DIRECT TESTIMONY OF

ROSWELL L. FINLAY

ON BEHALF OF HOUSTON LIGHTING & POWER COMPANY

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Q. Please state your name and position.

A. My name is Roswell L. Finlay. I am a vice president in the firm of URS Company, Dallas, Texas.

Q. Please describe your educational background.

A. I graduated from the Massachusetts Institute of Technology in 1939 with a degree of Bachelor of Science in Civil Engineering.

Q. Are you a Registered Professional Engineer?

A. Yes, I am registered in the states of Texas, Louisiana, Mississippi, Alabama, Georgia, Florida, Arkansas, Tennessee, Kentucky and New York.

Q. Are you a member of any professional organizations?

A. Yes, I am a member of the American Society of Civil Engineers, the National Society of Professional Engineers, the Texas Society of Professional Engineers and the Consulting Engineers Council.

Q. What is your area of expertise at URS Company?

A. I work primarily in the area of water resources planning, hydrology and hydraulic design, feasibility studies, and a variety of problems associated with reservoir development projects, such as reservoir operating procedures, gate operating schedules and flood control. I have testified in flood damages suits, in condemnation proceedings in connection

with land acquisition for reservoir sites and with respect to reservoir yield studies.

Q. Have you previously examined the question of water availability for the Allens Creek project?

A. Yes. URS/Forrest and Cotton, Inc., which was the name under which our organization operated throughout most of the 1970's, was retained by Houston Lighting & Power Company (HL&P) to study the Brazos River resource base and to advise that Company whether or not the Brazos River Authority (BRA) would be able to furnish to HL&P 176,000 acre-feet of water per year through the year 2030.

Q. What was the reason you considered a requirement of 176,000 acre-feet of water per year through 2030?

A. HL&P had negotiated a contract with the Brazos River Authority under which the Company could call for delivery of up to 176,000 acre-feet of water each year for use at its generating plants. This water was to be delivered at points selected by HL&P below the confluence of the Brazos and Navasota Rivers near Hempstead, Texas.

Q. How did your study take into account the rights of other entities to use water from the Brazos River?

A. Every appropriation, both permits and certified filings, within the Brazos River Basin was examined and honored in our basin operation simulation to the full extent

of the permitted right prior to allowing any run-off to be stored in BRA reservoirs or utilized for satisfaction of HL&P demand. For example, a run-of-river permit upstream from a BRA storage reservoir was assumed to have diverted its full quota of water under the permit terms, provided the water was available in the stream at the diversion point. Only surplus water was allowed to flow into the BRA reservoir. During periods of low flow, if there was not sufficient water in the stream this permit right might not be fully satisfied, but no water rightfully accruing to the permit holder was treated as available to BRA or HL&P. In the case of a downstream permit holder with a run-of-stream permit, he was accorded a call on reservoir inflows which must be passed through the reservoir in order to satisfy the downstream prior right. Thus, in our simulation no water was held in storage to which downstream prior appropriators have entitlement. In the case of local demand direct diversion from each reservoir was assumed to the full extent of the applicable permit regardless of stream flow conditions. The local demand placed on BRA reservoirs included all existing permitted and projected municipal uses.

Q. How were contractual rights taken into account?

A. Certain contractual rights were included as part of local demand and drawn directly from storage; however, a

large part of the contractual demand is associated with major run-of-river permits below the USGS Hempstead gauge which are firmed up by BRA storage contracts. In this case, water is released from storage as requested by downstream permit holders whenever the available flow within the river at the downstream point of diversion is insufficient to satisfy the needs of the contracting user and of remaining downstream priority rights. Permit terms are usually explicit as to when calls on storage must be made if the permit holder is to continue diversion at authorized rates. All such terms and restrictions as explained in individual permits were recognized in the operation simulations.

Q. What about riparian rights?

A. We assumed that there would be no change in historical usage. This is an extremely conservative assumption since irrigation from surface water is projected to be on the decline.

Q. What was the basic conclusion of that study?

A. We concluded that the Brazos River Authority had the capability at that time to meet all of its existing commitments, including the contract with HL&P, and that it would continue to have this capability through at least the year 2030, even after giving full consideration to rights of others and projected increases in municipal demand.

