Exhibit No.: ______________

Issue(s):	Allocation of Distribution Mains
Witness/Type of Exhibit:	Hall/Direct
Sponsoring Party:	Public Counsel
Case No.:	GR-98-374

DIRECT TESTIMONY

OF

BARRY F. HALL

Submitted on Behalf of the Office of the Public Counsel

LACLEDE GAS COMPANY

Case No.: GR-98-374
(RATE DESIGN)

August 21, 1998

BEFORE THE PUBLIC SERVICE COMMISSION
OF THE STATE OF MISSOURI

In the Matter of Laclede Gas Company's tariff designed to increase rates.	))	**Case No. GR-98-374**

AFFIDAVIT OF BARRY F. HALL

STATE OF MISSOURI)
) **ss**
COUNTY OF COLE)

Barry F. Hall, of lawful age and being first duly sworn, deposes and states:

1. My name is Barry F. Hall. I am the Public Utility Engineer for the Office of the Public Counsel.

2. Attached, hereto and made a part hereof for all purposes, is my direct testimony consisting of pages 1 through 10 along with Schedule BFH 1.1 to 1.3 and Attachments 1 and 2.

3. I hereby swear and affirm that my statements contained in the attached testimony are true and correct to the best of my knowledge and belief.

Barry F. Hall

Barry F. Hall

Subscribed and sworn to me this 21st day of August, 1998.

Mary S. Koestner

Mary S. Koestner, Notary Public

My Commission expires August 20, 2001.

DIRECT TESTIMONY

OF

BARRY F. HALL

LACLEDE GAS COMPANY

CASE NO. GR-98 - 374

Q. PLEASE STATE YOUR NAME, TITLE, AND BUSINESS ADDRESS.

A. Barry F. Hall, Public Utility Engineer
Missouri Office of the Public Counsel
P. O. Box 7800
Jefferson City, Missouri 65102

Q. DISCUSS YOUR QUALIFICATIONS.

A. Attachment 1 discusses my background. Attachment 2 indicates the previous Public Service Commission cases in which I submitted written testimony and/or testified.

1 Introduction

Q. WHAT IS THE PURPOSE OF YOUR TESTIMONY?

A. I have performed the calculations necessary to allocate the costs of Laclede Gas Company's ("Company's") system of distribution mains for Public Counsel's class cost of service ("CCOS") analysis. This testimony will also discuss some introductory facts that are pertinent to that calculation.

Q. WHAT IS THE PURPOSE UNDERLYING THE COMPANY'S INVESTMENT IN DISTRIBUTION MAINS?

A. The Company's investment in distribution mains provides the Company with the means to deliver the gas to its customers' locations in response to customers' year-round, hourly demands for natural gas.

Q. WHAT DOES "YEAR-ROUND, HOURLY DEMANDS" CONNOTATE IN THE ABOVE DEFINITION?

A. At any given hour in the year the Company's investment in mains allows it to deliver gas in response to customers' demands. This is true for both 'on-peak' times and 'off-peak' times. The definition above was formulated to underscore the fact that customers receive real benefits via use of the sytem during all the days which gas is delivered to their premises, not just under peak conditions.

Q. DO DISTRIBUTION MAINS HAVE INTRINSIC COST CHARACTERISTICS THAT ARE IMPORTANT TO CONSIDER IN THE ALLOCATION OF THE COSTS?

A. Yes, as larger demands are serviced by mains of increasing diameter there is a disproportionate decrease in per unit delivery costs. This is a fundamental cost characteristic of distribution main.

Q. EXPLAIN HOW IT IS CHEAPER ON A PER-UNIT BASIS TO SERVE LARGER DEMANDS AS THE SIZE OF THE DISTRIBUTION MAIN IS INCREASED.

A. There are two reasons for this reduction in per-unit delivery cost as main size (dia.) is increased to serve or aggregate larger loads. First, there is a rapid increase in the capacity of an individual main as the diameter of the main is increased. Second, as the diameter of the main is increased the total installed cost per foot increases more slowly than the increase in diameter. Each of these ideas bears some detailed examination.

