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ATLANTIC-PACIFIC SEA-LEVEL CANAL STUDY

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HEARING BEFORE THE COMMITTEE ON COMMERCE UNITED STATES SENATE NINETIETH CONGRESS

SECOND SESSION

ON

S. 2948

TO AMEND SECTIONS 3 AND 4 OF THE ACT APPROVED
SEPTEMBER 22, 1964 (78 STAT. 990), PROVIDING FOR AN
INVESTIGATION AND STUDY TO DETERMINE A SITE FOR
THE CONSTRUCTION OF A SEA-LEVEL CANAL CONNECT-
ING THE ATLANTIC AND PACIFIC OCEANS

APRIL 2, 1968

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the American isthmus and we believe that the study being conducted by the Commission is essential to guarantee the future growth of our interoceanic commerce, particularly as the Panama Canal becomes obsolete.

A copy and a check of \$2,500 a gift of the letter of Chairman

TO AMEND SECTIONS 3 AND 4 OF THE ACT APPROVED SEPTEMBER 22, 1964 (78 STAT. 990), PROVIDING FOR AN INVESTIGATION AND STUDY TO DETERMINE A SITE FOR THE CONSTRUCTION OF A SEA-LEVEL CANAL CONNECTING THE ATLANTIC AND PACIFIC OCEANS

TUESDAY, APRIL 2, 1968

U. S. SENATE,
COMMITTEE ON COMMERCE,
Washington, D. C.

The committee was convened at 10:10 a.m., in room 5110, New Senate Office Building, Washington, D.C., Hon. E. L. Bartlett presiding.
Present: Senators Bartlett and Moss.

OPENING STATEMENT BY THE CHAIRMAN

Senator BARTLETT. The committee will be in order.

I want to welcome to the hearings today Ambassador Robert B. Anderson, Chairman, Atlantic-Pacific Interoceanic Canal Commission; Brig. Gen. Charles C. Noble, the Commission's Engineering Agent; as well as Mr. William Oakley, Assistant Director of the Division of Peaceful Nuclear Explosives, of the Atomic Energy Commission.

On February 7, 1968, at the request of the Commission, the Chairman of this Committee, Senator Warren G. Magnuson, introduced S. 2948, to amend sections 3 and 4 of the act creating the Commission and providing for an investigation and study with respect to a sea-level canal between the Atlantic and Pacific Oceans. This bill would amend the enabling law to provide additional time, until December 1, 1970, and authorize sufficient funds up to \$24 million for the Commission to complete its work.

The committee members were pleased to learn that both Cabriole and Buggy I, the two nuclear excavation experiments conducted by the Atomic Energy Commission this year, were successful. Buggy I, I understand, was the first nuclear row-charge detonation we have tried.

I am sure that Mr. Oakley during his testimony will advise us further as to the results of these experiments and their contribution to the study program of the Commission.

I might say at the outset of this hearing that the Commerce Committee is committed to the principle of unrestricted shipping through

Staff counsel assigned to this hearing: Joseph R. Fogarty.

the American isthmus and we believe that the study being conducted by the Commission is essential to guarantee the future growth of our interoceanic commerce, particularly as the Panama Canal becomes obsolescent.

A copy and a digest of S. 2948, a copy of the letter of Chairman Anderson to Vice President Humphrey, dated January 31, 1968, requesting the introduction of this bill, and the Agency comment will be printed immediately following my remarks.

(The material follows:)

ATLANTIC-PACIFIC INTEROCEANIC
CANAL STUDY COMMISSION,
Washington, D.C., January 31, 1968.

HON. HUBERT H. HUMPHREY,
President of the Senate,
Washington, D.C.

DEAR MR. PRESIDENT: Provided herewith is a draft bill "To amend Sections 3 and 4 of the Act approved September 22, 1964 (78 Stat. 990), providing for an investigation and study to determine a site for the construction of a sea-level canal connecting the Atlantic and Pacific Oceans."

We recommend that this draft bill be referred to the appropriate committee for consideration, and we recommend its enactment.

The Atlantic-Pacific Interoceanic Canal Study Commission was established by the Act approved September 22, 1964 (Public Law 88-609, 78 Stat. 990), to make a full and complete investigation and study, including necessary on-site surveys for the purpose of determining the feasibility of, and the most suitable site for, construction of a sea-level canal connecting the Atlantic and Pacific Oceans, and the best means of construction.

When Public Law 88-609 was enacted, the expectation was that site surveys in Panama and Colombia would begin not later than January 1965. This expectation was the basis for the establishment of the June 30, 1968 reporting date and was a factor in fixing the \$17.5 million ceiling on appropriations.

On April 18, 1965, the President appointed the five present members of the Commission from private life. After the Commission was appointed, it adopted a plan of study that attempted to adjust the study program schedule to the circumstance that the favorable dry season occurring in fiscal year 1965 had already passed. At that time the Commission had no actual on-the-ground experience on which to base a more accurate time and cost estimate. The new program schedule assumed the start of full-scale data collection beginning in January 1966, with completion of the study by June 30, 1968.

In September 1965, it became apparent to the Commission that the necessary treaties with Panama and Colombia could not be negotiated and ratified before the advent of the 1966 dry season. It, therefore, requested the Department of State to direct its immediate efforts toward achieving early agreements for site surveys only, with the understanding that negotiations for sea-level canal treaties would continue with the hope of agreement at a later date. The negotiations of site surveys initiated with Panama in October 1965 were successfully concluded in an exchange of notes between the United States and Panama on February 15, 1966. A similar exchange of notes with the Colombian Government was made on October 25, 1966.

Although access to the survey route in Panama was achieved prior to the close of the 1966 dry season, only limited work could be accomplished there in the remaining weeks of dry weather. During the negotiation period, every advantage was taken to expedite those functions not requiring actual route access. Supplies and equipment were purchased and stored, but full-scale data collection had to be postponed until January 1967. In spite of maximum efforts during this period, two full years for data collection have been lost.

Evaluating the alternatives available to the Commission for completing their investigation and study, in the face of the delay caused by difficulties in starting actual on-site surveys and the delay in the nuclear excavation research program, the Commission determined that it will require until December 1, 1970, to complete and submit its study.

The Congress has extended the required completion dates but only to December 1, 1969. An additional year's time to complete and submit the study is

needed. Also, while this legislation originally included a provision for increasing the appropriate authorization, the Act as passed did not include such an increase. The Commission cannot accomplish its task within the current appropriation limitation of \$17.5 million. The current estimate of funds required to complete the study is \$24.0 million, an increase of \$6.5 million. The major items contributing to the increase in estimated cost are the result of delays in beginning on-site surveys, more realistic cost estimates based upon actual field conditions, and other changed conditions. Included in the Commission's present cost estimate are funds to extend the study, to cover unprogrammed Federal pay raises, to provide services for the Commission that otherwise would have been provided by the Department of Defense at little or no cost to the Commission had it not been for the Vietnam requirements, to support program changes resulting from actual on-site conditions, to support a program stretchout which will result from the extension of the nuclear excavation research activities, and other requirements resulting from conditions which were not envisioned in the original program planning.

The Atlantic-Pacific Interoceanic Canal Study Commission considers that the objectives of Public Law 88-609 can best be accomplished by enactment of the proposed amendment to extend the study until December 1, 1970, and to increase the appropriation ceiling to \$24.0 million so as to provide the Commission with sufficient time and funds to complete the study in an orderly and efficient manner.

For the reasons stated above and because of the fact that the concluding work plans of the Commission will be affected by the inclosed draft bill, its prompt and favorable consideration is recommended.

The Bureau of the Budget has advised that the enactment of the draft legislation would be consistent with the Administration's objectives.

Respectfully yours,

ROBERT B. ANDERSON,
Chairman.

[S. 2948, 90th Cong., second sess.]

A BILL To amend sections 3 and 4 of the Act approved September 22, 1964 (78 Stat. 990), providing for an investigation and study to determine a site for the construction of a sea level canal connecting the Atlantic and Pacific Oceans

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Act approved September 22, 1964 (Public Law 88-609, 78 Stat. 990), as amended, is hereby further amended (1) by striking out "December 1, 1969" in section 3 and inserting in lieu thereof "December 1, 1970", and (2) by striking out "\$17,500,000" in section 4 and inserting in lieu thereof "\$24,000,000".

DIGEST OF S. 2948

S. 2948, a bill to amend Section 3 and Section 4 of P. L. 88-609 creating the Atlantic-Pacific Interoceanic Canal Commission, would extent the time in which the Commission must file its final report and recommendations from December 1, 1969, to December 1, 1970, and would increase the authorized appropriation for the canal studies from \$17.5 million to \$24 million.

COMPTROLLER GENERAL OF THE UNITED STATES,
Washington, D.C., February 26, 1968.

Hon. WARREN G. MAGNUSON,
Chairman, Committee on Commerce, U.S. Senate.

DEAR MR. CHAIRMAN: Your letter of February 8, 1968, invites our comments on S. 2948, a bill to amend sections 3 and 4 of the Act approved September 22, 1964 (78 Stat. 990), providing for an investigation and study to determine a site for the construction of a sea level canal connecting the Atlantic and Pacific Oceans.

We have no special information or knowledge that would assist in the consideration of S. 2948, and therefore have no comments to offer.

Sincerely yours,

FRANK H. WEITZEL,
Assistant Comptroller General of the United States.

PANAMA CANAL COMPANY,
Washington, D.C., March 4, 1968.

Hon. WARREN G. MAGNUSON,
*Chairman, Committee on Commerce,
U.S. Senate, Washington, D.C.*

DEAR SENATOR MAGNUSON: This is in response to your request for the views of the Panama Canal Company on S. 2948, a bill "To amend sections 3 and 4 of the Act approved September 22, 1964 (78 Stat. 990), providing for an investigation and study to determine a site for the construction of a sea level canal connecting the Atlantic and Pacific Oceans."

This bill would amend section 3 of the Act to extend the life of the Atlantic-Pacific Interoceanic Canal Study Commission until December 1, 1970, and would amend section 4 to increase the limit on amounts which may be appropriated under the Act from \$17,500,000 to \$24,000,000. The bill is identical to H.R. 15190, introduced by Mr. Garmatz on February 7, 1968, and is substantially identical to two bills introduced during the first session of this Congress: S. 1566, which you introduced, and H.R. 6791, introduced by Mr. Garmatz. S. 1566 was enacted as Pub. L. 90-244, 81 Stat. 781. As passed, however, the measure provided only for an extension of the lifetime of the Commission from June 30, 1968 to December 1, 1969.