Q. You mentioned the Brazos River resource base. Can you briefly describe this?

A. The resource base constitutes the flows in the Brazos River and its tributaries, together with the regulation afforded by the BRA-controlled reservoirs, less uses under prior rights of other entities within the drainage basin, plus return flows from upstream uses. The Brazos River Basin has a drainage area of 44,460 square miles, of which about 9,240 square miles above the Caprock Escarpement is considered noncontributing. This leaves an effective drainage area of about 35,400 square miles. The average discharge of the Brazos River, based on a 50-year record maintained by the USGS, at the Richmond, Texas gauge amounts of 7,354 cfs or 5,328,000 acre-feet per year. This flow is partially regulated by reservoirs, including six under the control of the Brazos River Authority as of the date of our study (1973), with aggregate storage capacity in excess of 1,000,000 acre-feet. The six reservoirs in existence at the time of our study and under Brazos River Authority control included Possum Kingdom Reservoir, Lake Granbury, Lake Procter, Lake Belton, Lake Stillhouse Hollow and Lake Somerville. In addition, four other reservoirs were planned. These were Aquilla, Millican, Laneport, and North Fork Reservoirs. Our studies considered both the six reservoir

system then in existence and the ten reservoir system anticipated to be in existence prior to the end of the study period in the year 2030. Two of these reservoirs, Laneport and North Fork on the San Gabriel River, have now been constructed. The San Gabriel River is a tributary of the Brazos River.

Q. How was this resource base analyzed to determine availability of water for Houston Lighting & Power Company?

A. Two basin operation simulations were considered in the study, the first based on the six reservoir system then in existence and under the control of the BRA, and the second based on the ten reservoir system ultimately contemplated as being under the control of the BRA. Each of these basin operation simulations was run for the entire 25-year study period from 1941 through 1965 with detailed analysis on a month-by-month basis.

Q. You speak of reservoirs under BRA control. Was consideration given to other reservoirs within the basin?

A. Yes, full recognition was given to the impact of all existing reservoirs in the basin, regardless of owner, on the available water resource below the point at which the Navasota River empties into the Brazos River. This included consideration of evaporation losses from reservoir surface and diversions from these reservoirs to serve other users.

Recognition was given to the resource depletion associated with Stamford, Millers Creek, Graham, Hubbard Creek, Fort Phanton Hill, Elm Creek, Leon and Smithers Reservoirs, none of which are under BRA control and to two existing federally controlled reservoirs, Waco and Whitney, in which the BRA has no conservation rights. Recognition was also given to the 220 Soil Conservation Service (SCS) floodwater retarding reservoirs which had been completed as of 1972. Allowance was also made for anticipated future SCS reservoirs under year 2030 conditions.

Q. Why was the period 1941 through 1965 chosen as the study period?

A. This 25-year period is representative of the full range of hydrologic phenomena which would be expected to occur in the Brazos River Basin. It covers the continuous period of historical flow records, including a period of relative plentitude from 1941 through 1948, a period of severe drought from 1949 through 1956, and a period of plentitude from 1957 to 1965. The drought of 1949 through 1956 extended more specifically from July 1949 through January 1957. In both of our simulation operations, all reservoirs were full at the end of June 1949, experienced rapid recovery beginning in February 1957 and were full and spilling by May 1957. This drought is generally referred to

as the 1950 to 1956 Drought. In order to test the severity of this drought period against other periods, rainfall records were examined for the much longer period starting in the 1880's and extending into the 1970's. These records confirmed that the drought from 1950 to 1956 is the most severe drought experienced in the Brazos River Basin since records have been available. It can be inferred from reference to records from rainfall gauge stations in operation prior to the 1880's and lying outside of the Brazos River Basin but subject to the influence of the same meteorological conditions that this is possibly the most severe drought since 1856. There were some severe droughts of short duration during the 1915 to 1918 period, but these short duration droughts are not critical in basin operation or reservoir yield studies.