Q. EXPLAIN HOW THE DELIVERY CAPACITY OF A MAIN DEPENDS ON THE DIAMETER OF THE MAIN OR PIPE.

A. The delivery capacity of a distribution main increases exponentially with diameter (*d*) and somewhat faster than would be suggested by the (d^2) growth in the cross-sectional area. Various formula for the flow of natural gas through pipe have exponents which range around 2.5. Below is a table which shows the increase in delivery capacity with diameter for a formula in common use (exponent of 2.665):

Main Diameter	Relative Flow Capacity (2" Dia. Main = 1.0)
2"	1.0
4"	6.3
6"	18.6
8"	40.0
12"	117.5
24"	742.4

Table 1 Relative Flow Capacity vs. Main Diameter

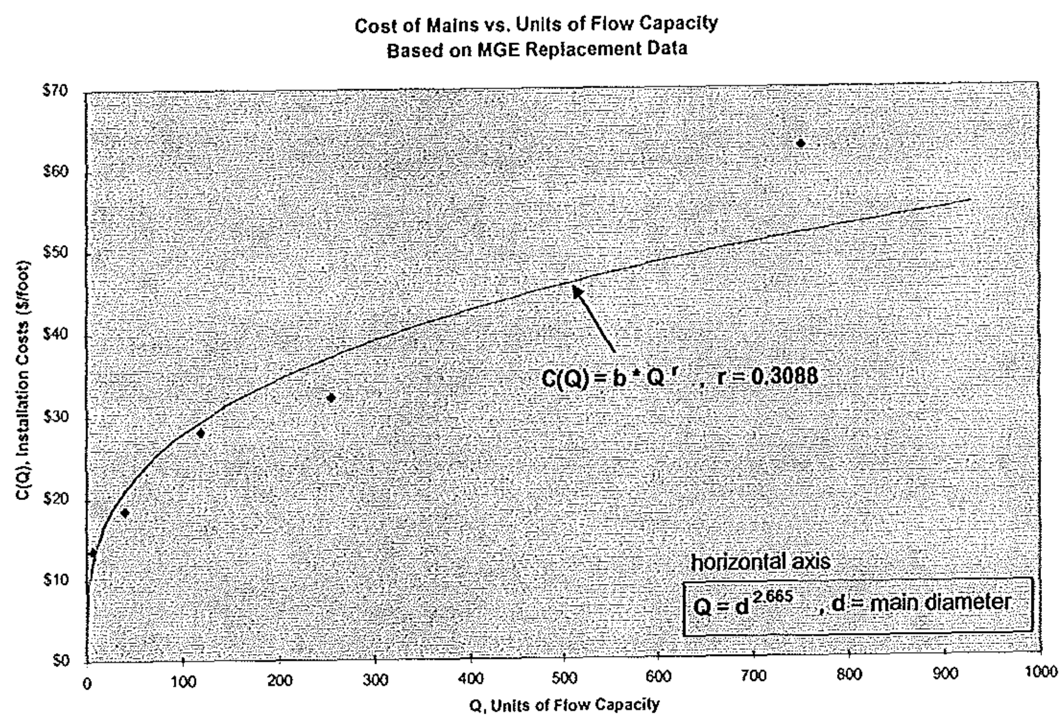
Thus as the diameter of a pipe is doubles from 2 inches to 4 inches the flow capacity increases by 6.3 times. The table above extends the comparison of available flow capacity of a 2" diameter main to some other common sizes based on the flow capacity of a 2" main being equal to one. It's important to remember that <u>the capability of a main to deliver gas increases quite rapidly with increasing diameter</u>.

Q. EXPLAIN HOW THE INSTALLED COST PER FOOT OF MAIN INCREASES WITH MAIN DIAMETER.

A. One can consider at least 3 different components to the total installed cost of a distribution main. There is the material cost of the pipe, labor costs of installation and overhead costs. For the sizes which represent the largest proportion of overall costs of the system, labor and overheads comprise the major part of the total installed costs. The increase in labor and overheads is slow in proportion to the increase in pipe diameter because the labor necessary to install the pipe is essentially the same regardless of pipe size (there are some discrete changes here as the size gets larger, but this statement is true in general). The effect of the slowly increasing labor costs tends to 'swamp' the increasing material costs. The net result is that there is a quite slow rise in total installed costs with increasing pipe diameter.