Although the Panama Canal Company has no direct responsibility for the study involved in this legislation, the Company is in agreement with the purpose of the bill which authorized the establishment of the Commission, and with the previous amendatory bills discussed above. Any further legislation considered necessary to the fulfillment of the objectives of the Commission would seem to be desirable.

The Bureau of the Budget advises that it has no objection to submission of this report to your committee.

Sincerely yours,

W. M. WHITMAN, *Secretary.*

DEPARTMENT OF THE ARMY,
Washington, D.C., March 7, 1968.

Hon. WARREN G. MAGNUSON,
Chairman, Committee on Commerce, U.S. Senate.

DEAR MR. CHAIRMAN: Reference is made to your request for the views of the Department of the Army on S. 2948, 90th Congress, a bill "To amend sections 3 and 4 of the Act approved September 22, 1964 (78 Stat. 990), providing for an investigation and study to determine a site for the construction of a sea-level canal connecting the Atlantic and Pacific Ocean."

The Act, under consideration for amendment, established the Atlantic Pacific Interoceanic Canal Study Commission to make a full and complete investigation and study, including necessary on-site surveys, for the purpose of determining the feasibility of, the most suitable site for, and the best means to accomplish the construction of a sea-level canal connecting the Atlantic and Pacific Oceans.

This bill would amend section 3 of the Act to extend the reporting date of the study from December 1, 1969 to December 1, 1970; and it would amend section 4 of the Act to increase the appropriation ceiling from \$17,500,000 to \$24,000,000.

When the Act establishing the Commission was passed in September 1964, it was expected that the site surveys in both Panama and Colombia would begin in January 1965. The Commission members were not appointed until April 18, 1965, however, and this delay resulted in the loss of the favorable dry season for the start of on-site surveys. Delay in securing access agreements with Panama and Colombia caused a further loss of time. Negotiations were finally concluded with Panama on February 15, 1966, and with Colombia on October 25, 1966. These delays cost the Commission the full use of the 1966 dry season and thus two seasons of data collection time were lost. The increased appropriation ceiling and extended reporting date are necessary to secure two full years of data collection in the field and make full use of the information in the office.

Another item which caused delay was the reduced activity in the Atomic Energy Commission's PLOWSHARE Program. The Canal Commission's study is partly dependent upon information concerning nuclear excavation that is forthcoming from this program. This program was resumed with the nuclear test CABRIOLET which was detonated on January 26, 1968. Further experiments in this field are

expected in the near future. The requested extension of time will enable the Commission to include this information and its analysis in its study.

The need to increase the Commission's appropriation ceiling results from a variety of causes. Increased costs have stemmed from such things as the above-mentioned delays and unprogramed Federal pay raises. Some cost estimates have had to be increased because of actual field experience, while others have been changed because of a reorienting of the study program.

The program before the Commission is a very complex one, and it, therefore, requires the best possible analysis of all its facets. S. 2948 would provide the Commission with the necessary time and funds with which to study these facets and to accomplish the objectives for which it was established. Accordingly, for the reasons stated above, the Department of the Army favors enactment of S. 2948.

The Bureau of the Budget advises that, from the standpoint of the Administration's program, there is no objection to the presentation of this report for the consideration of the Committee.

Sincerely,

STANLEY R. RESOR, *Secretary of the Army.*

GENERAL COUNSEL OF THE DEPARTMENT OF COMMERCE,
Washington, D.C., March 11, 1968.

HON. WARREN G. MAGNUSON,
*Chairman, Committee on Commerce,
U.S. Senate,
Washington, D.C.*

DEAR MR. CHAIRMAN: This is in further reply to your request for the views of this Department concerning S. 2948, a bill "to amend sections 3 and 4 of the Act approved September 22, 1964 (78 Stat. 990), providing for an investigation and study to determine a site for the construction of a sea level canal connecting the Atlantic and Pacific Oceans."

The bill would amend the Act of September 22, 1964, as amended so as to (1) extend to December 1, 1970, the time in which the Atlantic-Pacific Interoceanic Canal Study Commission has to continue its investigation and study and (2) increase the funds authorized for the investigation and study by \$6.5 million.

The Department of Commerce favors the enactment of S. 2948.

We have been advised by the Bureau of the Budget that there would be no objection to the submission of this report from the standpoint of the Administration's program.

Sincerely,

PEDRO R. VAZQUEZ
(For General Counsel).

Senator BARTLETT. You may proceed with your testimony, Ambassador Anderson.

STATEMENT OF HON. ROBERT B. ANDERSON, CHAIRMAN, ATLANTIC-PACIFIC INTEROCEANIC CANAL COMMISSION; ACCOMPANIED BY COMMISSIONER KENNETH E. FIELDS; JOHN P. SHEFFEY, COMMISSION'S EXECUTIVE DIRECTOR; BRIG. GEN. CHARLES C. NOBLE, COMMISSION'S ENGINEERING AGENT; AND WILLIAM OAKLEY, ASSISTANT DIRECTOR OF THE DIVISION OF PEACEFUL NUCLEAR EXPLOSIVES, OF THE ATOMIC ENERGY COMMISSION

Mr. ANDERSON. Mr. Chairman and members of the committee, it is a pleasure to appear before you as a witness for the Atlantic-Pacific Interoceanic Canal Study Commission.

In addition to those gentlemen mentioned by the chairman, I am also accompanied by General Fields, a member of the Commission, and Mr. John P. Sheffey, the Commission's Executive Director.

We are here for two purposes: one, to report to you on the progress of the Commission's investigation; and the other, to request your approval of S. 2948, an amendment to the Commission's authorizing legislation, Public Law 88-609.

Since our last appearance before this committee, the Commission has continued to meet quarterly. Individual Commission members have had numerous meetings with the agencies working with the Commission. Members have made many field trips to activities of special interest to our study, and each of us has devoted time as needed to conduct Commission business at our home offices.

The activities of the Commission during fiscal year 1967 were detailed in our third annual report, dated July 31, 1967, which the President submitted to the Congress. Copies are available in the hearing room.

You will recall that last year the Canal Study Commission requested in S. 1566 essentially the same amendment to its authorizing legislation as we are again requesting this year. That is, that our appropriation authority be increased from \$17.5 million to \$24 million and that our reporting date be extended to December 1, 1970. Last year the Senate approved the new reporting date and a large part of the requested additional appropriation authority. However, in the House of Representatives the companion bill to S. 1566, H.R. 6791, was not approved as submitted. Instead the House extended our reporting date only from June 30, 1968, to December 1, 1969, and granted none of the requested additional appropriation authority. This action was taken in the House because of the continued postponement of the Atomic Energy Commission's nuclear excavation experiments needed to determine the technical feasibility of nuclear canal excavation.

Prior to the conference committee meeting on the Senate and House bills, we informed your committee that the House version would meet our needs if the nuclear excavation experiments planned in support of our investigation continued to be postponed. In this event, we planned to curtail our investigation of the routes under consideration for nuclear excavation, and use the remainder of our currently authorized funds to complete our investigation and report only on the most promising routes for conventional excavation. This we could accomplish by December 1, 1969, within our \$17.5 million appropriation ceiling. As a result, the Senate accepted the House version with the understanding that new legislation authorizing additional time and money would be considered this year if the planned nuclear experiments were permitted to proceed. The Senate bill, S 1566, as amended, became Public Law 90-244.

Shortly after the passage of Public Law 90-244 last December, the President authorized the execution of the first of six nuclear excavation experiments planned by the Atomic Energy Commission to determine the feasibility of nuclear canal excavation. This experiment, Cabriole, was executed on January 26, 1968. The second, Buggy, the initial nuclear row-charge experiment, was executed on March 12, 1968. The results of both experiments, I understand, exceeded predictions and expectations. Mr. William Oakley of the Atomic Energy Commission will tell you more about these experiments later. The rate of progress toward development of the nuclear excavation tech-

nology now seems to have picked up to the pace necessary to advise the Canal Study Commission on the feasibility of nuclear canal excavation within the next $2\frac{1}{2}$ years. In the light of these developments, the expectation again exists that the Commission will be able to accomplish the entire mission given it in Public Law 88-609, to include the determination of the feasibility of nuclear canal excavation. But to do so will require additional time and money as proposed in S. 2948.

Let me review for you the circumstances that have caused us to fall 2 to 3 years behind the schedules originally conceived for our studies when Public Law 88-609 was passed on September 22, 1964.

It was expected that site surveys would begin in Panama and Colombia not later than January 1965, and would take 3 years; this was the basis for the June 30, 1968, reporting date. But the Commission was not appointed until April 19, 1965, and it was not until February 15, 1966, that agreement was reached with the Government of Panama authorizing us to survey sites for the proposed sea-level canal in Panama. Not until October 25, 1966, was a similar agreement reached with the Government of Colombia for site surveys in that country.

Because heavy rainfall limits most site-survey operations in Panama and Colombia to the January-to-April dry season, site-survey operations were not fully underway on Route 17 in Panama until January 1967. On Route 25 in Colombia, operations could not even begin until then and did not come into full operation until January 1968. Moreover, the original \$17.5 million Commission budget was necessarily estimated without on-the-ground experience upon which to base more reliable time and cost estimates.

To further complicate our timetable and increase our costs, we found it necessary to use more commercial air transportation in the remote jungle areas of our field surveys than had been foreseen when our first budget was prepared. Helicopter transport turned out to be the only practical means for reaching many of our instrument stations and drilling sites. This service had to be obtained on a contract basis at considerable cost.

A second development unforeseen when the Commission's timetable and budget were prepared back in 1964 is the addition of Route 10 in Panama to our investigation.

Before the appointment of our Commission, the four most promising sea-level canal routes reported upon in earlier studies were selected for our investigation. The 1947 study by the Governor of the Canal Zone had concluded that Route 14 within the existing Canal Zone would be the most suitable for conventional excavation. This study, together with subsequent studies, indicated the order of merit of possible routes for nuclear excavation. In the original plans, further investigation of the zone routes, Routes 14 and 14D, and the two most promising nuclear routes, Route 17 in Panama and Route 25 in Colombia, were the basis for the proposed Commission budget and the \$17.5 million appropriation authorization in Public Law 88-609.

Subsequent to the passage of this legislation, Route 8 in Nicaragua was added to the routes to be considered. As we have informed you earlier, our conceptual evaluation of this route led us to conclude that it did not merit a full-scale engineering field survey at this time, and this evaluation involved only limited unforeseen expenses.