Q. What exactly is a basin operation simulation?

A. It is computer analysis, starting at the upper end of the drainage basin, and working step by step downstream through the various sub-basins of the Brazos River, in this instance, and tributary streams. The analysis starts with runoff data within each sub-basin, accounts for all diversions for beneficial use in accordance with existing rights, with due consideration of relative priority between these rights, and develops net inflows to all water supply re-

1 servoirs. Calls on inflows by prior downstream rights are
2 identified so that they may be passed on through to satisfy
3 these rights. BRA system reservoir routings are accomplished,
4 as a part of the overall basin operation simulation, in
5 which storage changes, evaporation losses, reservoir de-
6 mands, spills and releases are all quantified on a monthly
7 basis. The impact of non-system reservoirs on downstream
8 flows was also evaluated by individual reservoir routings
9 which, in general, were accomplished by equating demand with
10 reservoir yield to determine spills. In some instances,
11 where minor water supply reservoirs were involved, it was
12 simply assumed that the entire watershed above the reservoir
13 would be non-contributing to the downstream resource. In
14 this way, all basin reservoirs and uses were evaluated in a
15 step-by-step process. This process develops the total
16 available flow in the Brazos River just below the USGS
17 Hempstead gauge. It also demonstrates how these flows,
18 together with releases from BRA reservoirs, and calls on
19 inflows to BRA reservoirs are able to satisfy the rights
20 below Hempstead, including the projected HL&P demand to the
21 year 2030.
22 Q. Why is your study based on flows as measured by
23 the USGS Hempstead gauge?
24 A. The August 1, 1972 contract which Houston Lighting

& Power Company has with the Brazos River Authority provides that the water to be furnished under the contract will be delivered at diversion points selected by Houston Lighting & Power Company below the point at which the Navasota River empties into the Brazos River. Hempstead is a long-term gauge upstream from the proposed point of diversion for the Allens Creek facility and above major prior rights in the lower basin. It is also downstream from all major tributaries, such as the Navasota River. It is primarily a point of convenient reference for the operation simulation in which the net effect of all upstream run-off, permitted diversions, evaporation losses, impact of SCS reservoirs, and storage changes can be accumulated to develop the total available flow below the mouth of the Navasota River. Also, it is a realistic point of reference in that many permits in the lower basin are tied to the downstream gauge at Richmond, and the surplus flow at Hempstead, as compared with minimum flow requirements at Richmond, is a measure of water available on a run-of-river basis to satisfy existing permits.

Q. What was the basic data on which you based your basin operation simulation?

A. Each of the basin operation simulations utilized reservoir inflow data based on "natural runoff" data. These were adjusted to reflect the affect of diversions under all

prior rights, assuming full utilization of such rights and full satisfaction of all BRA contracts. In addition to the priority afforded existing rights, municipal and domestic water requirements from surface water sources were projected to the year 2030 and these requirements were given priority over all demands in the river basin and dependent coastal areas, including HL&P's requirements. Recognition was also given to the effect of re-regulation of main stem flows by Whitney Reservoir and to evaporation losses from all reservoirs within the Brazos River Basin whether or not the reservoirs are controlled by the Brazos River Authority. The basin operation simulation also included consideration of losses attributable to existing and planned floodwater retardation structures.

Q. What do you mean by "natural runoff"?

A. The Bureau of Reclamation has prepared estimates of runoff in the Brazos River watershed. "Natural runoff" is defined by the Bureau of Reclamation as follows:

> Natural runoff at a point or from a watershed is the runoff which would have occurred with historic land treatment, ponds and minor reservoirs, and floodwater retarding structures but a constant minimum condition of development in all other respects. Thus, if a reservoir were constructed within a watershed during the period of streamflow record and period of study, the historic runoff from the subwatershed after the reservoir began operation would be increased by the amount of the estimated reservoir depletions to obtain natural runoff. Diversions and return flows which

reflect changed development are adjusted out in a similar manner. Small depletions caused by developments which were unchanged during the entire period of streamflow record or entire period of study are not adjusted out in calculating natural runoff.

Q. What provision was made for future municipal demands which would have priority over HL&P's contract with the BRA?

A. We projected future population and associated municipal type demands to determine the extent to which the existing resource would be taxed by this anticipated higher priority requirement. These projections indicated a 2030 population of 2,275,635 for the Brazos River contributing watershed areas as compared with the 1970 census value of 1,115,770 for the same area. The municipal and rural water requirements associated with this projected population as of the year 2030 amounts to 375,406 acre-feet from surface water sources and 99,816 acre-feet per year from ground water sources for a total of 475,222 acre-feet per year.

