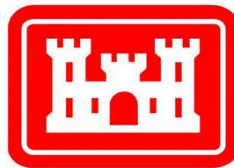


F.E. Walter Dam & Reservoir Initial Appraisal Report

**Conducted under Section 216 of the Flood
Control Act of 1970, as amended**

U.S. Army Corps of Engineers, Philadelphia District

7/9/2015



**US Army Corps of Engineers
Philadelphia District**

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F.E. Walter Dam & Reservoir Re-evaluation Initial Appraisal Report

1. Authority:

The preparation of this Initial Appraisal Report is authorized by Section 216 of the Flood Control Act of 1970 (33 USC 426 et seq) as amended, which reads:

"The Secretary of the Army, acting through the Chief of Engineers, is authorized to review the operation of projects the construction of which has been completed and which were constructed by the Corps of Engineers in the interest of navigation, flood control, water supply, and related purposes, when found advisable due to significantly changed physical or economic conditions, and to report thereon to Congress with recommendations on the advisability of modifying the structures or their operation, and for improving the quality of the environment in the overall public interest. "

This IAR was prepared using FY 14 Operations and Maintenance funds and its cost was limited to \$20,000 per the guidance in paragraph 3-10b of ER 1105-2-100.

2. Purpose:

The purpose of this Initial Appraisal Report (IAR) is to determine whether there is a need to conduct formal investigations to examine the feasibility of changing the congressionally authorized operation and/or making modifications to the existing dam at Francis E. Walter Reservoir to better meet present and future flood control objectives, in-lake and downstream recreational use, water quality, water supply, and environmental sustainability demands.

Due to the limited nature of this IAR, considerations are limited to the review of existing, readily-available information and best professional judgment. This IAR will be used to determine whether changes in physical and economic conditions are sufficient to justify a formal investigation of optimizing project operation given this change in conditions. Table 1 summarizes significant physical and economic changes that have occurred since the construction of the dam and reservoir and warrant a future Feasibility Study to examine opportunities to modify the operation and/or structure and to improve the quality of the environment in the overall public interest. Although some of these changes have been partially addressed within the limits of the current authorization and operation, permanent changes to storage authorization, operations, or physical modifications are needed to maximize benefits for current and future recreational, water quality, and water supply needs.

The existing Francis E. Walter Dam and Reservoir was initially designed and constructed as a single purpose flood control project and became operational in 1961. The Water Resources Development Act of 1988 added recreation as another authorized purpose. Current NED benefits provided by the project are substantial. Average annual historic flood damages prevented by the dam operations since 1961 are estimated, at the current price level, to be \$3.82 million per year (derived from a \$206.3 million total over the full period of operation). Census population growth and related increased housing stock in the floodplain from 1960-2010 for the

three local counties of Carbon, Northampton, and Lehigh has been significant, with county populations increasing from 23% to 54%. Recreation directly at the lake at Walter has grown substantially, from 48,000 visitor days in 1961 to 246,000 visitor days in 2014. The current magnitude of lake visitation can be applied to the table in the Corps' Economic Guidance Memorandum, Unit Day Values (UDV) for Recreation for FY 15 for a monetary approximation of the total recreational unit day value experience. The magnitude and type of visitation is appropriate for use of the UDV method for quantifying general recreation. Applying a \$5.00 per visitor UDV (a value in the lower end of the potential range provided) provides a total NED benefit willingness to pay valuation estimate of \$1.23 million in 2014. Scheduled operational releases to enhance whitewater rafting experiences downstream of the dam on the Lehigh River have expanded six-fold from 1968 to the current scheduled releases of 24 per year. Whitewater rafting is currently estimated at 75,000 people per year on the Lehigh River. A recreational UDV experience value of \$5.00 per rafter (again applying the value in the lower end of the potential range provided) estimates a total NED valuation of \$0.375 million for the actual rafting experience on the Lehigh River. Regional benefits also accrue to the whitewater rafting companies, suppliers, etc. providing ancillary services. The annualized cost of the district's current O&M cost requirements at Walter is reasonable in comparison to the set of above benefits. Thus, the estimate of NED benefits provided by the project's current operations with the potential for future enhanced NED benefits from changes to project operations or modifications compared to current project costs provides justification for initiation of a Feasibility Study as the next study phase.