Route 10 is another matter. Our restudy of the Canal Zone Routes 14 and 14D of the 1947 study, using some of the most eminent private technical consultants in the United States, has led us to question the earlier conclusion that a route in the Canal Zone would be best for conventional excavation. We believe now that we must have a comparable evaluation of Route 10, some 5 miles to the west of the Canal Zone border, which may have significant advantages over the zone routes. We urge that additional funds be authorized to cover the costs of data collection on Route 10.

In its planned parallel program of Plowshare nuclear excavation experiments in support of our investigation, the Atomic Energy Commission also fell more than 2 years behind the schedule originally contemplated as a result of repeated postponements of its experiments, for reasons beyond Atomic Energy Commission control.

With the delays in the Plowshare excavation experiments, we were nearly to the point of deciding that we would be unable to determine the feasibility of nuclear canal excavation. Now, with two experiments executed, the outlook seems one of step-by-step and timely execution of the orders needed to develop nuclear excavation technology. If such is the case, we could, with the additional time and money we are asking, apply that technology to the conditions found on the route in Colombia, Route 25, as well as on Route 17 for which our data collection is almost complete. The necessary personnel and equipment have been placed on-site at great expense and more than two-thirds of our planned work has been completed. However, without the requested amendment to our legislation, we cannot finish the job.

We are again requesting that our final reporting date be postponed to December 1, 1970, and our appropriation authorization be increased from \$17.5 million to \$24 million. Without this time and money we will be unable to evaluate the feasibility of the canal routes suitable for nuclear excavation.

The House Committee on Merchant Marine and Fisheries held hearings on March 7 on companion legislation, H.R. 15190. On March 21 the Appropriations Committees of the Senate and the House held hearings on our appropriation request for fiscal year 1969 under the proposed amended authority. On April 1 the House considered H.R. 15190 under suspension of rules, which requires a two-thirds vote. This procedure was not accepted by the House. The vote was 216 for and 137 against, which is 19 short of the two-thirds majority. The President has included \$4.9 million for the Commission in his fiscal year 1969 budget, with the understanding that we would obtain the necessary additional authorization authority from the Congress.

Without the proposed amendment we will be forced to curtail our investigation of the only sea-level canal route outside Panama which appears to be financially attractive, Route 25 in Colombia. Our remaining time and money will not permit a full evaluation of its suitability. The importance of this alternative to the nuclear and conventional routes in Panama is well known to this committee.

Now, Mr. Chairman, I would like to call on Mr. Sheffey to outline the status for each of the Commission-directed studies other than that of engineering feasibility. General Noble will explain to you in detail the status of our engineering study, where most of our funds have been expended, and what remains to be funded and accomplished.

Mr. Oakley will apprise you of the progress and the plans of the nuclear excavation experiment program.

Senator BARTLETT. We will hear from Mr. Sheffey.

Mr. SHEFFEY. Mr. Chairman, I will briefly review the organization of the Commission's study effort and the purposes of five of our studies. General Noble will cover our study of engineering feasibility, where our major timing and funding problems lie. While we are not in a position to report final conclusions in any study area, I can give you some indication of the directions the studies are taking and their progress.

For obvious reasons, the current working drafts are for the internal use of the Commission and will have no official status until they are in final form as a part of the Commission's report to the President for transmission to the Congress. At this point they are no more than the interim reports of our study groups, and have been approved neither by the departments participating in the studies nor by the Commission itself.

Chart A on the side of the room indicates the organization for the studies. I would like to point out that, while the responsibility and chairmanship of the various study groups are vested in the agency indicated underneath the title, the composition of the group includes members from other Government agencies which have an interest or contribution to make in the field of study.

(Chart A follows:)

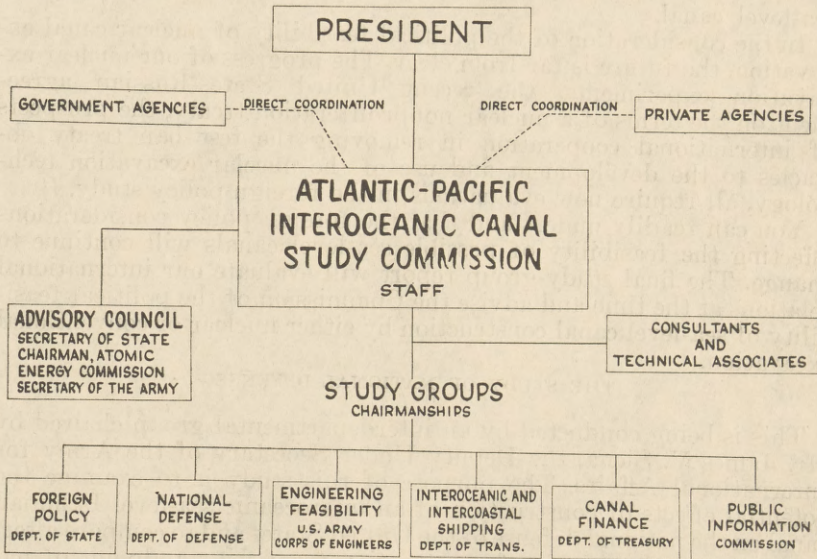


CHART A

A

Mr. SHEFFEY. Our major expenditures are in the study of engineering feasibility. With the exception of a contract study of the possible economic impacts of the various sea-level canals on the host countries for the foreign policy study, the other five studies are being conducted without expense to the Commission.

The overall purpose of these studies directed by the Commission is to provide a comprehensive foundation of factual data, estimates, and expert opinions upon which to base the Commission's own ultimate findings and recommendations.

THE FOREIGN POLICY STUDY

The study of foreign policy considerations is being accomplished by an interdepartmental group chaired by Mr. Robert M. Sayre, Deputy Assistant Secretary of State for Inter-American Affairs. The purpose of this study is:

1. To evaluate the effects of construction of a sea-level Isthmian canal on the United States relations with (a) the canal-site countries and (b) the countries that are significant users of the present canal.
2. To advise the Commission whether U.S. foreign policy interests are best served by the construction of a sea-level canal by conventional or by nuclear methods.
3. To advise the Commission on the foreign policy aspects of sea-level canal finance and operation.

An initial draft of the study has been completed, but much remains to be done. The supporting contract study of the economic impacts of the possible sea-level canals will not be completed until later this year. The study group must attempt to evaluate the possible treaty terms in Panama and Colombia as they would affect the feasibility of a sea-level canal.

In the consideration of the political feasibility of nuclear canal excavation, the future is far from clear. The progress of our nuclear excavation experiments, the recent United States-Russian agreement on the terms of a nuclear nonproliferation treaty, the prospects of international cooperation in removing the test ban treaty obstacles to the development and use of the nuclear excavation technology, all require new evaluations in the foreign policy study.

You can readily understand that the foreign policy considerations affecting the feasibility of possible sea-level canals will continue to change. The final study-group report will evaluate our international relations at the time and advise the Commission of the political feasibility of sea-level canal construction by either nuclear or conventional excavation.

THE STUDY OF NATIONAL DEFENSE

This is being conducted by an interdepartmental group chaired by Mr. James V. Siena, the Deputy Under Secretary of the Army for International Affairs. The purpose of this study is to examine the potential effects of construction of an interoceanic sea-level Isthmian canal on the national defense of the United States and to compare alternate routes and methods of construction from the standpoint of national defense.

This interdepartmental group has already completed an evaluation of the contribution that a sea-level canal could make to our defense posture, although some points require further qualification. This study is necessarily classified. I am divulging no classified matter, however, to report to you that the study group sees great national security advantages in a wide, deep sea-level canal without the capacity limitations and inherent military vulnerability of the existing lock canal.

For example, it is already well known that our 25 largest aircraft carriers cannot transit the Panama Canal.

THE SHIPPING STUDY

The study of interoceanic and intercoastal shipping is being accomplished by an interdepartmental group chaired by Mr. M. Cecil Mackey, Assistant Secretary of Transportation for Policy Development. The purpose of this study is:

1. To analyze the long-range trends in intercoastal and interoceanic shipping related to the canal.
2. To examine the interrelationships between the sea-level canal, shipping, and finance.
3. In cooperation with other agencies, to analyze the effects of various toll collections and distribution plans upon interoceanic shipping.

A complete initial draft of this study has just been produced; it has not yet been accepted by the Commission, however.

The study indicates that the real cost per ton of surface shipping of bulk materials is decreasing and that the dramatic growth of such movements in recent years will continue unabated for many years to come.

The study indicates that the capacity of the existing lock canal may be exceeded before the end of this century in the absence of toll increases sufficient to discourage traffic growth or yet unforeseen developments in the transportation of bulk cargoes.

The present canal probably will continue to be adequate for general-cargo carriers, including large container ships, throughout this century. The bulk-carrier fleet, however, is growing rapidly; its continued efficient support of U.S. and worldwide industry and agriculture will require increased Isthmian Canal facilities. Needed capacity could be provided by the construction of a third and larger set of locks for the present canal. This could, however, be a temporary solution with important disadvantages which must be weighed carefully in the final choice.

The most difficult forecast required of the shipping study group is still in development. This is a forecast of potential sea-level-canal revenues for some 70 years into the future. This forecast must take into consideration not only the total number of ships that would use the isthmian canal routes during the coming years but also the economics of the large bulk carriers. What will they pay in tolls to avoid the longer routes around Africa or South America? The answer to this question will greatly influence the width and depth, and hence the cost, of the optimum conventionally excavated canal.

An incontrovertible forecast of potential canal revenues through the year 2040 is, of course, impossible. We can only produce a detailed analysis of the factors which will affect traffic and revenues, and then forecast a range of reasonable possibilities. However, even our most conservative estimates at this time indicate the probability of a very large increase in canal shipping and revenues if adequate capacity for larger ships is provided at reasonable tolls.

THE STUDY OF CANAL FINANCE

The study of canal finance is being accomplished by an interdepartmental group chaired by Mr. R. Duane Saunders, Assistant to the Secretary of the Treasury for Debt Management. The purpose of this study is:

1. To examine the methods available for financing the construction and operation of a sea-level canal.
2. In cooperation with other agencies and the Commission, to analyze the effects of each method.

This study is dependent upon (1) the completion of firm estimates of construction and operating costs for alternative canals, (2) the completion of traffic and potential revenue forecasts that are acceptable to the Commission, and (3) a determination of the actual or probable treaty terms under which the various possible canals could be constructed and operated. Because these inputs will be among the final conclusions of other studies, the finance study will be one of the last to be completed.

