96-04227

BEFORE THE
FLORIDA PUBLIC SERVICE COMMISSION

In the Matter of : **DOCKET NO. 950495-WS**

Application for a rate increase and Increase in service availability charges By SOUTHERN STATES UTILITIES, INC., for Orange-Osceola Utilities, Inc., in Osceola County, and in Bradford, Brevard, Charlotte, Citrus, Clay, Collier, Duval, Highlands, Lake, Lee, Marion, Martin, Nassau, Orange, Osceola, Pasco, Putnam, Seminole, St. Johns, St. Lucie, Volusia, and Washington Counties.

SECOND DAY - EVENING SESSION

VOLUME 10

Pages 926 through 1081

PROCEEDINGS: **HEARING**

BEFORE: CHAIRMAN SUSAN F. CLARK
COMMISSIONER J. TERRY DEASON
COMMISSIONER JULIA L. JOHNSON
COMMISSIONER DIANE K. KIESLING
COMMISSIONER JOE GARCIA

DATE: **May 1, 1996**

TIME: Commenced at 4:50 p.m.

PLACE: Betty Easley Conference Center
Room 148
4075 Esplanade Way
Tallahassee, Florida

REPORTED BY: PEGGY L. OWENS, RMR, RPR

APPEARANCES:

(As heretofore noted.)

WITNESSES

NAME	PAGE NO.
GERALD C. HARTMAN	
Redirect Examination by Mr. Feil	929
ROBERT C. EDMUNDS	
Direct Examination by Mr. Feil	938
Prefiled Direct Testimony Inserted	939
Prefiled Rebuttal Testimony Inserted	959
Cross Examination by Mr. Riley	971
Cross Examination by Mr. Twomey	982
Cross Examination by Mr. Pelligrini	1019
Redirect Examination by Mr. Feil	1029
JAMES P. ELLIOTT	
Direct Examination by Mr. Feil	1030
Prefiled Direct Testimony Inserted	1032
Prefiled Rebuttal Testimony Inserted	1040
Cross Examination by Mr. Riley	1053
Cross Examination by Mr. Twomey	1059
Cross Examination by Mr. Pelligrini	1070

EXHIBITS

NUMBER		ID.	ADMTD.
90			936
91			936
92			936
94			937
95			937
96			937
97			937
98	(Edmunds) RCE-1	971	1030
99	(Edmunds) Schedule F-7(W)	997	1030

PROCEEDINGS

(Transcript continues from Volume 9.)

CHAIRMAN CLARK: Redirect.

MR. FEIL: Thank you, Commissioners.

GERALD C. HARTMAN

resumed the stand on behalf of Southern States Utilities, and having previously been duly sworn, testified as follows:

REDIRECT EXAMINATION

BY MR. FEIL:

Q Mr. Hartman, you were asked a number of questions about the use of a five day average, and whether or not you could expect a differential of the five maximum days on average being different from the highest single maximum day.

Is it your testimony the single maximum day is what is required to use for permitting and design purposes?

A Yes.

Q And did you say earlier that you have not conducted an evaluation of the relationship between the five average days used in this case to the single maximum day used in this case?

A That's correct.

Q Did SSU do such an analysis? Was that done by Mr. Bliss, if you know?

A I don't know.

Q You said in your testimony that in this case SSU requested 100 percent used and useful on reuse for public accessory use facilities; is that correct?

A That's correct. That's the highest level of reuse facility.

Q Is it your understanding that the comments you made concerning the four different types of reuse coincide with how DEP defines reuse?

A Typically, yes, generally.

Q So the rapid infiltration basins you referred to are defined by DEP as reuse?

A Yes.

Q But do you know whether or not SSU requested rapid infiltration basins in this case to be 100 percent used and useful?

A To my knowledge, they did not. It is only the public access reuse facilities that make up the overintegrated service for public access reuse that were utilized for 100 percent use and reuse.

Q Mr. Riley asked you a number of questions about how DEP has interpreted the statutes regarding 100 percent used and useful on reuse. Do you believe that letters that DEP sent to the PSC are DEP's interpretation of those statutes?

A By their senior staff, yes.

Q Do you have the F schedules from the MFRs in front of you?

A Yes, I do.

Q Mr. Riley asked you a number of questions about whether or not the PSC had historically rounded off used and useful figures so as to give the utility 100 percent used and useful on something when mathematically it was calculated to be 90 or 95 percent. Could you refer to the MFR schedules?

A Yes.

Q Could you tell me whether or not the Commission did, in fact, do that in the last rate case?

A In the last rate case there are a lot of 96's, 97's, 98's, and things like that that were not rounded off.

Q Thank you. Are there benefits other than long-term cost benefits to the customers resulting from economies of scale?

A Oh, yes. We were only talking about a tank; but if you looked at a treatment plant, you get internal digestion of the sludge which reduces your operation and maintenance cost for sludge disposal.

You get a better treatment level. You get better protection of the environment. It is a buffer basically for the public health, safety and welfare. When you run these facilities 100 percent all the way out, it is like running your car at 120 miles an hour all the time. You are on the ragged edge. And an upset of your treatment plan, especially wastewater treatment plant, would then of course create an event which allows for pollution. But if you are below that, then the upset can be handled within the volume of the plant. So there is a lot more environmental protection, many other benefits that are not easily quantified.

Q Mr. Riley asked you a number of questions about the plants at SSU acquired from Deltona and I suppose various other plants. Then in some of those questions he asked about or he suggested that SSU was seeking to take a benefit now from plants designed by Deltona or other utilities in the past.

And the question I would like to ask you is, to the extent that Mr. Riley was suggesting that used and useful should be calculated one way for acquired facilities or facilities designed at one point in time versus used and useful for facilities designed at a subsequent point in time, do you think that such a scheme is workable?

A The used and useful percentage, once it is established, should be maintained if there is no changes. It is not workable to start creating new criterion, and then adjusting way down the used and useful or way up the used and useful. What you've got is you've got historical determined used and useful. Then you work through the regulatory requirement and get the full recovery of the investment. But, no, it is not workable to go retroactively backwards.

Q Do you think it is workable to have, for instance, if one were applying a formula approach, do you think it is workable to have one formula that applies to plants acquired at time T-1 and another formula to apply to plants required at time T-2?

A I don't think it is workable to do that. It puts the investment at risk.

Q You had a discussion with Commissioner Clark regarding the use of the peaking factor. Could you explain the relationship of the peaking factor, briefly explain the relationship of the peaking factor to design criteria?

A Yes. Like a peak hour, it is an event that would happen that you have to meet in your system that may happen due to half time in the Super Bowl or something like that. It reoccurs in a system. In a small system that peaking factor is great because everybody in that small town or that small subdivision may be doing similar things.

As you get bigger, let's say the City of Tampa, everyone in the City of Tampa will not be going to Mr., you know, Smith's party in his subdivision. The diversity of the customer base off-sets that peaking situation and dampens the peak.

So to understand the 1.3 versus the 2, in a large system where you have people doing all kinds of different things, the peaking factor for peak hour that you have to meet for the public health, safety, and welfare, you have to meet that, is lower. But when you have a smaller system, the peak factor is much greater because of commonality of use.

Q So that peaking factor is something you have to design for?

A Definitely. And it is invested, money is invested to pay for the facilities.

Q By the same token, if you design for an average of the five highest days rather than for the maximum day would you be able to meet the customer's requirements for service?

A No. Or public health, safety, and welfare requirements for the state. Regulatory requirements would not be met.

Q Is the gist of your testimony that SSU has included as used and useful the facilities required for SSU to provide service from a technical and engineering standpoint?

A All facilities require it? No, I don't think they have. I think they provided a used and useful amount less than that.

Q Thank you. Mr. Pelligrini asked you whether or not it was practical or workable for the PSC to device a way to account for the economies of scale in a formula approach.

Has SSU requested that the Commission account for economies of scale through the margin reserve calculation?

A It buttressed the margin reserve calculation, yes. There is no doubt about it. And when you consider the margin reserve, economy of scale should be a consideration in there.

MR. FEIL: I have nothing further.

CHAIRMAN CLARK: Thank you. Exhibits?

MR. FEIL: I believe SSU moves 90 and 91, which should have been Mr. Hartman's prefiled exhibits.

(Exhibit Nos. 90 and 91 admitted.)

CHAIRMAN CLARK: That's correct. 92 is a late filed exhibit.

MR. TWOMEY: 93 is --

CHAIRMAN CLARK: Just a minute.

MR. PELLIGRINI: 92 is the Hartman summary.

CHAIRMAN CLARK: It is a late-filed exhibit.

(Late-Filed Exhibit No. 92 admitted.)

MR. PELLIGRINI: All right.

CHAIRMAN CLARK: 93.

MR. FEIL: Commissioner, I have an objection to 93. It is a relatively large compendium of documents of which Mr. Hartman spoke of only one page. I mean, if Mr. Twomey wishes to ask another SSU questions regarding the other pages included in this compendium, that's fine; but in terms of what Mr. Hartman spoke of, he spoke of only one page and basically said that Mr. Twomey's questions would best be directed to SSU witness Bliss.

MR. TWOMEY: We can wait on this.

CHAIRMAN CLARK: You want to wait. Okay.

CHAIRMAN CLARK: I think 94 is a late-filed exhibit, also.

(Late-Filed Exhibit No. 94 admitted.)

MR. PELLIGRINI: Staff would move to have Exhibits 95, 96 and 97 placed into the record.

MR. FEIL: Commissioner, I have an objection to Exhibits 96 and 97.

CHAIRMAN CLARK: Okay.

MR. FEIL: And the objection is that I don't understand what issue it goes to. I don't understand the relevance of it. I don't understand the materiality of it.

MR. PELLIGRINI: Commissioner Clark, we feel these two exhibits and the line of questioning is relevant to the rate case expense, issue 93.

MR. FEIL: So it is your position these exhibits pertain only to the amount of rate case expense and the amount of charges that Mr. Hartman billed for the economies of scale evaluation, that may or may not be included in rate case expense?

MR. PELLIGRINI: Yes.

MR. FEIL: All right. With that understanding, commissioner, I will withdraw my objection.

CHAIRMAN CLARK: 96 and 97 are admitted

without objection.

(Exhibit Nos. 95, 96 and 97 admitted.)

CHAIRMAN CLARK: Thank you, Mr. Hartman. You are excused. It seems to me it may be prudent to take up Mr. Edmunds before Mr. Elliott. We will take a ten-minute break and allow Mr. Edmunds to get arranged on the stand. We will be back at ten minutes after 5:00.

(Brief recess.)

CHAIRMAN CLARK: Let's reconvene the hearing. Mr. Feil.

MR. FEIL: Mr. Edmunds. Have you been sworn?

WITNESS EDMUNDS: No, sir, I don't believe I have.

ROBERT C. EDMUNDS

resumed the stand on behalf of Southern States Utilities, and having first been duly sworn, testified as follows:

DIRECT EXAMINATION

BY MR. FEIL:

Q Could you please state your name and business address for the record?

A My name is Robert C. Edmunds, business address is 730 N. Waldo Road, Gainesville, Florida.

Q Are you the same Robert C. Edmunds for whom prefiled direct testimony in this case was filed consisting of 16 pages?

A Yes, sir, I am.

Q If I ask you the questions in that prefiled direct testimony today would your answers to those questions be the same?

A Yes, sir, they would.

Q So you have no corrections to your prefiled direct testimony?

A No, sir, I don't.

MR. FEIL: Commissioner, I ask that Mr. Edmunds prefiled direct be inserted into the record as though read.

CHAIRMAN CLARK: The prefiled direct testimony of Mr. Robert Edmunds will be inserted into the record as though read.

(Prefiled Direct Testimony of Robert C. Edmunds inserted as follows:)

DIRECT TESTIMONY OF ROBERT C. EDMUNDS, P.E.

BEFORE THE FLORIDA PUBLIC SERVICE COMMISSION

ON BEHALF OF

SOUTHERN STATES UTILITIES, INC.

DOCKET NO. 950495-WS

Q. WHAT IS YOUR NAME AND BUSINESS ADDRESS?

A. My name is Robert C. Edmunds, P.E. My business address is Jones Edmunds & Associates, Inc., 730 N. Waldo Road, Gainesville, Florida 32601.

Q. BY WHOM ARE YOU EMPLOYED AND WHAT IS YOUR POSITION?

A. I am Executive Vice President and Chief of Project Design at Jones Edmunds & Associates, Inc.

Q. WHAT IS YOUR EDUCATIONAL BACKGROUND AND WORK EXPERIENCE?

A. I graduated from the University of Florida with a B.C.E. in Civil Engineering in 1968 and an M.C.E. in Engineering in 1975. Before becoming a founding member of Jones Edmunds in 1974, I was the Manager of Plant Design at Black, Crow & Eidness, which is now CH2M Hill, in Gainesville, Florida. I am a registered professional engineer in the States of Florida, Georgia, Kentucky, Alabama, North Carolina, South Carolina, Pennsylvania, New York and Ohio. I am also a certified general contractor in the State of Florida.

I have planned, analyzed, and designed water supply, transmission, and distribution facilities of many types: those serving residential developments, multi-million dollar pipelines spanning hundreds of miles, and specialized water and fire protection facilities for launch pads at

Kennedy Space Center. My clients have included private utilities, cities, counties, and other governmental agencies.

My recent experience relative to my testimony in this case includes serving as project manager or engineer on several large scale projects for which I directed extensive hydraulic modeling. For instance, I served as project engineer for Pinellas County's comprehensive master plan for its water system. For this project, I directed a complete hydraulic analysis for maximum day, peak hour, fire flow, and other conditions for water supply, transmission, and distribution facilities serving commercial, industrial, and residential customers throughout the entire county, and I completed conceptual designs for additional supply, storage, transmission, and distribution facilities throughout the county. I also served as project manager for the West Coast Regional Water Supply Authority's master plan for the Brandon, Florida, water system. For this project, I directed extensive hydraulic modeling for the primarily residential and commercial demands of the system and completed the conceptual design of facilities and improvements needed to meet demand for the 1988-2005 planning period, including the addition of a fifteen million gallon per day wellfield and treatment plant. I also served as project engineer for Hillsborough County's evaluation of its 20-year master plan for its water system. For this project, I performed extensive hydraulic modeling for the commercial, industrial, and residential demand of the system through the 20-year planning period and completed conceptual designs for supply, transmission, and distribution main additions throughout south-central Hillsborough County.

Q. WHAT ARE YOUR PROFESSIONAL AFFILIATIONS?

A. I am a participating member of the American Society of Civil Engineers, the American Water Resources Association, the American Water Works Association, and several other professional societies and associations.

Q. HAVE YOU PREVIOUSLY TESTIFIED BEFORE THE FLORIDA PUBLIC SERVICE COMMISSION?

A. No.

Q. HAVE YOU PREVIOUSLY TESTIFIED BEFORE A STATE OR FEDERAL REGULATORY AGENCY OR IN A STATE OR FEDERAL COURT AS AN EXPERT IN THE AREA OF WATER TRANSMISSION AND DISTRIBUTION FACILITY ANALYSIS AND DESIGN?

A. Yes, I have testified as an expert in the area of water transmission and distribution facilities analysis, design, and construction on several occasions in both court and administrative proceedings. For example, I recently testified as an expert on the subject of transmission and distribution facilities design before a Division of Administrative Hearings Hearing Officer in a case concerning a request by the West Coast Regional Water Supply Authority for a 45 million gallon per day consumptive use permit. I also testified as the plaintiff's chief expert in a suit brought by Pinellas County against several parties for claims arising from pipeline deterioration.

Q. **WHAT IS THE PURPOSE OF YOUR TESTIMONY?**

A. For this case, Southern States prepared hydraulic models of its water transmission and distribution facilities in Citrus Springs, Marion Oaks, Pine Ridge, and Sunny Hills. The purpose of my testimony is to inform the Commission of the basic tenets of hydraulic modeling and of the use of this modeling in designing and evaluating transmission and distribution facilities. I will also testify that hydraulic modeling is the most accurate way of evaluating the demands placed on transmission and distribution facilities.

Q. **COULD YOU BRIEFLY EXPLAIN THE PURPOSE OF HYDRAULIC MODELING?**

A. Basically, hydraulic modeling is a means of evaluating the ability of designed or existing transmission and distribution facilities to transmit water safely and reliably under various demand conditions, including peak hour demand, maximum day demand, and fire flow conditions.

Q. **DO GOVERNMENTAL REGULATIONS OR GENERALLY ACCEPTED DESIGN CRITERIA SPECIFICALLY REQUIRE SOME FORM OF HYDRAULIC MODELING TO EVALUATE THE ADEQUACY OF TRANSMISSION AND DISTRIBUTION**

FACILITIES FOR A RESIDENTIAL COMMUNITY WATER SYSTEM PRIOR TO PERMITTING OR AT ANY OTHER TIME?

A. Over the last twenty-five to thirty years, regulations and generally accepted design criteria have undergone evolution, as has the sophistication of various modeling techniques. For instance, twenty-five to thirty years ago, which I am told is about the time the transmission and distribution facilities were designed for Southern States' Citrus Springs, Marion Oaks, Pine Ridge and Sunny Hills service locations, generally accepted engineering practice called for pipe sizes of four inches and larger within residential developments. Today, the generally accepted minimum line size for residential developments is six inches and larger, and some local government ordinances or regulations require eight inches and larger.

As a matter of accepted professional practice, design engineers rely on the guidance and direction provided in a number of authoritative publications and manuals addressing distribution facilities design in detail. DEP has incorporated some of these materials into its rules by reference. Specifically, I refer the Commission to the Recommended Standards For Water Works ("The Ten States' Standards"), a design manual incorporated by reference in Rule 62-555.330, F.A.C. In The Ten States' Standards, section 8, subsection 8.1, under the heading "Water Main Design," it states as follows:

8.1.1 Pressure. All water mains, including those not designed to

> provide fire protection, shall be sized after a hydraulic analysis based on flow demands and pressure requirements. The system shall be designed to maintain a minimum pressure of 20 psi at ground level at all points in the distribution system under all conditions of flow. The normal working pressure in the distribution system should be approximately 60 psi and not less than 35 psi.
>
> 8.1.2 Diameter. The minimum size of the water main for providing fire protection and serving fire hydrants shall be six-inch diameter. Larger size mains will be required if necessary to allow the withdrawal of the required fire flow while maintaining residual pressure specified in Section 8.1.1.

Rule 62-555.330, F.A.C., expressly states that DEP is to consider these criteria from The Ten States' Standards when evaluating permit applications to construct or alter distribution facilities.

In the way of providing an example of the local requirements which vary from jurisdiction to jurisdiction, I refer the Commission to Section 2 of Citrus County's Public Water System Design and Construction Standards, which states as follows:

> A. General Design Criteria. A water distribution network analysis shall be required with all distribution submittals. The supplying utility shall provide the available pressure and flow at the proposed

point of connection under the following flows to the proposed connection:

1. Estimated Peak Demand, as determined by the methods of AWWA publication M22, current edition, inclusive of any proposed irrigation facilities, and applicable criteria from Section I, herein, whichever is greater.

2. Fire Flow, as estimated by the criteria addressed in Section I, "Public Water Supply and Treatment Facilities."

Hydraulic modeling is the only reliable way of determining whether these design criteria are met. Several county review agencies have in recent years gone so far as to require a computer program's hydraulic model output as part of the permit application for a new water distribution system or the expansion of existing facilities. It should also be noted that, aside from these requirements, hydraulic modeling is an important tool used regularly by practicing professional engineers to evaluate the capabilities of utility facilities.

My understanding from Southern States' witness Terrero is that when Deltona Utilities, Inc. designed the transmission and distribution facilities for the locations I have referred to, it performed a Hardy-Cross analysis to evaluate the capacity of the facilities. The Hardy-Cross analysis is a type of hydraulic modeling, and its use as an aid in designing the referenced facilities would have been consistent with design requirements and practices at the time those facilities were designed. Hydraulic modeling today can be done by use of a Hardy-Cross analysis which, as evolved, can still produce a fairly reliable result, or by use of sophisticated computer programs available, such as Haestad Methods, Inc.'s Cybernet® computer software which Southern States has utilized in this case.

Q. CAN YOU GENERALLY DESCRIBE HOW COMPUTERIZED HYDRAULIC MODELING IS PERFORMED FOR EXISTING WATER TRANSMISSION AND DISTRIBUTION FACILITIES SERVING A RESIDENTIAL COMMUNITY?

A. As I indicated earlier, hydraulic modeling takes into consideration two basic categories of calculations: demand and capacity. It should also be kept in mind that transmission and distribution facilities will not only be evaluated on a network basis, but analyses are often made and needed on a component basis, where the demand and capacity of a part or portions of a network are examined based on their type and function.

The first step typically performed for a hydraulic model of existing facilities is the preparation of a schematic representation of the supply, transmission, and distribution facilities. This schematic is prepared using lines and dots representing pipes and nodes respectively. Nodes are locations in the existing piping network where water is added (supply), where water is removed (demand), and where two or more pipes intersect, including all joints where pipe diameters change. Essentially, the schematic is the framework for the capacity side of the evaluation. The next step would be to define demands to be assigned to the nodes in the model. Supply, transmission, and distribution facilities serving a residential community must, by regulation and accepted practice, be designed to meet maximum day, peak hour, and fire flow conditions. Accordingly, demand data reflecting these conditions is determined and, along with any other required information, is entered into the program input data file. The model is then compiled and the output data file created.

Q. WHAT IS YOUR TESTIMONY RELATIVE TO THE HYDRAULIC MODELING DONE IN SUPPORT OF SOUTHERN STATES' RATE APPLICATION?

A. As explained in detail by Southern States' witness Bliss, Southern States has conducted hydraulic modeling analyses for Southern States' transmission and distribution facilities in Citrus Springs, Marion Oaks, Pine Ridge and Sunny Hills. The computer software Southern States used to perform its modeling, Cybernet®, is very well regarded by and widely used in the industry and, in my experience, produces very reliable results. Further, it is my professional opinion that hydraulic modeling is the preferred and the most accurate way of evaluating the demands placed on water transmission and distribution facilities.

Q. **HAVE YOU HAD THE OPPORTUNITY TO REVIEW ANY FLORIDA PUBLIC SERVICE COMMISSION ORDERS ADDRESSING THE SUBJECT OF THE USED AND USEFULNESS OF TRANSMISSION AND DISTRIBUTION FACILITIES FOR RATEMAKING PURPOSES?**

A. Yes, Southern States has provided me copies of the order issued in Southern State's 1992 consolidated rate case -- that order was issued on March 22, 1993, in Commission Docket No. 920199-WS -- and a copy of an order in a consolidated General Development Utilities, Inc. rate case -- that order was issued March 30, 1993, in Commission Dockets Nos. 920733-WS and 920734-WS. I have reviewed the used and useful portions of both of those orders.

Q. **ASSUMING BOTH OF THOSE ORDERS ARE REPRESENTATIVE OF COMMISSION DETERMINATIONS OF USED AND USEFUL FOR WATER TRANSMISSION AND DISTRIBUTION FACILITIES, WHAT IS YOUR OPINION OF THE RELATIONSHIP BETWEEN THE RATEMAKING CONCEPT OF USED AND USEFUL AND THE ENGINEERING REQUIREMENTS FOR TRANSMISSION AND DISTRIBUTION FACILITIES?**

A. There does not seem to be a direct relationship between the two. It appears that in an attempt to allocate costs between current and future connections, the Commission would not adequately consider the criteria which a utility must follow in designing the facilities which serve both current and future connections. As a design engineer, the ramifications of the Commission's methodology are a matter of concern to me. The Commission's methodology can make it difficult for me to recommend to a private utility that its facilities be designed in accordance with regulatory requirements and accepted design criteria -- as I have a professional obligation to do -- when the Commission's allocation methodology poses an economic disincentive for the utility to construct adequately designed facilities (so as to avoid the risk of not recovering the associated investment) and an economic disincentive for the utility to take advantage of economies of scale.

Q. HAS THIS TYPE OF QUANDARY PRESENTED ITSELF IN THE COURSE OF YOUR ADVISING CLIENTS WHO ARE NOT REGULATED BY THE FLORIDA PUBLIC SERVICE COMMISSION?

A. Although cost pressures frequently come into play, I can think of no instance where those pressures acted as such a direct disincentive for proper design and utilization of economies of scale as the used and useful methodology presented in these Commission orders potentially does.

Q. IS IT YOUR TESTIMONY THAT HYDRAULIC MODELING WILL MORE ACCURATELY REFLECT THAT PORTION OF PLANT ACTUALLY UTILIZED BY CURRENT CONNECTIONS THAN

DOES THE COMMISSION'S METHOD?

A. Yes, I believe hydraulic modeling is considerably more accurate and is preferable to the method described in the orders I have reviewed. The method used by the Commission, referred to as the lot count method, does not provide an accurate representation of or consider the demands placed on transmission and distribution facilities by current connections. Current connections utilize that portion of the transmission and distribution facilities which are required to meet the existing demand conditions placed on the facilities by those connections. Hydraulic modeling will clearly demonstrate this demand.

Q. OTHER THAN A GENERALLY INACCURATE RECOGNITION OF THE DEMAND PLACED ON THE FACILITIES BY CURRENT CONNECTIONS, WHAT OTHER SPECIFIC PROBLEMS DO YOU PERCEIVE WITH THE COMMISSION'S METHODOLOGY?

A. From a design engineer's point of view, the Commission's method fails to recognize that transmission and distribution facilities must accommodate fire flow and must be designed and sized to accommodate fire flow. Further, the Commission's methodology can also, depending on the manner of its application, ignore the current connections' utilization of looped lines.

Q. WHAT PARTICULAR CONCERNS DO YOU HAVE REGARDING FIRE FLOW?

A. The design criteria and regulations I referred to earlier require that if fire flow is provided to a service area, the transmission and distribution facilities serving that area must be designed and sized to accommodate the applicable level of fire flow. This requirement is supported by the fundamental design principle that a water utility system's ability to provide reliable fire flow is only as effective as the weakest link in the withdrawal-to-delivery sequence. If the distribution lines were not designed and sized so as to accommodate peak demands plus fire flow, the utility's ability to provide reliable fire flow would be diminished. Using a hydraulic analysis as the basis for the used and useful allocation is preferable not only because hydraulic considerations for fire flow are a design requirement, but also because the hydraulic analysis will accurately portray that portion of the transmission and distribution facilities necessary to provide those connections with adequate and reliable fire flow. The Commission's lot count methodology is fundamentally flawed because it does not -- or cannot -- recognize the demand for fire flow placed on transmission and distribution facilities by current connections.

Q. **YOU HAVE SAID YOU REVIEWED THE COMMISSION'S 1993 GDU RATE CASE ORDER. DO YOU DISAGREE WITH THE COMMISSION'S REFUSAL TO RECOGNIZE FIRE FLOW FOR TRANSMISSION AND DISTRIBUTION LINES IN THAT ORDER?**

A. Yes. I believe the Commission's refusal to recognize fire flow for distribution lines simply because fire flow is considered a function of water storage is incorrect for the reasons I have just stated. Moreover, storage will not serve to put out a fire if the transmission and distribution lines are too small to handle the flow.

Q. **DO YOU HAVE ANY PARTICULAR COMMENTS WITH REGARD TO LINE LOOPING?**

A. Yes. From my experience, sound system design for residential service areas requires line looping in order to improve pressure and the continuity of quality water service throughout a distribution network. That portion of transmission and distribution facilities attributable to looping is utilized by current connections for these purposes. Under the Commission's method, portions of the transmission and distribution facilities utilized to loop the system are not subjected to direct analysis and therefore could, by using the lot count methodology, not be considered. Conversely, with hydraulic modeling, lines used for looping purposes may be specifically analyzed.

Q. **YOU MENTIONED A DISINCENTIVE FOR PROPER DESIGN POSED BY THE COMMISSION'S LOT COUNT METHOD. COULD YOU ELABORATE WHAT YOU MEAN?**

Yes. The non-recognition of the fire flow demands placed on transmission and distribution lines, for example, brings the disincentive for proper design clearly into focus. The lot count method sends an economic signal to the regulated utility to reduce its line sizes, despite design requirements to accommodate fire flow, so the utility will decrease the risk of not recovering the investment associated with proper design. The disincentive against sizing lines to meet maximum day and peak hour requirements is the same. I believe that this disincentive would be abated if the Commission used a hydraulic analysis to determine used and useful for transmission and distribution facilities.

Q. YOU ALSO MENTIONED ECONOMIES OF SCALE. IN YOUR EXPERIENCE, DO UTILITIES AND OTHER WATER SUPPLIERS GENERALLY PREFER TO CONSTRUCT TRANSMISSION AND DISTRIBUTION FACILITIES IN ORDER TO TAKE ADVANTAGE OF ECONOMIES OF SCALE?

A. Yes. Utilities and water suppliers take advantage of economies of scale by bulk purchasing materials, taking advantage of the time value of money, competitively bidding projects, parallelling water lines with other utility facilities, and minimizing other costs such as contractor mobilization costs, permitting costs, pressure testing, bacteriological testing and engineering costs. By taking advantage of available economies of scale, utilities and water suppliers can provide water at a lower per unit cost, and that lower per unit cost is in the long term best interests of the parties paying for the facilities.

Q. IS IT YOUR TESTIMONY THAT THE COMMISSION'S LOT

COUNT METHODOLOGY FOR DETERMINING USED AND USEFUL DISCOURAGES UTILITIES FROM TAKING ADVANTAGE OF THESE ECONOMIES?