A Feasibility Study is recommended to further define problems, needs, and opportunities associated with project operation and evaluate the feasibility of various alternatives to optimize project operation given the change in project conditions. This Feasibility report would be submitted to Division and Headquarters offices for approval and review by Civil Works Review Board prior to moving forward with Pre-Construction, Engineering, and Design.

Table 1. Synopsis of physical and economic changes

Change	Magnitude of change	Effects on current operation	Conclusion for future study
<p>Watershed and Regional Population Growth</p>	<p>1960-2010¹</p> <p>Pennsylvania +12%</p> <p>Northampton County +48%</p> <p>Lehigh County +54%</p> <p>Carbon County +23%</p>	<p>Operating within authority, but there is increased recreation use, increased impacts to water quality (in-lake and downstream fisheries), and increased watershed-wide water supply needs. In addition, increased population may mean that there are increased flood risk management benefits.</p>	<p>Current operations address flood risk management and recreation within the limits of the authorization and physical limits of the dam, but future study is needed to evaluate future demands for services; evaluate existing infrastructure to support the current and future demand for services; and investigate opportunities to optimize operation to maximize benefits for current and future recreational, water quality, and water supply needs.</p>
<p>Visitation</p>	<p>Pocono Regional Visitation²</p> <p>2006 – 6 Million</p> <p>2013 – 25 Million</p> <p>F.E. Walter Reservoir Visitation³</p> <p>1961 – 48,200</p> <p>2014 – 246,381</p>	<p>Operating within authority, but recreation use (water and land based recreation) has increased.</p>	<p>Current operations address recreation within the limits of the authorization and physical limits of the dam, but future study is needed to address increases in recreation use, and evaluate future demands for recreation services; evaluate existing infrastructure to support the current and future demand for services; and investigate opportunities to optimize operation to maximize benefits for current and future regional recreational needs.</p>

Change	Magnitude of change	Effects on current operation	Conclusion for future study
Whitewater Recreation	<u>Annual Planned Releases</u> 1968 – 4x Year 2014 – 24x Year <u>Lehigh Gorge Annual Rafter Use</u> ⁴ 1986-2005 average 50,072 2006-2012 average 75,000	Operating within authority, but recreational demand has increased. Recreation Operations Plans are developed annually with stakeholder input and approved as a planned deviation from the water control manual.	Current operations address recreation within the limits of the authorization and physical limits of the dam. Future study is needed to investigate more permanent solutions to an annual recreation plan and evaluate future demands for services; evaluate existing infrastructure to support the current and future demand for services; and investigate opportunities to optimize operation to maximize benefits to current and future regional recreational needs.
Flood Damages Prevented	1961-2014 ⁵ \$206.3 million cumulative 2014 annual \$185,000	Operating to meet designed flood control objectives.	Future study will ensure that flood control objectives are not negatively affected by proposed changes in operation or infrastructure.
Structural modifications	<u>Access Road Construction</u> 2004 F.E. Walter Access Road Construction allowed cross dam access during flood control and recreational storage events. <u>F.E. Walter Dam Safety</u> 2006 - Portfolio Risk Analysis 2010 - Grout Curtain Installed 2012 – DSAC rating changed to 4	<u>Access Road Construction</u> Physical modifications were completed that allowed the Corps to operate more effectively for recreation by temporarily storing larger volumes of water. <u>F.E. Walter Dam Safety</u> Improvement in dam safety rating allowed for safer operations for flood control and recreation.	Future study is needed to evaluate existing infrastructure to support the current and future demand for services without having a negative impact to the DSAC rating (see Section 6, Existing Conditions, Dam Safety). Investigation is needed to examine a combination of changes in authorization, operational changes, and additional structural modifications to maximize benefits for current and future recreational, water quality, and water supply needs.