THE PUBLIC INFORMATION STUDY

The initial study of the public information aspects of sea-level canal construction has been accomplished by an interdepartmental group which I chaired as the Executive Director of the Commission. Its purpose is to anticipate public reaction to the alternatives which could be recommended by the Commission and to advise the Commission of the public information requirement associated with the ultimate course of action that it might recommend.

This study is a very limited one and is being accomplished entirely within U.S. Government agencies; ultimately, it will be incorporated into the foreign policy study.

To date, this study indicates that all nations which use the Panama Canal expect the United States eventually to build a sea-level Isthmian canal. Only its construction by nuclear excavation would require a significant public information program.

The Commission's public information activity is limited to response to inquiry for unclassified information. Its completed studies, findings, and recommendations will not be publicly released until proper authorization has been given.

I will be followed by General Noble, who will cover our most detailed and expensive study, that of engineering feasibility.

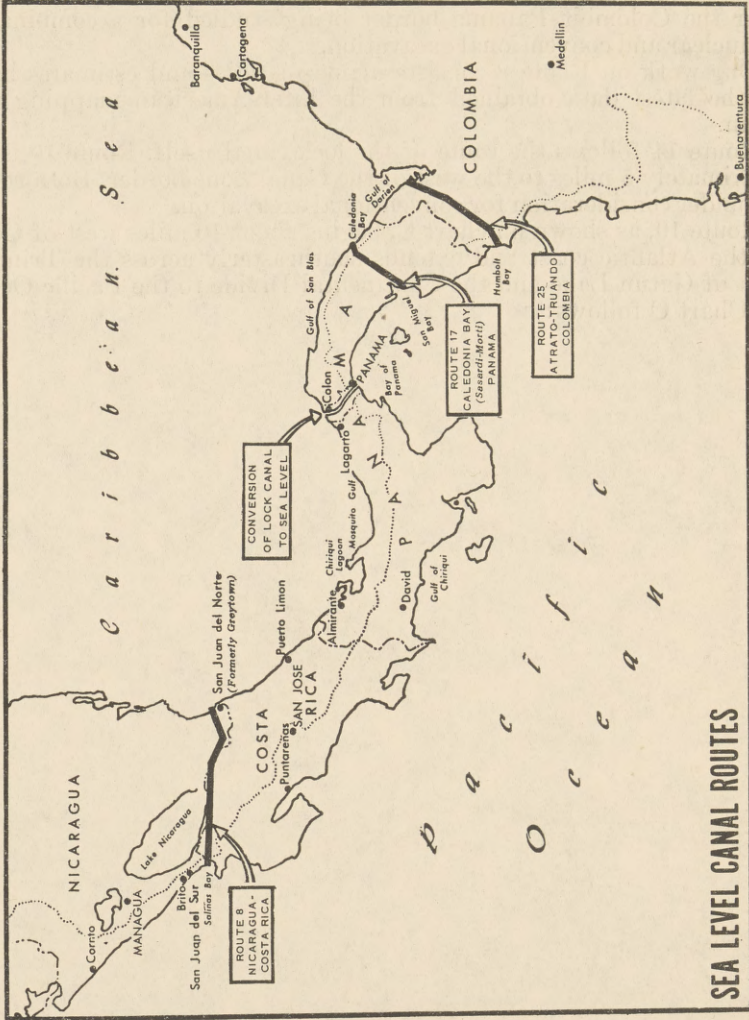
Senator BARTLETT. Thank you, sir.

General.

General NOBLE. The study of engineering feasibility is a cooperative effort involving the U.S. Army, the U.S. Atomic Energy Commission, the Panama Canal Company, the Environmental Science Services Administration, and other Federal agencies.

There are four general routes on the American isthmus which are under consideration for a sea-level canal. These routes are indicated on chart B.

(Chart B follows:)



General NOBLE. Route 8—A route generally along the Nicaragua-Costa Rica border;

Routes 10 and 14—Alinements in or near the Panama Canal Zone which are being studied for conventional excavation; in addition, modernization of the present lock canal is also being investigated;

Route 17—A route in the Darien region of Panama being examined for nuclear excavation;

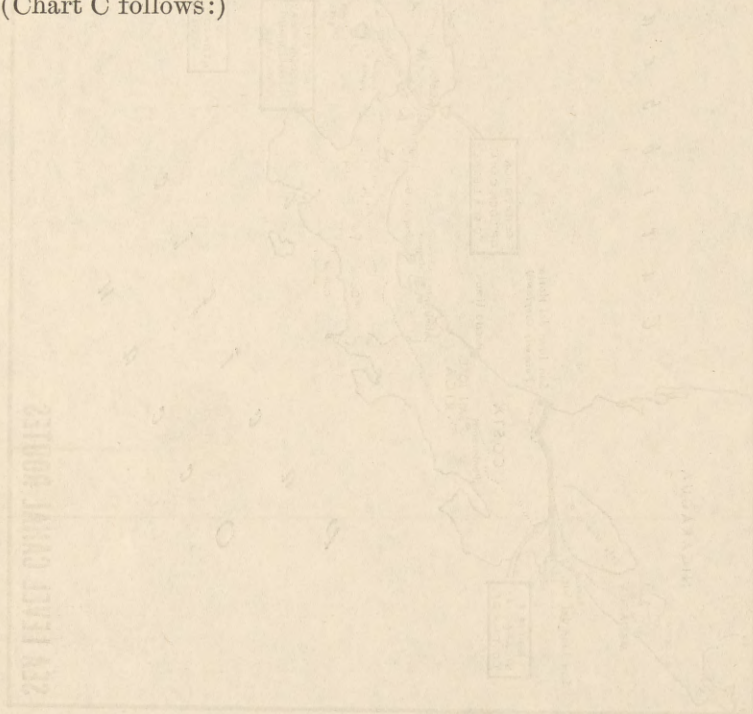
Route 25—A route in the extreme northwestern portion of Colombia near the Colombia-Panama border being studied for a combination of nuclear and conventional excavation.

Our work on Route 8 consists of map studies and estimates based on the latest data obtained from the inter-American mapping program.

Route 14 follows the route of the lock canal itself. Route 10 is approximately 5 miles to the west of the Canal Zone border. Both routes are under consideration for conventional excavation.

Route 10, as shown on chart C, begins about 10 miles west of Colon on the Atlantic coast and extends southeasterly across the Trinidad area of Gatun Lake and the Continental Divide to the Pacific Ocean.

(Chart C follows:)



Route 17 is located in the Darien region of Panama approximately 100 miles east of the Panama Canal. Base camps, weather stations, airstrips, and hydrology stations were constructed to support the effort in this remote area. The Santa Fe base camp and radar weather stations along the 50-mile length of the route were closed on December 31, 1967. Data collection on Route 17 is limited to readings obtained from hydrology stations using automatic recording equipment. Our field effort at this time has been concentrated on Route 25 in Colombia.

Route 25 is located in the Choco region of northwestern Colombia approximately 200 miles east of the Panama Canal. Geologic, meteorologic, and hydrologic surveys are in progress. Operational base camps are located at Curiche on the Pacific terminus and at Teresita in the Continental Divide region. Radar weather stations are located at Alto Curiche and Loma Teguerre to obtain weather information for the Pacific and Atlantic sides of Route 25. About 55 miles of the Atlantic end of Route 25 extends through the alluvial valley of the Atrato River and would be excavated primarily by conventional dredging techniques. The remaining portion of the route is being studied as a potential nuclear route. The length of Route 25 is approximately 100 miles.

The table, on page three of the handout, lists the Commission program elements within the available authorization.

(The table follows:)

PROGRAM REQUIREMENTS FOR ATLANTIC-PACIFIC INTEROCEANIC CANAL STUDY COMMISSION

	Funds available	Balance to complete study	Total study requirement
I. Commission, consultants, and engineering agent	\$815,000	\$885,000	\$1,700,000
II. Data collection	13,748,000	3,161,000	16,909,000
III. Data evaluation	2,937,000	2,454,000	5,391,000
Total	17,500,000	6,500,000	24,000,000

General NOBLE. Additional requirements for the three primary Commission programs and the total requirements to complete the study are also shown.

As shown in the middle column, the balance remaining to complete the study is \$6½ million, for which authorization is being requested. The additional fund authorization requested has been programed as listed on this table.

(The table follows:)

Program requirements for Atlantic-Pacific Interoceanic Canal Study Commission

I. Commission, consultants, and engineering agent.....	\$885,000
II. Data collection:	
(a) Topography.....	128,000
(b) Geology.....	955,000
(c) Hydrology.....	256,000
(d) Hydrography.....	120,000
(e) Meteorology.....	777,000
(f) Management and general support.....	925,000
Subtotal.....	<u>3,161,000</u>
III. Data evaluation:	
(a) Nuclear excavation design.....	83,000
(b) Radioactivity effects.....	1,013,000
(c) Acoustic wave effects.....	65,000
(d) Seismic effects.....	30,000
(e) AEC coordination.....	395,000
(f) Engineering studies.....	868,000
Subtotal.....	<u>2,454,000</u>
Total.....	<u>6,500,000</u>

General NOBLE. You can see that part of it will go to Commission, consultants, and engineering agent, part of it on data collection, and part of it on data evaluation, a total of \$6½ million.

The first program element shown on the chart for which additional fund authorization is required is for the Commission, consultants, and engineering agent; \$885,000 will provide for the operation of the Commission and the engineering agent through December 1, 1970. It also provides for continued use of the technical associates, an Advisory Committee on Construction Methods, and the publication of the final report of the Commission.

The second program element for which additional fund authorization is required is data collection. Data collection activities include the technical disciplines shown in the table above. A total of \$3,161,000 is needed to accomplish the following:

(a) Under topography, there remains to be completed the topographic survey of Route 25. Because of lack of funds, we have been unable to survey the Atrato Valley which comprises over one-half the length of the Colombia route. An accurate profile and cross sections are required in order to estimate earthwork excavation quantities.

(b) Under geology, an additional authorization is needed to complete the geological surveys of Route 25 and Route 10, including drilling 50 holes on Route 10, the subsurface exploration program in the Atrato Valley of Route 25 to determine depth of the underlying rock formations, geophysical logging and bore-hole photography in the Continental Divide region, and laboratory testing of core samples from both these routes.

(c) Under hydrology, we must continue the hydrologic data collection program on Route 17 until November 1968 and on Route 25 until July 1969. A total of 36 rain, stream, and tide stations are involved.

(d) Under hydrography, we must perform a hydrographic survey consisting of a study of the approach channels to the canal and the condition of the ocean bottom in them. This information will be used to estimate construction requirements at the approaches to the various routes.