A. Yes. The lot count methodology would act as a disincentive to taking advantage of economies of scale. To illustrate, under the lot count method, a water utility regulated by the Commission is discouraged from installing water lines concurrent with the electric, telephone, or other utility facilities laid by county, city, or other entities despite the fact that the water utility could save money on construction by doing so. Again, I think a hydraulic analysis would pose less of a disincentive.

Q. DO YOU HAVE ANYTHING FURTHER TO ADD?

A. No.

BY MR. FEIL:

Q Mr. Edmunds, did you also have prefiled rebuttal testimony filed in this case consisting of 11 pages?

A Yes, sir, I did.

Q Do you have any changes or corrections to those 11 pages of testimony?

A I have one in the answer given on line 18, Page 7, where my answer states in part, "regarding peak demand for equivalent residential connection in particular," the clarification requires that state, "regarding maximum day demand per equivalent residential connection in particular."

That's the only correction or clarification.

Q So if I ask you the questions in your prefiled rebuttal testimony today your answers would be the same except with that one correction?

A Yes, sir, that's correct.

CHAIRMAN CLARK: Mr. Feil, just so I'm clear on the correction, the word "peak" should be deleted and maximum day substituted?

MR. FEIL: Yes, ma'am.

CHAIRMAN CLARK: Okay. With that correction?

MR. FEIL: I would ask his testimony be inserted in the record as though read.

CHAIRMAN CLARK: With that correction, the prefiled rebuttal testimony of Robert Edmunds will be inserted in the record as though read.

(The Prefiled Rebuttal Testimony of Robert C. Edmunds is inserted as follows:)

REBUTTAL TESTIMONY OF ROBERT C. *EDMUNDS*, P.E.

BEFORE THE FLORIDA PUBLIC SERVICE COMMISSION

ON BEHALF OF

SOUTHERN STATES UTILITIES, INC.

DOCKET NO. 950495-WS

Q. PLEASE STATE YOUR NAME AND BUSINESS ADDRESS FOR THE RECORD.

A. My name is Robert C. Edmunds, P.E. My business address is Jones Edmunds & Associates, Inc., 730 N. Waldo Rd., Gainesville, Florida 32601.

Q. ARE YOU THE SAME ROBERT C. EDMUNDS WHO PREVIOUSLY PROVIDED DIRECT TESTIMONY?

A. Yes, I am.

Q. HAVE YOU REVIEWED THAT PORTION OF THE PREFILED DIRECT TESTIMONY OF OPC WITNESS TED BIDDY WHICH CONCERNS HYDRAULIC MODELING?

A. Yes, I have.

Q. DO YOU AGREE WITH MR. BIDDY'S TESTIMONY REGARDING HYDRAULIC MODELING?

A. No, I do not, and I would like to specifically address several aspects of Mr. Biddy's testimony regarding hydraulic modeling. First, it is inconceivable to me to suggest, as Mr. Biddy does, that the Commission ignore hydraulic modeling when, as I explained in my prefiled direct testimony, hydraulic modeling is the preferred and the most accurate way of quantifying the actual used capacity of water transmission and distribution facilities. Once the appropriate flow rate is selected to apply for used and useful determinations, it is indisputably true that no more valid technique exists for projecting the actual flow in each and every pipe than hydraulic modeling, short of installing devices to record simultaneous flow rate measurements in each and every pipe. This latter alternative would be so complicated and costly as to be impractical; consequently, hydraulic modeling is the only valid, realistic approach. The lot-count method cannot even be characterized as a method for evaluating used capacity and is absolutely and undeniably erroneous by comparison. I also disagree with Mr. Biddy's statements regarding calibration. Calibration is not, as he suggests, mandatory for hydraulic models in all cases. Additionally, I note that Mr. Biddy avoids entirely the importance of having used and useful considerations parallel design requirements.

Q. WOULD YOU ADDRESS MR. BIDDY'S ASSERTION THAT THE LOT-COUNT METHOD IS A BETTER METHOD THAN THE HYDRAULIC MODELING ANALYSIS TO EVALUATE USED AND USEFUL FOR DISTRIBUTION AND TRANSMISSION FACILITIES?

A. I disagree with Mr. Biddy in a very fundamental sense. Current connections utilize that portion of the transmission and distribution facilities which are required to meet the existing demand conditions placed on the facilities by those connections. The hydraulic modeling analysis will clearly quantify those demands. The hydraulic analysis is a flow-based approach similar to the flow-based approach utilized by the Commission in the past for evaluating used and useful for other components of water service facilities, and which Mr. Biddy himself recommends for those other water plant components. The lot-count method has no rational correlation whatsoever to the demand placed on transmission and distribution facilities by current customers and should be rejected on that basis alone.

Q. HAS YOUR FIRM PERFORMED A FIELD CALIBRATION OF THE TRANSMISSION AND DISTRIBUTION FACILITIES SERVING SSU'S PINE RIDGE SERVICE AREA?

A. Yes, we have.

Q. COULD YOU DESCRIBE THE RESULTS OF THAT CALIBRATION?

A. Yes. The calibration testing confirmed the validity of the hydraulic model for the east part of the Pine Ridge service area. In addition, test results clearly indicate that following installation of appropriately placed air release valves to purge entrapped air, the west part of the Pine Ridge model will achieve full calibration as well.

Q. COULD YOU DESCRIBE HOW THE PINE RIDGE FACILITIES WERE CALIBRATED?

A. Yes. A copy of the calibration report prepared under my supervision and control is identified as Exhibit 98 (RCE-1). To perform calibration, the Pine Ridge distribution facilities were hydraulically stressed at various locations by opening fire hydrants, with flows and pressures measured or computed at key locations. The field measured values then were compared with values predicted by the hydraulic model. The eastern part of the Pine Ridge model was immediately found to be satisfactorily calibrated, but the western part was found to be *experiencing* pressures as much as 13 psi lower than predicted by the model. As explained in the calibration report, experienced pressures within approximately 5 psi of modelled pressures are typically considered acceptable. Using the model as an investigative tool, a specific piping reach was found to be air bound. Upon air purging, a 12.5 psi measured versus modeled pressure disagreement was reduced to 5.3

psi. This indicates that, following installation of appropriate air release valves, the western part of the Pine Ridge model would be expected to achieve satisfactory calibration as well.

Q. **ON THE SUBJECT OF CALIBRATION, YOU SAID YOU DISAGREE WITH MR. BIDDY'S STATEMENT THAT CALIBRATION IS REQUIRED FOR HYDRAULIC MODELS THAT ARE UTILIZED TO EVALUATE USED AND USEFUL. COULD YOU EXPLAIN YOUR STATEMENT.**

A. Yes, I believe Mr. Biddy errs in stating an absolute regarding the need for calibration. Calibration is important in many cases; in other cases, it is less important. In designing new facilities, for example, modeling is relied on without the benefit of field calibration. Further, in certain cases, it is perfectly appropriate to undertake measures short of full calibration to confirm the reliability of a model's results. Whether a hydraulic model should be fully calibrated depends on a number of factors, particularly the cost-effectiveness of full calibration in light of the use being made of the model. Full calibration is a fairly expensive proposition. For the service areas the size of the four at issue in this case, complete calibration could cost anywhere in the approximate range of $25,000 to $60,000 for each service area, depending upon the difficulties encountered.

Q. COULD YOU ADDRESS THE NEED FOR FULL CALIBRATION ON THE SSU MODELS OTHER THAN PINE RIDGE?

A. There are several factors the Commission must keep in mind regarding the need for calibrating all of the models in this case. Considering all of these factors, I do not believe it necessary to require SSU to fully calibrate all four of the models submitted.

As I have stated, calibration, while always desirable, is not a mandatory industry practice in all cases. Hydraulic modeling is an important tool used regularly by practicing professional engineers to evaluate utility facilities for various purposes. In this case, the model is being used as a tool to compile flow ratios to arrive at a used and useful percentage. Considering this use to which the model is being put, I do not believe full calibration is particularly essential. However, I think it desirable to have adequate insurance that the ratios developed have a sufficient correlation to the facilities capabilities, and SSU has provided as much in this case through (1) the confirmation of the Pine Ridge model results as I have already explained and as stated in the calibration report and (2) Mr. Terrero's direct knowledge that all four of the distribution networks at issue were designed in the same way, constructed at about the same time, by the same firm, in accordance with those designs using the same materials. If deemed necessary, spot-testing of facility performance, rather than full calibration, may also be a useful verification mechanism to demonstrate that the model accurately reflects actual hydraulic performance. One additional consideration which carries somewhat more weight than those I just mentioned concerns how SSU's models were developed. In creating the steady state models for this filing, SSU made assumptions of a conservative nature, regarding ~~peak demand~~ maximum day demand per equivalent residential connection in particular, such that calibrated results would very likely reveal overall current flows throughout each distribution network higher than those in the models SSU filed. Thus, the used and useful computations should be relatively insensitive to minor variations in actual versus modeled flows.

Q. **YOU MENTIONED EARLIER THAT MR. BIDDY IGNORES THE**

IMPORTANCE OF HAVING USED AND USEFUL CONSIDERATIONS PARALLEL DESIGN REQUIREMENTS. COULD YOU EXPLAIN WHAT YOU MEAN?

A. Yes. Mr. Biddy acknowledges, at page 5 line 17 of his testimony, that mains must be sized to accommodate fireflow. He also seems to concede proper distribution network design requires system looping, for instance at page 18, line 6 of his testimony. He acknowledges, at page 15, line 8, that a hydraulic model is a reliable design tool. But he then concludes that design considerations should not be the same as used and useful considerations for distribution and transmission facilities. As I mentioned above, Mr. Biddy consistently invokes design considerations to support his views as to the used and useful percentages of all other water facility components, but eschews them as to transmission and distribution facilities.

Mr. Biddy does not address, and therefore seems wholly unconcerned with, the message the Commission sends utilities and design engineers through his proposed use of the lot-count method. As stated in my direct testimony, that message to utilities and engineers is basically two-fold: 1) design and construct transmission and distribution facilities properly at the utility's economic peril and 2) ignore available economies of scale.

Mr. Biddy states that the lot-count method recognizes an allowance for fireflow and looped lines in that current customers have allocated to them a portion of the total cost for all transmission and distribution lines throughout a service area or defined portion thereof. I believe Mr. Biddy glosses over several key points I made in my direct testimony.

Under the lot-count method, a utility's ability to recover investment associated with looping installations is entirely dependent upon the number of customers, if any, which connect directly to the loop lines. Thus, the utility's ability for meaningful recovery of investment associated with looping facilities is subject to an unknown variable. Contingent recovery of this sort, I maintain, poses little incentive to a utility to loop lines where installation of such facilities is required by design criteria to insure adequate and proper service to the customers. Mr. Biddy would put a utility in a position of being required to install looping facilities but being completely uncertain as to its ability to recover the costs therefor.

Another critical point Mr. Biddy glosses over is that the lot-count method attributes to current connections only a small fraction of that portion of the existing lines' capacity needed to meet the water service requirements of those current connections. As a result, the lot-count method provides little or no incentive to the utility to size its lines in accordance with the design standards and requirements mentioned in my direct testimony and basically penalizes the utility for proper design.

Mr. Biddy also apparently attempts to bolster his argument by stating that even under the lot-count method, current connections must bear a portion of the additional cost of a utility's sizing lines to accommodate a defined buildout condition. This, I believe, is an irrelevant consideration, primarily because a flow-based used and useful approach allocates these so-called additional costs to future customers anyway and also because current connections will benefit from the offsetting savings associated with a one-time facilities installation designed to meet a buildout condition (i.e., the economies of scale, avoided cost of facilities upgrading, and time value of money) when future connections come on line. Using Mr. Biddy's proposal, a utility would not be able to recover its full investment in transmission and distribution facilities even if the utility sized and structured such facilities to serve only current connections.

The more rational approach for measuring used and useful for transmission and distribution facilities is one which represents that portion of installed facilities utilized to meet the needs of current connections, incents a utility to follow design criteria, and incents a utility to take advantage of economies of scale. The hydraulic analysis approach fulfills all of these criteria infinitely better than the lot-count method.

Q. DO YOU HAVE ANYTHING FURTHER TO ADD?

A. No, not at this time.

BY MR. FEIL:

Q Mr. Edmunds, to your prefiled direct testimony you had no exhibits attached; is that correct?

A That is correct.

Q To your rebuttal testimony you had one exhibit attached identified as RCE-1 consisting of 48 pages?

A Yes, sir.

MR. FEIL: Madam Commissioner, I ask that RCE-1 be given an exhibit number for identification.

CHAIRMAN CLARK: It will be given Exhibit No. 98.

(Exhibit No. 98 identified.)

MR. FEIL: I tender the witness for cross.

CHAIRMAN CLARK: Mr. Riley.

CROSS EXAMINATION

BY MR. RILEY:

Q Okay. Mr. Edmunds, I have just a few questions for you. The problem we have, of course, is we have six or seven engineering witnesses all pretty much oftentimes saying the same things and supporting each other. There is some question as to the value of plodding through the same series of questions to solicit the same approximate answers from six or seven engineering witnesses. So I am endeavoring to not replod those territories that we did with several of the other witnesses.

But Mr. Edmunds, if I could direct your attention to Page 11 of your testimony.

A Which testimony sir?

Q Your prefiled direct, particularly around lines 8 through 11 were you speak of the lot count as an economic disincentive for the utility to take advantage of economies of scale.

Is it not true, though, that if a system is serving a relatively well-developed subdivision that is 80 or percent more built out that the lot count method and hydraulic analysis method would generate very similar used and useful percentages; is that true?

A I don't know where the threshold is, where the true convergence would take place. It certainly is correct that as the subdivision approaches buildout that the lot count method and the hydraulic method would be expected to converge.

Q You couldn't enlighten us at all as to --

A I don't know if it would be 80 percent or not. No, I've not studied that.

Q On Page 12 of your prefiled direct, around lines 2 through 10, you are talking about hydraulic analysis is more accurate reflecting actual use than lot count.

A That's correct.

Q My question to you is to validate a hydraulic model an engineer has to calibrate the model to be, to certain levels; is that not correct?

A I think the answer to that is that it depends on the use to which the model is being put. In some cases, calibration is not possible. In other cases, full calibration is not necessary. In some cases, full calibration is necessary.

Q And may I assume the purpose of the calibration is to attempt to verify the validity of the model?

A Yes, but my response was specific toward the purpose and use to which the model was being made. Modelling is utilized for a variety of purposes in the engineering field. So the answer to your question is it depends upon the purpose of the model.

Q Okay. But if in our case we are talking about an existing system, would the calibration be necessary to validate?

A Not necessarily. It depends upon the use, the useful purpose of the model.

Q Isn't it correct that the quantity of water carried or passed through each pipe increases with pumping pressure?

A It increases with many, many things. Pumping pressure is merely one of them.

Q What would be some of the other factors that would increase the capacity of an existing pipe?

A Increased demand.

Q Isn't it correct that the real capacity of each pipe is not necessarily limited by build-out conditions, the demand factor, that you could have a pipe that is designed let's say in our example to serve a section of say ten lots. And it is designed to serve those; but if, in fact, that section is completely built out and all ten lots are developed and connected to that line, that by increasing the pump pressure that same line could serve still another five connections? Is that an engineering --

A That's a very hypothetical question. The, I think we need to recognize that a hydraulic network is an organism that is unique. It is composed of pipes. Each pipe, if it were removed and placed in another hydraulic organism, could function at a different capacity. But in that organism, in that network, at the buildout, that is the maximum capacity that pipe would be expected to function at.

Q I think we are not talking so much about hydraulic analysis as we are that the pipe -- that as an engineer looking at a system, that normally pipes, in fact, could carry more water than build-out conditions. Or would you say otherwise, that in engineering that the pipe will only carry out what is a buildout?

A I really don't understand the context of the question. I don't understand that question. I believe I was responsive in that "a" section of pipe can be utilized in a variety of different ways and a variety of different contexts. It will function at a variety of different flows depending upon the system it is placed in or the network and the functioning of the network.

I'm sorry, I'm not trying to be evasive. I just don't understand from a technical standpoint the question.

Q From an engineering standpoint is it not possible that even the lot count method could overstate the used and useful percentage if, in fact, the pipe which is in the ground to serve buildout could, in fact, serve greater than buildout by increasing such factors as pump pressure?

A I would say no.

Q Why is that?

A It is very difficult for me to imagine any cases in which that might take place. The lot count method completely fails to recognize the conveyance capacity that is required in order to transmit flow past vacant lots. And yet, in order to service those lots that lie down stream of the vacant lots the piping has to be in the ground abutting those vacant lots.

So it is my opinion that the lot count method is always biased on the low side, that it doesn't reflect reality at all, and that it is irrational and an erroneous technique to attempt to simulate reality with.

Q And nevertheless, though, as an engineer it is possible that these lines could, in fact, be understated if these pump pressures are increased?

A Only if the buildout is incorrect; and in fact, the buildout is greater than the buildout that is being used in the computations. But that isn't the context of your question, as I understand it.

Q On this same page, and even going over to Page 13, you talk about the lot count method does not recognize fire flow. You say that the lot count method fails to recognize water main size and cost to accommodate fire flow and loop lines. However, isn't it correct that lot count method still uses the same cost that includes those loop lines and proper size mains for fire flow?

A No. The lot count method completely neglects lines that are looped -- that need to be looped -- to provide reliable service, to provide chlorine residual, and to provide fire flow, unless those lines happen to be abutted by an occupied lot. But in order to provide the level of service, and in order to provide the quality of drinking water that the regulations require, looping is required.

Q So you are suggesting that the lot count method does not count the loop lines and the proper size mains, that the lot count does not take into account the entire distribution system?

A That is correct. It doesn't take into account the entire distribution system until it approaches buildout. When, in fact, theoretically, using your hypothetical, all lots would be built upon; in which case, presumably the lots that abut those line loops would also be built upon, and the loops, themselves, would have some used and useful attributed to them.

But the problem with the lot count technique is that it is completely erroneous and does not in any way simulate the hydraulic reality of a water system.

Q Well, I understand your opinion on that point, but isn't the lot count applied to the total cost of the system?

A The lot count is applied incrementally to each pipe on the basis of the frontage of property that abuts that pipe. It makes no allowance for whether that pipe is required to be placed in the ground in order to provide service in the system.

Q So your understanding of the lot count method is that there is, that it is not applied to the total cost of the complete system, but somehow portions of the system are deemed not even plant in service?

A The lot count method allocates used and useful costs on the basis of which lots are occupied. And that is not the reality of the way the system functions hydraulically.

Q Do you understand what I'm trying to say about the difference between plant in service and rate base? Are you suggesting that the lot count method is a means used by Public Counsel or any other intervenor to get utility plant to not even be considered plant in service?

A I guess I don't understand your question. Maybe you need to rephrase it in a fashion that I will understand.

Q Do we not apply the lot count methodology against the total cost of all of the utility plant in service to arrive at a used and useful figure?

A Yes.

Q So I'm not sure how applying that methodology -- you will have to explain to me how that takes out or reduces the size of lines that are sized for fire flow, or comes over here and takes out three of the loops that are otherwise part of the plant in service, and doesn't take those into account because we are applying a percentage against these elements of the system which are part of plant in service.

A My understanding of the way that the lot count is applied is that it does not take into account fire flow, A. And it does not take into account loops that may be necessary in the system for water quality purposes, but are not involved in the early distribution of local flow.

Q Well, if I told you, though, that the lot count method is applied against the total cost of plant in service, which includes these loops you are speaking of, which includes a larger diameter of pipe that is sufficient to take care of fire flow, would you change your opinion --
A No, I would not.
Q -- about the lot count method?
A No, I would not.
Q Okay.
A The reason that I would not is that the lot count method does not reflect the hydraulic reality of what actually happens in the system.
Q Let's turn, if you would, to Page 14 and 15 of your prefiled direct. Here you state that the lot count method encourages the utility to reduce the water main size; is that correct?
A Yes.
Q Has the PSC ever used the lot count method to alter an engineer's design?
A I don't know whether the PSC has done that or not. I know the lot count approach coerces, by virtue of the way it is structured, the utility to put in less than the minimum requirements.
Q Well, but if we have a series of lots out

there and we are dealing with a 12-inch water main, does the lot count used and useful percentage change when you use a 12-inch water main instead of a six-inch water main? Isn't it just the same percentage being applied against whatever plant in service is there serving the customers?

A That is correct. The problem, though, is that hydraulically more actual capacity on a percentage basis is required in the hydraulic system than the lot count method allows for.

Q And yet the main size -- I mean, I understand the company is not recovering as much money as a result of applying the lot count method, but to suggest that it is changing the size of the mains is the thing we had a problem with.

A Well, you know, I don't understand your problem, because hydraulically the system does not function the way the lot count method infers that it functions. Hydraulically, a greater pro rata share of the installed system capacity is required hydraulically than the lot count method permits.

As a consequence, there is a financial pressure on the utility to do less than that which is necessary in order to provide appropriate level of service and to comply with the regulations.

MR. RILEY: No further questions.

CHAIRMAN CLARK: Mr. Twomey.

CROSS EXAMINATION

BY MR. TWOMEY:

Q Good afternoon, sir.

A How are you, sir?

Q I'm good, thanks. Did you drive here or fly?

A Drove.

Q Let's say you were, say you were flying to Atlanta and you got on the airplane, and it had 100 seats, and only ten of the seats were occupied. Would you expect to pay for the full cost of the aircraft, you and your nine fellow passengers, or would you expect to pay some type of a tariff rate?

A I would expect to pay a tariff rate, but I would not expect the pilot to fly me 10 percent of the way and then say he couldn't take me the other 90 percent of the way.

Q Okay. Let me ask you, you've got pretty extensive credentials here. You are a professional engineer.

A Yes, sir.

Q I wanted to ask you on Page 2 --

A Which testimony, please.

Q I'm sorry, your direct, line 19. It starts out, "I also served as project engineer for the Hillsborough County's evaluation of its 20-year master plan."

In that regard, I want to ask you did you have an opportunity to conduct any used and useful analysis of that system for economic rate setting purposes?

A No, we did not.

Q What was your assignment in that regard?

A The assignment was to basically bring that system into the 20th century. It was a series of very marginal, developer-constructed systems that did not function well. It had zero chlorine residual in some locations, negative pressures at maximum demand periods at some locations.

And our charge was to provide a master plan that would provide a unified water system, made the regulations, met the requirements for dependable service, and then to master plan the design of the piping network, pumping and treatment facilities, and to implement the design of the pumping and treatment facilities.

Q I take that to mean that you were commissioned to do that job and to do an engineering task.

A Comprehensive master planning and design and construction.

Q But it did not involve economic rate setting?

A No, we did not set the rates.

Q You would concede, would you not, sir, irrespective of what your other views are on hydraulic analysis versus the connected lot, that this setting here is one of economic rate setting; right?

A I would concede that this is a setting of economic rate setting. I would not concede that the rate setting should be divorced from reality.

Q So you are saying that these people are divorced from reality in what they established in the last case?

A I would say, as my testimony states, that the lot count technique for determining used and useful is divorced from reality.

Q Your testimony is it is divorced from engineering design reality; isn't that correct?

A No, I'm saying it is divorced from the physical reality from the way the system actually works and it has to work.

Q The way the system has to work?

A The way the network that is being reviewed has to work.

Q Okay. Help me understand this. Let's say that I come to you and I have some land I want to develop. And I have a three-mile stretch, and I want you to lay water pipe, a single main down the three miles. It stops at the end of three miles. I want to put 100 homes on that system, okay?

A All right.

Q I assume you have to make some type of assumptions on -- and I want you to design it for 100 homes, okay?

A (Nodding head.)

Q What type of assumption do you make or would you make for the consumption of each home?

A That would depend on the area. I tend to distrust rules of thumb and prefer to use local information from comparable water systems, if I can; if not, regional information. Generally, some --

COMMISSIONER GARCIA: What do you mean by information from local water systems? Are you talking about their pricing schemes or their cost of service?

WITNESS EDMUNDS: No, sir, I'm talking about consumption information. For example, the water consumption in Minnesota is very different from the water consumption in Florida. So I would, I would prefer to, rather than use national rules of thumb, I prefer to use data that is as local as possible.

If, for example, this three-mile stretch of pipeline were an adjunct to an existing network, my preference would be to go into that network and determine what is happening within that network from the standpoint of average day flow, max day flow, peak hour flow, and then use that data in the planning and the design of the facility.

BY MR. TWOMEY:

Q If you used local data, would you come up with some figure like two gallons per minute per connection or something in that -- I mean, not that number, is that the kind of thing you look for?

A I would come up with all of the variables that are used in design.

Q Okay.

A Of which would be average day flow, max day flow, peak hour flow.

Q Okay. And then you would design the pipe to accommodate that, right?

A That plus the projections of growth, yes, I would.

Q I'm sorry, I asked you to design it for 100 homes.

A Yes.

Q Period.

A Well, if that is the ultimate limit, then that is what I would design it for.

Q Now --

A If there was a possibility of more, I might have some conversations about the future.

Q Yes, sir. Now, you get, if -- you build the system and advise the developer sell the last lot at the end of the three miles, and it is connected to the system, how much is the hydraulic capacity of that system might that one home take?

A That would depend upon the time for buildout and the decisions that were made about the piping, interim and ultimate piping. It would also depend upon the regulations that were applied to that specific subdivision area.

Q Yes, sir, but I guess that wasn't specific enough in my assumptions. I want you to build the entire system at one time. Assume that 100 people are going to move in. I don't want to go ripping up any of the main as people add on. Okay. I want to let them build wherever they darn well please on that three mile stretch, okay?

Now, given those assumptions, if I move myself in, in the very last lot, furthest lot away from the water treatment plant, it strikes me that every foot of that main from my house to the water treatment plant is necessary to serve me.

A That's absolutely right. That's the point.

Q That's what I thought you were saying. You are saying, are you not, that if there was one home, one customer at the very end of my system, that under hydraulic analysis methodology that home, that customer is responsible for 100 percent of the system; right?

A No, I did not say that.

Q I'm sorry. What did you say?

A I said that every foot of that main was necessary. I agreed with you that every foot of that main is necessary.

Q Well, what hydraulic capacity, what percentage of the hydraulic capacity of the entire system approximately would be necessary to serve me at the end?

A Well, I don't know until I know the way the numbers roughly come out. It would be more than one percent.

Q Well, it would be a lot more than one percent, wouldn't it?

A Well, it depends upon how the numbers come out.

Q Would it necessarily be more than 50 percent?

A That depends on a number of things. Would you like me to enumerate what they are?

Q Yes, sir.

A Okay. This is more complex than lay people tend to understand because regulations are imperatives. Local regulations are imperatives, and state regulations are imperatives.

If, for example, the local regulations require that fire flow has to be provided to that connection that you have hypothesized, and the developer is constrained to do that, then in a one hundred unit line extension it is probable that the fire flow would be the predominant flow and would greatly overshadow the maximum day or peak hour flows.

So in that case, that single user at the end of our hypothetical main could require the developer to provide, in essence, the full size main, the full extent of that block or of that subdivision.

Q I see.

A If on the other hand fire flow --

COMMISSIONER GARCIA: Could you go back -- I'm sorry, could you go back a second? Start at the beginning of that statement again because I just missed the end of it. I'm sorry.

WITNESS EDMUNDS: All right, sir. What I was saying, sir, is that if the developer is required by some means -- be it local regulation, be it commitment to seller, be it master plan -- to provide fire flow and a hydrant to that lot purchaser at the very limit of that line, then the fire flow will probably be the predominant flow in that pipe line.

The fire flow will be order of magnitude of about 500 GPM. Peak hour flow in that line will probably be, oh, goodness, maybe half that at buildout, roughly. So we can see from that the fire flow is the predominant flow. So the developer has to provide the maximum line size or something close to that in order to provide the fire flow that he is constrained to provide at the end of the subdivision.

COMMISSIONER GARCIA: Right, but that he is having to provide it out there is the developer's problem, not the person that is receiving that service, wouldn't you say?

WITNESS EDMUNDS: The developer has to provide the service.

COMMISSIONER GARCIA: Absolutely. But if I let someone build out a mile -- if I have a five-mile development, and instead of building mile one out first and I sell -- because I have ambitions of a great development, and I sell at the end of my development, and it costs me more to maintain that pressure, which I'm required to by local ordinance, that cost, though, is my fault as a developer, correct?

WITNESS EDMUNDS: Well, the cost has to be paid. If, for example, we are talking about a municipal or a governmental water system, 100 percent of the installed facility is carried by the rate payer.

COMMISSIONER GARCIA: But as a general rule those systems don't make money, as a general rule they loose money and they are subsidized by the general base of tax payers and not rate payers.

WITNESS EDMUNDS: Not in my experience.

COMMISSIONER GARCIA: Let's say they

aren't. Neither here nor there. In this case we are in a profit-making venture, or at least trying to be. So if a system is built out in a certain way, that because of ordinances I have to pay more -- I'm sorry, Mr. Twomey, I jumped in.

MR. TWOMEY: No, sir, you just keep going as long as you want.

COMMISSIONER GARCIA: And I build it out in a certain way that in the end it will incur greater costs on it because of local regulation and ordinances, is that not my mistake as a developer as opposed to the rate payer who received service from the developer because it was in the developer's interest at that time?

WITNESS EDMUNDS: I don't believe that it is because the rate payer receives the service. It is always done in governmentally-owned facilities, that the cost of those very extreme situations -- this hypothetical is a very extreme situation -- is spread over the entire rate base. And as a consequence, it disappears into the rate base because this kind of situation doesn't happen that frequently.