Q. How do municipal uses as projected by you to the year 2030 compare with current usage?

A. We have projected a population increase within the service area of the Brazos River Basin of approximately 204 percent between the 1970 census and the year 2030. We have also projected an increase of about 30 percent in the per capita daily consumption. This results in an increase in

1 municipal use from about 154,000 acre-feet per year in 1970
2 to about 475,000 acre-feet per year in the year 2030, or an
3 overall increase of about 321,000 acre-feet per year. We
4 also assumed a shift from ground water to surface water for
5 a portion of this demand even though it is highly possible
6 that present ground water source will continue to be utilized.
7 Q. What consideration did you give to riparian rights?
8 A. We gave full consideration to riparian rights,
9 which have been filed in accordance with Texas Law. It must
10 be recognized that these filings in many instances were
11 simply claims made in an attempt to establish the right and
12 do not necessarily bear any relationship to historical usage
13 or probable future usage. As a result, it is extremely
14 doubtful that these claims will ever be exercised to the
15 extent implied by the filings. With respect to the impact
16 of possible future riparian irrigation, our investigation
17 indicates that irrigation within the Brazos River Basin will
18 probably be on the decline and apparently lacks economic
19 justification when the high investment and operating costs
20 associated with the utilization of surface water resources
21 are considered. Nevertheless, no adjustment of riparian
22 irrigation was made. Since historical uses were reflected
23 by the runoff data utilized, this was equivalent to assuming
24 that future riparian uses will continue in amounts equivalent

to historical uses.

Q. How many permits and certified filings are there in the Brazos River Basin?

A. In the range of 400-500. These were all analyzed in the course of our study.

Q. Were they all considered in your basin operation simulations?

A. Yes. Detailed consideration was given to all existing appropriations and contracts, all of which were assumed to remain in force through the year 2030, regardless of actual termination dates on some of the contracts. These rights were fully honored in basin operation simulations, and the requirements of Houston Lighting & Power Company were satisfied only after satisfaction of all of these other rights.

Q. Does this mean that, in your basin operation simulations, HL&P only took water after all holders of prior appropriations and contracts were fully satisfied?

A. No. There is a big difference between permit holders being satisfied and permit rights being fully honored. In our operation simulations, all prior rights were fully honored in accordance with permit terms. However, permits can only grant rights to a resource to the extent that it exists. For example, a permit holder on a tributary stream

may be granted the right to the natural flow in the stream at his authorized point of diversion, but if there is no flow, he is out of luck. He might have to call on the inflows to an upstream reservoir, and all such rights were honored in our simulations. But, he would not have any rights to water which entered the stream below his point of diversion. Of course, this would be the case whether or not HL&P uses any water for the Allens Creek project.

Q. Can you give us some concept, based on your studies, of the relationship between water supply available within the Brazos River Basin, and existing commitments on this resource?

A. The resource base constitutes the flows in the Brazos River and its tributaries, together with the regulation afforded by the BRA-controlled reservoirs, less uses under prior rights of others within the drainage basin and plus return flows. The average natural runoff for the 25 year study period of 1941 through 1965 in the Brazos Basin is 6,190,640 acre-feet. Of more significance is the natural runoff in the critical drought period, 1950 through 1956, for which the average natural runoff is only 2,695,000 acre-feet, or about 44% of the long term average.

In that portion of our study dealing with the initial six reservoir system controlled by BRA, the adjusted inflow

to these reservoirs averaged 953,000 acre-feet per year during the critical drought period. The usable storage available, allowing for siltation to the year 2030, amounts to about 1,084,000 acre-feet, of which about 268,000 acre-feet were still available at the end of the critical period. This indicates a total storage draw down of about 816,000 acre-feet over the six year drought period or an average of about 122,000 acre-feet of water per year. Thus, the available resource under the control of the BRA with the initial six reservoir system in operation amounts to about 953,000 + 122,000 or 1,075,000 acre-feet per year during the critical drought period. Of this amount, approximately 173,000 acre-feet per year is lost during the critical period to evaporation from the six system reservoirs. This leaves an average of about 902,000 acre-feet per year, during the critical period, with which BRA can satisfy up its contractual obligations, and satisfy local demands.