(e) Under meteorology, we must continue the meteorological survey on Route 25 until July 1969. Radar observations are recorded for wind and precipitation patterns in the area of Route 25.

(f) The management and general support of data collection is required until July 1969 and during the demobilization period. The support activities sustain base camps, operating equipment, transportation requirements, medical support, and communications effort, all of which are necessary to survey efforts in the remote areas of Panama and Colombia.

The third program element is data evaluation. A total of \$2,454,000 is needed to accomplish the following:

(a) Nuclear excavation studies will develop nuclear excavation design, including channel alignment; number, yield, and location of nuclear explosives; sequence and schedule of detonations; and the cost and schedule for the emplacement hole-drilling program.

(b) Radioactivity studies will include the evaluation of bioenvironmental data collected in the land and water areas affected by nuclear operations. The fallout patterns and exclusion areas will be determined for nuclear operations.

(c) Acoustic wave effects will be analyzed to determine the number of safe firing days when damage will not result from the propagation of blast waves. The analysis will be based upon 2 years of data collected from the firing of high-altitude rocket probes in the Canal Zone.

(d) Seismic effects will be analyzed to determine the maximum size of nuclear explosives which can be employed without damage to population centers near Routes 17 and 25.

(e) AEC coordination will provide the operation of the Canal Studies Branch of the AEC's Nevada Operation Office and the technical working groups which analyze the effects of nuclear excavation.

(f) Engineering studies to be completed will include the evaluation of alternative sea-level canals and the alternatives of modernization of the present canal or its conversion to a sea-level canal. These studies involve the analysis of: traffic requirements, past, present, and future; size and shape of the canal; effects of tidal currents in and on the canal; cost estimates and construction methods; and estimated annual cost for operation and maintenance.

ADDITIONAL TIME

The proposed completion date of December 1, 1970, will provide time for completion of survey activities and for application of the results of the Atomic Energy Commission's Plowshare program as they apply to canal studies. The recent cratering experiments of the AEC have been very successful. The most recent, Buggy I, produced a clean, well-formed channel in hard rock. The results of these and subsequent cratering experiments in the current series are necessary for a determination of the feasibility of nuclear excavation on Routes 17 and 25.

REQUEST FOR EARLY ACTION

In closing, Mr. Chairman, as engineering agent for the Commission, charged with the conduct of the data collection and evaluation studies under policies and programs approved by the Commission, I hope you will permit me to make a special plea for early action by your committee on this legislation request. I am daily coming under increased pressures resulting from deferred decisions on whether to close up facilities or to keep them operational; to send people home or to keep them on the job; to let, continue, or terminate contracts; to undertake needed supporting studies or not; to decide one way or another on a myriad of day-to-day decisions necessary to keep a farflung, complicated operation of this magnitude running smoothly. The long-sustained uncertainties concerning the program are making it extremely difficult to keep our field organization from melting away. In the meantime we have to either shut down our data collection effort on Route 25 because of lack of funds, or carry on in anticipation that additional authorization and funding will be provided by this Congress.

I have some slides which I can show the committee later if desired. In the meantime, I will be followed by Mr. Oakley of the Atomic Energy Commission.

Senator BARTLETT. Thank you, gentlemen. Mr. Oakley.

Mr. OAKLEY. Mr. Chairman, it is a pleasure to appear before you to provide information on the status of AEC's nuclear excavation program in relation to the Atlantic-Pacific Interoceanic Canal Study Commission's program. Last year, when you were considering S. 1566, Mr. Kelly described AEC's cooperation in the Canal Study Commission's engineering feasibility studies and AEC's research and development program, including planned experiments for developing a nuclear excavation technology. The research and development of a nuclear excavation technology under the Plowshare program is jointly carried out with the U.S. Army Corps of Engineers. Their chemical-explosive cratering experiments provide significant data for our nuclear experiments, and the results of their studies of engineering characteristics of explosion craters are important contributions to development of a cratering technology.

Today I would like to update this information based on progress during the intervening period and our program plans for the future.

With the exception of meteorology on Route 25, in Colombia, AEC's data collection activities on behalf of the Canal Study Commission

have been largely completed. Analysis and evaluation of samples, specimens, and other data collected in the field are progressing in all programs of the nuclear operation feasibility studies and initial-draft reports are in preparation.

AEC's supporting nuclear excavation program includes two major activities. The first is the development of minimum fission—"clean"—explosives with a variety of yields into the megaton range and of special emplacement techniques to minimize the release of radioactivity. This effort also is directed toward increasing the reliability and safety of the nuclear explosive system with optimum nuclear efficiency and performance, and toward reducing the costs of the explosives. Using reasonable projections of these factors in planning for major excavation projects, it can be expected that, for each individual explosive detonated, the sum of fission products airborne in the radioactive cloud and in the fallout will be as low as the equivalent of 20 tons. The second major activity is the development of a thorough understanding of explosive cratering mechanisms in order to accurately predict cratering characteristics. Both of these activities continue to be oriented and timed to provide technical data for the Atlantic-Pacific Interoceanic Canal Study Commission's assessment of the feasibility of nuclear excavation of a sea-level canal in the American isthmus region.

During 1967, two explosive development tests were conducted on AEC's Nevada Test Site (NTS) and each contributed significant data to our explosive development and program. The first of these, the Switch event, a low-yield, fully contained underground nuclear explosion, was conducted on June 22. Data indicated that the explosive tested was successful in keeping fission product and induced radioactivity to a low level.

The Marvel experiment, a low-yield, fully contained underground nuclear test, was conducted on September 21, as part of the effort to develop special emplacement techniques to entrap, underground, greater amounts of the radioactivity produced in cratering explosions. Preliminary evaluations indicate that this experiment was also successful.

We plan to conduct two more tests in fiscal year 1969 to further the development of excavation explosions with larger yields than previous tests, and, possibly, one additional test directed toward development of emplacement techniques.

Studies continued to refine and expand the promising computer calculation method of predicting crater effects from nuclear explosions. The method has been refined so that calculations are faster, reducing computer time and giving predictions earlier. Using data from previous cratering experiments, calculations were made using characteristics of other types of rocks that may be encountered in the excavation program. The computer codes have also been modified to permit predictions of crater characteristics from higher yield explosions. Currently, data from Cabriole, our recent nuclear cratering experiment, are being incorporated in the computer studies and were used in calculations made for predicting crater dimensions for Buggy I, the first nuclear row-charge cratering experiment.

Cabriole, a 2.5-kiloton nuclear cratering explosion in basalt, was successfully conducted on January 26 of this year on the NTS. The

explosion, at a depth of 170 feet, produced a crater of approximately 360 feet in diameter and 120 feet in depth. Only a very small amount of radioactivity, less than that predicted, was released, and most of that small amount was deposited in and near the crater. Data from Cabrioleet will provide significant input to our computer codes for cratering-effects prediction capability and our ability to predict the amount and distribution of radioactivity that might be released in following experiments.

Buggy I was successfully conducted on March 12 of this year on the Nevada Test Site. Buggy I was the first nuclear row-charge detonation, and is considered very important in determining the feasibility of nuclear excavation of canals. It involved the simultaneous detonation of five approximately 1-kiloton nuclear explosives, each spaced 150 feet apart at a depth of 135 feet in basalt. Preliminary results indicate a linear or ditchlike crater was produced with the following approximate dimensions: Length 860 feet; width, 250 feet; and depth, 65 feet. The experiment will provide basic cratering data and information on the distribution of radioactivity from a row of simultaneous cratering nuclear explosions in level terrain.

It might also be worth adding that Project Gasbuggy, an experiment being conducted jointly with the El Paso Natural Gas Co. and the Department of Interior's Bureau of Mines this year to study stimulation of the natural gas production from a tight, or low-permeability, reservoir rock, has significantly increased the interest in the Plowshare program. Gasbuggy has also clearly demonstrated that the United States is developing peaceful uses for nuclear explosions which may provide significant assistance to other countries.

A report giving preliminary results of Gasbuggy was favorably received by the Eighteen Nation Disarmament Committee representatives at the opening of their recent discussion on a nonproliferation treaty.

The nuclear cratering experimental program in fiscal year 1969 includes plans for conducting Project Schooner, a point charge of about 100 kilotons in hard, dry rock. We had previously planned to conduct Schooner either at a location in southwestern Idaho or on the NTS. We now plan to do the experiment on the NTS because of the significant reduction in costs that can be achieved by using the permanent support facilities at the site. Schooner will provide necessary cratering experience at an intermediate yield in hard rock and a basis for extrapolating to the higher yields needed for practical large-scale nuclear excavation.

Preparations will also be made for Buggy II. This experiment will involve the simultaneous detonation of a row of nuclear explosives with somewhat higher yields than Buggy I. At present, the concept for Buggy II is to create a ditchlike crater connecting with the Buggy I crater. Connection of row-charge craters without a significant dividing barrier is important in developing a technology for excavating canals and passes through mountain barriers. Results from previous experiments may modify this concept, and we may incorporate additional experimental objectives in the design of Buggy II.

As results from research and experiments become available, the concept of future experiments are reviewed and our program will be modified as necessary. We contemplate that at least two experi-

ments, in addition to those I have described, may be required for purposes of the canal studies. One higher yield nuclear row charge in varying terrain and media, and a major experiment or demonstration project that would combine several objectives, are contemplated. Concepts of these may be modified or the two experiments may be combined, depending on the state of technology at the time.

To summarize, Cabriole and Buggy I have been conducted successfully—the first two of a series of six experiments that were planned to aid the Canal Study Commission. With results from these two experiments, only a highly qualified determination of the technical feasibility of nuclear excavation could be provided at this time.

Extension of the final reporting date, in accordance with the legislation proposed by the Canal Study Commission, would provide adequate time for the AEC to conduct the minimum excavation program in an orderly manner and report the data and evaluations to the Canal Study Commission for consideration in its final report.

Senator BARTLETT. Does that complete your formal testimony?

Mr. ANDERSON. Yes.

Mr. OAKLEY. If I may, I have slides of some nuclear excavation experiments, if the committee would like to see them.

Senator BARTLETT. We would like to see all the slides after a brief recess.

(Recess.)

Senator BARTLETT. The committee will be in order.

Now, perhaps it would be advisable to look at the slides. (Slide.)

General NOBLE. Mr. Chairman, we have a few slides of the field data-collection activity in Panama and Colombia. This slide shows the Atrato River, which is a very distinctive feature of the Colombia area route. This river valley comprises some 55 miles of that route, and it would be our idea that this part of the Colombia route would be excavated by conventional dredging techniques.