You know, one could argue, sir, that a variable rate is appropriate for each residence in a system, depending upon the cost of his --

COMMISSIONER GARCIA: Let's say --

WITNESS EDMUNDS: -- specific service.

COMMISSIONER GARCIA: Let's say --

CHAIRMAN CLARK: Hang on a minute. You guys need to remember we have one court reporter and she can't take both of your conversations at the same time.

COMMISSIONER GARCIA: That's my fault. I'm sorry. I have a tendency to do that.

Let's say that is the case, and I agree with you philosophically, but let's go back to Mr. Twomey's system, and we will call it hypothetically Sunny Hills, where I develop a huge system in anticipation of a great development; but with that forecasting, I make an error. But clearly the provision of water was essential for me to do the development, by local ordinance and by simply as you put it reality when you described hydraulic.

If I didn't have water, I wouldn't have anyone because I couldn't get occupancy; and therefore, I couldn't sell the property, and so on. In this particular case, you put people out there in the system because you knew that sooner or later, because of the great benefit of the sales that would incur as a developer, your system would be perfectly situated to serve all these people that you were going to sell to, but unfortunately you had another reality.

Someone moved in mile ten from your source, and you are having to provide hydraulic pressure all the way out there and all the problems. There is clearly an additional cost for providing service to that person all the way at the end.

If I understand you correctly you said that, right, that persons costs a little bit more and they should pay a little bit more, or you are saying to me that person should pay exactly the same and the company should be reimbursed for the provision of that service?

WITNESS EDMUNDS: What I am saying is that reality that you described exists at every connection in the water system. For example, the homes that are right next door to the water plant should have by one argument a very low rate because the cost of getting water to them is right next door, and so they should have a very low rate.

If we take the same argument out to that person who is at the very end of the line, he should have a very high rate by that argument. I don't agree with that argument. It is not my opinion that argument is appropriate. But what I do believe though is that the utility has an obligation to provide the service.

If the utility has the obligation to also provide the fire flow, then in this extreme case there is an anomalous cost. The reason that common rates, uniform rates, are utilized in public water works is to level the playing field for all customers.

COMMISSIONER GARCIA: But in this particular case it wasn't the utility who had an obligation to serve, let's say, but it was the developer who wanted to sell; and therefore, provided service at an additional cost, nonetheless, but he sold the property. He derived the benefit. Unfortunately, it didn't end up the way he wanted. But that provision of service was contingent on the sale and not necessarily on the obligation to serve.

If that were the case, would that not be the developer's mistake as opposed to the rate payer's mistake?

WITNESS EDMUNDS: Our hypothetical is getting pretty hypothetical here. I mean, a number of predicates are being laid that could lead to the answer to your question being, yes, that was his problem; but with the change of just one predicate the answer could be, no, that is not his problem. And so I guess I would prefer to leave the domain of hypothesis and look a little more at reality. Now --

COMMISSIONER GARCIA: All right. But since my question is about the hypothetical, let's answer that one and then tell me why it doesn't work. In that particular case you would then answer, yes, that it was the developer's error that perhaps made that provision of service more expensive; correct?

WITNESS EDMUNDS: I think my answer would be it depends upon the conditions under which the decision was made to sell that lot, to provide service to that lot, a number of conditions that we're really speculating over.

What I can tell you is that this is not a new problem. This is a problem that has been addressed in water works probably since Ben Franklin helped to start the first water work in 1800. And the common answer has been a uniform rate so that all customers have a level playing field, no matter how they are stressing the system.

COMMISSIONER GARCIA: Thank you, Mr. Twomey.

MR. TWOMEY: Thank you. Let me pass something out. Can I have the next number, please?

CHAIRMAN CLARK: The next number is 99.

MR. TWOMEY: 99, thank you.

(Exhibit No. 99 identified.)

CHAIRMAN CLARK: Just a minute, Mr. Twomey. I think we don't have enough copies. Mr. Feil, you can have mine and I will look on with Commissioner --

MR. TWOMEY: I apologize. I made one more than last time.

CHAIRMAN CLARK: I will look on with Commissioner Johnson.

MR. TWOMEY: We are running a big tab at the Clerk's Office.

MR. TWOMEY: This is three sheets of paper, Madam Chairman. It is four sides, four pages. . Taken from the company's MFRs. It is a schedule F-7, Pages 115, 119, 120 and 122.

BY MR. TWOMEY:

Q I want to make sure again I understand this, Mr. Edmunds. You don't purport at all to be an economic rate analyst or rate setter, right?

A That is correct.

Q You are a professional engineer whose experience solely resides in designing systems, that's where most of it is?

A I won't say that it is where it solely resides, but that is one area of expertise I have, yes, sir.

Q But you don't have any expertise in rate setting; is that correct?

A I have not been asked to set rates.

Q So but to answer my question, if I said to you, "Do you have any rate setting expertise, economic, water or sewer rate setting expertise," what would your answer be?

A I think my answer would have to be "yes", because as I understand the concept of used and useful, it is an attempt to allocate to today's customers the portion of the facility that they actually account for. And to that extent I would have to say, yes, that I do have the expertise in being able to testify here and to derive the portion of the installed facility that they actually account for.

Q Okay. I forgot to ask you, how much are you being paid for this assignment?

A I'm being paid by the hour.

Q How much are you being paid?

A I don't recall. My billing rate exactly, it is, I think it is around $150 an hour.

Q All right, sir. Do you do other engineering assignments -- have you done other engineering assignments for SSU?

A No, I have not.

Q Now, if you would look at Page 1, that is Page 115 of this exhibit, 99, my understanding is -- do you know which system on this page is the system for which SSU is requesting hydraulic analysis?

A I believe Citrus Springs.

Q Okay, sir. Now, just before we get into that, if we look at some of the apparent realities of some of the numbers that might reflect wild-eyed optimism in the developer's mind, the Citrus Park has got 355 connected lots based on 1996, with the one year margin of reserve; right?

A That is what it says, yes.

Q They have, and they only have 335 lots, right?

A That is what it says.

Q Okay. So that would be, the calculated percentage would be more than 100 percent, but SSU is not asking for more than 100 percent; right?

A I'm not sure I understand.

Q Well --

A -- the calculation.

Q Well, if you have, if you have, if you take 355 as a percentage of 335, it is more than 100 percent; isn't it?

A Yes. That indicates that there is some question about the 335.

Q Or the methodology?

A Something needs to be questioned, yes.

Q But they've only asked for 100 percent.

A Yes.

Q Because they don't want to, well, never mind. Now, if we look at Crystal River, for example, they have 78 out of'91 lots, right?

A Yes.

Q And the other systems, even Deltona Lakes has got twenty-four thousand five out of approximately 35,000 connections or lots; right?

A Yes.

Q Now, when we get to Citrus Springs, Mr. Edmunds, they only have -- based on what SSU is projecting for 1996, plus one year's margin reserve -- they only show 1,944 connections; right?

A Yes.

Q That we know is a number that doesn't exist today, right, by definition?

A Yes, that's the assumption.

Q Yet, Citrus Springs has 11,667 lots; right?

A Yes.

Q Okay. It is perhaps something close to what Commissioner Garcia had in mind in his example. Now, the calculated percentage on line four, can you tell me what that means in terms of SSU's filing?

A I have not been asked to consult on this. I can only project the calculated percentages on the basis of the lot count method.

Q That the 16.66 percent?

A I would assume so.

Q Do you have a calculator?

A Yes, sir, I do.

Q Would you run that and let's see if --

A It is.

Q It is.

A To the one-hundredth.

Q Sir?

A It is correct to the hundredth.

Q Yes. Now, do you have any greater understanding of what they are asking for in line five, the used and useful per order, 21 percent?

A I do not.

Q And yet, sir, line six, they are asking for 42.71 percent, correct?

A That is what it says.

Q And the double asterisk apparently indicates that is based on the Cybernet Hydraulic Model Results, right?

A Yes.

Q Which is, I'm sorry to interrupt you, which is the methodology that the company has utilized in this filing, right?

A That's my understanding, yes.

Q So that is approximately, that is approximately 270, 280 percent of what the calculated percentage is, right, 42.71 versus 16.66?

A Approximately two and a half.

Q And --

A 2.56 times.

Q Okay, sir. And you support that?

A I support what, sir?

Q You support that number, that used and useful calculation.

A I have not, as I believe I've just testified, I have not been asked to review specifically the used and useful calculations which SSU has provided.

Q Okay, sir.

A I'm testifying as to the reliability of the technique of utilizing hydraulic modelling, to understand the actual portion of the capacity on a line-by-line basis that is required by today's connected users.

Q Yes, sir. Were you here this morning early at the outset?

A I got in about 9:15.

Q Did you hear any of the customers testifying about their high water rates?

A I believe I recall a gentleman testifying about that, yes.

Q Okay. Now, I don't mean to be unfair about this, but what I meant to try and ask you was that, is that you support the results, don't you? Which is to say, you support the Commission who is charged by the company's request with giving them quote, unquote, affordable rates, who are charged by law with approving fair and reasonable rates.

You approve a methodology, do you not, that would have them increase a lot connection, used and useful calculation, for the transmission and distribution system at Citrus Springs of 16.66 percent; and you would, your testimony is that based on what the company has asked for, they should increase that by 250 percent to 42.71 percent; right?

A No, that's not my testimony. I have not, as I've testified I believe several times now, I have not reviewed the specifics of the used and useful calculations that SSU has presented. I am here to say to you that the lot count approach is irrational and erroneous, does not reflect reality, and is scientifically unfounded.

I'm here to tell you that it creates a disincentive to comply with the regulations and to provide service. I'm not here to say that I have reviewed their calculations meticulously, and that 42.71 percent is the number.

There may be some adjustments that may be desirable. I don't know. But I am here to tell you that on the lot count basis that an underutilization is always projected. And that does not meet a fairness standard by any measure.

Q I'm sorry, fairness in what sense?

A Fairness in terms of incentivising the developer to provide service, incentivising the developer to comply with regulations, and providing appropriate rates to the developer for the pro rata share of the system that is actually utilized.

COMMISSIONER GARCIA: What do you mean by incentivising the developer, I guess, with the water company to comply with regulations?

WITNESS EDMUNDS: Sir, I think the most dramatic example of this is the fire flow case where if the percentage of the installed pipe that the developer is permitted to recover is solely on the basis of the lot count, that he is not permitted to recover the actual costs of the installed facility that he has to provide.

So there is a coercion in the rate process on the developer to not meet the regulations and not to provide the standard of service that the regulations require.

MR. FEIL: Mr. Edmunds, just for clarification, you are referring to the developer, but you are also referring to utilities, as well?

WITNESS EDMUNDS: Yes, sir, I think I'm still following on with this hypothetical that perhaps we should dispense with.

BY MR. TWOMEY:

Q We'll see. Did you take a course in fairness at the University of --

MR. FEIL: Objection, irrelevant, immaterial.

MR. TWOMEY: Let's see, Madam Chair. Did you take --

CHAIRMAN CLARK: Mr. Twomey, he has objected.

MR. TWOMEY: I would like to finish my question.

CHAIRMAN CLARK: I thought you did finish your question.

MR. TWOMEY: I didn't finish my question. He interrupted me.

CHAIRMAN CLARK: Go ahead.

MR. TWOMEY: I would like to finish my question.

CHAIRMAN CLARK: Finish your question.

MR. TWOMEY: Then he can object.

BY MR. TWOMEY:

Q My question, sir, is at the University of Florida, when you were acquiring your bachelor's and master's of engineering, did you take any courses in fairness in those schools?

MR. FEIL: Same objection, irrelevant, immaterial. A course in fairness, never heard of such a thing.

CHAIRMAN CLARK: Mr. Twomey.

MR. TWOMEY: The point is this, Madam Chair, the gentleman is an engineer. He has conceded that he has, with the one exception, no experience in economic rate setting. It is a caveat, I should say, that he threw in.

He just said he doesn't think that the lot connection method is fair. And I want to know from him whether fairness is something he was taught in engineering school, if it is something that is a consideration in the designing of water systems.

CHAIRMAN CLARK: So you want him to explain what he means by fairness?

MR. TWOMEY: Yes.

WITNESS EDMUNDS: By God's grace I was born with common sense. And common sense tells me that one cannot totally violate reality in rate setting or anything else. The reality that is being violated by the lot count method is that it has no basis in the way a system actually has to function, and the system that the utility has to actually provide in order to comply with the regulations and to provide the service that is required for the safety, health, and welfare of the customer.

BY MR. TWOMEY:

Q Mr. Edmunds, in the Citrus Springs example, do you know whether SSU developed that system or they purchased it?

A I do not.

Q There is --

A Excuse me, a moment. Let me think back. I'm not certain of this, but that may have been a Deltona system.

Q If it is a Deltona system, there have been a number of Deltona systems in this state that have failed, right? That is, developments that have bankrupted, right, do you know?

A I believe that there have been a number of systems that have been sold and Deltona Corporation no longer exists.

Q My question to you, though, is we've already established that even taking projected customers and adding a year of margin reserve, that there is less than 17 percent of the existing lots in this development connected after however many years it has been in existence.

And my question to you is do you think it is the fault of the customers that is the relationship of connected lots versus the total lots?

A Sir, I don't have that level of knowledge concerning Citrus Springs or any other development. I do not know who is at fault, if anyone is.

Q Well, if, in fact, Southern States went in and purchased this system and the connected lot, the total lot situation was as it is now or smaller, don't you find, don't you hold them responsible, don't you hold SSU responsible for a caveat emptor approach?

A In what way?

Q That if they bought a system that had less than 2,000 connected lots out of close to 12,000, wouldn't you expect them to know that when they bought it?

A I would expect them to know how many lots were occupied when they bought the system, yes. I would expect them to know how many lots ultimately were platted.

Q Sir?

A I would expect them to know how many lots also were ultimately platted. Is that your question?

Q Yes.

A Okay.

Q Now, if you turn to Page 119, please. Let me ask you this. If I didn't know which system SSU was proposing for hydraulic analysis here, would I be safe in taking the system that had the lowest percentage of connected versus total lots?

A I don't know the answer to that.

Q Isn't that the case on this page, though?
A I'm not sure I understand your question.
Q Which system is the one on this page that is proposed for hydraulic analysis?
A Marion Oaks.
Q Okay. And doesn't it appear -- not doesn't it appear -- isn't it a fact, Mr. Edmunds, that when you look at the calculated percentage that Marion Oaks is by far the smallest percentage?

MR. FEIL: Commissioner, aren't we getting a little repetitious here? The exhibit shows what the exhibit shows. Why is it that Mr. Edmunds has to say what the exhibit shows whatever it is that it shows?

CHAIRMAN CLARK: I think -- Mr. Twomey, do you want to respond?

MR. TWOMEY: Yes, because we are talking about only four systems, Madam Chair, okay? They are distinct. The company has made a big deal of this. And I think that we can go through this real quick and establish the percentages, ask Mr. Edmunds if he thinks that is fair, and we can dispense with it. I mean, we are not talking -- I didn't hear him say it was irrelevant.

MR. FEIL: I said it is cumulative and

repetitious is what I said.

MR. TWOMEY: You said it twice. So I would suggest that we could just go ahead and it won't take but a few more minutes.

CHAIRMAN CLARK: You aren't really responding to his objection, but I will allow the line of questioning. Go ahead.

MR. TWOMEY: Thank you. I won't --

CHAIRMAN CLARK: Take it and go with it, Mr. Twomey.

MR. TWOMEY: Yes.

BY MR. TWOMEY:

Q Now, I'm going to move, Mr. Edmunds, to not be repetitious, I will move to a different system. I will ask you to turn to Page 120. Pine Ridge is the hydraulic analysis system, right?

A Yes.

Q Okay. And you don't, if I heard you before, you don't vouch for anything on this except for the methodology that was used.

A That's correct. That's correct.

Q If you look at Sunny Hills, which sounds remarkably like Commissioner Garcia's hypothetical on Page 122, is that the system for which SSU is seeking hydraulic analysis?

A Yes, although I see two Sunny Hills here, yes, I see the one that is identified as the one based on the Cybernet model. It would be the one under column three.

Q Okay. And I'm having a hard time with the number, but doesn't it appear to you that the number looks like 8.09 percent calculated percentage?

A Yes, sir, I believe that is what it says.

Q They are asking for 28.09, right?

A Yes, sir.

Q Now, I'm holding in my hand Volume 6, Book 2 of 2 of the company's MFR F schedule. It says it contains the water hydraulic analysis. Have you examined this document?

A No, I have not.

Q Do you know whether or not the hydraulic analysis is a fairly lengthy process? I shouldn't say lengthy. It is complicated, is it not?

A Relative to what?

Q Relative to the lot count methodology.

A Oh, yes, it is complicated relative to the lot count method because the lot count method is very simplistic.

Q Okay. My client can handle the lot count methodology. Do you think that my clients would have a chance at trying to analyze whether SSU or any utility has conducted the hydraulic analysis methodology properly?

A I believe they would if they hired an expert that has that capability, yes.

Q I see. Would you turn to Page 8 of your direct testimony, please?

A I'm sorry?

Q Page 8 of your direct testimony.

A Page 8? Did you say Page 8?

Q I'm sorry, eight, yes, sir.

A Eight.

Q Line three, what do you mean by the apparent qualification of the Hardy-Cross analysis can still produce fairly reliable results? What do you mean by the caveat of fairly reliable?

A Hardy-Cross analysis was a manual technique that had a number of mathematical simplifications for solving loop hydraulic network analyses. It is time-consuming. It is an iterative process. It does not converge to accuracy in a time-saving fashion.

And so very often the hydraulic engineers who utilize the Hardy-Cross technique would not converge to a very accurate answer, because it is so time-consuming. Whereas, the mathematical computer model will converge very quickly on an accurate solution. So that is what that means, that Hardy-Cross analysis is fairly reliable, but it is very time-consuming, and as a consequence is not the preferred means of performing these analyses.

Q Okay, sir. On Page 9 of your testimony at line, beginning at line 17, you say the computer software Southern States used to prepare its modeling, Cybernet, is very well regarded by and widely used in the industry and in my experience produces very reliable results.

My question to you is by industry do you mean in the engineering design industry?

A I mean in the engineering community and also the utilities community.

Q I see. Do you mean that, is it your testimony that the utility industry finds this system to be well regarded and widely used for rate making purposes?

A My testimony is that all who are knowledgeable in the hydraulics field in this country today consider Cybernet one of the very well regarded modeling software techniques.

Q Okay, sir. On Page 11, Mr. Riley asked you earlier about the statement beginning at line 16, and on 17 where you say these pressures, those pressures act as a direct disincentive to proper design. How about situations where an utility goes out and acquires other systems. There is no direct disincentive, is there, when they acquire an existing system as opposed to designing a new system?

A I'm not sure I understand your question.

Q The lot, I thought it was your testimony that -- in fact, you said I think at one point that the direct, the lot connection methodology coerced utilities so that they had less than the minimum requirements. Do you recall that?

A Yes, that is correct.

Q I intended to ask you, how can you have less than minimum?

A Well, that is the point, isn't it? If you are going to remain within the law and comply with the regulations, that you would have to cheat to do that. And from a public policy standpoint it isn't sensible for a rate making body to coerce a utility or anyone else in that direction.

Q Right. And I took from that statement that you were speaking in the context of somebody designing a system, were you not?

A Yes.

Q That you were afraid that the lot connection methodology would result in them building less than it otherwise should?

A I think it provides a uniform coercion in that direction.

Q How does that uniform coercion apply, if it does, when a utility goes out and buys a complete existing system?

A In expansions to that system?

Q No, sir. I'm a utility -- SSU goes out and buys a system, an existing system, without any plans for expansion or anything else. Is it your testimony that the lot count or connection method provides a disincentive there?

A Is your hypothetical including that the system they purchase is 100 percent used and useful?

Q No, sir. They go out and they buy Sunny Hills where only eight percent of the lots are connected.

A Well, I believe, sir, that Sunny Hills will be extended and expanded. It is my testimony that it is in that extension and that expansion that the coercion exists.

Q I see. One last series of questions. Do you understand that this company proposes to not only pass -- you recognize from Exhibit 99 that increased rate base and, therefore, increased revenue requirements have to result from the Cybernet methodology; do you not?

A I assume that from what I am seeing here; but once again let me say, sir, that I have not in a detailed fashion reviewed the used and useful calculations that SSU has made.

Q Yes, sir. But in answer to my question, you do recognize that if, do you not, that if used and useful goes from 8 percent to 28 percent, that revenue requirement has to go up, all other things being equal; right?

A Yes, I would assume that would be the case.

Q Now, do you understand as well that this company is asking that not only the customers of that system, Sunny Hills in this example, pay that additional revenue requirement, but that they try and spread it around the state to other systems including my clients through the device of uniform rates?

A I would hope that would be done because that is in the utilities industry and governmentally-owned utilities recognized as being the fairest standard to set rates by.

Q Is that right?

A Yes.

Q Can you tell me of any two separate and distinct municipalities that set rates on an averaging basis, or did you mean within a municipality?

A I'm saying within a system; and SSU in whole is one system.

Q Is it?

A Yes. They utilize and apply their personnel over the entire system, their overhead costs over the entire system, which is composed of a great number of these local sub systems, if you will. They operate it as a single system.

Q I see. Last question. Isn't it true, if you know, that the federal environmental protection agency has a definition of system that encompasses a facility or plant by plant? Do you know?

A System is used in a variety of contexts and a variety of different ways. I am using it in the context of a multitude of networks, if you will, that are basically operated as a single unified system from a management, personnel, labor allocation, maintenance standpoint.

Q Yes, sir, but do you know if the federal

EPA -- I don't think, I don't think I got an answer to my question is why I'm asking it again. Do you know if the federal EPA has a definition of system that is consistent with a plant facility geographic location?

A They may have, but it would be a function of the specific context of what is being dealt with.

MR. TWOMEY: Okay. Thank you.

CHAIRMAN CLARK: Staff? How much do you have?

MR. PELLIGRINI: Not very much.

CHAIRMAN CLARK: Okay.

CROSS EXAMINATION

BY MR. PELLIGRINI:

Q Good evening, Mr. Edmunds.

A How are you, sir?

Q Good. How are you?

A Oh, I'm fine.

Q Mr. Edmunds, it seems that the basic used and useful analysis problem we have is how does the utility recoup its expenses for putting in a distribution or collection system? Would you agree?

A Yes, I believe I would agree with that.

Q Are you familiar with AFPI, the Allowance for Funds Prudently Invested mechanism?

A In general, yes.

Q Would you agree then that what we need as a solution to this difficulty is some wise mix of margin reserve and AFPI?

A No, I'm afraid I would not be able to agree with that. The reason I could not agree with that is because the hydraulic modeling tells us the pro rata share of each line in a network that is being utilized for the customers who exist today.

And I believe that if that allocation is made correctly, then there may be some other adjustments that would be appropriate for AFPI, for margin reserve; but my concern is with the misallocation of the affect on the network of the customer base that exists today.

Q You would not see in that then an inequitable distribution of costs or an inequitable allocation between present and future customers?

A I don't believe so because of the effect of the uniform rate, if the uniform rate is applied. That is the intention of the uniform rate.

Q Mr. Edmunds, isn't it correct that you have stated that there are basically two components to a water system; that is, the water supply side and then the transmission and distribution piping?

A Yes, sir, I believe I did say that.

Q And when you were asked how an ultimate build-out flow of 4,300 GPMs could be a valid output in a hydraulic analysis when there was only 500 GPMs supplied, you stated that you needed to look at the two components separately; isn't that correct?

A Yes.

Q And further, you stated that the distribution piping -- you stated that distribution piping is installed for its ultimate sizing so that the utility would not need to dig up streets every year, every two years, et cetera; is that correct?

A That is the usual practice, yes.

Q With respect to the water supply component, you said that it can be expanded more incrementally or it can be expanded incrementally more easily, did you not?

A Yes.

Q Would that be like adding another well or storage?

A Yes.

Q Did you also say that as the water supply increases, for example, you incrementally expanded the water supply, that the pipe flows generally go up?

A Yes.

Q Okay. So, are you aware that the utility compared, SSU in this proceeding, that the utility compared the flows in the pipe today with today's water supply calling that the numerator, and then compared it to the flows in the pipes at buildout with today's water supply, calling that the denominator, to derive the used and useful ratio?

A I don't know that I am aware that they assume there would be no expansion to the water supply, but that would be the appropriate way to determine used and useful for the distribution component.

Q Would you accept my statement of the methodology subject to check?

A I'm willing to for hypothetical purposes. As I also said, that would be the appropriate methodology for determining used and useful for the distribution component.

Q If the Commission were to accept hydraulic modeling, the hydraulic modeling methodology, would it not be a better comparison to use today's flows supplied by today's sources compared to build-out flows supplied by sources needed at buildout?

A No, because if we are evaluating the used and useful for the distribution component, as I've testified we can divorce our look at the distribution component from our look at the supply component. And we can say on the basis of the assumption that water supply will be provided to meet buildout, what is the pro rata share of today's hydraulic impact on the system relative to the build-out impact on the system.

Q But would you not agree that when I add supply to the system that the hydraulics change, the flows change?

A I would agree that the flows change, yes.

MR. PELLIGRINI: Just a moment, please.

MR. FEIL: Madam Chairman, do you know how long we intend to go to this evening?

CHAIRMAN CLARK: 8:00 o'clock.

MR. FEIL: Thank you.

CHAIRMAN CLARK: We will go ahead and take a 20 minute break right now. You can order food or maybe you have it here. I know some commissioners have already gotten their food. We will take until 7:00 o'clock. We will reconvene at 7:00.

(Brief recess.)

CHAIRMAN CLARK: We will reconvene the hearing. Mr. Pelligrini.

MR. PELLIGRINI: I would like the court reporter to read back Mr. Edmunds' answer to I believe the last question or two questions ago.

COMMISSIONER KIESLING: Charlie, You have to stop talking so she can go back, because she can't write down what you are saying and go back.

MR. PELLIGRINI: I'm sorry. That never occurred to me.

COMMISSIONER KIESLING: I'm trying to help you out.

(The preceding questions were read back.)

MR. PELLIGRINI: Thank you.

BY MR. PELLIGRINI:

Q Mr. Edmunds, would you clarify what you meant by assuming no expansion of the water supply?

A If the water supply that is in place today is not sufficient to provide the build-out demands to meet the build-out demands, then that would obviously be a limitation on the future modeling case.

What I believe that the utility did was to model today's condition, using today's demand, and the future condition using the future demand in the numerator and denominator.

Q I believe that rather than that, the methodology used compared -- used today's supply in both numerator and denominator.

MR. FEIL: Are we talking about source of supply, is that the source of the confusion?

MR. PELLIGRINI: I'm not sure about that.

WITNESS EDMUNDS: I'm not sure what we are talking about here. That would not make any sense.

BY MR. PELLIGRINI:

Q Well --

A What makes sense is that the today's demand is, and the effect of today's demand is the numerator. And it insofar as the future condition where the distribution system -- I'm not dealing with the supply side of the system, I'm dealing with the distribution side of the system -- that is demand driven.

The assumption is that supply will be developed to meet the demand of that day. That is always the assumption that is made.

Q But what I'm suggesting is that in the comparison of today's conditions to build-out conditions, for today's conditions the present source of supply should be considered; and for build-out conditions, the necessary supply to meet the build-out conditions should be considered.

A It doesn't matter when we are talking about the distribution facilities, because the assumption is always made that supply will be provided to satisfy the demands.

Q The difficulty we have with that, Mr. Edmunds, is that as supply increases, the hydraulics of the system changes, the flows change.

A Of course. Why is that a problem? I mean, if the flows don't change then the system is at buildout and it is 100 percent used and useful now, so, by anybody's definition.

Q We think that unless that consideration is taken into account that the comparison is really an inconsistent one and apparently you don't agree?

A I don't agree. The reason that I don't agree is that when a system is initially or when a network is initially designed, the ultimate location of all future sources supply is assumed as part of the, as part of the analysis, or can be assumed, or can be assumed when the evaluation of the ultimate build-out situation is prepared.

And so, yes, it is true that the flows do change as the network evolves and grows to maturity. But assumptions are always made either at the time of design or the time that the future, that the future network is being modeled concerning the sources of supply.

Now, from a global standpoint, if the source of supply is at one location in the system or at another location in the system, the sensitivity of the used and useful number would not be that great under most circumstances as the source of supply, the location of supply changes.

MR. PELLIGRINI: We have no further questions. Thank you, Mr. Edmunds.

CHAIRMAN CLARK: Thank you. Commissioners?

COMMISSIONER DEASON: I have a question. Mr. Edmunds, I believe before we took the break, in response to a question in Mr. Pelligrini you indicated that you did not believe there would be an unfair allocation between existing and future customers if the uniform rate structure is adopted. I think his question was in relation to utilization of the hydraulic model. Do you recall that question?

WITNESS EDMUNDS: Yes, sir, I believe I do.

COMMISSIONER DEASON: My question is what if the Commission adopts a stand alone rate structure? Would there be then an unfair allocation between existing and future customers?

WITNESS EDMUNDS: Between existing and future customers, or between customers in different networks?

COMMISSIONER DEASON: Well, as I understand his question, my notes may be incorrect, I thought his original question was in relation to existing and future customers in the sense that use of the hydraulic model would be allocating more to existing customers than the traditional lot count method.