Q. What is the total demand on this supply?

A. Local demand on the six BRA controlled reservoirs totals about 203,000 acre-feet per year, and has been treated as a constant in our operation simulation. Another 62,000 acre-feet average demand during the critical period went to firm up BRA contracts below Hempstead other than the contract for HL&P. Finally, an average of about 65,000 acre-

feet per year was used during the critical period to firm up the projected HL&P demand for 176,000 acre-feet per year. Thus, actual delivery from BRA reservoirs averages about 330,000 acre-feet per year during the critical period, including the HL&P demand. Had it been necessary to supply the full 176,000 contracted to HL&P out of the BRA reservoirs each year, there would have still been a 76,500 acre-feet supply of water in storage left in the six BRA system reservoirs at the end of the critical period, under projected year 2030 demand and siltation conditions. With a ten-reservoir system, the residual usable supply of water in storage at the end of the critical period would have been 669,000 acre-feet.

Q. In your reservoir operation simulations, has any water been utilized to satisfy HL&P demands at the expense of other appropriations?

A. No. All rights were fully honored in the data processing phase. The adjusted inflow to BRA reservoirs was fully depleted to the extent of all upstream run-of-river permitted diversions; permitted calls on inflows for downstream use; and the effects of the SCS program.

Q. Have you reviewed your 1973 study to see if it is still an accurate analysis of supply and demand on the Brazos River?

A. Yes, I have and I find no reason to change any of our prior conclusions. You must keep in mind that we were asked to give HL&P our professional opinion that there would be an adequate water supply in the Brazos River for the BRA to honor its contract and supply water to the year 2030. HL&P had entered into negotiations with the Brazos River Authority for 176,000 acre-feet per year of water supply, and contract terms based on this requirement had been negotiated. However, a condition to HL&P's obligations under the contract was assurance from independent consultants relative to the BRA's capability of furnishing the desired quantity of water. Accordingly, we were requested to examine in detail all outstanding rights and the burden that these would place on the Brazos River resource base, plus future projected requirements which might be anticipated as having a priority over HL&P's contractual rights. HL&P recognized from the outset that a contract, even though signed in good faith, would be worthless if the resource base and the level of regulation available to the BRA should prove insufficient to satisfy all priority demands ahead of the HL&P needs throughout the life of the project. In view of this realization, they imposed extremely strict criteria on our study. The end objective was to assure HL&P that water would be available in accordance with contract terms

through the year 2030 or to alert them that they could anticipate deficiencies and that the BRA might not be able to supply the contracted amount under certain conditions. We were in no way attempting to produce a "favorable answer" which would in any way go in the face of possible reality. Nevertheless, our conclusion was that BRA could, with the then-existing six-reservoir system, supply the necessary water until the year 2030 and would have even further enhanced capability upon completion of the projected ten-reservoir system.

Q. Do you feel that this is a conservative conclusion?

A. Yes, I do.

Q. Why do you feel that it is conservative?

A. In each of the basin operation simulations, the full HL&P contract demand of 176,000 acre-feet per year was satisfied without any shortages, and with prior satisfaction of all other rights, present and projected. In our six reservoir study the total storage in the existing (1973) BRA controlled reservoirs amounted to 1,084,000 acre-feet. This storage was full at the end of June, 1949, the start of the critical period, and was drawn to its lowest level by January of 1957 when the available storage reserve had been reduced to 268,000 acre-feet. The total storage in the future ten

reservoir study amounted to 1,961,000 acre-feet. This storage was also full at the end of June, 1949, and was drawn to its lowest level by January of 1957 when the available storage reserve had been reduced to 842,000 acre-feet. This residual storage reserve remaining at the end of the critical period, amounting to 25% of the total available in the six reservoirs and 43% of the total available in the ten reservoirs affords a substantial margin of safety, indicating that the BRA should have the capability of firming up a significantly larger supply at the HL&P delivery points than the 176,000 acre-feet per year stipulated in the contract. As a further test of the margin of safety provided by the system operation, additional computer runs were made utilizing a demand of 276,000 acre-feet per year by HL&P, an amount which exceeds the contract limit by 100,000 acre-feet per year. These test runs indicated that with the existing six reservoir system, the remaining storage at the end of the critical period would still be 118,000 acre-feet, and with a ten reservoir system the remaining storage would be 660,000 acre-feet at the end of the critical period. Even with this deliberate test overdraft of 100,000 acre-feet per year, no shortages were experienced.