We still have to complete our topographic survey of this route. It has not been done and would be done with the additional authorization and funds being requested. And we have to do our geological investigations of this route in order to ascertain whether we are going to be excavating alluvial muck or whether we are going to have some rock spots in there which could affect the cost estimate in a major way. (Slide.)

This is a typical geological drilling site. It is a clearing in the jungle. We bring in a tower—I think another slide will show how we move these towers around—and we line up our drilling gear and proceed to drill.

It is these spots, picked here and there throughout the jungle, that enable us to conduct our geological investigation.

It is a very expensive process. (Slide.)

This is the way we have to move our drilling towers around. There is no communication between these drillholes other than by helicopter. In this particular case we hitchhiked a ride on an Air Force helicopter. We get considerable support from the Army and the Navy and the Air Force in the zone to the degree that they can give it to us.

They are not able to do all that we need, however, because of the Vietnam demands, as you can imagine. (Slide.)

This is a typical hydrology station. You recall I said there were some 36 stations strung along the two jungle routes. This is one of them. It is a prefabricated hut set up in the jungle with automatic reading instruments and tapes, and once we set these things up, from then on we just visit them occasionally, collect our tapes, repair anything that has been broken, and leave it for a future reading. (Slide.)

This is a slide of the various routes which we covered on the chart. (Slide.)

This is a typical meteorological weather station. I show it to give you an indication of the difficulty under which our data collection is taking place. In this particular case Colonel Sutton, the field director of the Commission's engineering feasibility studies, had to chop off the top of that mountain, laboriously dig a route up to the top of that mountain, and then drag, slide, push, or bulldoze his equipment up there.

He has radar vans and housing facilities up there for this isolated crew. This operation, then, will proceed for 2 years of meteorological readings. (Slide.)

This is an indication of what goes on on the top of that mountain. These balloons are filled every 6 hours and released, and then followed by radar to give us data on winds, cloud patterns, and precipitation which are necessary for the studies. (Slide.)

This is a van from which all the radar readings are taken. They are surplus Army vans that we picked up and converted to our use. It is very difficult to get them on top of the mountain and subsequently very difficult to maintain them. (Slide.)

This is Curiche on the Pacific coast of Route 25. It happened to be our best airfield. Mother Nature gave it to us. This gives an indication of the kind of operation that takes place at a base camp. We must have facilities to take care of people. We must have some kind of an airstrip on which to land our planes from the zone. We must have some provision for bringing in our naval LST's. These base camps are where all of our supplies come in and are then redistributed to our work camps in the jungle. (Slide.)

This is a slide of the cratering effort by the Corps of Engineers which is carried on in conjunction with the Atomic Energy Commission's program.

This happens to be a chemical explosive shot of a ditch which provided data for use in setting up the Atomic Energy Commission experiment which followed.

Senator BARTLETT. Where was that?

General NOBLE. This was in Montana in the clay shales area near the Fort Peck Reservoir. (Slide.)

This is the crater that resulted. These clay shales are very similar to the clay shales we find in certain parts of our jungle routes in Panama and Colombia. (Slide.)

This is a shot of some of our agricultural scientists on a route conducting environmental data collection that is necessary for the Atomic Energy Commission's program.

In this case he is studying plants and how the plants work into the food chain that the Atomic Energy Commission must study. These people are working for the Atomic Energy Commission under a subcontract. (Slide.)

This slide shows one of the high-altitude rocket probes being prepared for firing at Battery McKenzie in the Canal Zone. This program is being carried on in conjunction with the Army and the Air Force, who also provided a portion of the funds required for the program.

All three agencies are interested in the results of this data. At the present time we have stopped financing the program. The Army is continuing the program and providing us the data. (Slide.)

Mr. OAKLEY. I brought this slide along to give the scale of some nuclear detonations that might be involved in canal excavation. This is an experiment we did in 1962, called Sedan. At the bottom of the crater is a bulldozer, while the construction activity on the left involves large cranes and trucks.

The dimensions across the crater are about 1,200 feet, and it is about 320 feet deep. In other words, this is about the size of the excavation one would need in level terrain to provide a canal. (Slide.)

This shows the Cabriole experiment crater that I described earlier. It was conducted in January of this year and was the largest nuclear cratering experiment to date in hard rock. The 2.5-kiloton explosive was detonated at a depth of 170 feet in rhyolite. The crater is about 120 feet deep and 360 feet wide; in other words, about a quarter of the width of the Sedan crater I showed earlier. (Slide.)

This is a picture of the Buggy experiment conducted on March 12 and involved the simultaneous detonation of five nuclear explosives. This experiment is, of course, most significant and directly relevant to the canal studies.

To give you some idea of the scale involved here, there is a red pickup truck in the lower right-hand corner. (Slide.)

This is a different view of the same experiment. In the lower left-hand corner is the same pickup truck.

That is all I have, Mr. Chairman.

Senator BARTLETT. Thank you very much. I have a few questions to ask. I am not going to ask them of any particular person. Mr. Anderson, anyone you designate may answer. Of the \$17.5 million authority, how much has now been appropriated?

Mr. ANDERSON. All of the \$17.5 million.

Senator BARTLETT. How much do you have left?

General NOBLE. Sir, all the money appropriated in the last budget is programed under current activities. We have nothing uncommitted, sir.

Senator BARTLETT. All committed?

General NOBLE. All committed; yes, sir.

Senator BARTLETT. Buggy I, as we understand, was the first nuclear row-charge shots ever detonated?

Mr. OAKLEY. Yes, sir; as far as I know. It was the first nuclear row-charge experiment in this country and was quite significant in that respect.

Senator BARTLETT. I didn't have a chance this morning at home, because my copy came late, to read the Congressional Record of yesterday. I am assuming that all of you or some of you did read the Record or were there when the House acted on the companion bill to S. 2948.

I wonder if you could give me a hint as to why the rules were not

suspended so this bill could be taken up, what were the reasons assigned?

Mr. ANDERSON. I was not there.

STATEMENT OF LT. COL. JAMES H. TORMEY, DEPUTY ENGINEERING AGENT, ATLANTIC-PACIFIC INTEROCEANIC CANAL STUDY COMMISSION

Lieutenant Colonel TORMEY. Sir, the bill was supported by Chairman Garmatz of the House Merchant Marine and Fisheries Committee. It was supported by Representative Grover of the minority. Several others spoke, including Representative Davis of the Appropriations Committee. I think possibly the desire for economy or the desire to look into this further to see that there was no treaty conflict was behind this not being passed.

Mrs. Sullivan, the subcommittee chairman, spoke against the bill.

Senator BARTLETT. Why?

Lieutenant Colonel TORMEY. Mrs. Sullivan said that she was not personally convinced that it was necessary to have these additional funds. I believe she felt that it was possible there would be a loss of the present canal as a result of proposed treaties with Panama.

Senator BARTLETT. Was there any indication of feeling on the part of House Members that sufficient work had not been done in places other than those located within Panama?

Lieutenant Colonel TORMEY. A number of Members of the House expressed the opinion that work should be done outside of Panama. This opinion was expressed by both those who supported the bill and those who spoke against it.

It was pointed out by Congressman Murphy that a great deal of work had been done in Colombia. It was pointed out by Representative Grover that this was due to delays for which the Commission was not responsible—that is, that work in Colombia had fallen behind schedule, and the main requirement for the additional funds was to finish up the work in Colombia so that the Commission could give a report on an option other than the Panama option.

Senator BARTLETT. It has been my understanding from the testimony given here that you want an extension of time and you want these additional funds chiefly so that you can complete these other studies?

Lieutenant Colonel TORMEY. That is correct.

Senator BARTLETT. Thank you.

Mr. Sheffey, you said at one point in your prepared statement:

In the consideration of the political feasibility of nuclear canal excavation, the future is far from clear. The progress of our nuclear excavation experiments, the recent United States-Russian agreement on the terms of a nuclear nonproliferation treaty, the prospects of international cooperation in removing the test ban treaty obstacles to the development and use of the nuclear excavation technology will require new evaluations in the foreign policy study.

Let us ask this question: Under the terms of existing treaties, can we go ahead and conduct canal excavation by the use of nuclear devices?

Mr. SHEFFEY. Mr. Chairman, at this moment the answer to that question must be "No." But with your permission I would like to

read a letter from the Assistant Secretary of State to Mrs. Sullivan of the Merchant Marine Committee on this very same question. May I have your permission to read this?

Senator BARTLETT. Yes.

Mr. ANDERSON. May we just insert it in the record, Senator?

Senator BARTLETT. I would like to hear it right now because sometimes material is inserted in the record that is never read later.

Mr. SHEFFEY (reading):

MARCH 11, 1968.

DEAR CONGRESSWOMAN SULLIVAN: I promised in my letter of March 8, 1968 to inform you of the views of the Department of State on the political factors which might affect the construction of an Atlantic-Pacific sea-level canal.

As you know, Public Law 88-609 requires the Atlantic-Pacific Canal Study Commission to determine the feasibility of a sea-level isthmian canal and the best means for its construction. It has been the view of the Commission, with which the Department concurs, that the determination of the technical feasibility of nuclear canal excavation and the determination of the political feasibility must be treated separately. The Atomic Energy Commission has advised the Canal Study Commission that the technical question can be answered as a result of its planned experiments, provided the needed data are gathered on the proposed canal routes. The political questions, both locally in the canal site countries and the broader questions inherent in Test Ban Treaty amendments, are not immediately answerable. It is Department's view that, if the promised technical advantages and safety of nuclear excavation were established beyond reasonable doubt, the political obstacles to its use could eventually be removed. There is broad interest in this technology throughout the world.

On the other hand, if the planned experiments and canal site surveys were to determine that nuclear canal excavation is not feasible, the political problems would not need to be solved. In any event, the U.S. Government needs the evaluation of the possible canal sites, including the one in Colombia, to reach the proper decision on our future canal policy.

With regard to your concern about the impact of the Test Ban Treaty on the prospects of nuclear excavation of a canal, I believe the following observations are pertinent. At the conclusion of its hearings on that treaty in 1963, the Senate Foreign Relations Committee reported:

"The United States will also be able to explode nuclear devices underground for peaceful purposes in other countries, at their request, provided, of course, that such an explosion does not cause debris to be issued beyond that country's territorial limits. If and when a project is proposed that might possibly violate the terms of the treaty—development of a new Panama Canal with nuclear explosives, for example—an amendment to the treaty would presumably be sought."