WITNESS EDMUNDS: Yes.

COMMISSIONER DEASON: I think that was the nature of his question. And you said, no, there would not be an unfair allocation, but you put the caveat on that answer, assuming a uniform rate structure.

WITNESS EDMUNDS: Yes.

COMMISSIONER DEASON: My question is, what if there is going to be a stand-alone rate.

WITNESS EDMUNDS: If there was a stand-alone rate structure with no cap, in other words, no modification, there is the potential for, depending upon the physical setting, for there to be an unfair rate allocation. There is the potential. And that might have to be dealt with on a case-by-case basis or a network-by-network basis.

COMMISSIONER DEASON: Thank you.

CHAIRMAN CLARK: Redirect?

REDIRECT EXAMINATION

BY MR. FEIL:

Q I just have one question. Mr. Edmunds, when Mr. Twomey was questioning you he referred to a Volume 6, Book 2 of 2, and did not show you the volume. He just recited the number. I would like to show this to you and have you answer the question of whether or not you've seen this volume before.

A Yes, sir. In answer to your question, I have seen this. I have not reviewed it in great detail. I have glanced through it and I've looked at some of the summary pages.

Q But you know it to be the hydraulic analysis in used and useful tabulations?

A Yes, sir.

MR. FEIL: Nothing further.

CHAIRMAN CLARK: Thank you, Mr. Edmunds. Exhibits?

MR. FEIL: SSU moves Exhibit 98.

MR. TWOMEY: 99.

CHAIRMAN CLARK: Without objection Exhibit 98 and 99 will be entered in the record.

(Exhibit Nos. 98 and 99 admitted.)

CHAIRMAN CLARK: Mr. Elliott. Thank you, Mr. Edmunds. You are excused.

JAMES P. ELLIOTT

was called as a witness on behalf of Southern States Utilities and, having been previously duly sworn, testified as follows:

CHAIRMAN CLARK: Go ahead, Mr. Feil.

DIRECT EXAMINATION

BY MR. FEIL:

Q Mr. Elliott, you have been sworn in; correct?

A That's correct.

Q Would you please state your name and business address for the record.

A James Paul Elliott. My business address is 1334 Lafayette Street in Cape Coral, Florida.

Q Are you the same James P. Elliott for whom prefiled direct testimony was filed in this case consisting of six pages?

A That's correct.

Q Do you have any changes or corrections to that prefiled testimony?

A No, I do not.

Q If I asked you the questions asked in the prefiled direct testimony today would your answers be the same?

A They would.

MR. FEIL: I ask that Mr. Elliott's prefiled direct testimony be inserted in the record as though read.

CHAIRMAN CLARK: The prefiled direct testimony of Mr. James Elliott will be inserted in the record as though read.

(The Prefiled Direct Testimony of James P. Elliott was inserted in the record as follows:)

DIRECT TESTIMONY OF JAMES P. ELLIOTT

BEFORE THE FLORIDA PUBLIC SERVICE COMMISSION

ON BEHALF OF

SOUTHERN STATES UTILITIES, INC.

DOCKET NO. 950495-WS

Q. PLEASE STATE YOUR NAME AND BUSINESS ADDRESS.

A. James P. Elliott, 1334 Lafayette Street, Cape Coral, Florida 33904.

Q. BY WHOM ARE YOU EMPLOYED AND IN WHAT CAPACITY?

A. I am employed by Source, Inc., an engineering and planning firm, as President.

Q. PLEASE DESCRIBE YOUR EDUCATIONAL AND PROFESSIONAL BACKGROUND?

A. I am a graduate engineer with a Bachelor of Science degree in Civil Engineering from Kansas State University in 1968. I am a registered Professional Engineer in Florida and Illinois. Prior to founding Source, Inc. in 1979, I was employed for four years with Black Crow and Eidness/CH2M Hill ("CH2M Hill") in Gainesville, Florida. At CH2M Hill, I was the Construction Service Manager for a wide variety of Florida projects. Prior to joining CH2M Hill, I worked for Greeley and Hansen in Chicago for five years as a design engineer, project manager, and resident engineer.

Q. ARE YOU A MEMBER OF ANY PROFESSIONAL SOCIETIES OR AFFILIATIONS?

A. Yes. I am a member of the American Society of Civil Engineers, American Water Works Association, Florida Engineering Society, National Society of Professional Engineers, Water Environment Federation, American Desalting Association and the Southeast Desalting Association.

Q. **HAVE YOU PREVIOUSLY TESTIFIED BEFORE THE FLORIDA PUBLIC SERVICE COMMISSION OR ANY OTHER REGULATORY BODY?**

A. Yes. I testified in three administrative hearings relating to Florida Department of Environmental Protection (then the Department of Environmental Regulation) permitting issues. I also testified before the Commission on behalf of Southern States in Docket No. 920655-WS.

Q. **WHAT IS THE PURPOSE OF YOUR TESTIMONY?**

A. I support Southern States' proposal to use the hydraulic flow method to determine the used and useful capacity of the water transmission and distribution lines and the maximum day flow from 1994 to determine the used and useful capacity of supply and treatment facilities. I also support the Company's proposal to use two service classifications for water service -- conventional treatment and reverse osmosis treatment.

Q. **COULD YOU EXPLAIN WHY THE USE OF THE HYDRAULIC FLOW METHOD IS JUSTIFIED FOR WATER TRANSMISSION AND DISTRIBUTION LINES?**

A. Use of the hydraulic flow method to determine the used and useful capacity of water transmission and distribution lines is justified primarily because the hydraulic flow method is used to design those facilities. I have designed facilities for private as well as governmental utilities and, without exception, I have used the hydraulic flow method to design the capacities and configuration of transmission and distribution lines. The hydraulic flow method not only is most reasonable to use because it is the method used to design such facilities but it also is the most accurate means of simulating the hydraulic capacity being used in the distribution system. A lot count method for determining the used and useful capacity has no basis in reality. It is beyond dispute that flows are determined more by the type of customer being served, the personal water consuming habits or needs of the people being served, the irrigation requirements, the number of people in each household and a number of other factors than from a simplistic determination of lots platted versus lots connected. Therefore, I believe the Commission's current practice is overly simplistic and bears no relationship to reality. As an engineer, I cannot accept it as a valid flow measurement or projected flow measurement technique. In contrast, the hydraulic flow method is rooted in reality and precision.

Q. **COULD YOU EXPLAIN WHY YOU BELIEVE THE USE OF THE MAXIMUM DAY FLOW IS THE MOST REASONABLE MEANS OF DETERMINING THE USED AND USEFUL LEVEL OF WATER SUPPLY AND TREATMENT FACILITIES?**

A. When designing water supply and treatment facilities, an engineer must utilize the maximum day demand projections as the basis for his or her design. To use any other basis would be a dereliction of the professional engineer's obligation and responsibilities. Since the maximum day criteria is the basis for designing the facilities, it appears to me to be unreasonable to measure the used and useful level of the facilities using any measurement other than the maximum day criteria.

Q. **IS A PROFESSIONAL ENGINEER REQUIRED TO CONSIDER POTENTIAL FIRE FLOW DEMANDS WHEN DESIGNING WATER SUPPLY, STORAGE, TREATMENT AND DISTRIBUTION FACILITIES?**

A. Yes. A professional engineer must design water supply, storage, treatment and distribution facilities to accommodate fire flow requirements in addition to residential and other water needs which may exist. Therefore, I believe that actual fire flows which may have been experienced in a maximum day should be included for purposes of determining the used and useful levels of these facilities.

Q. **DO YOU BELIEVE THAT IT WOULD BE REASONABLE TO EXCLUDE FROM MAXIMUM DAY FLOWS THE AMOUNT OF WATER LOST TO WATER MAIN BREAKS, FOR EXAMPLE, FOR USED AND USEFUL PURPOSES?**

A. No, I do not. Water main breaks and other occurrences such as line flushing, fire incidence and fire department use are expected, ordinary occurrences for all water facilities. As such, if the facilities experience such occurrences and nevertheless continue to meet the water needs of customers served by them, I see no reason to exclude volumes of water lost to such occurrences for purposes of calculating the facilities' used and useful levels and, in fact, for this reason I believe it would be unreasonable to do so.

Q. **COULD YOU EXPLAIN WHY YOU AGREE WITH SOUTHERN STATES' DIVISION OF WATER CUSTOMERS INTO SEPARATE SERVICE CLASSIFICATIONS DEPENDING UPON WHETHER THEY ARE SERVED BY CONVENTIONAL OR REVERSE OSMOSIS WATER TREATMENT FACILITIES?**

A. I agree that the classification of customers into two groups based on whether the customers are served by conventional or reverse osmosis water treatment facilities is appropriate because the existence of reverse osmosis facilities confirms that the customers are served by brackish water supplies. Brackish water, without exception, must be treated, at minimum, by reverse osmosis facilities which undeniably are the most expensive treatment methods available other than facilities treating seawater. The existence of brackish water is evidence that the fresh water supplies previously had been consumed to such an extent that treatment of brackish water became necessary. It appears logical that one of the indirect benefits of the division into conventional and reverse osmosis service classifications would be to dissuade customers currently served by conventional treatment facilities from consuming water in quantities which would hasten the deterioration of the supply source to brackish water and thus the need for higher cost reverse osmosis facilities as well as the corresponding higher rates proposed by Southern States.

Q. DOES THAT CONCLUDE YOUR TESTIMONY?

A. Yes, it does.

BY MR. FEIL:

Q Mr. Elliott, you had no exhibits attached to your prefiled direct?

A That's correct, I did not.

Q Mr. Elliott, you also had prefiled rebuttal testimony filed in this case consisting of eight pages; is that correct?

A That's correct.

Q Do you have any changes or corrections to that prefiled rebuttal testimony?

A No, I do not.

Q If I ask you the questions in the prefiled rebuttal testimony today, would your answers be the same to those questions?

A They would be, yes.

MR. FEIL: I ask that Mr. Elliott's prefiled rebuttal testimony be inserted in the record as though read.

CHAIRMAN CLARK: Mr. Elliott's prefiled rebuttal testimony will be inserted in the record as though read.

(Prefiled Rebuttal Testimony of James P. Elliott was inserted as follows:)

REBUTTAL TESTIMONY OF JAMES P. ELLIOTT

BEFORE THE FLORIDA PUBLIC SERVICE COMMISSION

ON BEHALF OF

SOUTHERN STATES UTILITIES, INC.

DOCKET NO. 950495-WS

Q. PLEASE STATE YOUR NAME AND BUSINESS ADDRESS.

A. James P. Elliott, 1334 Lafayette Street, Cape Coral, Florida 33904.

Q. ARE YOU THE SAME JAMES P. ELLIOTT WHO PROVIDED DIRECT TESTIMONY IN THIS PROCEEDING?

A. Yes.

Q. WHAT IS THE PURPOSE OF YOUR REBUTTAL TESTIMONY?

A. The purpose of my testimony is to rebut certain portions of the direct testimony of Office of Public Counsel ("OPC") witness Mr. Ted L. Biddy and Sugar Mill Woods Civic Association ("SMWCA") witness Mr. Buddy L. Hansen. Specifically, I will rebut some of the arguments made by these witnesses on the subject of SSU's hydraulic modeling analysis.

Q. DO YOU AGREE WITH MR. BIDDY'S ARGUMENT THAT HYDRAULIC MODELING SHOULD BE REJECTED BECAUSE IT IS "UNDULY COMPLICATED" AND AN "UNNECESSARY BURDEN"?

A. No, I do not. Today, hydraulic modeling is an everyday tool used by engineers for design purposes as well as other purposes. The computer software necessary for modeling is standard office equipment for most engineering firms. I would assume Mr. Biddy has hydraulic modeling capability in his office, as I do, and it is my understanding that the Commission staff also has Cybernet software available for its use. To effectively regulate water and wastewater utilities, the Commission must refer to and rely on sound engineering principles and practices. It therefore makes little sense for the Commission to reject out-of-hand an accepted engineering tool of commonly available technology as Mr. Biddy recommends.

Mr. Biddy supports his opinion that hydraulic modeling is too complicated by arguing that used and useful should be a cost allocation technique, not related to utility engineering. This rationale should be rejected on its own merit for the reasons Mr. Hartman has already enumerated at length and because Mr. Biddy is inexplicably inconsistent in his views. The Commission should note that throughout his testimony, Mr. Biddy makes a number of recommendations whereby used and useful evaluations parallel his perception of proper engineering considerations. Yet, he recommends that engineering considerations be ignored for transmission and distribution facilities. Mr. Biddy states that hydraulic modeling will unnecessarily complicate used and useful, yet he advocates a very detailed used and useful partitioning of every water well, every treatment unit, every pump, every hydropneumatic tank, every storage facility, every auxiliary power generator, every square foot of land -- every nut and bolt the utility invested in -- all according to his perception of which fragments are needed to provide service. I do not think the hydraulic models filed in this case are more complicated than the other used and useful evaluations the Commission will be asked to make in this case.

In addition, contrary Mr. Biddy's assertion, I do not believe the economic feasibility for other utilities to use a hydraulic model to evaluate used and useful is relevant in this case. This case involves SSU and its hydraulic models, not other utilities. Besides, for the reasons I have already indicated, I think it very advisable for investor-owned utilities of suitable size to make use of hydraulic models for designing and evaluating facilities, as well as for used and useful analyses. By accepting SSU's hydraulic used and useful analyses, the Commission does not force every last one of the utilities it regulates to use hydraulic models to evaluate used and useful for transmission and distribution facilities, as Mr.

Biddy seems to believe. Each situation must be evaluated on its own merits. And regardless of Mr. Biddy's unfounded concern for other cases, the simple fact of the matter is that the hydraulic method SSU has proposed in this case is vastly superior to the illogical and inherently flawed lot-count method, as a number of SSU witnesses have already explained.

Q. DO YOU AGREE WITH MR. BIDDY'S AND MR. HANSEN'S ARGUMENTS THAT THE HYDRAULIC ANALYSIS METHOD IS AN UNREASONABLE WAY TO ALLOCATE COSTS TO CURRENT CONNECTIONS?

A. No. As a starting point for my comments, I think one of Mr. Hansen's statements may serve to bring the issue more into focus. Beginning at line 24 of page 28 of his testimony, Mr. Hansen asks how SSU could serve more customers at Pine Ridge if the Pine Ridge transmission and distribution facilities are 100% used and useful according to the hydraulic analysis. Mr. Hansen's statement illustrates the distorted perception the lot-count method, or any other used and useful method, produces when viewed exclusively as a crude point-in-time measuring stick instead of being viewed as an evaluation of needs and uses. To illustrate what a crooked measuring stick the lot-count method is, one need only consider that in a service area where the distribution piping is sized just large enough to meet the needs of the current connections, and where additional connections may impair service to current connections, the distribution facilities would still not be 100% used and useful because not all lots are receiving service. In such a situation, the utility might even be penalized for not being able to provide service to additional connections. SSU would therefore like to know how properly-sized lines cannot be 100% used and useful when those lines are used and needed to provide service to customers notwithstanding any ability to serve additional connections.

In the way of analogy, I would point out that auxiliary power generators are not put to their full use at all times, yet by the Commission's order in SSU's last case and by staff's May 1995 draft used and useful rules, auxiliary power generators, as well as hydropneumatic tanks and disinfection facilities among others, are properly be considered 100% used and useful. Again, a properly-sized facility which is needed and used to provide service should be 100% used and useful. I don't use my car to its fullest by driving it 24 hours a day. But I still need the whole car to get me around -- a fraction of a car would not do me much good. I could use the car more often if I needed to. And, of course, I still have to make my entire car payment no matter how much I use the car.

Current connections should pay at least for that portion of the transmission and distribution facilities which those connections utilize. SSU used a hydraulic analysis to assess what current connections utilize, including what is needed to provide current connections fireflow. Mr. Biddy states that the lot-count method allocates to current connections a portion of the costs associated with sizing lines to provide fireflow. However, the lot-count method allocates to current connections only a fraction of the actual capacity which the existing lines must have available to provide fireflow to those connections. Under the lot-count method, current connections would not have to pay the cost of sizing lines to provide them with fireflow unless and until the service area was completely built-out, despite the fact that the utility's lines, just like its wells, pumps, and storage facilities, must be capable of providing current connections with the same amount of fireflow it must provide all connections at build-out. Thus, Mr. Biddy's proposal is not only incorrect because current connections would not pay the costs of providing them fireflow under the lot-count method, but Mr. Biddy is inconsistent because he recommends that if a utility can provide fireflow, current connections should pay the full cost of sizing wells, pumps, and storage to meet fireflow for a built-out service area, but not distribution facilities for a built-out service area.

Any relationship between potable demand and fireflow is site specific and will vary to some degree between current and build-out conditions for those components needed to provide fireflow. Total fireflow requirements, however, must be met with the <u>first</u> building even though the total potable demand capacity is not realized until the <u>last</u> building is occupied. It is simply unreasonable to put SSU in a position where it has been required by local codes and ordinances to follow minimum line size, looping, and fireflow criteria based on building classifications without providing a mechanism for recovering the costs for compliance.

Q. **DOES THAT CONCLUDE YOUR TESTIMONY?**

A. Yes, it does.

BY MR. FEIL:

Q Mr. Elliott, you had no exhibits attached to your prefiled rebuttal testimony, as well?

A That's correct.

Q Do you have a prepared summary of prefiled direct and prefiled rebuttal?

A I do.

Q Could you please read from those summaries, please?

A Yes. Some of this will be redundant from the previous witnesses, but I support SSU's use of hydraulic flow method for the used and useful capacity determinations for water transmission and distribution lines, as well as the use of maximum daily flows to determine the used and useful capacity of supply and treatment facilities.

I also support Southern States proposal for two water treatment classifications being conventional and reverse osmosis types.

The hydraulic flow modeling method for used and useful determination is justified, as this is the method used for engineering, planning and design. The hydraulic flow analysis method is by far the most accurate method simulating pipeline capacity, which accounts for the consuming habits, needs of people served, irrigation requirements, and fire flow. And all this is in contrast to the simplistic lot count method.

Lot count method has no relationship to reality. I cannot accept the lot count method as a flow measurement technique. The maximum daily flow must be used when designing facilities. It is unreasonable to expect the utility's engineers to use flow factors other than maximum daily flow, which is a design convention.

Fire flow statements here, as professional engineers we are obligated to design water supply treatment, storage, transmission, and distribution facilities to accommodate fire flow, in addition to residential consumption and other needs that may exist. All flows must be included in the used and useful levels of those facilities.

On the existence of reverse osmosis, the existence of reverse osmosis water plant indicates the available water supply is brackish, such that an expensive treatment method process is required, as compared to conventional treatment processes that treat basically water from a potable quality supplies. The use of brackish water implies that fresh water may have been depleted.

That ends my summary from my direct.

Q Could you please proceed with the summary from your rebuttal?

A Yes. The purpose of my testimony to rebut, is to rebut the arguments made by Mr. Biddy and Mr. Hansen regarding the use of hydraulic modeling. Hydraulic modeling is used as an everyday tool by utility engineers for planning and design purposes.

Software for hydraulic modeling is standard office equipment for most firms. I understand Cybernet modeling is available to the Commission staff. Used and useful determinations should not be solely a cost allocation technique, as it has no basis in reality as compared to the piping functions.

Mr. Biddy presents a detailed used and useful partitioning for every well, treatment unit, hydropneumatic tank, storage tanks, and auxiliary powered generators, but not for transmission and distribution lines.

I feel the hydraulic modeling filed in this case, the models are not more complicated than other use and usefulness evaluations presented for the consideration of the Commission.

The hydraulic modeling analysis best

simulates the actual flow behavior that accounts for existing use, fire flow irrigation demands, et cetera, yet allows for the future customers due to design considerations primarily of looping.

The lot count method, by contrast, is a crude linear point in time measuring stick. All required facilities must be considered 100 percent used and useful, same as auxiliary power generation facilities, hydropneumatic tanks and disinfection facilities.

Properly-sized facilities needed and used to provide service should be a hundred percent used and useful. As an example, I don't use my car 24 hours a day, but I still need the whole car. The car is available certainly for more use; and of course, I have to make my car payments every month regardless of that use.

Current connections should pay for at least that portion of the transmission and distribution facilities they utilize, including fire flow. The flaw in the lot count method is the current connections do not pay for fire flow, unless and until the facilities are at buildout.

Mr. Biddy is inconsistent in that he recommends current connections pay the full cost of wells, pumps and storage for fire flow for a build-out service area. Total fire flow must be available with the first building, even though the total potable demand is not realized until the last lot is occupied, the last building is occupied.

It is totally unreasonable to put SSU in a position where it is required by local codes to follow minimum line sizing, looping, and fire flow criteria based on building classifications without providing a means of assuring recovery with the cost of compliance. That ends my --

Q That concludes your summary?

A Yes.

MR. FEIL: Thank you, sir. Tender for cross.

CHAIRMAN CLARK: Mr. Riley.

CROSS EXAMINATION

BY MR. RILEY:

Q Mr. Elliott, just a few questions for you this evening. I could direct your attention to Page 4 of your prefiled direct, lines 8 and 9. You state a professional engineer must design water supply, storage, treatment and distribution facilities to accommodate fire flow requirement; is that correct?

A That's correct.

Q Is it your testimony that water supply and treatment alone should meet fire flow requirements when fire storage does not exist?
A Could you repeat that question, please?
Q Is it your testimony that water supply and treatment alone should meet fire flow requirements when fire storage does not exist?
A I would say in the cases I heard Mr. Hartman elaborated on.
Q The answer is yes?
A Yes.
Q Would there be instances when you wouldn't think it would be appropriate to size supply and treatment sufficient to meet fire flow needs?
A I would say yes, if you are in an aquifer that provides that utilization. In my area of Florida that is not a very typical case.
Q Is the reason for that, that it is an extremely -- it is not at all a cost-effective way of meeting the fire flow demand; is that correct?
A What is not?
Q Meeting the fire flow through supply and treatment as opposed to storage.
A It depends on the circumstance of the system and the aquifer and several other factors.

Q Could you elaborate?

A For example, some systems in northern Florida where you might have the Florida aquifer, and I think Mr. Hartman alluded to some examples in Duval County and Jacksonville where they yielded to the aquifer. He was equating the aquifer of being the reservoir. In those cases it would be quite, it would be much more economical to provide that flow through the aquifer system and the pumping system.

Q So in South Florida it would not be appropriate?

A Again, it depends on the circumstances of the aquifer, the size of the system, and probably several other factors.

Q But generally speaking it might not be appropriate in that area of the state?

A Again, I would have to say that it depends on the aquifer. I'm not familiar with all the areas of the state, but I would say in Lee County, in most portions of Lee County, that is probably not a potential because of the circumstance of the aquifer.

Q Isn't it correct that fire flow should come from storage or high service pumping when elevated storage is not available?

A I'm not aware of -- could you repeat the question, please?

Q The question is do you believe it is correct that fire flow should come from storage or high service pumping when elevated storage is not available?

A I would say that is probably most often the case in design we do these days. We are providing the flow from grounds storage reservoirs if you don't have an aquifer capable of doing that.

Q Could I have you turn back to Page 3 and look at lines 19 and 20 on that page. This is your prefiled direct.

A Yes.

Q You state that an engineer must utilize the maximum day demand projections. This is I guess in reference to water again, supply and treatment. As you stated, the engineers must use maximum day demand projections in design. But my question is that projection does not include fire fighting, main breaks, and line leaks; is that correct? That projection of max day does not include fire fighting, main breaks and line leaks?

A It would depend whether you are talking about historical data that you have collected and known events, or if it is a case where you are talking about design, whether you are projecting a maximum day and a new design.

Q I think we are talking about design, maximum daily flow.

A Yes. I think that the answer is that maximum day demand projections would not include fire flow.

Q Or those other?

A Pardon me?

Q Or the other two I mentioned, main breaks and line leaks?

A No.

Q If the maximum day flow already includes unaccounted for water, would you still include fire fighting and main breaks in design?

A I would in design of storage facilities. Again, that depends on the aquifer and the circumstance of supply.

Q One other question. When Mr. Feil was posing some redirect questions to Mr. Hartman, I believe he asked him concerning what the regulatory requirements were for, and I use the term single max day.

And I'm not sure whether that was just a slip or a term of art that he was using; but of course, we understand a lot of the requirements have used the term max day flow. As you understand, there are those of us who believe the more appropriate representation of max day is this by average of the five max days.

Can you share with me your understanding of any governmental regulation or DEP rule that would require a single max day flow as opposed to just the max day flow?

A I can't site the rule specific, but DEP requires that you use the max day. I don't recall of any circumstance where they call for the average of five days. We are always lead to the standards and a lot of local ordinances, for example. I looked at Collier, Lee and the City of Naples. They all reference to maximum day.

Q Max day.

A That's what we have to design to.

Q So you can't share with this Commission any regulatory requirement that uses that extra word that was put in that question; is that correct?

A No, that's not a familiar word to me.

MR. RILEY: Okay. That concludes our questions.

CHAIRMAN CLARK: Mr. Twomey.

MR. TWOMEY: Yes, Madam Chairman, thank you.

CROSS EXAMINATION

BY MR. TWOMEY:

Q Mr. Elliott, if I were to ask you all the same questions I asked Mr. Edmunds would your answer be the same?

A They might be identical, and I didn't take a course in reasonableness.

Q How about common sense?

A That either.

CHAIRMAN CLARK: Does that conclude your cross examination?

WITNESS ELLIOTT: Could I go now?

MR. TWOMEY: Not quite.

BY MR. TWOMEY:

Q But you are a professional registered engineer.

A That's correct.

Q A registered professional engineer.

A Yes, in Florida and Illinois.

Q Okay, sir. I want to ask you to look at Exhibit 99, which I hope Mr. Edmunds didn't cart off with him.

A I don't have it or see it here.

Q Before you examine it, because you don't need to look at the whole thing, let me ask you, throughout your testimony you referred to, for example, at Page 2, line 22, I have used the hydraulic flow method to design?

A Is this in my direct?

Q Direct, I'm sorry. I won't ask you any questions on your rebuttal.

A Page two.

Q Page 2, line 22. You say I've used the hydraulic flow method to design the capacities and configuration and transmission and distribution lines, right?

A That's --

Q I'm sorry.

A No. Finish the question.

Q Well, that's correct, right, you say design?

A Yes.

Q And line 3, Page 3, you say used that method to design such facilities, right? And you used design again a couple other times again throughout your testimony.

A Yes.

Q My question is, that is your focus, isn't it, that you think it is appropriate to use the hydraulic method in designing systems, right?

A That is not the only place that it is used, but as I have referred to design in my testimony, however, that we used it in planning and master planning utilities, preliminary planning, verifying systems in design that will meet the county requirements.

Q Engineering requirements?

A Engineering requirements, that's correct.

Q Okay. Because isn't it true, Mr. Elliott, that you don't either -- you do not claim economic regulatory rate making experience?

A No, I do not.

Q Okay. I would like to ask you to look at page 120, which should be the third page.

A Oh, this.

Q I'm sorry, of Exhibit 99.

A Yes.

Q Now, it is your testimony, is it not, that as a professional engineer you have to design systems using the methodologies employed in the hydraulic model, right?

A That's correct.

Q Okay. I want to ask you, sir, to look at the system described in Page 120 as Pine Ridge. It is in the third column. And tell me in your professional opinion as a professional engineer how much additional capacity does the Department of Environmental Protection require for Pine Ridge before SSU can add another customer to its existing system?

A Could you repeat that question, please?

Q Yes, sir. Look at the Pine Ridge system.

A I am.

Q My question is how much additional capacity in terms of water distribution systems, transmission and distribution, must SSU add by DEP requirement before they can add another single customer to the system?

A I'm not familiar with the details of that system, so I would have to -- I wasn't asked to review that.

Q Well, okay, fair. Let me ask you this. Doesn't it appear from the analysis reflected here that SSU is claiming that the system is 100 percent used and useful?

A That's what it says here, yes.

Q Doesn't it stand to reason -- and they are using the Cybernet hydraulic model to make that determination; correct?

A That's what it asterisked here, that's what it says.

Q Okay. And you support that methodology, correct?

A That's correct.

Q And my question to you is if the system is now 100 percent used and useful, doesn't common sense say that you have to build some more capacity before you can add additional customers?

A I have to look at this case specifically. I haven't had that opportunity, nor was I asked to do that.

Q Let me explore that just a little bit more. The system apparently was designed to serve 3,828 lots, was it not?

A That's what it says here, number of lots.

Q It only has connected, when you throw in the one-year margin reserve in 1996 projections, 892 connections, right, connected lots?

A That's what it says under line 2.

Q Okay. And line 4, the calculated percentage is 23.3 percent, right?

A That's what it says.

Q Okay. Well, help me understand,

Mr. Elliott. Do you think that this reflects a situation where SSU really can't add customers and still provide them with adequate service?

A Not specifically to this example because they haven't reviewed it, but in a network system, that is entirely possible. Because again, back to my testimony that you have to provide service, it is in context of the service that you are providing these people that in the loop system that it could be integrated throughout that system; and providing fire flow to that very first building, this is a possible scenario. But I'm not saying without reviewing this whether this is absolutely correct. I can endorse the methodology.

Q You recognize, don't you, that SSU has only requested the hydraulic model methodology be utilized in four systems of the many that are included in this file, correct?

A I'm aware of that, yes.

Q And if that is the case, don't we suffer a risk of some sort that there are a lot of other systems out there that SSU has that, because they are having their used and useful calculated on the connected lot method, are on the verge of being populated with excessive numbers of customers; is that a possibility?