Change	Magnitude of change	Effects on current operation	Conclusion for future study
<p>Improvement in Lehigh River Water Quality</p>	<p>Water quality has improved in the Lehigh River over the past 60-70 years because of various environmental regulations and public activities (see Appendix A for details).</p>	<p>Currently operating within current authorization (no water quality storage) and with limited selective withdrawal capabilities. Currently unable to adequately address downstream water quality objectives without changes in authorization, and/or structural modifications.</p> <p>The Fish and Wildlife Coordination Act of 1958 provided that fish and wildlife conservation shall receive equal consideration with other project purposes and be coordinated with other features of water resource development programs.</p>	<p>Investigation is needed to examine a combination of changes in authorization, operations, and structural modifications to maximize benefits for water quality and environmental conditions.</p>

¹Pennsylvania State Data Center. Census Profiles, <http://pasdc.hbg.psu.edu/Data/PASStats/tabid/1014/Default.aspx>

²Pocono Mountains Visitor Bureau, 2013. Annual Report, <http://issuu.com/800poconos/docs/annualreportfinal>

³U.S. Army Corps of Engineers, Philadelphia District Annual Visitation estimates 1961-2014, personal communication, Philadelphia District staff.

⁴D.M. Madl. Personal Communication. Pennsylvania Department of Conservation and Natural Resources. November 8th, 2013

⁵U.S. Army Corps of Engineers, Philadelphia District Annual Prevented Flood Damage estimates 1961-2014, personal communication, Philadelphia District staff.

3. Congressional Delegation:

The F.E. Walter Dam and Reservoir is located in PA-11 and impacts the following members of the delegation: Representative Lou Barletta (PA-11), Senators Pat Toomey and Robert Casey (PA). In addition, the following members of the delegation and their districts are impacted by the operation of the F. E. Walter Dam and Reservoir: Representative Jim Gerlach (PA-6), Representative Charlie Dent (PA-15), Representative Matt Cartwright (PA-17), and Representative Brendan Boyle (PA-13). Representative Chris Gibson (NY-19), Representative Charlie Dent (PA-15), and Representative John Carney (DE-AL) are co-Chairs of the Delaware River Basin Task Force.

4. History of Authorization and Operation:

Pertinent Authorizing Language

The following paragraphs highlight pertinent authorizing language as it pertains to the F.E. Walter Dam & Reservoir. Appendix A contains detailed information concerning each authorization.

1946 Flood Control Act: *The project for flood protection on the Lehigh River, Pennsylvania, is hereby authorized substantially in accordance with the recommendations of the Chief of Engineers in House Document Number 587, Seventy-ninth Congress, second session, at an estimated cost of \$12,471,000.*

1962 River and Harbor Act: *The project for the comprehensive development of the Delaware River Basin, New York, New Jersey, Pennsylvania and Delaware, is hereby authorized substantially in accordance with the recommendations of the Chief of Engineers, in House Document Numbered 522, Eighty-seventh Congress, at an estimated cost of \$192,400,000.*

House Document No. 522, 87th Congress, 2nd Session: *The Bear Creek Project is a modification of the single-purpose flood control project with incidental recreational use now under construction, which is located on Lehigh River 75 miles above its confluence with Delaware River and about 5 miles north of White Haven, Pennsylvania. The proposed project would be a multiple-purpose development to provide for supplies of water and recreation in addition to the present flood control purpose.*

Fish and Wildlife Coordination Act of 1958: *For the purpose of recognizing the vital contribution of our wildlife resources to the Nation, the increasing public interest and significance thereof due to expansion of our national economy and other factors, and to provide that wildlife conservation shall receive equal consideration and be coordinated with other features of water-resource development programs through the effectual and harmonious planning, development, maintenance and coordination of wildlife conservation and rehabilitation for the purposes of this Act in the United States, its Territories and possessions...*

Water Resources Development Act of 1988: *The Secretary shall ensure, to the extent compatible with other project purposes, that each water resources project referred to in this*

subsection is operated in such a manner as will protect and enhance recreation associated with such project....(4) France E. Walter Dam, Pennsylvania.

