



UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

AUG 29 1978

MEMORANDUM FOR: Robert E. Jackson, Chief
Geosciences Branch, DSS

THRU: Leon Reiter, Leader ^R
Geology and Seismology Section
Geosciences Branch, DSS

FROM: Phyllis Sobel, Geophysicist
Geology and Seismology Section
Geosciences Branch, DSS

SUBJECT: DR. DAVID SIMPSON'S REVIEW OF LAKE JOCASSEE SEISMICITY

The three unit Oconee Nuclear Power Plant is located approximately 11 miles downstream from the Lake Jocassee Dam in northwestern South Carolina. Beginning in 1976 the NRC staff reviewed the potential impact of reservoir induced earthquake activity at Lake Jocassee on Jocassee Dam and the Oconee plant. Dr. David Simpson was asked to provide technical assistance to the NRC staff in their review. Dr. Simpson's contract (Order No. DR-77-1203) expired February 28, 1978. The contract specified that he would write an original comprehensive final report. However, the report was not written and the NRC staff has therefore not finished their review. I recommend that Dr. Simpson's contract be extended until February 28, 1980 so that he can provide the final report.

Background

The Jocassee hydro station in Oconee County, South Carolina was built by the Duke Power Company in the early 1970's. The lake was filled in January 1975 and maximum head was first achieved on March 15, 1975. The region had been one of low seismic activity. The first reported earthquake in the area occurred on August 12, 1973.

On October 18 and November 6 and 25, 1975, after the reservoir filling, three earthquakes were felt in the vicinity of the dam. The largest event was a magnitude (ML) 3.2 earthquake on November 25, 1975. The maximum estimated intensity of this event was III-IV(MM). In December, 1975 the Jocassee Hydro Consulting Board concluded that the largest earthquake would have no detrimental effect on the dam. However, the Board recommended that Duke Power coordinate the investigations of the University of South Carolina, Georgia Tech, and Law Engineering in evaluation the significance of these events and establishing a seismic monitoring program.

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Beginning after the October 18, 1975 earthquake, a network of portable seismographs were deployed in the vicinity of Jocassee reservoir. In an August 1976 report entitled "The Jocassee Earthquakes," Pradeep Talwani and other investigators at the University of South Carolina reported on the first six months of seismic monitoring (November 1975 to May 1976). Over one thousand events were recorded between November 8, 1975 and May 31, 1976. Fifteen felt events occurred between December 8, 1975 and June 2, 1976. The number of recorded events rarely exceeded 10 events per day.

The seismic activity at Lake Jocassee was associated with the impoundment of over 100 m of water behind Jocassee dam. The initial activity was centered near the dam and the epicentral volume increased with time while centering on the lake. Several possible precursors to the larger earthquakes were noticed, including (1) ts/tp ratio anomalies, (2) changes in b-values and (3) a lull in a period of increased seismicity before the larger earthquake.

During their May 20, 1976 meeting, the Jocassee Hydro Consulting Board concluded that the data did not suggest a hazard to the dam. The Board concurred with the Duke decision to terminate the seismic network on June 30 and replace it with a permanent high sensitivity seismograph that is integrated into the South Carolina network.

Initiation of NRC Review

Beginning in 1976 the NRC staff reviewed the potential impact of reservoir induced earthquake activity at Lake Jocassee on Jocassee dam and the Onocee Nuclear Power Plant located about 11 miles downstream. From March 1, 1977 through February 28, 1978, Dr. David Simpson was under contract to the NRC to provide technical assistance to the NRC staff. Dr. Simpson is a recognized authority and qualified expert in the very specialized field of research relating to reservoir-induced seismicity. He has worldwide experience in this area and his expertise would insure that the staff would review this situation in the best manner.

From June 1976 to December 1978 seismic monitoring continued and the level of seismic activity remained low. The average number of events per day was about one or two and the maximum earthquake was magnitude (M_L) 2.6. Before June 1976 the events occurred at depths of less than 2km; since June 1976 the seismicity deepened but there was no further growth in epicentral area. Pradeep Talwani has suggested that the large events ($M_L > 2.0$) occur after a sustained period of lake level increase.