A I can't really address that. I don't really know what the other systems -- I haven't investigated the other systems. And to that point I would say had there been time, opportunity, money, and everything else available, I'm sure that it would be nice to have modeled all the systems. And maybe in time they will model all the systems.

Q It would give them a whole lot more rate base, wouldn't it, Mr. Elliott?

A It would be an appropriate rate base because the modeling would be a function of what is actually in the ground, how the pipes actually perform in the field in relation to the design facilities.

Q I don't intend to be argumentative, but that didn't answer my question.

A Okay. Repeat the question.

Q Yes, sir. That would give them a whole lot more rate base, wouldn't it, if they modeled all their systems using the hydraulic model in this case?

A Well, again, I'm not familiar with all the systems. And I don't -- I'm not a rate making expert, so I don't know if I can answer that question. You might better ask it of somebody else.

Q Okay. Are you aware that SSU apparently took the fire hydrants out of Spring Gardens in Homosassa after it purchased the system, do you have any knowledge of that?

A I have no knowledge of that.

Q On the subject of the division of SSU's water customers in the separate classifications, depending upon conventional or reverse osmosis water treatment, you endorse that, right?

A Yes, I do.

Q It appears to me that you endorse it on the basis of operating and maintenance costs, am I correct?

A No, I endorse that partly, but partly because of the source of supply. The distinction is saline water versus potable supply, one that is more easily treatable. The distinction is basically the quality of the supply.

Q Yes, sir, but doesn't it necessarily follow that the distinction you make from that or one of the distinctions you make from that is that it cost more to treat brackish or saline water than it does to treat non-brackish or saline water?

A That's correct.

Q And therefore, isn't one of the bases for your adoption of this classification based upon cost?

A Correct.

Q But it is not total cost of the rates, is it, it is operation and maintenance expense?

A That would have to be a component of it. I'm not familiar with the exact operation maintenance expense, but it is definitely more treatment. I mean it is more treatment intensive, equipment intensive. Then there is also a regulatory element to it that you have in -- in reverse osmosis you have a unique feature that you have to comply with the industrial waste charge requirements which greatly increases the cost depending on what is available for disposal.

Q Yes, sir. My question to you is if I could show you a standard or traditional treatment, non-saline water plant whose total revenue requirement, that is total of all of its associated cost, was more expensive than a reverse osmosis plant, would your endorsement of the division remain the same?

A I'm not sure. I would have to study -- I'm not sure what you are talking about. I know that in my experience and in southwest Florida and I think two plants are within my area, that I've reviewed them both, you know, Marco Island and Burnt Store. And I was involved in the design and permitting of Burnt Store. I know that is a lot more expensive than a conventional treatment process from potable supply.

Q Yes, sir, but my point is this, do you understand economic regulation sufficiently well to understand the concept of contribution in aid of construction?

A Contribution in aid of construction? I've heard the term, I'm not real familiar with that.

Q Do you know the effect that the relationship that contribution in aid of construction has on a utility's rate base, and therefore its investment base?

A I'm not familiar with that.

Q Okay. Wouldn't it be -- well, let me ask you this. You say Page 5, line 18, it appears logical that one of the indirect benefits of the division into conventional and reverse osmosis service classifications would be to dissuade customers currently served by conventional treatment facilities from consuming water in quantities which would hasten the deterioration of the supply source of brackish water, and thus the need for higher cost reverse osmosis facilities, as well as the corresponding higher rates proposed by Southern States.

Let me ask you first, did you write that or did someone else write it for you?

A I wrote that. In our area we are probably tuned in, this may not have been case specific, but more of a local issue of salt water intrusion. It obviously wouldn't apply to customers in the northern part of Florida, the middle of Florida, because that is not an issue, but it is an issue in our area.

Q Help me understand. Why do you think this classification into two entities, two classes would dissuade customers from using more water? What mechanism would derive that?

A Well, the cost.

Q You mean supply and demand or just cost?

A Just cost. Your rates, the cost -- for example, if you were in Lee County and you are comparing utilities and you were aware that you had, if you used up all the potable water, that you would end up with a reverse osmosis process, for example, for demineralizing the water, that you would be paying a lot higher rate.

Q You are saying it is the price signal that would be sent that would dissuade people from using more?

A I don't know that is a big issue. That was a statement in my direct testimony.

Q Yes, sir, but it is part of your testimony. I wanted to ask you, if I could show you that some of the customers using standard treatment didn't get the proper price signal because their rates were supported by subsidies, would that change your view on this?

A I don't believe so. That wouldn't change my view, not in the context that my testimony is presented.

Q It is your testimony that if prices were modified by subsidies, that is the prices were made to be less than their true cost, that this wouldn't affect your conclusion?

A That's outside of my area, I don't -- I guess I'm not connecting with your question.

MR. TWOMEY: That's all I have.

CHAIRMAN CLARK: Staff.

CROSS EXAMINATION

BY MR. PELLIGRINI:

Q Good evening, Mr. Elliott.

A Good evening.

Q I want to take you back to your deposition of January 11, 1996. Do you have a transcript available?

A I'm not sure. Just a minute. Yes, sir, I have it.

Q Very well. Let me refer you to pages 10, 11 and 12, which all appear -- you have the compressed format?

MR. FEIL: What page references?

BY MR. PELLIGRINI:

Q Beginning at the middle of Page 10 and continuing to the top of Page 12. There you will note that -- I asked you some questions relative to the classification of facilities based upon treatment type.

A Yes. I'm on the same page, I believe.

Q Did you not agree that -- did you not agree at that time that it was possible that you would accept three classifications based on treatment, on treatment type?

A Hypothetically I would if I had, you know, had that opportunity and --

Q What three class -- I'm sorry.

A The classifications I stated here, let's see, lime softening, iron filtration, and I guess we will partition out reverse osmosis. You also have, I guess, another type where you are treating the Floridan aquifer, pumping it out of the ground, perhaps aerating it and disinfecting it. I didn't -- what's the question?

Q Well, I'm asking you to identify the classifications that would be acceptable to you based on treatment type.

MR. FEIL: I don't think he testified in his deposition there were any classifications that were acceptable based on treatment type other than those he mentioned in his direct testimony.

Q Would you read, Mr. Elliott, your testimony beginning at line 21 on Page 11, with the sentence beginning as you mentioned?

A 21 is a question, the beginning of 20, I would have to read the whole thing to put it in context.

Q On page 11?

A No, excuse me.

Q Line 21, Page 11, the sentence beginning, "as you mentioned". The question was --

A That's an answer, yes.

Q The question was, "And what would the three structures be?"

A As you mentioned, lime softening and iron removal are technologies that would probably have the same cost factor. Brackish water reverse osmosis system would have the distinctly higher number. That continues onto 25.

Q These three classifications, as I understand in your view, would justify three different rate structures.

A Not in this case. That's not what we proposed here. My testimony was that it was in two categories.

Q I realize that.

A I would say if I were to create a case from scratch and had the opportunity, that would be maybe a possibility. Again, that is kind of hypothetical.

Q Yes, I appreciate that. Let me take you to line 17 on Page 11. Would you read the last part of that, sir, the last part of that answer?

A I would start at 15 and read the answer. "In general, if I were creating or working on a rate case that had starting from scratch a theoretical model I would have perhaps three different rate structures."

I think you have to read the whole answer.

MR. PELLIGRINI: Fair enough. I have no

further questions.

CHAIRMAN CLARK: Redirect. Excuse me, Commissioners? Redirect.

MR. FEIL: No questions.

CHAIRMAN CLARK: No exhibits?

MR. FEIL: That's correct.

CHAIRMAN CLARK: Okay. Thank you, Mr. Elliott. You are excused.

CHAIRMAN CLARK: We are just about at 8:00 o'clock. I do want to inquire, I notice Mr. Ludsen is not going to be available on the 3rd and the 4th. Does it make sense to take him up first thing in the morning?

MR. ARMSTRONG: If that's acceptable to the parties, Madam Chair, that would be fine.

COMMISSIONER GARCIA: Who is it you are taking up?

CHAIRMAN CLARK: If you will notice, Mr. Ludsen will not be available on Friday or Saturday. And my question is would it be appropriate to take him up tomorrow.

MR. TWOMEY: My personal preference would be as opposed to tomorrow, Monday, if it wouldn't kill anybody else. The Ludsen is an important, extremely important witness. I will do, of course, whatever you want to do.

COMMISSIONER KIESLING: Let me kind of indicate as having looked through the testimony and judging how it was going, I kind of looked at how we could finish in two weeks. I had Mr. Ludsen for tomorrow, plus Mr. Bliss and Mr. Westrick and Mr. Bencini, which would give us another from 9:00 in the morning to 8:00 at night kind of day. Because then on Friday we have to take our Staff witness, one of the Staff witnesses out of order, which everyone agreed to at the pre-hearing, Dr. Beecher.

CHAIRMAN CLARK: Yes.

MS. O'SULLIVAN: Commissioners, Staff would request if we do take Mr. Ludsen tomorrow that it be after 10:00 o'clock to let Staff prepare for him because we are going by the list right now.

CHAIRMAN CLARK: Mr. Riley, who is questioning Mr. Ludsen for --

MR. RILEY: As I understand it, it is Charlie.

CHAIRMAN CLARK: Okay. What we will do then is just skip over Mr. Ludsen on those days and continue on. I hope that doesn't put us beyond, well, he may have to testify after we begin testimony from Intervenors. Is that acceptable?

MR. TWOMEY: Yes, it is acceptable, sure.

CHAIRMAN CLARK: It is preferable to you to take him up tomorrow.

MR. TWOMEY: Pardon?

CHAIRMAN CLARK: It is preferable to you, that if that happens as opposed to taking up Mr. Ludsen tomorrow.

COMMISSIONER DEASON: What if we get to Mr. Ludsen tomorrow through normal course of business? I may be overly optimistic, but what if we do him in the normal course of business?

MR. TWOMEY: Then that's what we will do. I just had the expectation, frankly, I could use more time, that he was in the order. That's my problem, to be frank about it.

COMMISSIONER DEASON: It would appear to me that the only flip-flop would be if we take Mr. Ludsen last tomorrow, that he would go in front of Ms. Kimball. That would be the only --

CHAIRMAN CLARK: Yeah, but I don't think taking him last will get it done.

COMMISSIONER KIESLING: I do.

MS. O'SULLIVAN: We also are concerned we just received the rate case expense information and we are trying to prepare that to cross Mr. Ludsen with.

CHAIRMAN CLARK: He is back on rebuttal, too.

MR. FEIL: SSU stipulated to Staff if they wanted to cross him about rate case expense they could do that on rebuttal, that's fine.

CHAIRMAN CLARK: We will continue on in the order we have.

COMMISSIONER GARCIA: Just to make sure, we are doing Bliss, Westrick and Bencini and Kimball tomorrow, and Mr. Ludsen if all goes well.

CHAIRMAN CLARK: At least. We may just skip Mr. Ludsen even if he comes up rather than splitting his testimony and move on to Ms. Lock.

COMMISSIONER KIESLING: I would just indicate that were we to do that we would get to Intervenors sometime Friday afternoon or Saturday. I knew that Mr. Twomey had at least requested at the pre-hearing, you had one witness that had a date problem.

MR. TWOMEY: Judge Mann.

COMMISSIONER KIESLING: When was it going to be he was going to be available?

MR. TWOMEY: I was hoping toward the first of next week.

COMMISSIONER KIESLING: So Saturday?

MR. TWOMEY: No, not Saturday, no. I mean, the beginning of next week.

CHAIRMAN CLARK: Mr. Hoffman.

MR. HOFFMAN: Madam Chairman, with respect to Judge Mann, I spoke with staff this afternoon. And if staff doesn't have any questions for Judge Mann, the company is willing to stipulate Judge Mann in. I don't know about Public Counsel, but I just assume Public Counsel might not have questions because it is a rate design witness.

MR. RILEY: That would be a fair assumption.

MS. O'SULLIVAN: Staff would agree.

CHAIRMAN CLARK: It looks like we can stipulate Judge Mann --

COMMISSIONER GARCIA: I was hoping we would get to meets him.

CHAIRMAN CLARK: I'm sure you will.

COMMISSIONER KIESLING: I do have one more question. Someone will have to present witnesses on Saturday. That's just the way it fell. It looks like it will be Mr. Twomey. Do you have other witnesses that are not going -- who don't want to be here on Saturday?

MR. TWOMEY: Well, I guess Mr. Hansen is here. And currently I didn't plan for Mr. Woelffer to be here until first thing Monday morning or Sunday night. My expectation was it will go a little bit slow. . But I will call him, I guess.

COMMISSIONER KIESLING: All right.

CHAIRMAN CLARK: We will reassess it when we get to the end of tomorrow. Okay.

COMMISSIONER KIESLING: I just wanted you to have as much notice as possible, but it may fall that most of your witnesses are going to be Saturday.

MR. TWOMEY: I appreciate that.

COMMISSIONER GARCIA: We have stipulated Judge Mann in, also.

CHAIRMAN CLARK: Can I ask this, Stephanie Smith was stipulated into the record, right? Will be.

COMMISSIONER KIESLING: Will be.

CHAIRMAN CLARK: All right.

COMMISSIONER GARCIA: Madam Chairman, are we going all day Saturday? Because I would rather have time left over at the end of the week, if we can. If Mr. Twomey can't have his people for a reason, I would like to make sure we fill up

Saturday.

CHAIRMAN CLARK: We will fill up Saturday.

COMMISSIONER KIESLING: Could I just clarify one more thing, Mr. Twomey? I think that you had made a decision not to call Charles Dusseau?

MR. TWOMEY: Yes.

COMMISSIONER KIESLING: So --

CHAIRMAN CLARK: He can be stricken from the witness list.

MR. TWOMEY: I think I will strike Koch, as well.

COMMISSIONER KIESLING: That takes care of a couple of hours I thought we wouldn't have.

CHAIRMAN CLARK: Okay. We will look at it again tomorrow, and take some assessment as to how the schedule looks, and who will be testifying on Saturday. But at least tomorrow we will go through the order of witnesses as they appear on the hearing.

COMMISSIONER GARCIA: If we have some more stipulations we may not have to come in Saturday.

CHAIRMAN CLARK: I'm sure that is a possibility. Mr. Hansen says it is a possibility. All right. With that, this hearing is adjourned. We will reconvene tomorrow at 9:00 o'clock and start with the testimony of Mr. Bliss. Thank you.

(Thereupon, the hearing adjourned at 8:00 p.m. to reconvene May 2, 1996 at 9:00 a.m.)

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(Transcript continues in sequence in Volume 11.)

STEADY-STATE MODEL CALIBRATION OF PINE RIDGE WATER TRANSMISSION AND DISTRIBUTION NETWORK

Presented to:

SOUTHERN STATES UTILITIES, INC.
Apopka, Florida

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TABLE OF CONTENTS

Section Page

1.0 INTRODUCTION . . . 1-1
1.1 PURPOSE . . . 1-1
1.2 SCOPE . . . 1-1

2.0 HYDRAULIC MODELING . . . 2-1
2.1 THEORY . . . 2-1
2.2 MODELING PROGRAM . . . 2-1
2.3 MODEL DESCRIPTION . . . 2-2
2.4 DEVELOPMENT OF PINE RIDGE WATER DISTRIBUTION MODEL . . . 2-2
2.5 ADJUSTMENT OF DEMAND FOR SIMULATIONS . . . 2-3
2.6 MODELING AND THE NEED FOR MODEL CALIBRATION . . . 2-3

3.0 FIELD CALIBRATION . . . 3-1
3.1 PROGRAM . . . 3-1
3.2 FIELD DATA . . . 3-2
3.3 DATA ANALYSIS . . . 3-3
3.4 FIRST FIELD INVESTIGATION . . . 3-4
3.5 SECOND FIELD INVESTIGATION . . . 3-4
3.6 AIR BINDING . . . 3-6
3.7 MODEL CALIBRATION . . . 3-7

4.0 CONCLUSION AND RECOMMENDATIONS . . . 4-1
4.1 RESULTS . . . 4-1
4.2 RECOMMENDATIONS . . . 4-1

1.0 INTRODUCTION

1.1 PURPOSE

A steady-state hydraulic model mathematically simulates the pressure and flow performance of a hydraulic network. Model calibration is performed for three purposes:

A. To verify the validity of the mathematical model in simulating network performance.

B. To identify and assist in resolving discrepancies in model versus network performance.

C. To "fine tune" model parameters for optimum model accuracy in the variety of expected demand conditions.

The purpose of this report is to evaluate the collected field data and the model calibration effort of the Pine Ridge water distribution network.

1.2 SCOPE

The scope of the work presented herein is focused on a general discussion of hydraulic modeling, collection and analysis of field data, air binding, localized model calibration, and circumstances associated with overall calibration of the Pine Ridge water distribution model.

2.0 HYDRAULIC MODELING

2.1 THEORY

Two basic principles are involved in steady-state modeling. These principles are the conservation of mass and the First Law of Thermodynamics. The conservation of mass principle states that the time rate of change of the system mass equals zero. The application of this principle leads to the continuity equation. The First Law of Thermodynamics states that the time rate of increase of the total stored energy of the system equals the net time rate of energy addition by heat transfer into the system plus the net time rate of energy addition by work transfer into the system. Steady-state application of this law leads to the energy equation. Energy dissipation due to wall shear stress (i.e., the energy lost due to friction at the pipe wall) is the most difficult term in the energy equation to accurately describe. The Hazen-Williams equation is an industry standard and is used herein to describe this energy dissipation.

Although manual solution to the energy and continuity equations is possible, it is very time consuming and prohibitive as a practical matter. Therefore, it is advantageous to solve the equations by use of a steady-state hydraulic computer program.

2.2 MODELING PROGRAM

The computer program used in this steady-state model calibration is Cybernet by Haestad Methods. Cybernet is basically a version of Kentucky Pipes with an AutoCAD graphical interface. Specifically, Cybernet solves the pressure network using the state-of-the-art KYPIPE2 computational algorithm. The program permits use of a variety of boundary conditions including constant head (given as elevation), pumps, constant demand, valves, and storage tanks. Pumps may be represented as useful power or by using head-discharge data from a pump curve.

2.3 MODEL DESCRIPTION

The first step in modeling a network of pipes is to describe the network as a series of nodes connected by pipe sections. This description results in a steady-state schematic representing pipe sections and nodes with a line-circle diagram.

A pipe section is described as constant diameter sections of pipe that may contain minor loss elements such as valves or bends. A complete pipe section description contains the section length, inside diameter, and pipe roughness. Pipe roughness is primarily a function of pipe material. Depending on pipe material and water chemistry, the pipe roughness may change with age. Pipe roughness is input in this model as the Hazen-Williams "C" coefficient. The Hazen-Williams "C" coefficient is a function of pipe roughness, pipe diameter, and the Reynold's number of flow in the pipe.

End points of pipe sections are connected by nodes which can be one of two types: junction nodes or fixed-grade nodes. Junction nodes are nodes located at the intersection of two or more pipes where flow is removed or added to the network. Fixed-grade nodes are nodes where both the elevation and pressure are known, such as at network discharge point.

Pumps used in the analysis are located in pipe sections and are described using a minimum of three points from the head-discharge curve. Other network components used in this analysis are pressure regulating valves (PRVs) and a check valve.

2.4 DEVELOPMENT OF PINE RIDGE WATER DISTRIBUTION MODEL

The two most important factors involved in the development of a representative model of a water distribution network are distribution of demand to nodes and accurate representation of the physical elements of the network. The Facilities Analysis Department of Southern States Utilities, Inc. (SSU) has assumed this responsibility.

SSU used water sales records from September 1994 to August 1995 to determine the current average daily flow (ADF) of each customer in Pine Ridge. The demand of each customer was then allocated to a hydraulically nearby node in the model. Customers that live in close hydraulic proximity to each other generally have their demands allocated to the same node.

SSU developed the model by use of construction plans, record drawings, well installation records, and accountant records. The current model is composed of 1,099 pipes, 989 junction nodes, 4 fixed-grade nodes, 3 well pumps, 2 booster pumps, 1 check valve, and 3 PRVs. Calibration of the model is dependent on the actual operational performance of the check valve, Field Booster Pump No. 1, and all three PRVs. Although only one booster pump (Model Booster Pump No. 2) was used during the calibration effort, operational performance of all pumps have been examined and the model adjusted accordingly. The PRVs act as control points in the model. For each simulation, the downstream set points of the PRVs in the model have been set to the actual hydraulic grade measured during each test event.

2.5 ADJUSTMENT OF DEMAND FOR SIMULATIONS

Network demand in the model may be adjusted to represent overall customer demand during any test by applying a multiplication factor to the nodal demands supplied by SSU. This effectively prorates the increase or decrease in overall network demand versus overall model ADF to all nodal demand locations equally.

2.6 MODELING AND THE NEED FOR MODEL CALIBRATION

The industry standard in modeling water distribution networks is to model required hydraulic elements (such as pumps, PRVs, check valves), ignore local losses, and apply a global Hazen-Williams "C" coefficient to the model for pipes of similar size, material, and internal condition. Some of the considerations associated with this type of modeling are as follows:

A. The Hazen-Williams “C” coefficient is a function of pipe inside diameter, pipe roughness, and the Reynold’s number of flow in the pipe.

B. The Hazen-Williams equation is an empirical equation that describes the frictional energy loss in the pipe. However, the equation has to be adjusted to account for local energy losses. (i.e., fitting losses, etc.)

C. Depending on pipe material and water chemistry, the pipe roughness and inside diameter may change with age.

D. The hydraulic performance of certain elements in the water network and facilities may deteriorate.

E. Other factors, such as air binding, network blockages, installed utilities differing from those in utility records, etc., may affect network performance.

Therefore, it is sometimes difficult for a model to accurately predict pressure and flow distribution in real water transmission and distribution networks. Model calibration is performed for reliable prediction of field pressure and flow distribution. Typically, a model is considered calibrated if it can predict field pressures within 5 psi. However, if fluctuations are 10 psi or greater and occur at fairly short intervals, one must select a pressure level during a cycle (a high, medium, or low point) and attempt to calibrate the model for that condition, recognizing that there are some inherent inaccuracies in using a steady-state model to describe unsteady conditions (***Water Systems: Simulation and Sizing***, Walski, Gessler and Sjostrom).

3.0 FIELD CALIBRATION

3.1 PROGRAM

Prior to developing a field test program the following events occurred:

A. Production meter calibration.
B. Well pump capacity tests.
C. Week long data logging for development of diurnal curves.
D. Survey of test locations for elevations.

The field test program was developed by selecting specific hydrants to impose a demand that hydraulically stressed the facilities by dropping local pressures in the network to 20 psi. The number of supply sources was kept to the minimum number which could provide for current customer and test demands while maintaining adequate network pressure performance. The test configuration included a listing of the operating status of all supply wells, booster pumping station, PRVs, and locations of pressure and flow monitoring points.

Each field test configuration included the following items:

A. Monitor each operating well for flow, pressure, and hydropneumatic tank level.

B. Monitor each booster pump for suction and discharge pressure.

C. Monitor each PRV for pressure upstream and downstream of the valve.

D. Monitor each operating hydrant for flow and monitor residual pressure at a location nearby.

E. Monitor network pressure at selected residual monitoring points.

Pressure gauges were calibrated in the installed position by JEA prior to the test (previous day) using a dead weight calibrator.

Specifically, five tests were planned. In all tests, pumps and hydropneumatic tanks at Well Nos. 2 and 3 were valved off. This simplified the facilities by making Well No. 4 the only supply source. Pressures were recorded at all the monitoring points listed above at various times for each test scenario.

Test 1 consisted of stressing a hydrant on West Ranger Street at approximately 300 GPM and recording residual pressure on West Deputy Drive.

Test 2 consisted of stressing a hydrant on North Hatchet Circle at approximately 300 GPM and recording residual pressure on Tomahawk Drive.

Test 3 consisted of stressing a hydrant on West Pine Ridge Boulevard at approximately 300 GPM and recording residual pressure on West Cavalry Lane.

Test 4 consisted of stressing a hydrant on North Buffalo Drive at approximately 300 GPM and recording residual pressure on North Buffalo Drive.

Test 5 consisted of stressing a hydrant on North Red Ribbon Point at approximately 400 GPM and recording residual pressure on North Princewood Drive.

3.2 FIELD DATA

Two field efforts were performed for data acquisition necessary for model calibration. The field efforts were performed on November 17, 1995 and January 16, 1996. The information gathered during the second field effort is more detailed and is deemed more reliable. The January 16, 1996 collected field data is presented in Attachment 1. Comparison of measured to modeled pressures is presented in Attachment 2 (including subsequently determined closed and throttled valve status).

3.3 DATA ANALYSIS

Comparison of the field data to the model output data indicated that differences in field versus model pressures generally in excess of a 5 psi to 10 psi range were occurring in the western part of the network when that part of the network was hydraulically stressed by hydrant flow. The consistency of this modeled versus measured difference at the pressure monitoring points indicated that there was a physical explanation for the head loss. It was believed that the head loss was due to one or more of the following:

A. Air binding may be occurring in the network.

B. An obstruction may exist in the network. This may be a closed valve(s) or a physical obstruction in one or more pipes.

C. Installed pipe(s) may be different in size or connection from modeled pipe(s).

D. The roughness of a pipe(s) may have deteriorated to the point that it is responsible for the head loss.

A comparison of field and model pressures is presented in Attachment 2. Copies of input and output files for these simulations are available upon request.

The data analysis indicated that a field investigation of the operational status of all the valves in the pipeline that runs along Pine Ridge Boulevard would have to be performed.

3.4 FIRST FIELD INVESTIGATION

On February 2, 1996, SSU performed a field investigation in an attempt to locate the source of the head loss. The results of the field investigation are as follows:

A. A fully closed field valve (10 inch gate valve) was found on the eastern side of the tee that connects modeled pipe nos. 511, 516, and 3241.

B. A field valve (12 inch gate valve) 7/36th closed was found in model pipe no. 851.

C. A notable head loss was found at the northern connection between the eastern and western parts of the network.

D. The pressure at the hydrant closest to Pine Ridge Boulevard and North Perry Drive (Perry Hydrant) was not fluctuating as was the pressure at the hydropneumatic tank at Well No. 4.

E. Closing and opening of a valve on North Perry Drive appeared to remove the source of the head loss and pressures began fluctuating at the referenced hydrant in synchronization with the pressure at the hydropneumatic tank at Well No. 4.

3.5 SECOND FIELD INVESTIGATION

A second field investigation to evaluate the overall network performance was conducted by SSU and JEA on February 28, 1996 and February 29, 1996.

On the first day (2/28/96), Test 3 with pressure monitoring points at West Cavalry Lane, North Buffalo Drive, and Well No. 2 was repeated. The results of the test indicated that the western part of the network was again experiencing pressure losses in excess of the 5 to 10 psi range. As a consequence, the hydrant flow was allowed to continue and the network was investigated along the 8 inch main on Pine Ridge Boulevard. The results of this investigation indicated that a notable local pressure loss was accruing between Perry Hydrant and the hydrant closest to the intersection of Pine Ridge Boulevard and North Carnation Drive (Carnation Hydrant). This section is represented by model pipe nos. 631, 771, 776 and 781. The result of this investigation is herein referred to as Obstruction Test (2/28/96). Additional investigation found as follows:

A. A closed field valve (8 inch gate valve) was encountered in model pipe no. 2787.

B. The pressure at Perry Hydrant was not fluctuating with the hydropneumatic tank pressure at Well No. 4.

C. Manipulation of network operation to isolate and flow the 8 inch main on Pine Ridge Boulevard, and subsequent opening of the Carnation Hydrant, resulted in air being expelled from the network.

D. After air was expelled from the network, the pressure at Perry Hydrant began fluctuating by 5 psi in synchronization with the pressure at the Well No. 4 hydropneumatic tank.

On the second day (2/29/96), further manipulation of network operation to backflow the referenced 8 inch main and subsequent opening of the Carnation Hydrant resulted in a significant amount of air expulsion from the network. Repeating Test 3, which is herein referred to as Obstruction Test (2/29/96), and monitoring pressures at Perry and Carnation

Hydrants indicated that the network performance was significantly closer to the performance predicted by the hydraulic model.

A comparison of the field and model pressures for the data collected during the second field investigation is presented in Attachment 3. Copies of input and output files for these simulations are available upon request. As indicated, expulsion of the air from the pipeline resulted in the pressure at the Perry Hydrant agreeing within 5.3 psi with the model pressure versus a 12.5 psi disagreement before air purging.

3.6 AIR BINDING

When enough air accumulates in a pipe, the cross-sectional area available for flow can be reduced. Should the cross-sectional area available for flow in the pipe be less than the full pipe cross-sectional area, the laws governing the flow in the pipe change from pipeline hydraulics to open channel hydraulics. This phenomenon is called air binding. Some of the results of air binding are reduced capacity and an energy loss equal to the vertical length of the air pocket(s) plus the energy dissipated in the hydraulic jump, if present. An article from the ***Journal of American Water Works Association***, written by Robert C. Edmunds, is provided in Attachment 4. The article gives a more detailed explanation of air binding. Case studies involving air binding are presented on page 276 of the article. The case studies are very useful in understanding the effects of air binding.