Whenever there was a choice as to procedure, the policy was to follow that procedure which resulted in the heaviest

burden on the resource. For example, not all permits below Hempstead predate Possum Kingdom, but because of the impracticability of separating these out, it was assumed that all permits below Hempstead had priority over Possum Kingdom, even though, in fact, priority exists only in relation to the more recent BRA-System reservoirs. It should also be recognized that some non-municipal water is utilized in the basin above Possum Kingdom which is junior to the Possum Kingdom right.

The assumption was made that existing appropriations would be exercised to the fullest extent at all times. Of course, this is an extremely conservative assumption because a permit right defines the upper limit of use and in no sense defines the use to be anticipated at any given point in time; nor does such a procedure give any credit to diversity of uses between different permit holders.

With reference to ground water, substantial amounts are now in use for both municipal and irrigation purposes within the drainage basin. In many instances it was assumed that current ground water supplies would be shifted to surface water with a net result that the return flow associated with the municipal ground water becomes lost to the system resource. The less conservative but possibly more realistic approach would have been to assume that existing ground

water remained in service thereby decreasing the local demands on reservoirs and increasing the return flow increment from ground water sources.

With reference to the utilization of a six reservoir system versus the anticipated future ten reservoir system, it should be noted that it was considered highly improbable that the year 2030 condition demands as projected would ever develop without prior construction of additional reservoirs. In spite of this, the computer runs indicated that the six reservoir system would meet all future demands without exhausting the available reserves and would even be able to satisfy an increased annual demand of an additional 100,000 acre-feet or a total of 276,000 acre-feet for Houston Lighting & Power Company. In other words, while future reservoir construction will enhance the BRA's capabilities and margin of safety in performing under its contract with HL&P, the capability of satisfactorily servicing this contract existed under the six reservoir system of 1973, without new construction.

Q. Have you examined each of the foregoing assumptions to determine if any should be changed because of changes in conditions since 1973?

A. Yes, I have. I have concluded that we were sufficiently conservative in our assumptions and no changes

need be made in our prior conclusions. The BRA has the capability today of furnishing the desired water to HL&P and will continue to be able to provide this water even in the absence of future reservoir construction and with due consideration of all existing prior rights and projected future demands.

Q. You stated Laneport and North Fork Reservoirs on the San Gabriel, two of the four additional reservoirs considered in the ten reservoir study, have been completed since the 1973 study. What effect would this have on your conclusions?

A. In terms of contract capability, there would be no effect whatsoever. Both of these reservoirs are downstream from the initial six reservoirs under BRA control considered in our study. The contract as written is based on the capability of these six reservoirs alone, and the addition of these two reservoirs on the San Gabriel has no impact on the yield capability of the upstream reservoir. However, in terms of overall basin yield, these two reservoirs add to the overall control of the basic basin resource through addition of an init .l 102,600 acre-feet of storage, of which 85,000 will still be available as of the year 2030. This increases BRA's flexibility in overall system operations to the extent of about 10 percent of the incremental

capability accorded by the future ten reservoir system over the initial six reservoir system.

Q. What about Lake Limestone?

A. Lake Limestone is located on the upper Navasota River below Lake Mexia. Its yield of 70,109 acre-feet is the result of an impoundment under a permit which is junior to all downstream permits existing at the time of our study. Furthermore, the HL&P contract is based solely on the yield capability of the initial six reservoirs without consideration of Lake Limestone. None of the water impounded in Lake Limestone flows into any of the initial six reservoirs considered in our study. Therefore, it is clear the construction of Lake Limestone in no way impairs the capability of the BRA to supply the requirements of the HL&P contract.

Q. Would you please summarize your testimony?

A. Based on the extensive study which we have done on the question of supply and demand in the Brazos River, it is my opinion that there is adequate water to supply the Allens Creek plant without jeopardizing the rights of other users in the Brazos River Basin. Our analysis demonstrates that the BRA can provide HL&P the full 176,000 acre-feet of water provided for in the contract. ACNGS Unit 1 will only have an annual makeup requirement of 30,000 acre-feet, less than one-fifth of the water from the Brazos River Basin which our

study confirms is available to HL&P under its contract.

Q. Does this complete your testimony?

A. Yes.