Lake Keowee Seismicity

While monitoring seismic activity near Lake Jocassee, a series of earthquakes was observed from December 29, 1977 to February 27, 1978 near Lake Keowee (15 or 20 km south of Lake Jocassee and 2 to 4 km west of the Oconee plant). A portable seismic network was installed in the area. The seismic activity was in the form of an earthquake swarm, with nearly 100 or more events per day between January 4 and 7, 1978. The level of seismic activity was low ($M_s \leq 2.2$). Before the swarm began fourteen possible Keowee events had been recorded by the Lake Jocassee network. Also it appeared that the July 13, 1971 Seneca earthquake (maximum intensity IV and 3.8 M_L) was located near the Keowee activity. The Seneca earthquake occurred after the last period of rapid filling of Lake Keowee in April 1971. This suggests that the area of the Keowee earthquake swarm has had a history of seismic activity which was possibly associated with Lake Keowee. The seismicity was probably undetected due to lack of instrumentation in the epicentral area. On January 19, 1979 a magnitude (M_s) 2.8 earthquake occurred in the same area a few weeks after the raising of the lake level by about 10 feet.

Recent Seismicity at Lake Jocassee

Pradeep Talwani has continued the seismic monitoring at Lake Jocassee with a three-station network funded by the U. S. Geological Survey. On August 25, 1979 a magnitude 3.6 earthquake occurred within the seismic network. The preliminary location is shown on the enclosed map. This event was felt in South Carolina, North Carolina and Georgia. There are no confirmed reports of damage. The generators at the Jocassee hydro station were tripped. The accelerometers at the Oconee plant were not triggered; I am currently investigating what their trigger level is. The morning after the event, portable seismometers were deployed to monitor for aftershock activity. I will inform you of any additional earthquake activity in the area.

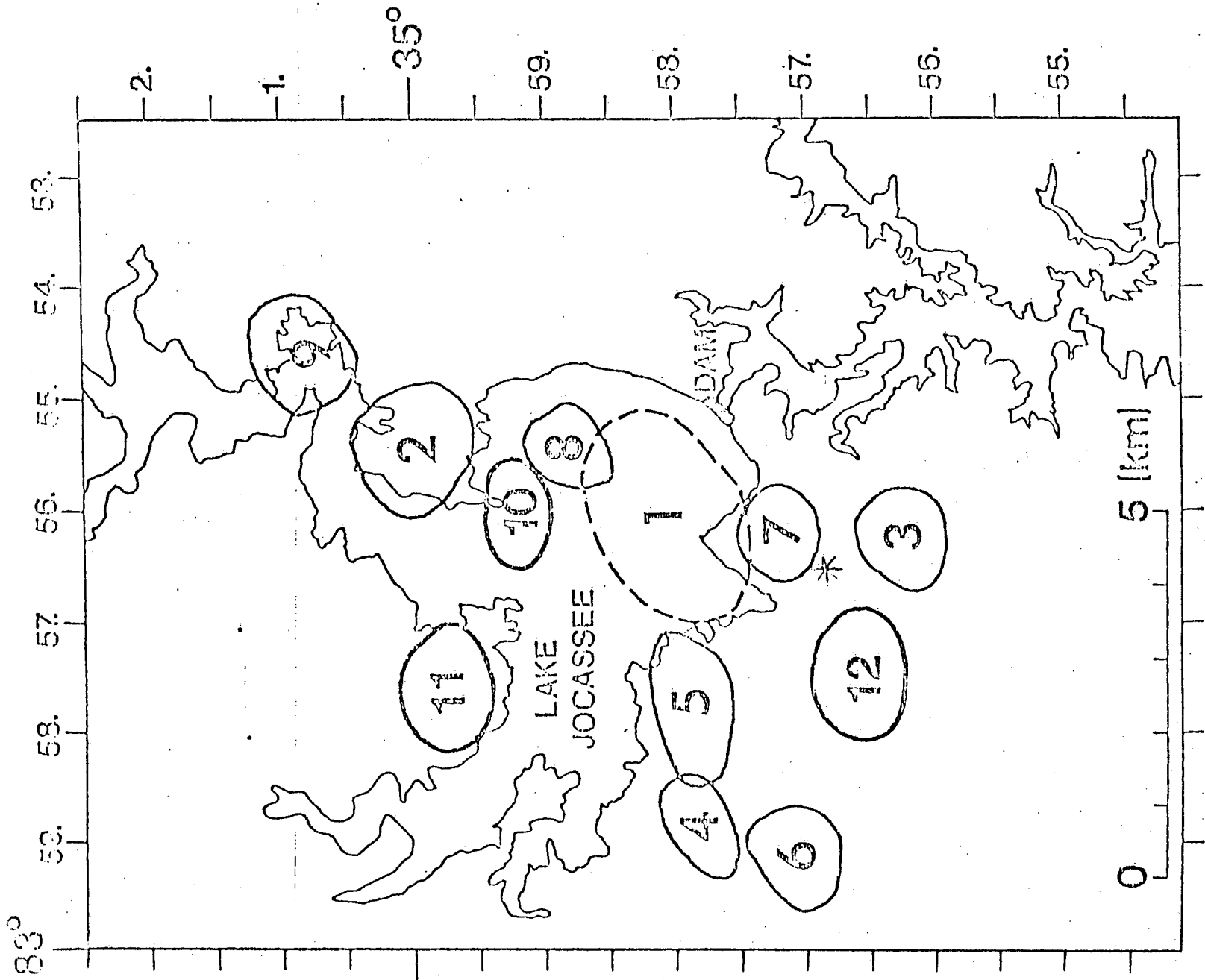
Extension of Dr. David Simpson's Contract