Authorization History

The Francis E. Walter Dam and Reservoir Project (formerly Bear Creek Dam and herein after referred to as “the project”) was completed in 1961 under the authorization of the 1946 Flood Control Act as a single purpose flood control project.

The project is located five miles upstream of White Haven, Pennsylvania on the Lehigh River, approximately 77 miles above the confluence with the Delaware River, in Carbon and Luzerne County in Northeastern Pennsylvania (Figure 1). The reservoir has a 234-foot-high earth-fill dam and a gate-controlled outlet that has a 17,000 cfs capacity. The reservoir capacity is 107,975 acre-feet for flood control with a conservation pool capacity of 1,993 acre-feet. The top of the conservation pool is at elevation 1300 feet NGVD.

The Philadelphia District owns, operates and maintains the project. The project is operated as part of the Lehigh River Flood Control Program, along with Philadelphia District’s Beltzville Reservoir and state or locally-owned flood control structures along the Lehigh River (Figure 2). The Beltzville Lake project (Figure 3) was constructed in 1971 and was authorized along with Bear Creek Project Modified (further studied in the early 1980’s) in the Flood Control Act of 1962, as part of the Corps’ Delaware River Basin Comprehensive Plan to collectively operate as a system to bring about flood control benefits on individual tributaries as well as the mainstream Lehigh River above Easton, Pennsylvania. The proposed modification was described in detail in the 1962, House Document No. 522, 87th Congress, 2nd Session.

All civil works projects are required to consider environmental resources in their operations, but fish and wildlife conservation is not a designated project purpose at F.E. Walter Dam & Reservoir. The Fish and Wildlife Coordination Act of 1958 (PL 85-624), which amended the Act of March 10, 1934, provides that fish and wildlife conservation shall receive equal consideration with other project purposes and be coordinated with other features of water resource development programs.

The Water Resources Development Act of 1988 added lake and downstream recreation (whitewater and recreational fishing and boating along with in-lake recreational opportunities) as an authorized purpose.