The results of the field efforts and investigations indicate a high probability that air binding exists as an intermittent or chronic condition in the western part of the network. Although air binding is not currently indicated in the eastern part of the network, it might occur. A theoretical analysis of air binding in pipe no. 631 (the descending leg between the two parts of the network) indicates the following:

A. Under normal network demand, the pipes have a high probability of becoming air bound due to the rolling terrain and the lack of air release valves.

B. Under fire flow demand, the pipes are more likely to be in the incipient to clearing phase of air binding.

The theoretical analysis is presented in Attachment 5. The Gandenberger curve was used in the theoretical analysis. As shown by the graph in Attachment 5, if the plotted point is below the line, air binding will occur; if the point is far above the line, air binding will not occur; and if the point is near the line air binding may be in an incipient phase. Note that an incipient phase is not necessarily a clearing phase.

3.7 MODEL CALIBRATION

Calibration of the hydraulic model for the eastern part of the network is considered complete. This is indicated by examination of the measured versus the modeled pressure at the North Princewood Drive Hydrant for all tests reported in Attachment 2. As indicated, the measured versus the modeled pressure agrees within 5.6 psi for all tests. However, examination of the measured versus modeled pressures at West Deputy Drive, North Buffalo Drive, Well No. 2, booster station (suction side), and West Cavalry Lane indicates disagreement by as much as 13 psi, with the measured pressure almost always below the modeled pressure for all cases. The measured pressure is always below the modeled pressure for cases where the western part of the network is stressed by hydrant flow. Also, as indicated, the measured versus modeled pressure disagreement is relatively consistent from point to point in the western part of the network. All of these observations are consistent with the finding of air binding in the 8 inch main connecting the eastern and western parts of the network. As indicated in section 3.5, purging of trapped air from the

8 inch pipeline reduced the measured versus modeled pressure disagreement at the Perry Hydrant from 12.5 psi to 5.3 psi. Because pressure loss in the 8 inch main affects pressures throughout the western part of the network, a comparable reduction in pressure discrepancies would be expected at all pressure measuring locations in the western part of the network as well. Consequently, it is our opinion that the pressure discrepancies and model calibration in the western part of the network are being adversely effected by occasional or chronic air binding. Installation of properly placed air release valves to purge pockets of entrapped air would be expected to permit the western part of the network to function hydraulically as indicated by the hydraulic model.

4.0 CONCLUSION AND RECOMMENDATIONS

4.1 RESULTS

The hydraulic model accurately predicts pressure within 5 psi for the eastern part of the network. Therefore, the model can be considered calibrated with respect to the eastern part. A head loss is experienced in the western part, which we believe is due to air binding. The results of various field investigations have confirmed the presence of air in the network and expulsion of some of the air from the network has resulted in a decrease of head loss in the western part of Pine Ridge.

Expulsion of air from the network resulted in the following:

A. Field pressure recorded at Well No. 2 went from 13.2 psi below model prediction to 8.18 psi below model prediction for the same test configuration.

B. Field pressure recorded at Perry Hydrant went from 12.48 psi below model prediction to 5.27 psi below model prediction for the same test configuration.

Following installation of devices that will allow air to be continually purged from the network, we expect that the model will calibrate at a C-value of 145.

4.2 RECOMMENDATIONS

The following recommendations are provided for operation of the Pine Ridge water transmission and distribution network.

A. Air release valves should be installed at critical points throughout the water distribution network.

B. Following this, if air binding persists, air traps should be installed at specific locations around all wells.

ATTACHMENT 1

TEST #1

EVENT	TIME	PUMP STATUS	HYDRANT STATUS OPEN/CLOSE	DISCHARGE PRESSURE (PSIG)	"PUMP ON" TOTALIZER READING (GAL)	"PUMP OFF" TOTALIZER READING (GAL)	HYDROTANK LEVEL (INCHES)	PRV #1 UPSTREAM PRESSURE (PSIG)	PRV #2 UPSTREAM PRESSURE (PSIG)	PRV #2 DOWNSTREAM PRESSURE (PSIG)	PRV #3 UPSTREAM PRESSURE (PSIG)	PRV #3 DOWNSTREAM PRESSURE (PSIG)	BOOSTER STATION PUMP #1 SUC. PRES. (PSIG)	BOOSTER STATION PUMP #1 DISC. PRES. (PSIG)	BOOSTER STATION PUMP #2 SUC. PRES. (PSIG)	BOOSTER STATION PUMP #2 DISC. PRES. (PSIG)	WELL #2 (PSIG)	BUFFALO (PSIG)	PRINCEWOOD (PSIG)	RESIDUAL HYDRANT (PSIG)	STRESSED HYDRANT MICROMETER (GPM)
1																					
2																					
	1:20:00	ON	CLOSED																		
3	1:21:00		CLOSED				16.75	64	62	54	53	40	56	98	58	97	56	52	64	64	0
4	1:27:00		CLOSED				21	73	75	54	61	50	68	105	72	105	64	54	81	72	0
	1:27:00	OFF	CLOSED																		
	1:33:00	ON	CLOSED																		
5	1:33:00		CLOSED				16	64	67	53	52	40	58	97	58	97	56	54	65	64	0
6	1:36:00		CLOSED				21	71	74	55	60	50	70	105	70	105	64	52	81	72	0
	1:36:00	OFF																			
	1:55:00	ON	OPEN		266,000,160																
7	1:57:00		OPEN	60			17.5	64	64	53	49	32	51	98	52	98	46	44	64	36	280
8	1:58:00		OPEN	63			19.5	65	65	54	51	33	53	98	53	99	48	45	74	35	260
9	1:59:00		OPEN	69			20.5	69	70	54	55	38	56	103	58	103	52	45	76	38	280
	1:59:00	OFF	OPEN			266,002,410															
	2:06:00	ON	CLOSED		266,002,410																
10	2:06:00		CLOSED	57			16	63	65	54	51	40	56	98	58	97	54	52	65	64	0
11	2:07:00		CLOSED	70			21	72	74	54	60	48	66	105	66	105	60	52	75	68	0
	2:07:42	OFF	CLOSED			266,003,900															

EVENT	TIME	HYDRANT STATUS OPEN/CLOSE	DISCHARGE HGL (FT)	PRV #1 UPSTREAM HGL (FT)	PRV #2 UPSTREAM HGL (FT)	PRV #2 DOWNSTREAM HGL (FT)	PRV #3 UPSTREAM HGL (FT)	PRV #3 DOWNSTREAM HGL (FT)	BOOSTER STATION PUMP #1 SUC. HGL (FT)	BOOSTER STATION PUMP #1 DISC. HGL (FT)	BOOSTER STATION PUMP #2 SUC. HGL (FT)	BOOSTER STATION PUMP #2 DISC. HGL (FT)	WELL #2 HGL (FT)	BUFFALO HGL (FT)	PRINCEWOOD HGL (FT)	RESIDUAL HYDRANT HGL (FT)
		ELEVATIONS	81.93	137.59	130.32	130.32	153.92	153.92	72.45	72.45	72.45	72.45	85.94	101.59	76.87	83.64
1																
2																
3	1:21	CLOSED		265.282	273.397	254.935	276.228	246.228	201.681	298.604	206.296	296.296	215.171	221.590	224.582	231.532
4	1:27	CLOSED		306.052	303.397	254.935	294.689	269.305	229.373	314.758	238.604	314.758	233.632	226.205	263.793	249.994
5	1:33	CLOSED		265.282	284.935	252.628	273.920	246.228	206.296	296.296	206.296	296.296	215.171	226.205	226.870	231.532
6	1:36	CLOSED		301.436	301.089	257.243	292.382	269.305	233.988	314.758	233.988	314.758	233.632	221.590	263.793	249.994
7	1:57	OPEN	220.392	265.282	278.012	252.628	266.997	227.766	190.142	298.604	192.450	298.604	192.094	203.128	224.582	165.917
8	1:58	OPEN	227.315	267.590	280.320	254.935	271.612	230.074	194.758	298.604	194.758	300.912	196.709	205.436	247.639	164.609
9	1:59	OPEN	241.161	296.821	291.858	254.935	280.843	241.612	201.681	310.142	206.296	310.142	205.940	205.436	252.255	171.532
10	2:06	CLOSED	213.468	282.975	280.320	254.935	271.612	246.228	201.681	293.988	206.296	296.296	210.555	221.590	226.870	231.532
11	2:07	CLOSED	243.468	303.744	301.089	254.935	292.382	264.689	224.758	314.758	224.758	314.758	224.402	221.590	249.947	240.763

NOTE: ONLY USE EVENT 7 THROUGH EVENT 11.

EXHIBIT (ACE-1)
PAGE 19 OF 48

TEST #2

EVENT	TIME	PUMP STATUS	HYDRANT STATUS (OPEN/CLOSE)	DISCHARGE PRESSURE (PSIG)	"PUMP ON" TOTALIZER READING (GAL)	"PUMP OFF" TOTALIZER READING (GAL)	HYDROTANK LEVEL (INCHES)	PRV #1 UPSTREAM PRESSURE (PSIG)	PRV #2		PRV #3		BOOSTER STATION				WELL #2 (PSIG)	BUFFALO (PSIG)	PRINCEWOOD (PSIG)	RESIDUAL HYDRANT (PSIG)	STRESSED HYDRANT MICROMETER (GPM)
									UPSTREAM PRESSURE (PSIG)	DOWNSTREAM PRESSURE (PSIG)	UPSTREAM PRESSURE (PSIG)	DOWNSTREAM PRESSURE (PSIG)	PUMP #1 SUC. PRES. (PSIG)	PUMP #1 DISC. PRES. (PSIG)	PUMP #2 SUC. PRES. (PSIG)	PUMP #2 DISC. PRES. (PSIG)					
	2:32:30	ON			266,007,100																
1	2:33:21		CLOSED	62			18	64	67	54	52	40	58	97	58	97	54	52	68	66	0
2	2:34:13		CLOSED	70			20.75	68	70	53	56	44	62	100	62	101	58	52	75	68	0
	2:34:22	OFF				266,008,770															
	2:36:30	ON			266,008,770																
3	2:38:44		OPEN	61			18	53	67	53	43	32	47	91	48	91	46	44	69	56	300
4	2:39:28		OPEN	66			19.5	55	67	53	44	34	50	94	50	93	49	44	71	56	320
5	2:40:05		OPEN	70			21	57	62	53	47	38	52	95	52	96	52	44	77	58	320
	2:40:40	OFF				266,011,150															
	2:45:40	ON			266,011,150																
6	2:46:00		CLOSED	63			18.5	66	69	53	53	42	60	96	60	98	54	50	67	68	0
7	2:47:00		CLOSED	72			22	73	76	53	62	51	71	105	70	106	64	52	77	74	0
	2:47:13	OFF				266,012,550															

EVENT	TIME	HYDRANT STATUS OPEN/CLOSE	DISCHARGE HGL (FT)	PRV #1 UPSTREAM HGL (FT)	PRV #2		PRV #3		BOOSTER STATION				WELL #2 HGL (FT)	BUFFALO HGL (FT)	PRINCEWOOD HGL (FT)	RESIDUAL HYDRANT HGL (FT)
		ELEVATIONS	81.93	137.59	130.32	130.32	153.92	153.92	72.45	72.45	72.45	72.45	85.94	101.59	76.87	139.4
					UPSTREAM HGL (FT)	DOWNSTREAM HGL (FT)	UPSTREAM HGL (FT)	DOWNSTREAM HGL (FT)	PUMP #1 SUC. HGL (FT)	PUMP #1 DISC. HGL (FT)	PUMP #2 SUC. HGL (FT)	PUMP #2 DISC. HGL (FT)				
1	2:33:21	CLOSED	225.007	285.282	284.935	254.935	273.920	246.228	206.296	296.296	206.296	296.296	210.555	221.590	233.793	291.706
2	2:34:13	CLOSED	243.468	294.513	291.858	252.628	283.151	255.458	215.527	303.219	215.527	305.527	219.786	221.590	249.947	296.323
3	2:38:44	OPEN	222.699	259.898	284.935	252.628	253.151	227.766	180.912	282.450	183.219	282.450	192.094	203.128	236.101	268.631
4	2:39:28	OPEN	234.238	264.513	284.935	252.628	256.458	232.382	187.835	289.373	187.835	287.065	199.017	203.128	240.716	268.631
5	2:40:05	OPEN	243.468	269.128	273.397	252.628	262.382	241.612	192.450	291.681	192.450	293.968	205.940	203.128	254.562	273.246
6	2:46:00	CLOSED	227.315	289.898	289.551	252.628	276.228	250.843	210.912	298.604	210.912	298.604	210.555	216.975	231.485	296.323
7	2:47:00	CLOSED	248.084	306.052	305.705	252.628	298.997	271.612	236.296	314.758	233.968	317.065	233.632	221.590	254.562	310.169

EXHIBIT CCE-1

PAGE 20 OF 48

TEST #3

EVENT	TIME	PUMP STATUS	HYDRANT STATUS OPEN/CLOSE	DISCHARGE PRESSURE (PSIG)	"PUMP ON" TOTALIZER READING (GAL)	"PUMP OFF" TOTALIZER READING (GAL)	HYDROTANK LEVEL (INCHES)	PRV #1 UPSTREAM PRESSURE (PSIG)	PRV #2 UPSTREAM PRESSURE (PSIG)	PRV #2 DOWNSTREAM PRESSURE (PSIG)	PRV #3 UPSTREAM PRESSURE (PSIG)	PRV #3 DOWNSTREAM PRESSURE (PSIG)	BOOSTER STATION PUMP #1 SUC. PRES. (PSIG)	BOOSTER STATION PUMP #1 DISC. PRES. (PSIG)	BOOSTER STATION PUMP #2 SUC. PRES. (PSIG)	BOOSTER STATION PUMP #2 DISC. PRES. (PSIG)	WELL #2 (PSIG)	BUFFALO (PSIG)	PRINCEWOOD (PSIG)	RESIDUAL HYDRANT (PSIG)	STRESSED HYDRANT MICROMETER (GPM)
	3:44:05	ON			266,020,170																
1	3:44:34		CLOSED	61			18.25	64	67	54	52	40	59	97	59	97	56	55	64	85	0
2	3:45:20		CLOSED	62		266,021,630	21	71	72	54	58	46	68	103	67	103	66	55	76	90	0
	3:45:43	OFF																			
	3:49:22	ON			266,021,630																
3	3:49:57		OPEN	61			18	65	67	53	52	37	50	98	51	99	46	44	65	75	310
4	3:50:33		OPEN	64			19	68	70	53	54	38	52	101	53	101	48	44	71	75	300
5	3:51:51		OPEN	71.5			21.75	70	71	53	56	42	60	102	60	102	55	44	76	79	340
	3:52:10	OFF				266,024,160															
	3:56:00	ON			266,024,160																
6	3:56:22		CLOSED	62			18.5	67	70	53	55	42	59	100	59	100	54	51	65	85	0
7	3:57:21		CLOSED	70			21.25	72	72	54	60	48	68	104	68	105	62	52	74	90	0
	3:57:47	OFF				266,025,740															

EVENT	TIME	HYDRANT STATUS OPEN/CLOSE	DISCHARGE HGL (FT)	PRV #1 UPSTREAM HGL (FT)	PRV #2 UPSTREAM HGL (FT)	PRV #2 DOWNSTREAM HGL (FT)	PRV #3 UPSTREAM HGL (FT)	PRV #3 DOWNSTREAM HGL (FT)	BOOSTER STATION PUMP #1 SUC. HGL (FT)	BOOSTER STATION PUMP #1 DISC. HGL (FT)	BOOSTER STATION PUMP #2 SUC. HGL (FT)	BOOSTER STATION PUMP #2 DISC. HGL (FT)	WELL #2 HGL (FT)	BUFFALO HGL (FT)	PRINCEWOOD HGL (FT)	RESIDUAL HYDRANT HGL (FT)
		ELEVATIONS	81.93	137.59	130.32	130.32	153.92	153.92	72.45	72.45	72.45	72.45	85.94	101.59	76.87	25.01
1	3:44:34	CLOSED	222.699	285.282	284.935	254.935	273.920	246.228	208.604	296.296	208.604	296.296	215.171	228.513	224.562	221.164
2	3:45:20	CLOSED	241.161	301.436	296.474	254.935	287.766	260.074	229.373	310.142	227.065	310.142	238.248	228.513	252.255	232.702
3	3:49:57	OPEN	222.699	287.590	284.935	252.628	273.920	239.305	187.835	298.604	190.142	300.912	192.094	203.128	226.870	198.087
4	3:50:33	OPEN	229.622	294.513	291.858	252.628	278.535	241.612	192.450	305.527	194.758	305.527	196.709	203.128	240.716	198.087
5	3:51:51	OPEN	246.930	299.128	294.166	252.628	283.151	250.843	210.912	307.835	210.912	307.835	212.863	203.128	252.255	207.318
6	3:56:22	CLOSED	225.007	292.205	291.858	252.628	280.843	250.843	208.604	303.219	208.604	303.219	210.555	219.282	226.870	221.164
7	3:57:21	CLOSED	243.468	303.744	296.474	254.935	292.382	264.689	229.373	312.450	229.373	314.758	229.017	221.590	247.639	232.702

EXHIBIT (CCE-1)
PAGE 21 OF 48

TEST #4

EVENT	TIME	PUMP STATUS	HYDRANT STATUS OPEN/CLOSE	DISCHARGE PRESSURE (PSIG)	"PUMP ON" TOTALIZER READING (GAL)	"PUMP OFF" TOTALIZER READING (GAL)	HYDROTANK LEVEL (INCHES)	PRV #1 UPSTREAM PRESSURE (PSIG)	PRV #2 UPSTREAM PRESSURE (PSIG)	PRV #2 DOWNSTREAM PRESSURE (PSIG)	PRV #3 UPSTREAM PRESSURE (PSIG)	PRV #3 DOWNSTREAM PRESSURE (PSIG)	BOOSTER STATION PUMP #1 SUC. PRES. (PSIG)	BOOSTER STATION PUMP #1 DISC. PRES. (PSIG)	BOOSTER STATION PUMP #2 SUC. PRES. (PSIG)	BOOSTER STATION PUMP #2 DISC. PRES. (PSIG)	WELL #2 (PSIG)	BUFFALO (PSIG)	PRINCEWOOD (PSIG)	STRESSED HYDRANT MICROMETER (GPM)
	4:24:47	ON			266,031,430															
1	4:25:15		CLOSED	61			18	64	67	58	51	39	58	97	58	97	52	54	64	0
2	4:26:12		CLOSED	69			21	70	72	58	57	46	68	104	65	103	59	54	74	0
	4:26:45	OFF				266,033,170														
	4:29:30	ON			266,033,170															
3	4:30:07		OPEN	60			18	62	64	63	50	36	52	98	52	95	46	46	60	270
4	4:31:05		OPEN	65			19.5	66	68	63	53	38	53	100	53	100	48	44	69	310
5	4:32:12		OPEN	70			20.25	69	72	63	56	41	58	102	58	102	51	44	75	320
	4:33:00	OFF				266,036,200														
	4:36:20	ON			266,036,200															
6	4:37:10		CLOSED	62.5			19	68	70	53	55	42	60	101	60	101	62	52	69	0
7	4:38:10		CLOSED	70.5			21.75	71	74	53	59	48	68	104	68	104	62	54	75	0
	4:38:20	OFF				266,037,970														

EVENT	TIME	HYDRANT STATUS OPEN/CLOSE	DISCHARGE HGL (FT)	PRV #1 UPSTREAM HGL (FT)	PRV #2 UPSTREAM HGL (FT)	PRV #2 DOWNSTREAM HGL (FT)	PRV #3 UPSTREAM HGL (FT)	PRV #3 DOWNSTREAM HGL (FT)	BOOSTER STATION PUMP #1 SUC. HGL (FT)	BOOSTER STATION PUMP #1 DISC. HGL (FT)	BOOSTER STATION PUMP #2 SUC. HGL (FT)	BOOSTER STATION PUMP #2 DISC. HGL (FT)	WELL #2 HGL (FT)	BUFFALO HGL (FT)	PRINCEWOOD HGL (FT)
		ELEVATIONS	81.93	137.59	130.32	130.32	153.92	153.92	72.45	72.45	72.45	72.45	85.94	101.59	76.87
1	4:25:15	CLOSED	222.699	285.262	284.935	264.166	271.612	243.920	206.296	296.296	206.296	296.296	205.940	226.205	224.562
2	4:26:12	CLOSED	241.161	299.128	296.474	264.166	285.458	260.074	224.758	312.450	222.450	310.142	222.094	226.205	247.639
3	4:30:07	OPEN	220.392	280.667	278.012	275.705	269.305	236.997	192.450	293.988	192.450	291.681	192.094	207.744	215.332
4	4:31:05	OPEN	231.930	289.898	287.243	275.705	276.228	241.612	194.758	303.219	194.758	303.219	196.709	203.128	236.101
5	4:32:12	OPEN	243.468	296.821	296.474	275.705	283.151	248.535	206.296	307.835	206.296	307.835	203.632	203.128	249.947
6	4:37:10	CLOSED	226.161	294.513	291.858	252.628	280.843	250.843	210.912	305.527	210.912	305.527	205.940	221.560	236.101
7	4:38:10	CLOSED	244.622	301.436	301.089	252.628	290.074	264.689	229.373	312.450	229.373	312.450	229.017	226.205	249.947

EXHIBIT CCE-1
PAGE 22 OF 48

TEST #5

EVENT	TIME	PUMP STATUS	HYDRANT STATUS (OPEN/CLOSE)	DISCHARGE PRESSURE (PSIG)	"PUMP ON" TOTALIZER READING (GAL)	"PUMP OFF" TOTALIZER READING (GAL)	HYDROTANK LEVEL (INCHES)	PRV #1 UPSTREAM PRESSURE (PSIG)	PRV #2 UPSTREAM PRESSURE (PSIG)	PRV #2 DOWNSTREAM PRESSURE (PSIG)	PRV #3 UPSTREAM PRESSURE (PSIG)	PRV #3 DOWNSTREAM PRESSURE (PSIG)	BOOSTER STATION PUMP #1 SUC. PRES. (PSIG)	BOOSTER STATION PUMP #1 DISC. PRES. (PSIG)	BOOSTER STATION PUMP #2 SUC. PRES. (PSIG)	BOOSTER STATION PUMP #2 DISC. PRES. (PSIG)	WELL #2 (PSIG)	BUFFALO (PSIG)	PRINCEWOOD (PSIG)	STRESSED HYDRANT MICROMETER (GPM)
	5:25:08	ON	CLOSED		266,049,710															
1	5:26:00		CLOSED	64			19.5	66	69	53	54	40	58	98	58	97	53	54	73	0
2	5:27:00		CLOSED	69			21	67	69	53	55	42	60	100	60	100	56	54	73	0
	5:27:30	OFF	CLOSED			266,051,790														
	MISSED CYCLE																			
	5:38:38	ON	OPEN		266,058,670															
3	5:39:15		OPEN	61			18.75	64	70	51	53	40	58	98	58	98	52	54	54	410
4	5:40:20		OPEN	64			19.75	66	70	51	54	40	59	100	59	99	53	54	58	420
5	5:42:30		OPEN	66			20.5	65	70	53	54	44	64	98	63	99	59	54	61	400
	5:44:22	OFF	CLOSED			266,063,890														
	5:48:50	ON	CLOSED		266,063,890															
6	5:49:30		CLOSED	62			19	64	64	53	52	40	58	98	58	98	53	54	67	0
7	5:50:15		CLOSED	68			21.25	72	69	51	55	42	60	101	60	101	58	54	73	0
	5:51:08	OFF	CLOSED			266,065,900														

EVENT	TIME	HYDRANT STATUS OPEN/CLOSE	DISCHARGE HGL (FT)	PRV #1 UPSTREAM HGL (FT)	PRV #2 UPSTREAM HGL (FT)	PRV #2 DOWNSTREAM HGL (FT)	PRV #3 UPSTREAM HGL (FT)	PRV #3 DOWNSTREAM HGL (FT)	BOOSTER STATION PUMP #1 SUC. HGL (FT)	BOOSTER STATION PUMP #1 DISC. HGL (FT)	BOOSTER STATION PUMP #2 SUC. HGL (FT)	BOOSTER STATION PUMP #2 DISC. HGL (FT)	WELL #2 HGL (FT)	BUFFALO HGL (FT)	PRINCEWOOD HGL (FT)
		ELEVATIONS	81.93	137.59	130.32	130.32	153.92	153.92	72.45	72.45	72.45	72.45	85.94	101.59	78.87
1	5:25:15	CLOSED	229.622	289.898	289.551	252.628	278.535	248.228	206.298	298.604	206.298	298.298	208.248	226.205	245.332
2	5:26:12	CLOSED	241.161	292.205	289.551	252.628	280.843	250.843	210.912	303.219	210.912	303.219	215.171	226.205	245.332
3	5:30:07	OPEN	222.699	285.282	291.858	248.012	276.228	246.228	206.298	298.604	206.298	298.604	205.940	226.205	201.485
4	5:31:05	OPEN	229.622	289.898	291.858	248.012	278.535	246.228	208.604	303.219	208.604	300.912	208.248	226.205	210.716
5	5:32:12	OPEN	234.238	287.590	291.858	252.628	278.535	255.458	220.142	298.604	217.835	300.912	222.094	226.205	217.639
6	5:37:10	CLOSED	225.007	285.282	278.012	252.628	273.920	246.228	206.298	298.604	206.298	298.604	208.248	226.205	231.485
7	5:38:10	CLOSED	238.853	303.744	289.551	248.012	280.843	250.843	210.912	305.527	210.912	305.527	215.171	226.205	245.332

EXHIBIT (ECE-1)

PAGE 23 OF 48

ATTACHMENT 2

RESULTS OF MODEL CALIBRATION USING TEST #1, EVENT 9 (1/16/96)

Project No.: 19540-489-01-09
Project Name: SSU Model Calibration

Hazen-Williams C Factor = 145

Booster Pump Speed = 1402.25 rpm (it is operating at 79% of full speed)

Location	Sub-System Monitored	Field Pressure (psi)	Model Pressure (psi)	Difference (psi)
Residual (West Deputy Drive)	Western	38	47.33	-9.33
North Princewood Drive	Eastern	76	70.43	5.57
North Buffalo Drive	Western	45	55.66	-10.66
Well #2	Western	52	62.48	-10.48
PRV #1 (upstream)		69	68.714	0.286
PRV #2 (upstream)		70	69.667	0.333
PRV #2 (downstream)		54	54.002	-0.002
PRV #3 (upstream)		55	58.015	-3.015
PRV #3 (downstream)		38	37.301	0.699
Booster Station (suction side)	Western	56	67.13	-11.13
Booster Station (discharge side)		103	97.86	5.14

Hydrant Flow = 280 GPM

System Demand = 180 GPM

RESULTS OF MODEL CALIBRATION USING TEST #1, EVENT 11 (1/16/96)

Project No.: 19540-489-01-09
Project Name: SSU Model Calibration

Hazen-Williams C Factor = 145

Booster Pump Speed = 1349 rpm (it is operating at 76% of full speed)

Location	Sub-System Monitored	Field Pressure (psi)	Model Pressure (psi)	Difference (psi)
Residual (West Deputy Drive)	Western	68	72.39	-4.39
North Princewood Drive	Eastern	75	72.11	2.89
North Buffalo Drive	Western	52	61.24	-9.24
Well #2	Western	60	67.99	-7.99
PRV #1 (upstream)		72	71.933	0.067
PRV #2 (upstream)		74	72.887	1.113
PRV #2 (downstream)		54	54.002	-0.002
PRV #3 (upstream)		60	61.239	-1.239
PRV #3 (downstream)		48	47.307	0.693
Booster Station (suction side)	Western	66	72.6	-6.6
Booster Station (discharge side)		105	101.01	3.99

Hydrant Flow = 0 GPM

System Demand = 180 GPM

RESULTS OF MODEL CALIBRATION USING TEST #3, EVENT 2 (1/16/96)

Project No.: 19540-489-01-09
Project Name: SSU Model Calibration

Hazen-Williams C Factor = 145

Booster Pump Speed = 1331.25 rpm (it is operating at 75% of full speed)

Location	Sub-System Monitored	Field Pressure (psi)	Model Pressure (psi)	Difference (psi)
Residual (West Cavalry Lane)	Western	90	93.82	-3.82
North Princewood Drive	Eastern	76	71.05	4.95
North Buffalo Drive	Western	55	60.28	-5.28
Well #2	Western	66	67.03	-1.03
PRV #1 (upstream)		71	70.581	0.419
PRV #2 (upstream)		72	71.786	0.214
PRV #2 (downstream)		54	54.002	-0.002
PRV #3 (upstream)		58	60.303	-2.303
PRV #3 (downstream)		46	45.383	0.617
Booster Station (suction side)	Western	68	71.78	-3.78
Booster Station (discharge side)		103	99.56	3.44

Hydrant Flow = 0 GPM

System Demand = 155 GPM

RESULTS OF MODEL CALIBRATION USING TEST #3, EVENT 5 (1/16/96)

Project No.: 19540-489-01-09
Project Name: SSU Model Calibration

Hazen-Williams C Factor = 145

Booster Pump Speed = 1384.5 rpm (it is operating at 78% of full speed)