Q. IF INCREASING THE DIAMETER OF THE MAIN IMPLIES A MODERATE INCREASE IN TOTAL INSTALLED COSTS, HOW DO COSTS RISE IN PROPORTION TO MAIN CAPACITY?

A. The combination of slowly increasing costs with diameter and rapidly increasing capacity with diameter as discussed above result in a very slow or "root-like" increase in costs with respect to main capacity as shown in the example below (this example graph was taken from data examined in an MGE rate case GR-96-285):



Q. WHAT IS THE ECONOMIC TERM WHICH DESCRIBES THE SITUATION WHERE LARGER AMOUNTS OF CAPACITY CAN BE ADDED MORE CHEAPLY ON A PER-UNIT BASIS?

A. Economists term this *economies of scale*. The existence of economies of scale in public utility investments is well recognized and has been written about widely. In the case of natural gas mains the economies of scale can be simply described by an exponential factor, ***r*** (not to be confused statistical parameter such as *r-squared*), which relates capacity, ***Q***, to costs, ***C***.

Q. HAVE YOU CALCULATED THE EXPONENT *r*, OR ECONOMY OF SCALE FACTOR, FOR A NUMBER OF DISTRIBUTION MAIN COST DATA SETS?

A. Yes, I have calculated this for at least three separate data sets as I have been participating in CCOS studies. The results are very consistent. The exponent ***r*** is typically about 0.3.

Q. WHY ARE ECONOMIES OF SCALE IMPORTANT TO CONSIDER AND INCORPORATE IN COST ALLOCATIONS?

A. Economies of scale are important to consider in making the proper link between capacity and the costs to provide that capacity. The proper cost relationship is necessary to consider directly, or at least indirectly, when allocating the costs of such facilities when they are used jointly by multiple customer rate classes.

2 Allocation of Distribution Mains

Q. DESCRIBE THE METHOD WHICH YOU USED TO ALLOCATE THE COSTS ASSOCIATED WITH THE COMPANY'S SYSTEM OF DISTRIBUTION MAINS.

A. Refer to Shedule BFH – 1. This schedule contains the sum of weather-normalized monthly peak day demands for all customer classes. These were provided by Public Service Commission Staff ("Staff") witness Beck. I have sorted these values here in descending order.

In the next column (Months % of Annual Peak) these peak day demands are convereted to percentages of the maximum monthly peak day demand. For instance, the month having the second highest peak day demand has a peak which is 91.34% of the maximum peak day demand. Another way of stating this is that there is an 8.66% increment of demand separating the two months.

In the third column, the percentages of peak day are converted to percentages of total capacity costs by raising the capacity percentages to the *r*th power. Considering the second and third columns it is easy to state what is indicated by the mathematical relationship here. The first 11.50% of capacity requires an expenditure of more than 52% of the costs of the system, i.e. there are substantial fixed costs involved. Likewise, 50.19% or approximately half of the capacity requires over 81% of the total costs to supply. Conversely, adding roughly the <u>last</u> 50% of the capacity accounts for less than 20% of the costs.

The fourth column simply calculates successive differences in percentages of costs from the third column. The top figure is the difference in percentage costs incurred to supply the additional capacity in moving from the second highest monthly peak to the maximum monthly peak day demand. The second figure in this column is the same difference only moving from the third highest monthly peak to the second highest monthly peak.

The adjacent column depicts the number of months over which that cost increment should be spread. The first (highest or top increment) cost increment, occuring only on the peak day of one month is only spread to that month. The next increment of cost/capacity is utilized for two months. The last or base increment is utilized in all the months. Each cost increment is divided by the number of months in which the correspoding capacity increment is utilized.

In the last column partial sums are formed for the costs increments utilized in each month. For instance, the peak month sums all the increments of costs in the previous column, since all increments of capacity are used in that month. The next partial sum for the next 'lowest month omits the top cost increment in its sum and so on. The result is the percentage of capacity costs attributable to each month.