This conclusion was based on testimony by Chairman Seaborg, who had said "A new trans-Isthmian canal . . . probably could not be done under the present treaty limitations because of the short distance to territorial borders." (Hearings, p. 210.)

However, if other considerations should lead the Commission to recommend nuclear excavation, this problem could be dealt with by amending the treaty. In fact it is clear that the parties foresaw the possible need for adjusting the provisions of the treaty on this point and provided for a relatively easy amendment procedure (requiring the concurrence of only a majority of the parties including that of the U.S., the U.K., and the U.S.S.R.). Moreover, in addition to considerable evidenced international interest in the potential benefits from peaceful uses of nuclear explosions, there have been several recent developments that encourage the belief that such an amendment may be attainable. Thus, specific provision was made in the Treaty of Tlateloco—signed in the past year by twenty-one Latin American Republics—to permit the use of nuclear explosions for peaceful purposes. And Article V of the draft non-proliferation treaty recommended by the U.S. and Soviet Co-Chairmen of the Eighteen Nation Disarmament Committee provides that:

"Each Party to this Treaty undertakes to cooperate to insure that potential benefits from any peaceful applications of nuclear explosions will be made available through appropriate international procedures to non-nuclear-weapon States Party to this Treaty on a non-discriminatory basis and that the charge to such

Parties for the explosive devices used will be as low as possible and exclude any charge for research and development. It is understood that non-nuclear-weapon States Party to this Treaty so desiring may, pursuant to a special agreement or agreements, obtain any such benefits on a bilateral basis or through an appropriate international body with adequate representation of non-nuclear-weapon States."

I hope the foregoing has been useful to you, and, if I can be of any further assistance, please let me know.

Sincerely,

WILLIAM B. McCOMBER,
Assistant Secretary of State
for Congressional Relations.

The general belief of the Department of State is that, if the technical feasibility of nuclear excavation is established beyond any doubt, the political obstacles can be overcome.

Senator BARTLETT. The truth remains, however, (a), that occasionally, very occasionally, of course, the Department of State has been in error; (b), from that letter one must come to the conclusion that if Russia said no, it couldn't be done, and woven all through this is the fact that a new canal would be in assistance of our national defense requirements. If they did not coincide with the views of the Soviet Union, at that particular moment in time when an amendment to the treaty was sought, it is very possible, is it not, that Russia would say "nyet"?

Mr. SHEFFEY. The possibility certainly exists, sir, but the Russians themselves are very interested in this technology. They may have conducted experiments similar to ours, although we have no knowledge of a row-charge experiment, and we are optimistic that the Russians have projects in their own territory that would lend themselves to nuclear excavation and, therefore, at some future date might well agree to the amendment of the test ban treaty to permit themselves and ourselves to use this technology.

Mr. ANDERSON. Senator, I might point out that the law setting up this Commission and instructing what it should do in reporting to the Congress, was passed after the test ban treaty was signed, and among its other provisions provides that the Commission shall study and shall report to the Congress the feasibility of the nuclear excavation of the canal. This doesn't mean the Congress can't change its mind. But the activity of the Commission has been based upon the responsibility of reporting both ways.

Senator BARTLETT. I think that is a very correct statement for you to make. The Commission, of course, is not the determining body in respect to the policy decisions which are later to be made.

Mr. ANDERSON. That is correct.

Senator BARTLETT. But I just wanted to probe into that a bit.

Mr. Sheffey, you have gone into the matter of a shipping study looking toward the revenues that may accrue by means of the construction of the sea-level canal 70 years into the future. Now, my advice in that connection is that all of us in this room, including the audience, should reassemble in the year 2040 to arrive at a conclusion as to how accurate those forecasts have been, and I am sure we would all be happy to do that. I only see two or three people in the room who are likely to make that year.

Mr. SHEFFEY. You have hit upon one of our most critical problems, the problem of arriving at estimates of such revenues.

Senator BARTLETT. Since it is 70 years in the future, you are safe. Is it your belief that enough oceanographic trade will be generated to warrant construction of the sea-level canal?

Mr. SHEFFEY. Sir, I can only speak as an individual and not as a representative of the Commission. The trends we see in the growth of ocean shipping, and we are supported in this by the Department of Transportation, indicate that unless developments not now foreseen occur, there will be adequate shipping to finance the canal if the costs of the canal are not excessive and the treaty costs for building it are not excessive.

This is a very difficult study in which we have not reached a final conclusion.

Senator BARTLETT. The testimony this morning informed us that 25 of our largest aircraft carriers cannot use the existing canal. How large a tanker will the present canal accommodate?

Mr. SHEFFEY. Approximately 60,000 tons, sir.

Senator BARTLETT. Do the plans under consideration for the new canal contemplate that it will be wide enough and deep enough to permit transit of the supertankers now being built, some over 200,000 deadweight tons, and the even larger tankers to come in the future?

Mr. SHEFFEY. Sir, you are asking for conclusions we have not reached yet. The minimum channel that we are considering for a conventionally excavated canal is 600 feet in width by 60 feet in depth. This would accommodate a tanker of approximately the 200,000-ton range. If a nuclear canal is technically feasible, this size limitation presents no problem, because it requires no additional investment, no additional cost to make a nuclear canal large enough for all the tankers foreseen now.

Senator BARTLETT. They are talking about 500,000-ton tankers to come. I guess we won't be building a canal for them.

Mr. SHEFFEY. Probably not a conventionally excavated canal, but it would come automatically if a nuclear canal were feasible, for the minimum channel in the nuclear canal is 250 feet deep in the center and 1,000 feet wide at a 60-foot depth.

Mr. ANDERSON. There are already approximately 800 ships afloat or under construction that either cannot transit the canal at all or cannot transit when fully loaded.

Senator BARTLETT. Each of those I assume is a potential customer for a larger canal?

Mr. ANDERSON. Potentially, yes, sir.

Senator BARTLETT. Let's turn to the public-information program which you said will be required if the canal is to be constructed by nuclear means. What form would that program take and why would it have to be mounted?

Mr. SHEFFEY. Sir, our survey through U.S. Embassy channels has indicated that there is some fear of nuclear excavation in the Central American area, that the educated people recognize that the United States would not undertake nuclear canal excavation until it is established that it is safe and had conducted demonstration projects on U.S. territory. The general belief of the embassies is that there would have to be a public-information program explaining this to the people of the countries in the whole Central American area to make it clear that

the United States had assured itself beyond any reasonable doubt that there were no dangers involved for the local people.

The details of such a program have not been prepared as yet. It would involve articles in the local press, information pamphlets, efforts by our embassies in speeches and in educational institutions, places like that.

Senator BARTLETT. Are the means at hand much more accurate for determining the safety of these explosions than they were a few years back?

Mr. SHEFFEY. May I refer the question to Mr. Oakley of the AEC? I believe he can answer it better than I.

Mr. OAKLEY. Sir, this is really what our Plowshare program is all about. It is a research and development program to find the answers. Perhaps you are referring to radioactivity. In that connection, I think it is fair to say that radioactivity is much, much less of a problem than it was several years ago in that our program to develop clean explosives has been phenomenally successful.

Going back to Project Sedan in 1962, which was done with the cleanest thermonuclear explosive then available to the United States, we estimate that the amount of radioactivity that would be released during the same experiment today would be a factor of 100 less. Our laboratories have accomplished a great deal in this regard. So, the dimensions, if you will, of the radiation problem are a hundredfold smaller than they were in 1962.

Senator BARTLETT. I want to go back—my memory tells me that this was spread upon the record last year—to Project Chariot, which was planned for northwestern Alaska—Cape Thompson—some years ago, and at that time the Atomic Energy Commission took the position that there was no danger from radiation. Are we to believe now that they couldn't really be sure then with the certainty of today?

Mr. OAKLEY. Sir, I know you are very familiar with this. The Chariot experiment was first proposed in 1958, if I recall correctly. That was 10 years ago. The initial estimates that were made about the release of radioactivity from the experiment that was under study up there were based on the explosives then available. The amount of radioactivity that would have been released would have been correspondingly, to tie this with my other statement, a hundredfold greater than it would be today. The Chariot experiment, as you know, was never approved and the Atomic Energy Commission never took an official position as to whether it would be safe or not. The activities underway were simply what we call feasibility studies. I think that we probably failed in our public-information effort to make the distinction, however.

I think people did, by and large, have the impression that we planned to carry that experiment out right away.

Senator BARTLETT. I want to be mindful of Ambassador Anderson's statement that your function is a reporting one, in a sense reporting to Congress. At the same time I think it is entirely appropriate and probably necessary to point out the fact that the Atomic Energy Commission did plan to make these experimental shots at or near Cape Thompson. I know that from personal knowledge through a series of consultations. I know likewise that the whole project was dropped because, although there were only a few hundred people in this entire

area, the scientists hired by the AEC itself, or some of them, raised such a hullabaloo about the possible effect on the wild life and sea life upon which the Eskimos subsist to a very large extent that there was a national uproar about this and finally the whole thing was dropped.

I am not going to pose this as a question, but there has always been this thought in my mind, and I compare the relatively small population in the Cape Thompson undertaking with the very considerable population down in Central America, and I apprehend that there is a distinct possibility that those people who oppose this sort of thing will be tremendously more active in this situation than they were in the Alaska one.

In this connection, perhaps the time is appropriate right now to call your attention to certain statements made in an article in the New York Times of March 31, the day before yesterday, by Lamont C. Cole, professor of ecology at Cornell University. The title of the article is "Can the World Be Saved?"

I would like to read this, if no one objects, in its entirety, and you may or may not want to comment:

A prime example of what irresponsible use of atomic power could bring about is provided by the proposal to use nuclear explosives to dig a sea-level canal across Central America. The argument in its favor is that it is evidently the most economical way to accomplish the task. Yet consider the effects upon our environment. If 170 megatons of nuclear charges will do the job, as has been estimated by the Corps of Engineers which apparently wants to do it * * *

And, parenthetically, I would say, from the statements made here, particularly by Mr. Anderson, that this isn't necessarily the case—

* * * And if the fission explosions take place in average materials of the earth's crust, enough 137 cesium would be produced to give every person on earth a radioactive dosage 26.5 times the permissible exposure level. Cesium behaves as a gas in such a cratering explosion, and prevailing winds in the region are from east to west, so the Pacific area would presumably be contaminated first. And cesium moves right up through biological food chains, so we could anticipate its rapid dissemination among living things.

The sea-level canal proposal also poses other dangers, whether or not atomic explosives are used. In that latitude, the Pacific Ocean stands higher than the Atlantic by a disputed amount I believe to average 6 feet. The tides are out of phase on the two sides of the Isthmus of Panama, so the maximum difference in level can be as great as 18 feet; and the Pacific has much colder water than the Atlantic.