Location	Sub-System Monitored	Field Pressure (psi)	Model Pressure (psi)	Difference (psi)_
Residual (West Cavalry Lane)	Western	79	87.97	-8.97
North Princewood Drive	Eastern	76	72.87	3.13
North Buffalo Drive	Western	44	57.03	-13.03
Well #2	Western	55	63.89	-8.89
PRV #1 (upstream)		70	69.97	0.03
PRV #2 (upstream)		71	71.201	-0.201
PRV #2 (downstream)		53	53.001	-0.001
PRV #3 (upstream)		56	59.735	-3.735
PRV #3 (downstream)		42	41.392	0.608
Booster Station (suction side)	Western	60	68.8	-8.8
Booster Station (discharge side)		102	98.94	3.06

Hydrant Flow = 340 GPM

System Demand = 155 GPM

RESULTS OF MODEL CALIBRATION USING TEST #4, EVENT 2 (1/16/96)

Project No.: 19540-489-01-09
Project Name: SSU Model Calibration

Hazen-Williams C Factor = 145

Booster Pump Speed = 1349 rpm (it is operating at 76% of full speed)

Location	Sub-System Monitored	Field Pressure (psi)	Model Pressure (psi)	Difference (psi)
North Princewood Drive	Eastern	74	71.03	2.97
Residual (North Buffalo Drive)	Western	54	59.93	-5.93
Well #2	Western	59	67.1	-8.1
PRV #1 (upstream)		70	70.69	-0.69
PRV #2 (upstream)		72	71.73	0.27
PRV #2 (downstream)		58	58.002	-0.002
PRV #3 (upstream)		57	60.16	-3.16
PRV #3 (downstream)		46	45.34	0.66
Booster Station (suction side)	Western	66	71.32	-5.32
Booster Station (discharge side)		104	99.75	4.25

Hydrant Flow = 0 GPM

System Demand = 255 GPM

RESULTS OF MODEL CALIBRATION USING TEST #4, EVENT 5 (1/16/96)

Project No.: 19540-489-01-09
Project Name: SSU Model Calibration

Hazen-Williams C Factor = 145

Booster Pump Speed = 1437.75 rpm (it is operating at 81% of full speed)

Location	Sub-System Monitored	Field Pressure (psi)	Model Pressure (psi)	Difference (psi)
North Princewood Drive	Eastern	75	70.99	4.01
Residual (North Buffalo Drive)	Western	44	52.08	-8.08
Well #2	Western	51	61.98	-10.98
PRV #1 (upstream)		69	69.65	-0.65
PRV #2 (upstream)		72	70.633	1.367
PRV #2 (downstream)		63	62.998	0.002
PRV #3 (upstream)		56	59.024	-3.024
PRV #3 (downstream)		41	40.326	0.674
Booster Station (suction side)	Western	58	66.32	-8.32
Booster Station (discharge side)		102	98.73	3.27

Hydrant Flow = 320 GPM

System Demand = 255 GPM

RESULTS OF MODEL CALIBRATION USING TEST #5, EVENT 5 (1/16/96)

Project No.: 19540-489-01-09
Project Name: SSU Model Calibration

Hazen-Williams C Factor = 145

Booster Pump Speed = 1775 rpm (it is operating at full speed)

Location	Sub-System Monitored	Field Pressure (psi)	Model Pressure (psi)	Difference (psi)
Residual (North Princewood Drive)	Eastern	61	56.69	4.31
North Buffalo Drive	Western	54	51.36	2.64
Well #2	Western	59	58.01	0.99
PRV #1 (upstream)		65	61.516	3.484
PRV #2 (upstream)		70	62.829	7.171
PRV #2 (downstream)		53	53.001	-0.001
PRV #3 (upstream)		54	50.28	3.72
PRV #3 (downstream)		44	42.865	1.135
Booster Station (suction side)	Western	64	56.48	7.52
Booster Station (discharge side)		98	96.97	1.03

Hydrant Flow = 400 GPM

System Demand = 279 GPM

RESULTS OF MODEL CALIBRATION USING TEST #5, EVENT 7 (1/16/96)

Project No.: 19540-489-01-09
Project Name: SSU Model Calibration

Hazen-Williams C Factor = 145

Booster Pump Speed = 1455.5 rpm (it is operating at 82% of full speed)

Location	Sub-System Monitored	Field Pressure (psi)	Model Pressure (psi)	Difference (psi)
Residual (North Princewood Drive)	Eastern	73	69.74	3.26
North Buffalo Drive	Western	54	57.75	-3.75
Well #2	Western	56	64.52	-8.52
PRV #1 (upstream)		67	70.681	-3.681
PRV #2 (upstream)		69	72.332	-3.332
PRV #2 (downstream)		53	50.999	2.001
PRV #3 (upstream)		55	61.026	-6.026
PRV #3 (downstream)		42	41.47	0.53
Booster Station (suction side)	Western	60	68.29	-8.29
Booster Station (discharge side)		100	100.62	-0.62

Hydrant Flow = 0 GPM

System Demand = 279 GPM

ATTACHMENT 3

TEST #3 (2/28/96) - [Before Air Purging]

Project No.: 19540-489-01-09
Project Name: SSU Model Calibration

Hazen-Williams C Factor = 145

Assumed Booster Pump Speed = 1384.5 rpm (it is operating at 78% of full speed)

Location	Sub-System Monitored	Field Pressure (psi)	Model Pressure (psi)	Difference (psi)
Residual (West Cavalry Lane)	Western	73	88.27	-15.27
North Buffalo Drive	Western	44	57.34	-13.34
Well #2	Western	51	64.2	-13.2

Stressed Hydrant @ West Pine Ridge Boulevard & West Cavalry Lane @ 340 GPM.

System Demand Without Fire Flow = 139 GPM

Total Demand = 479 GPM

OBSTRUCTION TEST (2/28/96) - [Before Air Purging]

Project No.: 19540-489-01-09
Project Name: SSU Model Calibration

Hazen-Williams C Factor = 145

Assumed Booster Pump Speed = 1384.5 rpm (it is operating at 78% of full speed)

Location	Sub-System Monitored	Field Pressure (psi)	Model Pressure (psi)	Difference (psi)
Carnation Hydrant	Eastern	56	56.85	-0.85
Perry Hydrant	Western	39	51.48	-12.48

Stressed Hydrant @ West Pine Ridge Boulevard & West Cavalry Lane @ 350 GPM.

System Demand Without Fire Flow = 278 GPM

Total Demand = 628 GPM

OBSTRUCTION TEST (2/29/96) - [Following 2nd Air Purging]

Project No.: 19540-489-01-09
Project Name: SSU Model Calibration

Hazen-Williams C Factor = 145

Assumed Booster Pump Speed = 1384.5 rpm (it is operating at 78% of full speed)

Location	Sub-System Monitored	Field Pressure (psi)	Model Pressure (psi)	Difference (psi)
Carnation Hydrant	Eastern	60	58.07	1.93
Perry Hydrant	Western	48	53.27	-5.27
Well #2	Western	56	64.18	-8.18

Stressed Hydrant @ West Pine Ridge Boulevard & West Cavalry Lane @ 350 GPM.

System Demand Without Fire Flow = 138 GPM

Total Demand = 488 GPM

ATTACHMENT 4

Air Binding in Pipes

Robert C. Edmunds

A survey of current research and recent case histories on the phenomenon of air binding suggests that while there is no generally agreed-upon solution to this problem, the adoption of some simple procedures can minimize its occurrence.

Air trapped in pipes can reduce pipeline carrying capacity, cause unexpected pressure surges, and produce objectionable "white water." This article summarizes state-of-the-art research and background data on the air binding phenomenon, compares case histories with theories developed to predict the occurrence of air binding, and describes a procedure that will assist pipeline designers in preventing air binding.

The Phenomenon

Two typical cases of air binding in pipelines demonstrate how this phenomenon occurs (Fig. 1). As flow begins in a pipe with mild slope, the normal depth—i.e., the depth associated with uniform flow—is greater than the critical depth for that flow and no hydraulic jump occurs. If the volume of the stagnant air pocket is not sufficient to fill the descending leg and if additional air reaches this zone in the pipeline, the air bubble grows in a downstream direction and maintains the same height at all points because of the fluid's uniform depth. The trapped air can be removed hydraulically either by generation of small air bubbles at the turbulent downstream end of the pocket, and entrainment into and transport by the fluid, or by sweeping the total air pocket down the pipeline. If an air pocket with low or no air velocity is assumed, the air pressure in the pocket must be everywhere the same. Calculating the general energy equation between the two sections of pipe (Fig. 1) will show that the head loss due to the trapped air pocket is equal to the vertical component of the length of the air pocket. Since in uniform flow the water surface is parallel to the channel invert, the energy loss is equal to the difference in invert elevation between the high and low points in the descending leg, assuming that the air pocket extends to the bottom of the slope. This point can be useful in locating unexplained head losses in pipelines by comparing the amount of unexplained head loss to the elevation differences in the pipeline profile.

In a pipe with steep slope (Fig. 2) the normal depth is less than the critical depth, and hydraulic jump is possible. (At mild slopes, special upstream control sections such as a partially opened gate or a rapid change in slope can also cause hydraulic jump to form.) The jump is the interface between upstream supercritical and downstream subcritical backwater curves or between upstream supercritical normal depth and the downstream subcritical backwater curve. If the hydraulic jump seals the line, air is pumped into the water downstream of the jump. At low flow the air hydraulically removed is a function of the flow conditions downstream of the jump. At some finite flow the entrained air is not carried downstream at all, but occasionally blows out through the jump, causing the jump to move temporarily downstream. At high flow the air, once entrained, is easily carried below the jump and the amount of air removed is a function of the hydraulic jump's ability to entrain air from the upstream pocket. As before, the entrapped air pocket can be hydraulically removed either by generation and entrainment of bubbles or by sweeping the air pocket down the pipeline.

To better demonstrate the hydraulic conditions within a closed pipeline

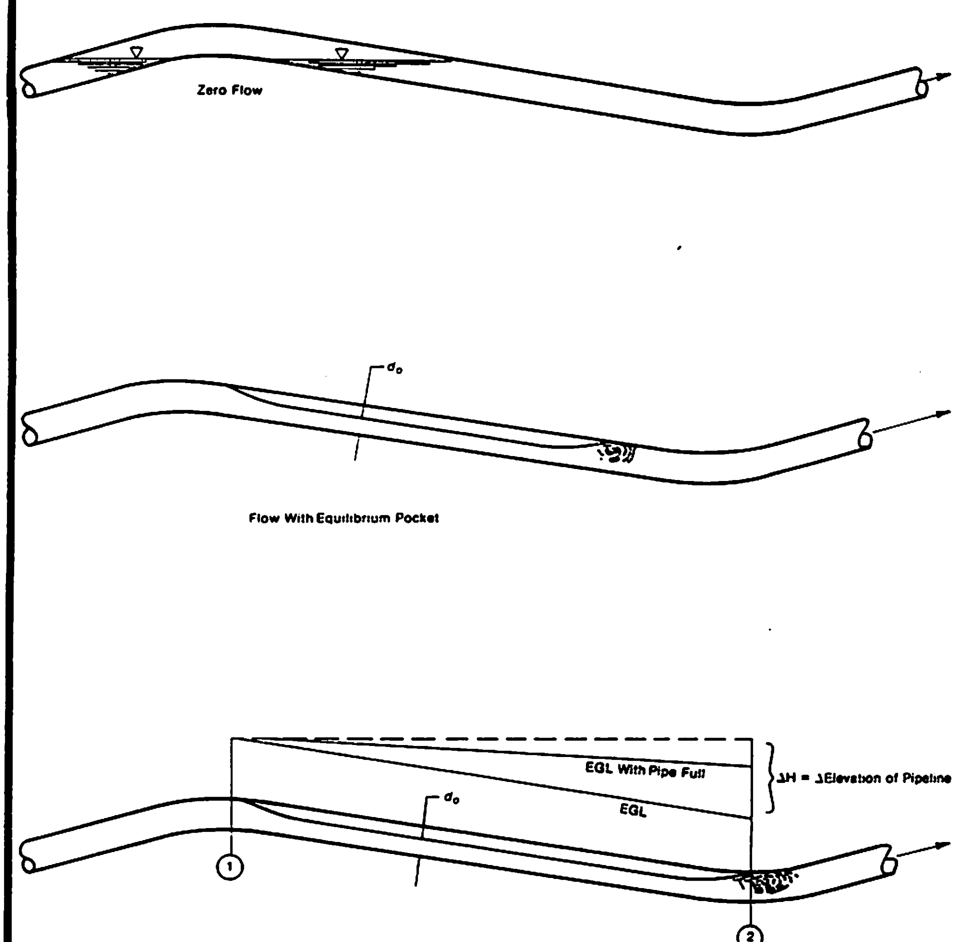

Fig. 1. Air Pocket in Pipe With Mild Slope
Normal Depth (d_o) > Critical Depth (d_{cr})

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containing air. Kennison[1] developed a useful diagram that illustrates the following relationships (Fig. 3):

1. The critical discharge as a function of the depth of flow; that is, the depth at which the Froude number equals 1.0 (giving unstable water surfaces). The critical depth of flow can also be found if the discharge is given.
2. The normal discharge for any depth and slope. Introduction of additional air increases the bubble length, not the depth. (This relationship is plotted by assuming a C of 100 in the Chezy equation. It is useful because the units are the same as those for the critical discharge, thus permitting an immediate comparison of normal depth vs critical depth.)
3. Given the slope and the depth, the minimum flow required for the hydraulic jump to just fill the pipe and thus possibly pump air downstream. This was plotted using data developed by Kalinske and Robertson.[2]
4. Assuming uniform flow, the limit of the ability of the hydraulic jump to fill the pipe. These curves result from the intercepts of the curves for uniform flow and the curves giving the discharge necessary for the jump to fill the pipe.
5. The value of the Froude number for uniform flow at any depth and slope. If this number is greater than or equal to 1.0, hydraulic jump is possible.

Summary of Research on Air Removal by Hydraulic Means

Air pockets can be removed hydraulically by bubble generation and entrainment or by sweeping the pockets from the line. Should hydraulic jump occur within the line, the air removal capacity may be limited by hydraulic conditions downstream of the jump at low flows and by the air entraining limitations of the hydraulic jump at high flows. Kalinske and Robertson[2] correlated the air removal capacity resulting only from the air entraining limitations of the hydraulic jump and developed the relationship

$$Q_a = Q_w \cdot 0.0066\,(F - 1)^{1.4} \qquad (1)$$

where Q_a is the air removal capacity, Q_w is the water discharge, and F is the Froude number of the approaching flow, defined as $V/\sqrt{gY_e}$ (where V is the approach velocity, g is the acceleration due to gravity and Y_e the effective depth—i.e., the water cross-sectional area upstream of the jump divided by the surface width). This equation was found to be valid for conditions in which the fluid carried away all of the air the jump entrained. For any value of approach depth divided by pipe diameter there was a critical Froude number below which the pipeline would carry only part of the air pumped into the water by the jump (Fig. 4). The family of curves in Fig. 4 defines the point at which the air

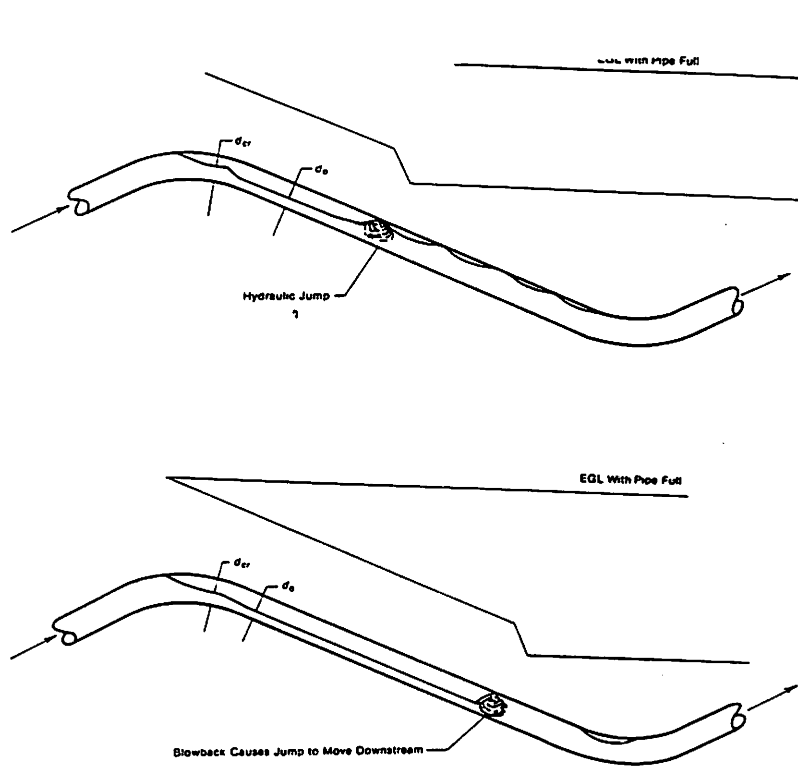

Fig. 2. Air Pocket in Pipe With Steep Slope
Normal Depth (d_e) < *Critical Depth* (d_{cr})

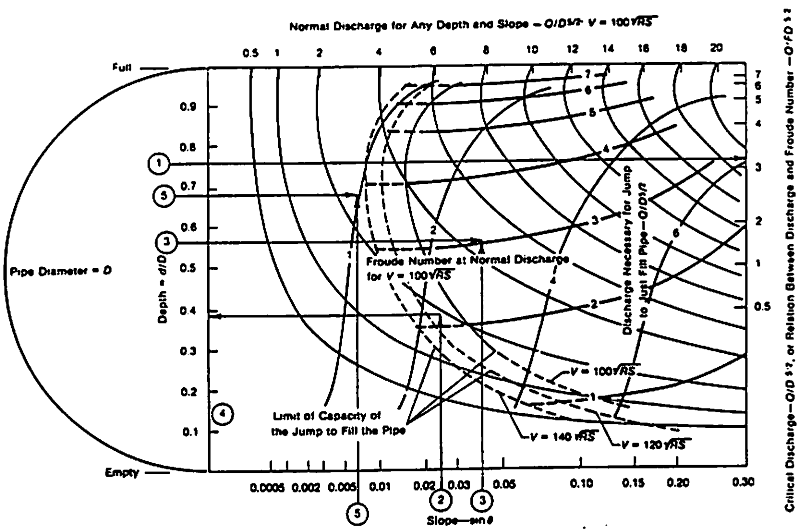

Fig. 3. Hydraulic Jump Inside a Pipe—F-P-S System (After Kennison[1])

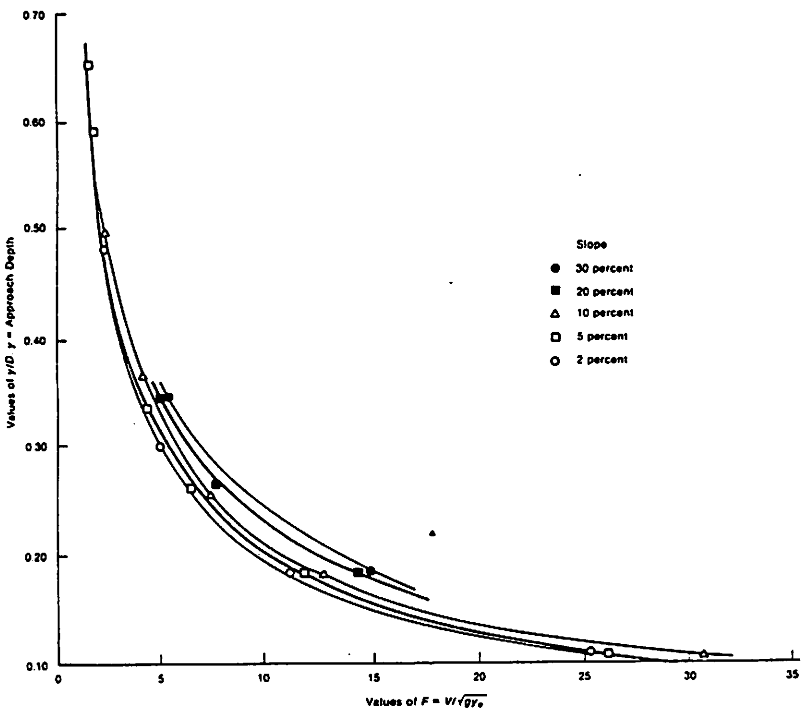

Fig. 4. Experimental Values of Critical Froude Numbers (After Kalinske & Robertson[2])

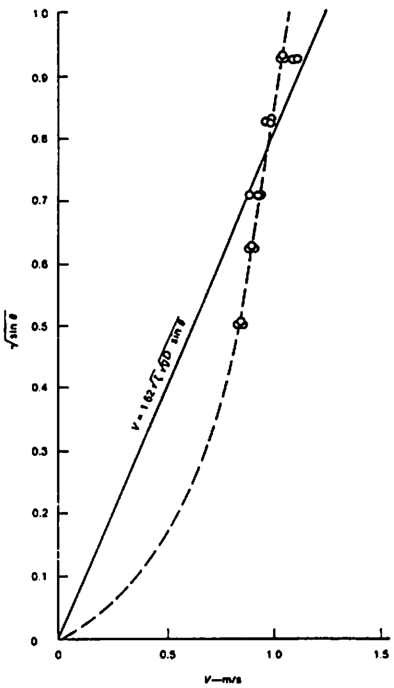

Fig. 6. Equilibrium Velocity vs Pipe Slope

4-in. Pipe; $\zeta \doteq 0.58$
(After Kent[4])

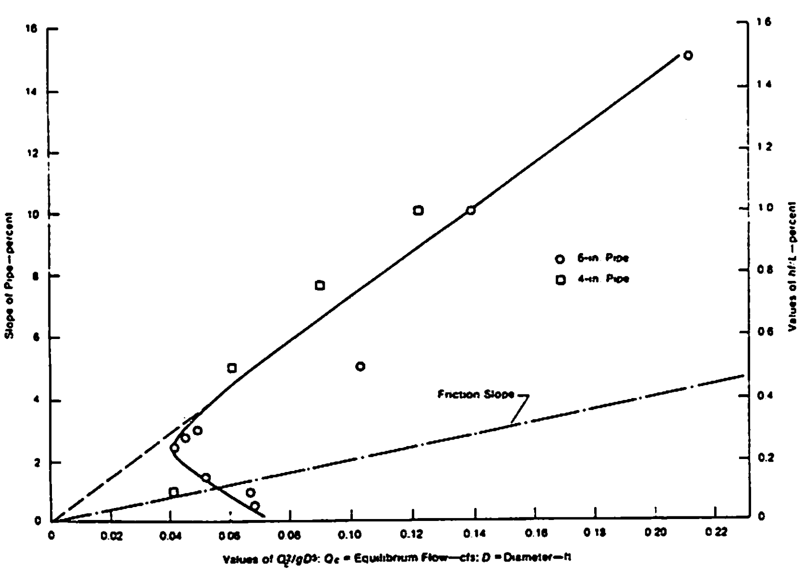

Fig. 5. Experimental Data Showing the Relation Between Pipe Slope, Pipe Diameter, Water Discharge, and Hydraulic Gradient When Air Removal Starts (After Kalinske & Bliss[3])

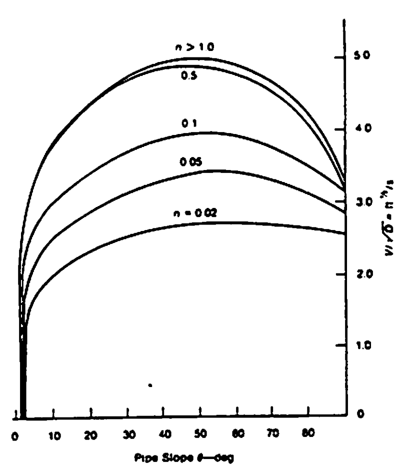

Fig. 7. Minimum Velocity to Move Air from High Point Pipe (After Gandenberger[6])

entraining capacity of the jump and air transporting capacity of the pipe downstream of the jump were found to be equal. These experiments were performed by inducing a hydraulic jump downstream of a partially open gate to easily manipulate the approach depth and effective depth. Experiments were performed in 4-in. and 6-in. acrylic pipes.

A number of researchers have examined the ability of the pipeline to transport discrete bubbles and pockets, where either no jump occurs or where the hydraulics downstream of the jump control air carrying capacity. Kalinske and Bliss[3] equated the theoretical drag and displacement forces on an air pocket in equilibrium and developed an expression relating the pipe slope and equilibrium flow, defined as the minimum discharge necessary to start air moving down the pipe downstream of the hydraulic jump (Fig. 5). The deviation in data at low slopes resulted from the hydraulic jump not completely sealing the line, thus requiring higher flows to entrain and transport the air. Also plotted is the friction slope of the full pipeline, indicating that air movement was obtained with energy grade line (EGL) slopes much milder than the pipe slopes. Experiments were performed in a 6-in. acrylic pipe.

Kent[4] also equated theoretical drag and displacement forces on an equilibrium air pocket. Experimental results were used to approximate the coefficient of drag, and the pocket equilibrium velocity was then correlated with pipeline slope as shown in Fig. 6. It was suggested that zeta (ζ), a shape factor, becomes constant for pockets whose length is greater than 1.5 times the pipe diameter. Kent also developed relationships for the loss-of-head vs percentage of air and pipe slope and the friction formula for flow with air pockets. Kent's experiments were performed in a 4-in. acrylic pipe.

Gandenberger[5] experimented on the movement of air bubbles and pockets from the peaks of 10.5-mm, 26-mm and 45-mm glass tubes and 100-mm steel pipe with slopes varying from zero to 90 degrees and water flowing upward and downward. Based on these experiments, a graph subsequently converted to English units by Mechler was developed that shows the minimum clearing velocity as a function of bubble volume (Fig. 7). The term n is defined as the bubble volume divided by $\pi D^3/4$ where D is pipe diameter. These relationships were considered to be valid for pipes with a diameter greater than 4 in. Both Kalinske and Gandenberger noted a tendency for bubbles to stop and adhere at irregularities in the pipeline.

Wisner et al[6] applied previous theories to several case histories and, noting

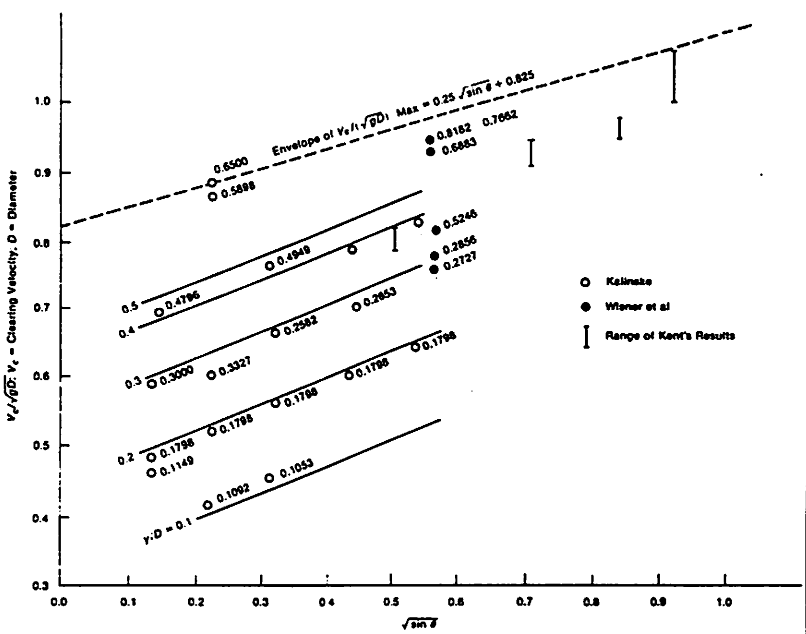

Fig. 8. Recommended Envelope Curve for Clearing of Aerated Pockets—F-P-S System

Figures Beside Each Point Indicate Corresponding y/D: y = Approach Depth
(After Wisner, Mohsen, & Kouwen[6])

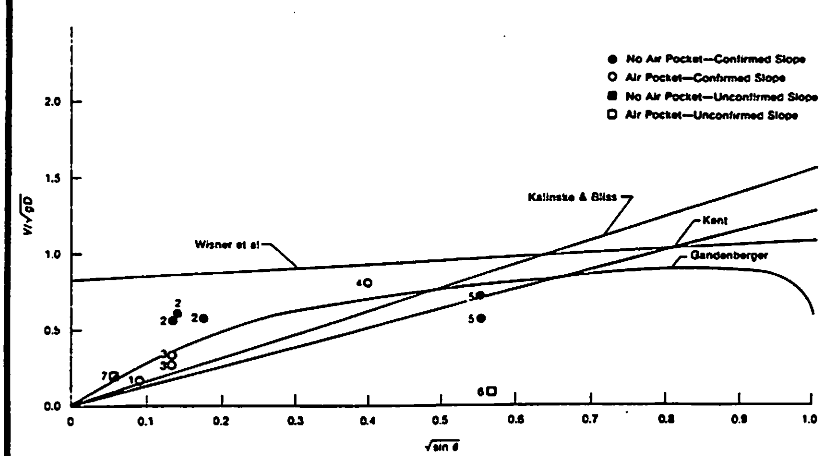

Fig. 9. Minimum Velocity vs Pipe Slope Recommended by Various Researchers—F-P-S System

EXHIBIT WCE-11

PAGE 42 OF 48

serious air binding in one case, experimented with the rise velocity of bubbles in still water and with equilibrium pockets in a 10-in. diameter clear pipe at 18.5-deg slope. Adding their data to the data of Kalinske and Robertson[3] and Kent,[4] they recommended a lower bound clearing velocity (Fig. 8), defined as the minimum velocity necessary to clear a pocket out of the line—without specific reference to sweeping or generation and entrainment removal methods. These authors replotted data from the chart of Kalinske and Robertson (Fig. 4). Kalinske and Robertson's data defined the points at which the pipeline would carry only a part of the air pumped into the water by the jump but where some air transport was taking place; Kent's data defined the velocities required for air pocket equilibrium. This inconsistent definition of the data points could cause Wisner's envelope to predict conservatively high velocities at low slopes.