Refer to Schedule BFH – 1.2. The top block of numbers is the class peak day demands by month. In the block below, class peaks have been converted to percentages of the sum of peak day demands for all the classes each month.

Summing the product of the class share of monthly peaks on Schedule BFH – 1.2 <u>and</u> the portion of total capacity costs in each month in the last column on Schedule BFH – 1.1 gives the RSUM allocators at the bottom of Schedule BFH – 1.2. These are allocators that are applicable to the 'common' portion of the distribution mains.

The RSUM allocators of Schedule BFH – 1.2 are repeated on Schedule BFH – 1.3. As all transmission main is regarded to be common to all the customer classes, the RSUM allocators are applied directly to these costs in the subsequent CCOS analysis.

However, for the distribution mains, a reasonable distinction can be drawn between mains which serve predomintly the smaller usage (i.e. per-capita) customers and those mains which serve all customer classes in common. Using trended costs from the prior Laclede case GR-96-163, I have apportioned a percentage of the costs based on main diameter (mains 2" or less in diameter which accounted for almost 60% of the total length) to be split only by those smaller usage customers, namely residential and general service customers. Thus ~27% of the costs are split between these two customer classes based on each class' RSUM allocator. The remaining ~73% of costs is split between all the customer classes according to the RSUM allocators. The result is shown on the last line as a *Composite Allocator*, the term referring to the two step procedure.

Q. IS IT REASONABLE TO USE THE TRENDED COSTS FROM A PREVIOUS CASE TO SPLIT COSTS IN THIS CASE?

A. Yes, unless there have been substantial installations made which would be expected to significantly shift the relative amount of investment between the two size categories used herein. Typical annual growth would not be enough to affect the percentages enough to have a material impact on the results. Nevertheless, I may revisit this assumption before filing of rebuttal testimony.

Q. WHY DO YOU USE TRENDED COSTS AND NOT BOOKED COSTS?

A. Trended costs are costs that have been put in terms of the value of a single years dollars. This is done so the relative benefits provided from one (size) grouping of mains is compared sensibly with the benefits provided by the other (size) grouping of mains.

Q. EXPLAIN SPECIFICALLY WHAT ALLOCATORS WERE PROVIDED TO OPC WITNESS KIND FOR INCLUSION IN OPC'S CCOS ANALYSIS.

A. On Schedule BFH – 1.3 there is a row entitled *RSUM Allocators*. These were utilized by Mr. Kind in the allocation of transmission mains costs. The last row on the same schedule is entitled *Composite Allocator* and was provided to Mr. Kind for the allocation of distribution mains costs.

Q. DOES THIS CONCLUDE YOUR DIRECT TESTIMONY ON THIS ISSUE?

A. Yes, it does.

Attachment 1

Q. PLEASE SUMMARIZE YOUR EDUCATIONAL AND EMPLOYMENT BACKGROUND.

A. I received the Bachelor of Science Degree in Electrical Engineering from the University of Missouri-Rolla (UMR) in December 1986. I received the Master of Science Degree in Electrical Engineering from the Georgia Institute of Technology (GT) in September 1988. My non-thesis Master's program emphasized three areas: optics, electromagnetics, and solid state theory. I have completed two additional courses in Power Systems since that time.

I worked for the Entry Systems Division of IBM in Boca Raton, Florida as part of a cooperative training program during 1985. I assisted design engineers in the logic simulation of the VGA video chip.

I was a Graduate Teaching Assistant for UMR's EE Dept. during the first semester of 1987. There I taught two sections of a laboratory course in electromagnetics.

I worked half-time as a Graduate Research Assistant for the Georgia Tech Research Institute while I was enrolled at Georgia Tech, performing some of the photolithographic and etching steps in the fabrication of special optoelectronic devices.

I was employed by the New Aircraft Products Division of McDonnell Douglas Corporation in St. Louis, Missouri from January 1989 to October 1991. There I researched methods and technology for the prediction and the reduction of the infrared contrast of fighter aircraft.

