available water is calculated in both inches and Ac-ft. it is the total water that is present either on the surface (as in storm runoff) or in the subsurface (groundwater recharge).

3.4 Recharge

The recharge is the part of precipitation which enters soils and joins the groundwater inventory. The charge is also calculated in Ac-ft. To mitigate the impact of urbanization, man-made recharge facilities, including dry wells, recharge basin, recharge trenches, and water garden are widely used to reduce surface runoff and to increase groundwater recharge. This will significantly impact the water distribution and is considered in the water budget calculation as a separate item.

3.5 Storm runoff

This indicates the average annual runoff from the study area. The storm runoff makes use of a third coefficient in the water budget program. This coefficient is given as a function of the type of soil, and depends on whether the vegetation is more like a forest or a lawn. Table 4 shows the storm runoff coefficients.

Table 4. Storm Runoff Coefficient.

Soil Type	Lawn	Forest
A	0.03	0.02
B	0.6	0.42
C	1.19	0.81
D	2.65	2.22
Other*		

*some site may have soil like Udorthents, which comprised of parts of A-C, 33%A, 44%B, and 23%C. Weighted average can be used for estimate.

4.0 Program Operation Guide

To run the water budget program, turn on a computer and enter the Quattro Pro application. Open a pre-designed water budget file, namely WB.wb2. Type in the name of your project in the appropriate space, along with your user name. The date is automatically put there. [If it is wrong, however, go ahead and change it.] Now you are ready to start entering the input data.

- As mentioned above, the annual average precipitation for the site's location can be found on the U.S.G.S. Hydrologic Atlas. Enter this value in the appropriate location on the spreadsheet.
- Using the Climatic Atlas of the U.S., determine the annual snowfall. Convert this to inches of rainfall by dividing by IO. Enter this in the appropriate location on the spreadsheet.
- Find the annual lake evaporation (in inches) from the U.S. National Weather Service evaporation atlas. Enter this value in the appropriate location on the spreadsheet.
- Enter the number of inches of runoff for the particular location, found on the U.S.G.S. map of mean annual runoff.
- Calculate the percentage of different types of vegetation present for both deciduous and evergreen plants. Mark these as either impervious, lawns, meadows, or forest plants on the water budget spreadsheet.
- Finally, enter in the area of each type of land use according to the appropriate hydrologic soil group. This should be in acres. The program automatically sums up all the areas, and this total value should equal what you have calculated.

Once all the input data has been entered, the water budget program calculates the output data described above. The completed spreadsheet can either be saved or printed, as you like. Save it under the correction directory. Print the spreadsheet by clicking on the "print" button, outlined in red or yellow.

References:

[11 "Map of Mean Annual Runoff for the Northeastern, Southeastern, and Mid-Atlantic States, Water Years 1951-90", U.S. Geological Survey Water-Resources Investigations Report 88-4094, Madison, WI, 1990.

[21 Knox, C.E. and Nordenson, T.J., "Average Annual Runoff and Precipitation in the New England-New York Area", U.S. Geological Survey, Hydrologic Investigations Atlas HA 7, Washington, DC, Undated.

[3] "Climatological Data Annual Summary, New England, 1993", National Climatic DataCenter, Asheville, NC, Vol. 105, No. 13, 1994.

[41 Climatic Atlas of the United States, ESSA, Department of Commerce, 1968.

[5] Maidment, D.R., *Handbook of Hydrology*, McGraw-Hill, Inc., N.Y., 1993.

[6] U.S. National Weather Service.

[7] Water-Resources Investigations Report 88-4094, Plate 1, Map of Mean Annual Run-off for the Northeastern, Southeastern, and Mid-Atlantic United States, Water Years 195 1 -80, U.S.G.S., Madison, WI, 1990.

[8] Chow, V.T., *Handbook of Applied Hydrology*, McGraw-Hill Book Co., N.Y., 1964.

[9] Kazmann, G. Kazphael, *Modern Hydrology*, the National Water Well Association, Dublin, OH, 1988.