Just what would happen to climates or to sea food industries in the Caribbean if a new canal moved a mass of cold Pacific water in there is uncertain; but I have heard suggestions that it might create a new hurricane center, or even bring about diversion of the Gulf Stream with a drastic effect on the climates of all regions bordering the North Atlantic. We know that the sea-level Suez Canal permitted the exchange of many marine species between the Red Sea and the Mediterranean. We know that the Weland Canal let sea lampreys and alewives enter the upper Great Lakes with disastrous effects on fisheries and, more recently, on bathing beaches. We just don't know what disruptions of this sort a sea-level canal in the Isthmus might cause.

I am going to hand this down to you, and you might study it for a moment. We will take a brief recess so you can prepare to comment.

(Short recess.)

Senator BARTLETT. The committee will come to order.

Mr. ANDERSON. Mr. Chairman, may I comment on the article that you read?

From the beginning the Commission has been aware of the fact that there is a tide differential in the Pacific side as compared with the Atlantic side, and from the beginning we have recognized that

we would have a mixture of waters between the Pacific and the Atlantic Oceans at a new place.

Senator BARTLETT. May I interrupt you for a moment. Professor Cole said some estimates have been at differentials of 6 feet. Is that your understanding?

Mr. ANDERSON. We are going to treat each one of these, if we may.

Senator BARTLETT. Go ahead.

Mr. ANDERSON. I simply want to say, recognizing these problems, a good part of our effort is going into bioenvironmental studies. Additionally, we have established liaison with the Smithsonian Tropical Research Institute. They are giving us guidance on how to do these sorts of things. We are working with all the marine groups that we know about in the country. One of the reasons that we are making meteorological studies and frequent probes into the atmosphere is because we do want to know what happens to any material that is released into the air.

With the chairman's permission, I am going to ask Mr. Oakley to comment first on the atomic energy aspects and then Mr. Sheffey on the matter of tides and temperature differentials.

Mr. OAKLEY. I think two things are relative, Senator. I think first of all Mr. Cole has apparently reached his judgment before the facts are in, and I don't want to make the same mistake and tell you that we have final answers. However, you will notice in the canal studies, programs underway for the Commission, there are several, managed by the Atomic Energy Commission and carried out by competent scientific institutions, like the Battelle Memorial Institute of Columbus, Ohio. These people are trying to predict, with the facts, what the situation might be with respect to radioactivity.

I would make one other point: It appears that Professor Cole has made an error in arithmetic by a factor of about 28,000. He has assumed that all of the nuclear explosives, with a total estimated yield of 170 megatons, are all fission and that all of them would be detonated on the surface. In fact, these would be thermonuclear explosives which I commented on earlier. Further, they would be buried from several hundred to several thousand feet deep. So, contrary to his calculations, I say he is off by a factor of 28,000 or more.

Senator BARTLETT. A slight error?

Mr. OAKLEY. Yes, sir.

Mr. SHEFFEY. Mr. Chairman, as Chairman Anderson has said, we are making a major investigation in each of these areas to present the Commission and the Congress with the facts, and the sort of allegation that Professor Cole has entered in the New York Times is a problem we have faced from the beginning.

Mr. Oakley has pointed out a major factual error in his special area of competence. I would like to list a few more to cite for you the kind of problem Professor Cole presents us.

First of all, there has been no actual proposal to build a sea-level canal by atomic methods. We are investigating the feasibility of it, and all of these questions that Professor Cole has mentioned are questions we are investigating and will report on.

A typical major error is his statement about the difference in average sea level. The difference in the average sea levels of the Pacific and the Caribbean is about 1 foot.

He is quite right about the tides. They range to +10 feet on the Pacific side to about -9 feet. So there are periods during the day, twice each day, that the Pacific is nearly 10 feet higher than the Atlantic and nearly 9 feet lower than the Atlantic. This means that the flow of current through the canal will be alternating, first north from the Pacific to the Caribbean and then south from the Caribbean to the Pacific. We have calculated that the average mean difference in elevation of about 1 foot would cause a small net flow northward from the Pacific to the Caribbean. We have calculated this could amount to about one-tenth thousandth of the volume of the Gulf Stream. The water temperature differences are about 1 degree in the summer and about 1.5 degrees in the winter.

Senator BARTLETT. Is that all?

Mr. SHEFFEY. Yes, sir. The threat of climatic change or a new hurricane center simply does not exist, and, as Chairman Anderson has pointed out, the Smithsonian has been enlisted to assist us in conducting long-term studies of the biological problems that this involves, and these studies have already begun.

We are a short-lived agency, even if extended until 1970. The kind of study that is needed must go much longer than that. From the beginning we sought a permanent agency to foster such studies, and we believe this is going to be done satisfactorily.

Senator BARTLETT. Thank you.

As chairman of the Merchant Marine and Fisheries Subcommittee of this very Commerce Committee, I, of course, should be completely impartial. However, as a Pacific coast man, I would say it would be a blessing if some of the fish from the Pacific got into the Atlantic.

In any case, I want to state a personal conclusion now, no matter what the ultimate decisions are to be, and I base my judgment upon what happened at Cape Thompson, the area in which you are making your studies—the entire world, in fact—will be greatly benefited by them. I think the far-ranging studies made in northwestern Alaska at that time, dealing with every branch of science that could be possibly involved and with social and economic problems, was probably one of the most comprehensive studies ever made by any Government anywhere, and it appears that you are undertaking an even more considerable assignment there, and the end results, no matter how the canal is to be dug, are all for the good.

I, for one, am for extending the life of the Commission and for giving you the necessary funds to carry out this essential work. I will state that because it may have appeared that some of my questions were critical.

Why is it necessary to use on Route 25 both conventional and nuclear explosives for excavation?

General NOBLE. We believe, sir, from looking at the topography and geology there that the means of getting through the divide would be best served by nuclear devices, and when you get into the Atrato Valley, as shown by my first slide, we could probably do it more economically by normal conventional dredging techniques. It is a question of economics, sir.

This, however, needs further geological and topographical studies.

Senator BARTLETT. What about the populations along these various proposed routes? Are they substantial or otherwise?

General NOBLE. No, sir; in the remote routes, the Route 17 and Route 25 of Panama and Colombia, there are very, very few people along these routes. This is the reason why they lend themselves so nicely to considerations of nuclear technology.

On the contrary, the routes in the Panama Canal Zone, in and near the zone, and the route in Costa Rica, Route 8, are heavily populated, and, therefore, they do not lend themselves easily to nuclear techniques and are being looked at from a conventional standpoint.

Senator BARTLETT. I was interested in the figure of \$777,000 you have assigned for studies in meteorology. Why is such a considerable sum dedicated to this field?

General NOBLE. It is expensive work, sir.

Senator BARTLETT. I guess I should ask, why do you need it?

General NOBLE. We need it in connection with the nuclear studies. The remote weather stations are costly to establish and operate but they are necessary to develop the data needed by the Atomic Energy Commission in order to predict fallout patterns and things of this nature in connection with the bioenvironmental work.

It also gives us data, of course, essential to flood control, but it is primarily in connection with the nuclear studies. The work is in remote areas; it is on mountaintops; it is hard to serve. The radar instruments are expensive to maintain. It is very expensive work, sir.

Mr. ANDERSON. Senator Bartlett, as a nonengineering member of the Commission, I was told that the atmosphere has a certain architecture, that you have to determine up to 120,000 or 130,000 feet what the architecture of the atmosphere is and the different wind levels, the directions, and also take into consideration whether or not temporarily any of this architectural pattern could be upset by nuclear blast effects. This is the reason for very-high-level rockets which are being used: to make probes into the atmosphere for determining these questions which up to now we have had very little use to know.

Senator BARTLETT. Mr. Oakley, you said, among other things, that it can be expected that for each individual explosive detonated that some of the fission products airborne in the radioactive cloud and in the fallout would be as low as the equivalent of 20 tons. I just don't know what that means. What factors should we assign to 20 tons?

Mr. OAKLEY. The unit of measure that we customarily use, Senator, on our explosives is tons, kilotons, or megatons. This means the amount of TNT that would produce the same effect. In other words, 1 kiloton of nuclear explosive energy is equivalent to 1,000 tons of TNT explosive energy detonated similarly. Thus, 20 tons is kind of a unit to measure.

If you recall back to the time when detonations used to be carried out in the atmosphere on towers or balloons in Nevada, if there had been a detonation of a 20-ton explosive, that would create the same amount of radioactivity.

By the way, the amount of radioactivity released in the course of nuclear excavation of a sea-level canal would actually be much smaller than was released during atmospheric testing in Nevada.

Senator BARTLETT. But these actual explosions, if that is the right word, to build a canal would have to be much larger than the experiments heretofore conducted in connection with this Cabriolet and Buggy I?

Mr. OAKLEY. Yes, sir; they would be larger than those. However, preliminary designs indicate that the size of explosive that would be most frequently used in a canal excavation on Route 17, if I recall correctly, is about 200 kilotons. Bear in mind, that is only twice as much as the explosive that was used for making the Sedan crater which was in the first slide that I showed.

Senator BARTLETT. That would be the largest?

Mr. OAKLEY. No, sir; not the largest. That would be the most frequently used explosive in the excavation job. The largest explosive that would be used would be 10 megatons, but that would be buried underground 2,000 to 3,000 feet.

Senator BARTLETT. Have there been any nuclear tests made in Idaho at all?

Mr. OAKLEY. No, sir. We looked for a site there for our Schooner experiment and found one that we would prefer. However, for reasons of economy, as indicated in my testimony, we have decided to do Schooner at our Nevada Test Site.

Senator BARTLETT. Let's say the decision is reached to dig a canal, in whole or in part, through the use of nuclear devices. General Noble, would there be a lot of conventional work required as a followup, I mean in bulldozing?

General NOBLE. There would be considerable, sir. The nuclear devices would be used to blast the main channels, but you would still need a lot of engineering work, flood-control work, entrances to the canal, exits to the canal, some "dental" work to clean up the area, and construction of necessary maintenance and operation facilities, and things of that nature. There would be a considerable amount of conventional engineering; yes, sir. But the main excavation work would be done by the nuclear devices.

Senator BARTLETT. I have no further questions, and counsel says he does not. So, the committee will stand in recess.

Thank you very much, Ambassador Anderson and General Noble, and all the other witnesses.

(Whereupon, at 12 o'clock noon, the committee was adjourned.)