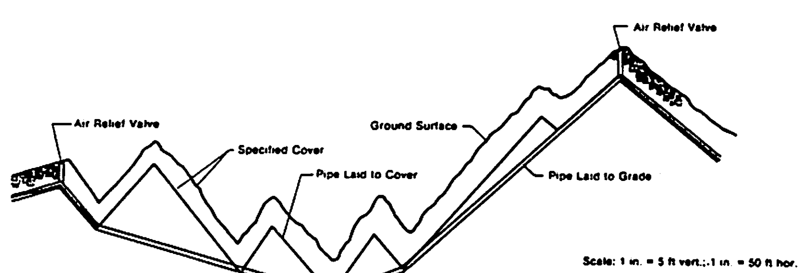

Fig. 10. Pipe Laid to Cover vs Pipe Laid to Grade

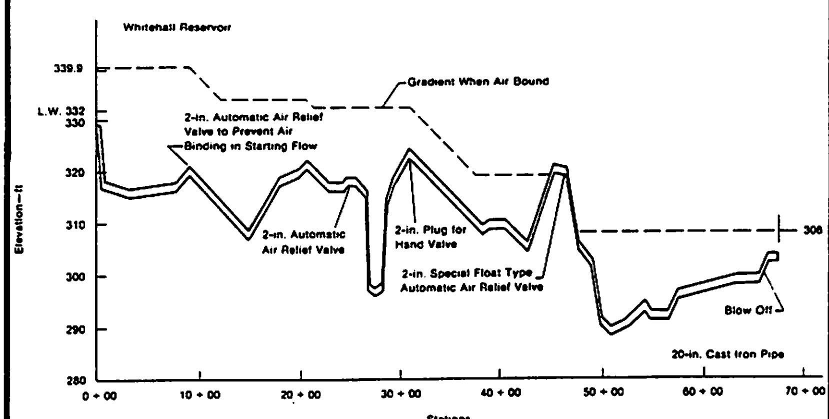

Fig. 11. Whitehall Pipeline Profile (After Kennison[1])

Correlation of Research and Field Data

If the recommendations of these researchers are reduced to consistent units and plotted to the same scale (Fig. 9), areas of agreement and divergence are evident. It should be noted that Kent[4] and Gandenberger[5] both defined velocities at which clearing was incipient but not necessarily in progress. Therefore air pockets could normally occur at and below velocities defined by their relationships. Divergences between these relationships may occur because of variations in the definition of terms, scale effects, or variation in the conditions adopted by each investigator.

Data taken from case histories of existing pipelines from both the literature and from the author's experience have also been plotted.

Case 1 is a 48-in. raw water collection line in south Florida fed by vertical turbine pumps which inject the air that bleeds into the pump discharge columns into the pipeline. The pipeline was erroneously suspected of air binding because of unexplained head loss in the line, which was actually caused by a partially closed valve. At the portion of the line that was investigated, the slope was 0.452 deg and the average flow 55.8 ML/day (14.4 mgd). An air pocket was found but was not large enough to produce serious loss of head.

The data points for Case 2 are reported by Kennison[1] and are taken from the 20-in. Whitehall and 24-in. Ashland lines in Massachusetts. No apparent air pockets were found.

Case 3 is reported by Richards[7] to be a 78-in. power plant discharge line flowing under partial vacuum. Air binding was found in the full length of the pipe slope; the existing vacuum priming system was insufficient to remove the air pocket.

Case 4 is reported by Richards[7] to be a 66-in. power plant condensor discharge line flowing under partial vacuum. The vacuum release tap was located upstream of the remaining air pocket, which extended part of the way down the downstream slope.

Case 5 is reported by Babb and Johnson[8] to be a 12-ft diameter discharge line siphon outlet structure at Grand Coulee dam. The line has a horizontal bend at the vertical knee. At the lower flow all air was cleared and vacuum established in 17 min. At the higher flow all air was cleared and vacuum established in 4.5 min.

Case 6 is a 16-in. D.I.P. force main in south Florida. A clogged air release valve upstream of a subaqueous canal crossing was unplugged and blew for several minutes, whereupon the 6-in. drain and blowoff valve was opened at the bottom of the descending leg at an elevation 6 m (20 ft) below that of the knee. This valve vented air for 10–15 min; the remainder of the air was vented through the air release valve.

Case 7 is a 36-in. D.I.P. outfall line in south Florida. Taps were made in the existing line to confirm friction coefficients with flows from 17.4–32.5 ML/day (4.6–8.6 mgd). A 1-in. tap just upstream of a 36-in. side outlet tee and 24 × 36-in. reducer vented air for 2–5 min each day it was opened. A 1-in. tap 146 m (480 ft) upstream vented no air although the flow and slope were identical. Slope of the EGL was 0.07 deg at 23.4 ML/day (6.2 mgd) or approximately 0.14 deg at 32.5 ML/day (8.6 mgd). Pipe slope is 0.20 deg.

Design of Pipelines to Prevent Air Binding

The following suggested design procedure incorporates other published recommendations along with the author's experience.

Step 1. Many unanticipated air pockets seem to be caused by the uncontrolled laying-to-cover of a pipeline. Typically the pipeline right of way is surveyed along a line offset from the centerline location. This profile is plotted on cross section sheets and air release valve locations determined by its use. A simple lay-to-cover specification permits the contractor to lay the pipeline at any depth so long as it is below the specified cover. Also, ground surface elevation differences may exist between the offset profile and the ground profile over the pipe centerline. It is suggested that if a lay-to-cover specification is preferred, the contract specify that the installed pipeline be profiled by the contractor as part of his work; as an alternative, cost permitting, the pipeline could be laid to a predetermined grade, particularly in hilly areas. This may permit the elimination of air release valves at intermediate high points (Fig. 10).

Step 2. Depending on the approach, the pipeline should be laid out to a trial profile. The design flow is then imposed on the pipeline to determine where air release valves are required for proper flow after the design flow is achieved.

Kennison[1] reported that where the energy grade line of a pipe during flow has a slope steeper than the pipe slope, bubbles move along easily because of the decreasing pressure gradient. In other words, the reference for air propagation is not necessarily a level line, but rather the energy grade line.

Alternatively, or at higher flows, one of the previously discussed criteria for pipe slope vs clearing velocity may be used. Because of air binding occurrences which conflict with some researchers' recommendations, conservative judgment is urged. For example, Kennison[1] placed air release valves at two obvious high points preceding steep descending legs—stations 25 + 50 and 46 + 64 (Fig. 11). Where air release valves are not yet placed but air binding is predicted, an energy loss equal to the vertical component of the descending leg should be included in the calculations.

Step 3. The pipeline should be analyzed for starting the flow. (With enough air-bound legs, the available head may not be able to start flow.) Assuming the worst case, the designer should total the vertical components of the remaining unvented descending legs and compare that figure with the available head. If the available head is less than or equal to the sum of these energy losses, the flow may not start. Therefore, additional release valves must be added until the energy grade line permits a flow that will clear all remaining flow pockets. Note that in the Fig. 11 profile, even with the aforementioned air valves, the starting head was not sufficient to overcome the remaining air-bound descending legs. Therefore, additional air release valves were added at stations 9 + 20 and 31 + 00.

Where it is difficult to obtain a sufficiently flat downgrade, it is better to have the steepest part of the slope near the upstream end and the flattest part near the downstream end. If the water flow cannot remove the air pocket, the loss of head will then be confined to a relatively short length of pipe. If the steepest invert grade were located near the downstream end of the slope, the air pocket would extend back to the top of the descending leg, causing a much greater head loss. Furthermore, the shorter the descending leg, the steeper the slope that can safely be designed, since the worst that might happen would be binding over a short section.

Investigators have found that a positive pipe slope in the direction of flow can be installed at any slope without encountering air problems in the ascending line.

Whitsett and Christiansen[9] report that the Metropolitan Water Dist. of Southern California experienced air problems caused by cascading; their experience indicates that the most severe problems occur with hydraulic jumps at vertical or horizontal bends in the pipeline. They recommend keeping the line and grade straight from the peak of the line to below the static water surface if cascading is necessary. Also, they have found that venting downstream of the hydraulic jump controls pressure surging but does not relieve white water.

In some circumstances it is desirable to obtain a sub-atmospheric siphon condition at knees above the operating energy grade line. Kennison has been successful in installing a combination air release and vacuum priming valve at such a point (station 47 + 00 of the Whitehall pipeline profile shown in Fig. 11). This valve releases air until the line approaches the normal depth for the flow resulting from the energy grade line with unprimed siphon. At this point it closes and remains closed as the water sweeps air pockets from the siphon knee. Kennison's data indicate that upon release of vacuum at this and other points, vacuum recovery occurs rapidly. Of course, the valve should always be installed below the minimum water surface of the upstream reservoir so that in case of air leakage into the pipe upstream of this valve some flow would still be maintained.

Conclusions

Additional field data will confirm one or more of these recommendations for minimum velocity to clear air pockets. A simple technique is to close existing air release valves on lines known to receive air from vertical turbine pumps or gases from septic sewage. In each case studied, the following data should be reliably noted:

1. Pipe slope—preferably expressed as the sine of the descending angle
2. Type of pipe material, its age, and, if possible, roughness coefficient. This will permit future evaluation of the effect of wall roughness on air removal.
3. Pipe inside diameter
4. Maximum sustained flow or, if little variation, average flow
5. Whether or not air pockets were discovered downstream of the knee. These data can be organized and plotted as shown in Fig. 9. (The author would appreciate receiving any such data.)

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8. Babb, A.F. & Johnson, W.K. Performance Characteristics of Siphon Outlets. *Jour. Hydr. Div.*, ASCE, 94:HY6:1421, Proceedings Paper 6237 (Nov. 1968).
9. Whitsett, A.M. & Christiansen, L.E. Air In Transmission Mains. *Jour. AWWA*, 61:11:592 (Nov. 1969).

A paper contributed to and selected by the Journal, authored by Robert C. Edmunds (Active Member, AWWA), exec. vice pres., Jones, Edmunds & Assoc., Inc., Gainesville, Fla.

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ATTACHMENT 5

AIR BINDING WITHOUT HYDRANT FLOW

Purpose: Determine if air binding is likely to occur in pipe #631under normal system demand. (Use Test 3, Event 2)

Given:

Elevation of node J3300 =	92.62	ft
Elevation of node J92080 =	107.32	ft
Length of pipe between nodes =	383	ft
Pipe inside diameter =	7.96	inches
Velocity in pipe #631 =	0.45	ft/sec

Solution:

1. Determine $(\sin\theta)^{0.5}$

   $\sin\theta =$ (107.32-92.62)/383 = 0.03838

   $(\sin\theta)^{0.5} = 0.196$

2. Determine $V/(gD)^{0.5}$

   $V/(\text{gravity}\times D)^{0.5} = 0.45/(32.174\times7.96/12)^{0.5} =$ 0.0974

3. Plot $V/(gD)^{0.5}$ vs. $(\sin\theta)^{0.5}$

   See FIGURE 1.

4. Conclusion

   The potential for the occurence of air binding is high.

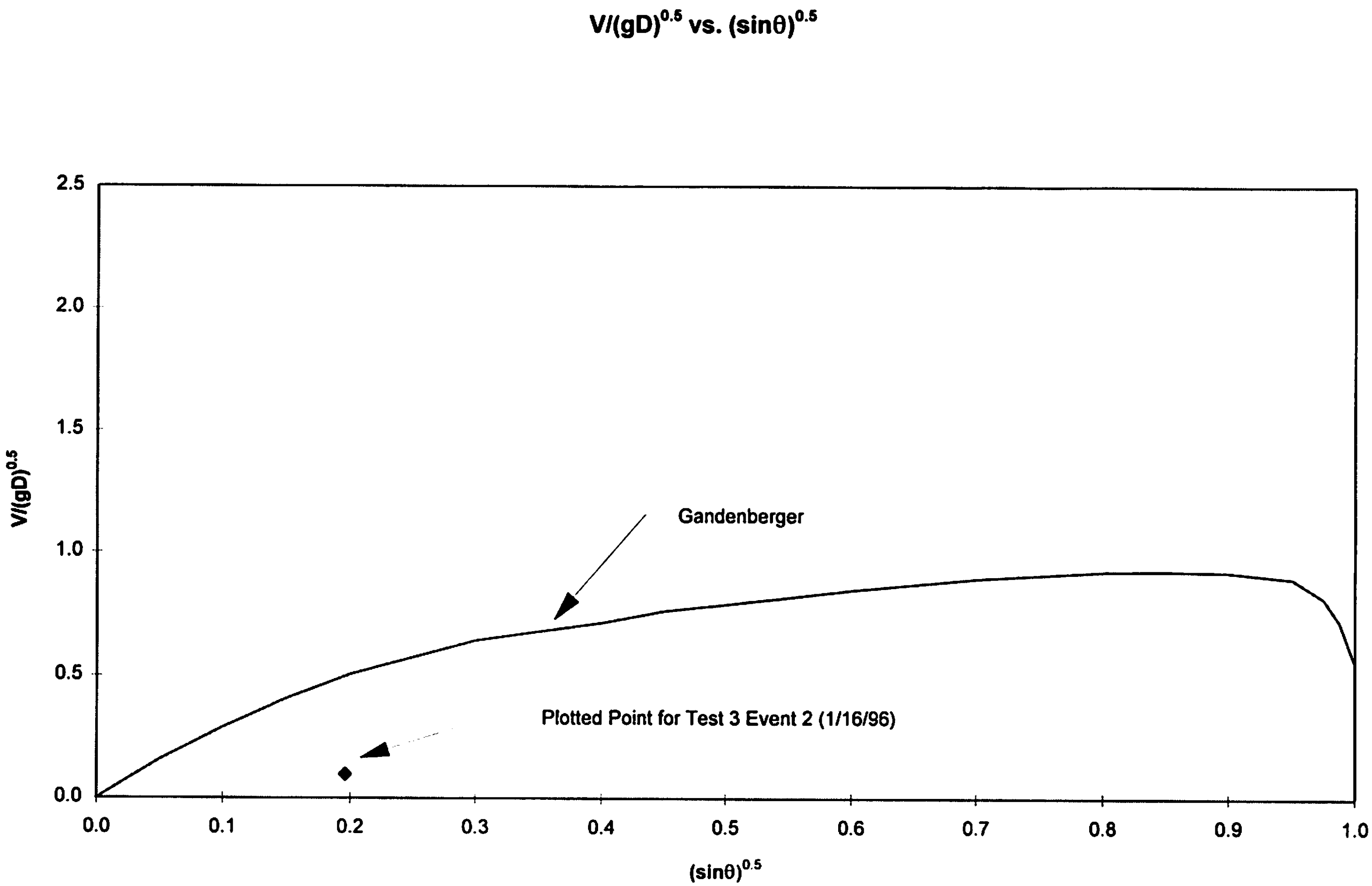

FIGURE 1. Indication of potential air binding under normal network demand (Test 3, Event 2).

AIR BINDING WITH HYDRANT FLOW

Project No.: 19540-489-01-09
Project Name: SSU Model Calibration

Purpose: Determine if air binding is likely to occur in pipe #631under fire flow demand.

Given:	Elevation of node J3300 =	92.62 ft
	Elevation of node J92080 =	107.32 ft
	Length of pipe between nodes =	383 ft
	Pipe inside diameter =	7.96 inches

Solution:

1. Determine $(\sin\theta)^{0.5}$

   $\sin\theta =$ (107.32-92.62)/383 = 0.03838

   $(\sin\theta)^{0.5} = 0.196$

2. Determine $V/(gD)^{0.5}$

   For Test 1 Event 9

   $V/(gD)^{0.5} = 2.36/(32.174x7.96/12)^{0.5} =$ 0.51085

   For Test 3 Event 5

   $V/(gD)^{0.5} = 2.64/(32.174x7.96/12)^{0.5} =$ 0.57146

   For Test 4 Event 5

   $V/(gD)^{0.5} = 2.80/(32.174x7.96/12)^{0.5} =$ 0.60609

   For Test 5 Event 5

   $V/(gD)^{0.5} = 2.62/(32.174x7.96/12)^{0.5} =$ 0.56713

3. Plot $V/(gD)^{0.5}$ vs. $(\sin\theta)^{0.5}$

   See FIGURE 2.

4. Conclusion

   Air binding is likely to be in the incipient to clearing phase.

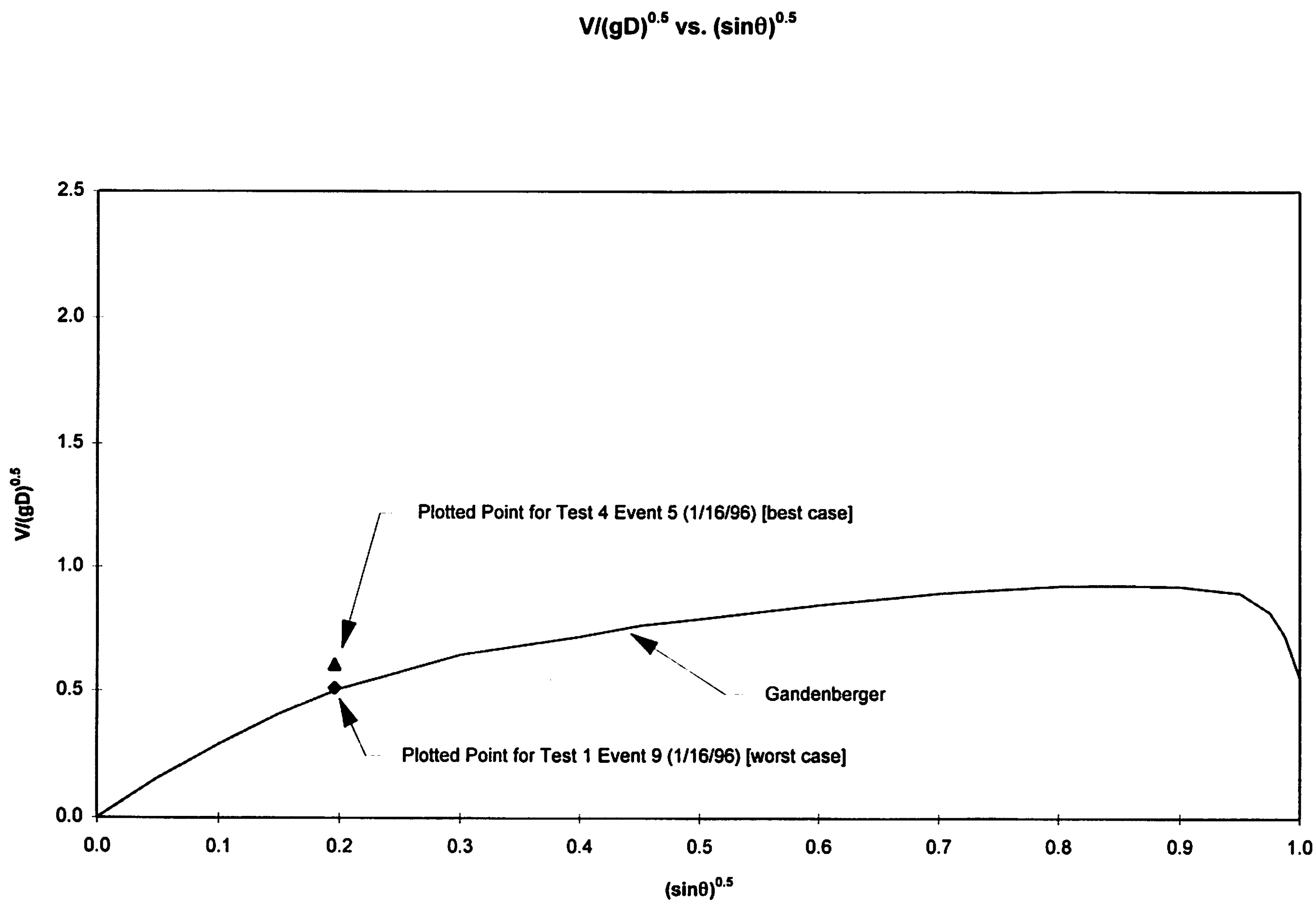

FIGURE 2. Indication of potential for air binding with hydrant flow.

EXHIBIT (QCE-1)
PAGE 48 OF 48

DOCKET 950495-WS
EXHIBIT NO. 99
CASE NO 96-04227

Ex. No. 99

USED AND USEFUL CALCULATIONS
WATER DISTRIBUTION SYSTEMS

Company: SSU/FPSC Jurisd.-Conventional Treatment
Docket No. 950495-WS
Schedule Year Ended: 12/31/96
Interim [ ] Final [X]
Historical [ ] Projected [X]
FPSC Uniform [X] FPSC Non-Uniform [X]
Conventional Treatment [X] Reverse Osmosis [ ]

Explanation: Provide calculations, analysis, and governmental requirements used to determine the used & useful percentages for the water distribution and wastewater collection systems for the historical and the projected test year (if applicable). The capacity should be in terms of ability to serve a designated number of connections. It should then be related to actual connected density for historical year calculations. Explain all assumptions for projected calculatins. If the distribution and collection systems are entirely contributed or built out, this schedule is not required.

FPSC
Schedules F-7(W)
Page 3 of 12
Preparer: Bliss
Recap Sched: A-5, A-9, B-13

Line No.	(1) Description	(2) 1117 Citrus Park	(3) 906 Citrus Springs	(4) 984 Crystal River	(5) 105 Daetwyler Shores	(6) 1806 Deltona Lakes	(7) 336 Dol Ray Manor	(8) 334 Druid Hills	(9) 557 East Lake Harris Est.	(10) 324 Fern Park
1	Transmission and Distribution									
2	CONNECTED LOTS 1996 w/ 1 Yr. MR	355	1,944	78	124	24,537	59	247	178	178
3	NUMBER OF LOTS	335	11,667	91	138	34,940	77	335	214	208
4	CALCULATED PERCENTAGE	100.00% [2]	16.66%	85.49%	89.52%	70.23%	76.39%	73.73%	83.41%	85.40%
5	U&U PER ORDER	100.00%	21.00%	100.00%	100.00%	89.30%	100.00%	100.00%	100.00%	100.00%
6	REQUESTED U & U [1]	100.00%	42.71% **	100.00%	100.00%	89.30%	100.00%	100.00%	100.00%	100.00%

[1] Composite percentage based on gross plant balances for the NARUC accounts applicable to each component.
[2] If calculated percentage exceeds 100% with MR, then 100% is requested.

** Based on Cybernet Hydraulic Model Results

6/16/95

FLORIDA PUBLIC SERVICE COMMISSION
DOCKET NO. 950495 EXHIBIT NO 99
COMPANY/
WITNESS:
DATE: 4/29/96

USED AND USEFUL CALCULATIONS
WATER DISTRIBUTION SYSTEMS

Company: SSU/FPSC Jurisd.-Conventional Treatment
Docket No. 950495-WS
Schedule Year Ended: 12/31/96
Interim [ ] Final [X]
Historical [ ] Projected [X]
FPSC Uniform [X] FPSC Non-Uniform [X]
Conventional Treatment [X] Reverse Osmosis [ ]

Explanation: Provide calculations, analysis, and governmental requirements used to determine the used & useful percentages for the water distribution and wastewater collection systems for the historical and the projected test year (If applicable). The capacity should be in terms of ability to serve a designated number of connections. It should then be related to actual connected density for historical year calculations. Explain all assumptions for projected calculatns. If the distribution and collection systems are entirely contributed or built out, this schedule is not required.

FPSC
Schedules F-7(W)
Page 7 of 12
Preparer: Bliss
Recap Sched: A-5, A-9, B-13

Line No.	(1) Description	(2) 1106 Marion Oaks	(3) 330 Meredith Manor	(4) 562 Morningview	(5) 993 Oak Forest	(6) 1702 Oakwood	(7) 579 Palisades	(8) 440 Palm Port	(9) 1429 Palm Terrace	(10) 559 Palms Mobile Home Park
1	Transmission and Distribution									
2	CONNECTED LOTS 1996 w/ 1 Yr. MR	2,816	640	36	147	209	57	110	1,185	59
3	NUMBER OF LOTS	12,262	867	42	287	191	141	137	1,213	87
4	CALCULATED PERCENTAGE	22.96%	73.81%	85.90%	51.28%	100.00% [2]	40.08%	80.22%	97.65%	67.82%
5	U&U PER ORDER	34.40%	85.20%	100.00%	50.70%	100.00%	6.30%	67.50%	100.00%	69.00%
6	REQUESTED U & U [1]	66.83% **	85.20%	100.00%	51.28%	100.00%	40.08%	80.22%	100.00%	69.00%

[1] Composite percentage based on gross plant balances for the NARUC accounts applicable to each component.
[2] If calculated percentage exceeds 100% with MR, then 100% is requested.

** Based on Cybernet Hydraulic Model Results

USED AND USEFUL CALCULATIONS
WATER DISTRIBUTION SYSTEMS

Company: SSU/FPSC Jurisd.-Conventional Treatment
Docket No. 950495-WS
Schedule Year Ended: 12/31/96
Interim [ ] Final [X]
Historical [ ] Projected [X]
FPSC Uniform [X] FPSC Non-Uniform [X]
Conventional Treatment [X] Reverse Osmosis [ ]

Explanation: Provide calculations, analysis, and governmental requirements used to determine the used & useful percentages for the water distribution and wastewater collection systems for the historical and the projected test year (if applicable). The capacity should be in terms of ability to serve a designated number of connections. It should then be related to actual connected density for historical year calculations. Explain all assumptions for projected calculatns. If the distribution and collection systems are entirely contributed or built out, this schedule is not required.

FPSC
Schedules F-7(W)
Page 8 of 12
Preparer: Bliss
Recap Sched: A-5, A-9, B-13

Line No.	(1) Description	(2) 564 Picciola Island	(3) 907 Pine Ridge	(4) 782 Pine Ridge Estates	(5) 553 Piney Woods	(6) 987 Point O'Woods	(7) 443 Pomona Park	(8) 1095 Postmaster Village	(9) 578 Quail Ridge	(10) 442 River Grove
1	Transmission and Distribution									
2	CONNECTED LOTS 1996 w/ 1 Yr. MR	140	892	227	171	375	175	165	30	104
3	NUMBER OF LOTS	213	3,828	292	215	415	535	345	114	119
4	CALCULATED PERCENTAGE	65.61%	23.30%	77.91%	79.44%	90.43%	32.72%	47.75%	26.20%	87.48%
5	U&U PER ORDER	100.00%	20.00%	100.00%	76.50%	83.50%	32.00%	44.70%	15.80%	100.00%
6	REQUESTED U & U [1]	100.00%	100.00% **	100.00%	79.44%	90.43%	32.72%	47.75%	26.20%	100.00%

[1] Composite percentage based on gross plant balances for the NARUC accounts applicable to each component
[2] If calculated percentage exceeds 100% with MR, then 100% is requested.

** Based on Cybernet Hydraulic Model Results

6/16/95

USED AND USEFUL CALCULATIONS
WATER DISTRIBUTION SYSTEMS

Company: SSU/FPSC Jurisd.-Conventional Treatment
Docket No. 950495-WS
Schedule Year Ended: 12/31/96
Interim [ ] Final [X]
Historical [ ] Projected [X]
FPSC Uniform [X] FPSC Non-Uniform [X]
Conventional Treatment [X] Reverse Osmosis [ ]

Explanation: Provide calculations, analysis, and governmental requirements used to determine the used & useful percentages for the water distribution and wastewater collection systems for the historical and the projected test year (if applicable). The capacity should be in terms of ability to serve a designated number of connections. It should then be related to actual connected density for historical year calculations. Explain all assumptions for projected calculatins. If the distribution and collection systems are entirely contributed or built out, this schedule is not required.

FPSC
Schedules F-7(W)
Page 10 of 12
Preparer: Bliss
Recap Sched: A-5, A-9, B-13

Line No.	(1) Description	(2) 989 Sugarmill Woods	(3) 2801 Sunny Hills (Wells 1&4)	(4) 2801 Sunny Hills (Well 5)	(5) 560 Sunshine Parkway	(6) 781 Tropical Park	(7) 106 University Shores	(8) 567 Venetian Village	(9) 447 Welaka/ Saratoga Harbor	(10) 122 Westmont
1	<u>Transmission and Distribution</u>									
2	CONNECTED LOTS 1996 w/ 1 Yr. MR	2,755	435	4	15	534	4,027	145	135	141
3	NUMBER OF LOTS	8,252	5,377	491	40	671	5,100	223	249	167
4	CALCULATED PERCENTAGE	33.39%	8.09%	0.81%	38.23%	79.58%	78.95%	65.13%	54.04%	84.19%
5	U&U PER ORDER	22.40%	11.00%	N/A	100.00%	81.40%	100.00%	61.70%	54.00%	100.00%
6	REQUESTED U & U [1]	33.39%	28.09% **	28.09% *	100.00%	81.40%	100.00%	65.13%	54.04%	100.00%

[1] Composite percentage based on gross plant balances for the NARUC accounts applicable to each component
[2] If calculated percentage exceeds 100% with MR, then 100% is requested

** Based on Cybernet Hydraulic Model Results

6/16/95