The NRC contract with Dr. Simpson (enclosed) specified that upon completion of the inquiry and evaluation of the data, Dr. Simpson would submit a final report to the NRC which would provide his findings, conclusions and recommendations concerning the potential hazard presented by the Jocassee Dam to the Oconee Plant site. The final report was not written and the NRC staff will not be able to complete their review without the report. Since Dr. Simpson's Contract (Order No. DR-77-1203) expired February 28, 1978, we request that Dr. Simpson's contract be extended until February 28, 1980 so that he can provide the final report. Dr. Simpson's report would help us close out this review and also be helpful in analyzing reservoir induced seismicity at other sites in the southeastern U. S.

Phyllis Sobel

Phyllis Sobel, Geophysicist
Geology and Seismology Section
Geosciences Branch, DSS

cc: T. Sullivan
J. Knight
L. Reiter
P. Sobel



* August 25, 1979 earthquake

Figure 78
Epicentral Areas of Large Events ($M_L \geq 2.0$) and Their Aftershocks

ORDER

U. S. NUCLEAR REGULATORY COMMISSION

POINT OF ISSUE:
WASHINGTON, D. C. 20555

THIS NUMBER MUST APPEAR ON ALL PACKAGES AND PAPERS RELATING TO THIS ORDER

ORDER NO.
DR-77-1203

REQUISITION NO.

DATE
March 1, 1977

PURCHASE ORDER PER YOUR written quote OF 2/24/77
 DELIVERY ORDER UNDER CONTRACT NO.

COST SYMBOL: 20-19-01-03
ALLOTMENT:
APPROPRIATION SYMBOL AND TITLE: 31X0200.207 B1186

TO: Mr. David Simpson
14 Mansfield Avenue
Nyack, NY 10960

CONSIGNEE AND DESTINATION
S U.S. Nuclear Regulatory Commission
H ATTN: Mr. R. Jackson
I Division of Site Safety and
P Environmental Analysis
T Washington, D.C. 20555
O VIA Re: P. O. No. DR-77-1203

DELIVERY F.O.B. Destination
TIME FOR DELIVERY See Below
GOV'T 3/L NO. N/A
DISCOUNT TERMS Net.

Please furnish the following on the terms specified on both sides of this sheet and on the attached sheets, if any, except that any such terms which might be inconsistent with the terms of any existing Federal contract or agreement under which this order is placed will not apply.