I was employed by Ledbetter, Toth & Associates of Springfield, Missouri from November 1991 to December 1992. Ledbetter, Toth & Associates is a consulting firm specializing in serving the needs of several electrical cooperatives and a few municipalities in Illinois, Missouri, Arkansas, and Oklahoma. I worked with two partners in the firm designing electrical substations.

I have been with the Missouri Office of the Public Counsel (OPC) since September 1993.

Q. ARE YOU A REGISTERED PROFESSIONAL ENGINEER?

A. Yes, I became a registered professional engineer in the state of Missouri on March 1, 1993. My registration number is E-25471.

ATTACHMENT 2 EXPERIENCE IN PRIOR CASES

Q. HAVE YOU PREVIOUSLY TESTIFIED BEFORE THIS COMMISSION?

A. Yes, I have submitted written testimony and/or testified in the following cases:

EO – 95 –181	Kansas City Power & Light Company	Special Contracts
ER – 94 – 174 et al	EmpireDistrict Electric Company	Cost Allocation
ER – 95 – 279	EmpireDistrict Electric Company	Permits
GR – 95 – 160	United Cities Gas Company	Cost Allocation
GR – 95 –285	Missouri Gas Energy	Cost Allocation / Rate Design
GR – 96 – 193	Laclede Gas Company	Cost Allocation
GR – 97 – 393	Union Electric Company	Cost Allocation
GR-97-272	Associated Natural Gas	Cost Allocation
GR –98 - 140	Missouri Gas Energy	Cost Allocation / Rates, Plant-in-service, et al
SC – 96 – 427	Imperial Utility Corporation	Plant-in service, Depreciation et al
WR –95-145	St. Louis County Water	Distribution Planning / Economics
WR –96-263	St. Louis County Water	Distribution Planning / Economics
WA-97-46 et al	Missouri American Water	Preapproval, Single Tariff Pricing
WR-97-237 et al	Missouri American Water	Rate Design / Cost of Service

Economy of Scale Factor[1]
r = **0.3**

Montly Sums of Class Peaks	Months % of Annual Peak	% of Cost To Satisfy	% Cost Increment in Month Over Prev	No. Months w/ Increment	Increment/ Months Occuring	Sum Cost Increments Occurring Each Month
9,638,161	100.00%	100.00%	2.68%	1	2.68%	15.41%
8,803,787	91.34%	97.32%	1.53%	2	0.76%	12.73%
8,352,018	86.66%	95.79%	6.70%	3	2.23%	11.97%
6,558,419	68.05%	89.09%	2.54%	4	0.64%	9.74%
5,955,060	61.79%	86.55%	5.23%	5	1.05%	9.10%
4,837,805	50.19%	81.32%	5.03%	6	0.84%	8.05%
3,911,168	40.58%	76.29%	5.37%	7	0.77%	7.22%
3,066,930	31.82%	70.93%	6.43%	8	0.80%	6.45%
2,234,560	23.18%	64.50%	6.90%	9	0.77%	5.65%
1,532,085	15.90%	57.60%	4.31%	10	0.43%	4.88%
1,182,457	12.27%	53.29%	1.02%	11	0.09%	4.45%
1,108,485	11.50%	52.27%	52.27%	12	4.36%	4.36%

Notes:
1 Each months percentage of annual peak is raised to the *rth* power to convert succesive monthly increments of capacity to increments of costs.