Item No.	ARTICLES OR SERVICES	QUAN.	UNIT	UNIT PRICE	AMOUNT
ARG/ec	<p>The Contractor shall provide technical assistance to the U.S. Nuclear Regulatory Commission (NRC) in connection with Oconee Nuclear Power Plant Post-OL unanticipated review problem. Specifically the Contractor shall aid the NRC by assisting in directing the inquiry into the induced seismicity in the vicinity of the Lake Jocassee Dam, and assist the staff in evaluating the data and reports relating to this situation which the NRC will provide. Periodic meetings with NRC staff is anticipated.</p> <p>Upon completion of the effort described above, the Contractor shall submit a final report to the NRC which will provide his findings, conclusions and recommendations concerning the potential hazard presented by the Jocassee Dam to the Oconee Plant Site.</p> <p>The period of performance for the work under this Order is March 1, 1977 through February 28, 1978.</p>				

Submit Invoices in **DUPLICATE** in accordance with instructions on reverse and forward to

U. S. NUCLEAR REGULATORY COMMISSION
OFFICE OF THE CONTROLLER
WASHINGTON, D. C. 20555

NOT TO EXCEED

TOTAL \$6,610.00

SIGNATURE

NAME

D. J. Dougherty

PURCHASE ORDER TERMS

DEFINITIONS. - As used throughout this contract, the following terms shall have the meaning set forth below:

(a) the term "Commission" means the United States Nuclear Regulatory Commission or any duly authorized representative thereof, including the Contracting Officer, except for the purpose of deciding an appeal under the clause entitled "Disputes."

(b) The term "Contracting Officer" means the person executing this Contract on behalf of the Government, and includes his successors or any duly authorized representatives of any such person.

2. VENDOR'S BILLING INSTRUCTIONS. - Vendor's invoices shall contain the following information: Contract or proposal number (if any), order number, and item number, description of supplies or services, sizes, quantities, unit prices, and extended totals. Bill of lading number and weight of shipment will be shown for shipments made on Government bills of lading. If prepaid parcel-post charges are billed the gross weight and shipping point must be shown on the invoice.

3. COVENANT AGAINST CONTINGENT FEES. - The Contractor warrants that no person or selling agency has been employed or retained to solicit or secure this contract upon an agreement or understanding for a commission, percentage, brokerage, contingent fee, excepting bona fide employees or bona fide established commercial or selling agencies maintained by the Contractor for the purpose of securing business. For breach or violation of this warranty the Government shall have the right to annul this contract without liability, or in its discretion to deduct from the contract price or consideration, or otherwise recover, the full amount of such commission, percentage, brokerage, or contingent fee.

4. OFFICIALS NOT TO BENEFIT. - No member of or delegate to Congress or resident commissioner shall be admitted to any share or part of this contract or to any benefit that may arise therefrom but this provision shall not be construed to extend to this contract if made with a corporation for its general benefit.

5. EQUAL OPPORTUNITY IN EMPLOYMENT. - The Equal Opportunity clause in FPR 1-12.803-2 is incorporated herein by reference and is applicable unless this contract is exempt under the rules and regulations of the Secretary of Labor issued pursuant to Executive Order No. 11246 of September 24, 1965 (30 F.R. 12319, Sept. 23, 1965).

6. CONVICT LABOR. - In connection with the performance of work under this contract, the Contractor agrees not to employ any person undergoing sentence of imprisonment at hard labor.

7. BUY AMERICAN ACT. - (a) in acquiring and products, the Buy American Act (41 U.S. Code 101-10) provides that the Government give preference to domestic source end products. For the purpose of this clause:

(i) "components" means those articles, materials, and supplies, which are directly incorporated in the end product,

(ii) "end products" means those articles, materials, and supplies, which are to be acquired under this contract for public use, and

(iii) a "domestic source end product" means (A) an unmanufactured end product which has been mined or produced in the United States and (B) an end product manufactured in the United States if the cost of the components thereof which are mined, produced, or manufactured in the United States exceeds 50 percent of the cost of all its components. For the purposes of this (a) (iii) (B), components of foreign origin of the same type or kind as the products referred to in (b) (i), (ii), or (iii) of this clause shall be treated as components mined, produced or manufactured in the United States.

(b) The Contractor agrees that there will be delivered under this contract only domestic source end products, except end products:

(i) which are for use outside the United States;

(ii) which the Government determines are not mined, produced, or manufactured in the United States in sufficient and reasonably available commercial quantities and of a satisfactory quality;

(iii) as to which the Commission determines the domestic preference to be inconsistent with the public interest; or

8. DISCOUNTS. - In connection with any discount offered, time will be computed from date of delivery of the supplies to carrier when delivery and acceptance are at point of origin, or from date of delivery at destination or port of embarkation when delivery and acceptance are at either of these points, or from date correct invoice or voucher is received in the office specified by the Government if the latter date is later than the date of delivery. Payment is deemed to be made for the purpose of earning the discount on the date of mailing of the Government check.

9. INSPECTION. - Except as may be otherwise provided in this contract, final inspection and acceptance will be made at destination. Supplies rejected at destination for nonconformance with specifications shall be removed by the Contractor at his expense promptly after notice of rejection.

10. CONTRACT WORK HOURS STANDARDS ACT-OVERTIME COMPENSATION. - This contract, to the extent that it is of a character specified in the Contract Work Hours Standards Act-Overtime Compensation (40 U.S.C. 327-330) and is not covered by the Walsh-Healey Public Contracts Act (41 U.S.C. 35-45), is subject to the following provisions and to all other provisions and exceptions of said Contract Work Hours Standards Act.

(a) No contractor or subcontractor contracting for any part of the contract work shall require or permit any laborer or mechanic to be employed on such work in excess of eight hours in any calendar day or in excess of forty hours in any workweek unless such laborer or mechanic receives compensation at a rate not less than one and one-half times his basic rate of pay for all hours worked in excess of eight hours in any calendar day or in excess of forty hours in such workweek, whichever is the greater number of overtime hours.

(b) In the event of any violation of the provisions of paragraph (a) the Contractor and any subcontractor responsible for such violation shall be liable for any affected employee for his unpaid wages. In addition, such Contractor or subcontractor shall be liable to the United States for liquidated damages. Such liquidated damages shall be computed, with respect to each individual laborer or mechanic employed in violation of the provisions of paragraph (a), in the sum of \$10 for each calendar day on which such employee was required or permitted to work in excess of eight hours or in excess of forty hours in a workweek without payment of the required overtime wages.

(c) The Contracting Officer may withhold, or cause to be withheld, from any moneys payable on account of work performed by the Contractor or subcontractor, the full amount of wages required by this contract and such sums as may administratively be determined to be necessary to satisfy any liabilities of such Contractor or subcontractor for liquidated damages as provided in paragraph (b).

(d) The Contractor shall insert paragraphs (a) through (d) of this clause in all subcontracts, and shall require their inclusion in all subcontracts of any tier.

(e) The Contractor shall maintain payroll records containing the information specified in 29 CFR 516.2(a). Such records shall be preserved for 3 years from the completion of the contract.

11. FEDERAL, STATE, AND LOCAL TAXES. - Except as may be otherwise provided in this contract, the contract price includes all applicable Federal taxes in effect on the date of this contract but does not include any State or local sales, use, or other tax directly applicable to the completed supplies or services covered by this contract nor any other tax from which the Contractor or this transaction is exempt. Upon request of the Contractor, the Government shall furnish a tax exemption certificate or similar evidence of exemption with respect to any such tax not included in the contract price pursuant to this clause. For the purpose of this clause, the term "date of this contract" means the date of the Contractor's quotation or, if no quotation, the date of this purchase order.

12. RENEGOTIATION. - This contract is subject to the Renegotiation Act of 1951, as amended. The contract shall be deemed to contain all the provisions required by section 104 of said Act.

13. PRIORITIES, ALLOCATIONS, AND EMBARGOS. - This contract is subject to the provisions of Executive Order 9801, as amended, and of all other orders, regulations, and directives of the United States Government.

NAME OF OFFEROR OR CONTRACTOR

David Simpson

ITEM NO.	SUPPLIES/SERVICES	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	<p>The Contractor shall be paid the fixed rate of \$200.00 per day. It is anticipated that 24 man-days of effort over the period of performance will be required. Travel costs associated with the above effort shall be reimbursed in accordance with Federal Travel Regulations. Miscellaneous costs which include printing, drafting, etc. shall be reimbursed at actual cost.</p> <p>In addition to the provisions outlined on the reverse of this Order, the Contractor is also subject to those provisions as applicable, outlined in Attachment I, hereof.</p>				