	Residential (therms/day)	General C&I (therms/day)	Large Volume (therms/day)	Interruptible (therms/day)	Firm Trans (therms/day)	Basic Trans (therms/day)	LP Gas (therms/day)	Unmetered GL (therms/day)	System Total
Jan	6,090,421	2,329,648	247,226	35,887	363,823	569,115	1,666	375	9,638,161
Feb	5,566,975	2,131,411	216,458	31,692	330,260	525,294	1,323	375	8,803,787
Dec	5,228,030	2,022,420	215,388	31,546	329,093	523,771	1,395	375	8,352,018
Mar	4,056,797	1,540,011	177,254	26,347	287,495	469,460	679	375	6,558,419
Nov	3,615,927	1,403,471	170,059	25,366	279,645	459,212	1,005	375	5,955,060
Apr	2,929,190	1,103,207	134,331	20,495	240,671	408,326	1,210	375	4,837,805
Oct	2,245,637	885,084	127,730	19,595	233,471	398,926	349	375	3,911,168
May	1,725,939	643,941	104,889	16,481	208,555	366,396	354	375	3,066,930
Sep	1,161,925	472,981	78,267	12,851	179,514	328,479	168	375	2,234,560
Jun	737,939	281,753	54,369	9,593	153,445	294,443	169	375	1,532,085
Jul	473,891	196,158	54,369	9,593	153,445	294,443	183	375	1,182,457
Aug	416,532	179,572	54,369	9,593	153,445	294,443	155	375	1,108,485

Percentage of System Total for Each Month

Jan	63.19%	24.17%	2.57%	0.37%	3.77%	5.90%	0.02%	0.00%	100.00%
Feb	63.23%	24.21%	2.46%	0.36%	3.75%	5.97%	0.02%	0.00%	100.00%
Dec	62.60%	24.21%	2.58%	0.38%	3.94%	6.27%	0.02%	0.00%	100.00%
Mar	61.86%	23.48%	2.70%	0.40%	4.38%	7.16%	0.01%	0.01%	100.00%
Nov	60.72%	23.57%	2.86%	0.43%	4.70%	7.71%	0.02%	0.01%	100.00%
Apr	60.55%	22.80%	2.78%	0.42%	4.97%	8.44%	0.03%	0.01%	100.00%
Oct	57.42%	22.63%	3.27%	0.50%	5.97%	10.20%	0.01%	0.01%	100.00%
May	56.28%	21.00%	3.42%	0.54%	6.80%	11.95%	0.01%	0.01%	100.00%
Sep	52.00%	21.17%	3.50%	0.58%	8.03%	14.70%	0.01%	0.02%	100.00%
Jun	48.17%	18.39%	3.55%	0.63%	10.02%	19.22%	0.01%	0.02%	100.00%
Jul	40.08%	16.59%	4.60%	0.81%	12.98%	24.90%	0.02%	0.03%	100.00%
Aug	37.58%	16.20%	4.90%	0.87%	13.84%	26.56%	0.01%	0.03%	100.00%

	Residential	General C&I	Large Volume	Interruptible	Firm Trans	Basic Trans	LP Gas	Unmetered GL	System
RSUM Allocators	**58.19%**	**22.50%**	**3.01%**	**0.468%**	**5.78%**	**10.04%**	**0.015%**	**0.010%**	**100.00%**

Calculation of Mains Allocators

Main Diameter	Trended Costs
1	$1,132,399
2	$292,051,465
3	$12,658,477
4	$149,670,636
5	$677,506
6	$183,460,977
8	$111,203,417
10	$20,141,949
12	$79,288,752
13	$1,074,615
14	$12,080
16	$60,742,330
18	$639,098
20	$53,295,276
22	$11,077,286
24	$64,293,784
26	$8,235,984
30	$22,213,196
	$1,071,869,226

Lower Usage Customers (Residential & Gen C&I) ↑

↓ *Common System*

		Residential	General C&I	Large Volume	Interruptible	Firm Trans	Basic Trans	LP Gas	Unmtrd GL
RSUM Allocators (Trans. Mains)		58.186 %	22.497 %	3.009 %	0.468 %	5.778 %	10.038 %	0.015 %	0.010 %
"Direct Assign"	$293,183,864	$211,434,792	$81,749,071						
Common System	$778,685,362	$453,084,370	$175,180,376	$23,431,008	$3,644,601	$44,989,835	$78,162,680	$115,100	$77,393
Sum	$1,071,869,226	$664,519,162	$256,929,448	$23,431,008	$3,644,601	$44,989,835	$78,162,680	$115,100	$77,393
Composite Allocator (Distr. Mains)		61.996 %	23.970 %	2.186 %	0.340 %	4.197 %	7.292 %	0.011 %	0.007 %