Figure 1. F.E. Walter Dam & Reservoir Project Map



Figure 2. Regional Project Map

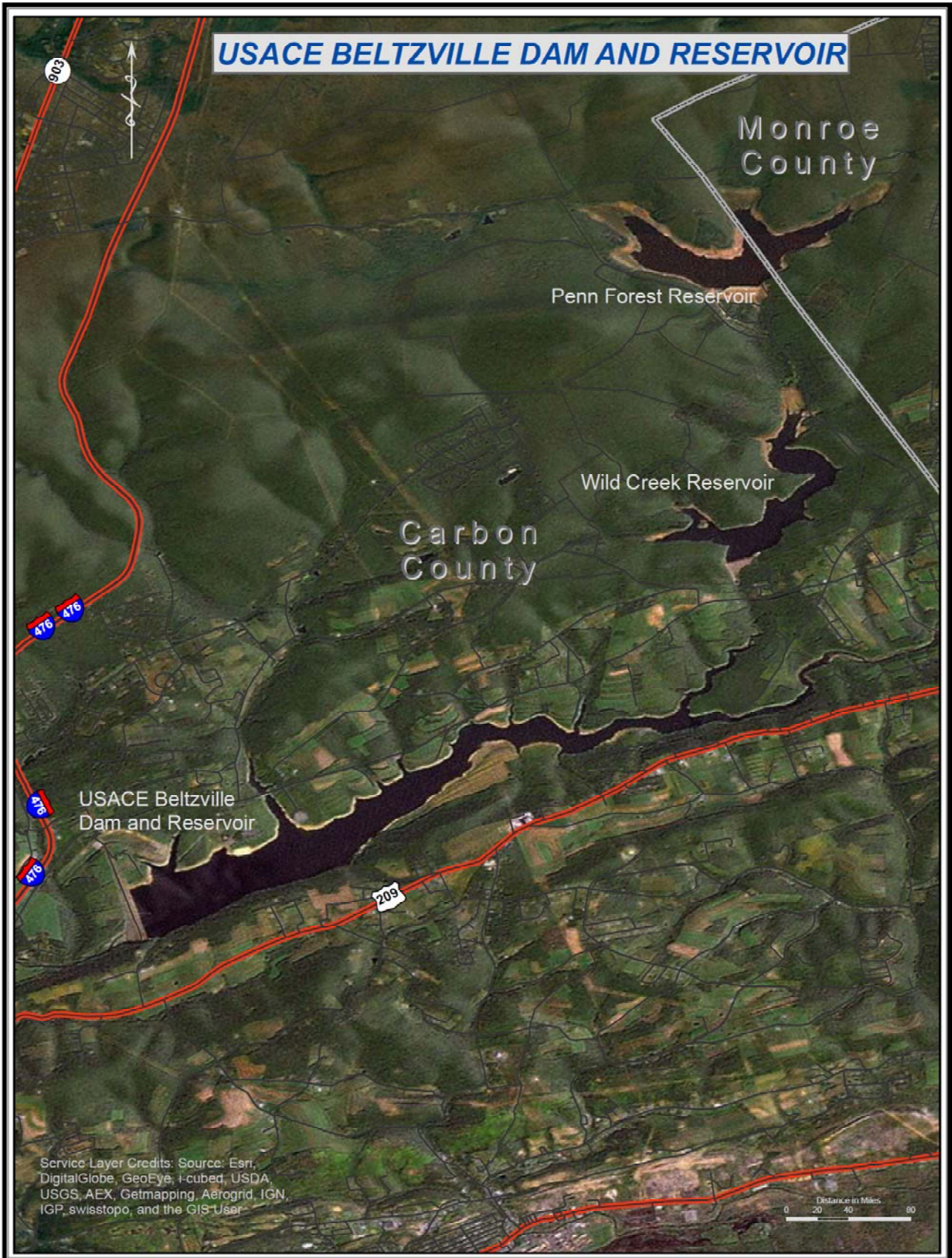


Figure 3. Beltzville Dam and Reservoir Project Map

Operation History

The F. E. Walter Reservoir Project was completed in 1961 with flood control as the primary objective as an integral part of the Lehigh River Flood Control Program (USACE, 1994). A timeline showing the project evolution from 1940 to present can be found in Appendix B.

The control tower does not have the ability to pull water at select locations within the reservoir pool. However, the project's bypass system is operated as a limited selective withdrawal system for recreation. All releases of water are made through the project's bypass system, flood control release system, or a combination of both systems. The bypass system allows the operator to release water from elevation 1297 ft. National Geodetic Vertical Datum (N.G.V.D.) and has limited discharge capacity. The flood control release system allows the operator to release water from the tower flood gates (elevation 1250-1260 ft. N.G.V.D.).

Historic Operation for Whitewater Recreation

In 1968, the Philadelphia District began operating specifically for whitewater recreation on one selected weekend each month during the months of July through October at the request of various organized canoe clubs in the area. Photograph 1 shows current recreational whitewater rafting downstream of the F.E. Walter Dam & Reservoir in the Lehigh River Gorge State Park. Although the primary purpose of the project is flood control, there were no restrictions on accommodating additional activities such as recreation, when possible as a public service for supporting a popular public activity.



Photograph 1. Photograph of recreational whitewater rafting.

In November 1970, representatives of the District met with representatives of the Pennsylvania Department of Environmental Resources, Pennsylvania Fish and Boat Commission,

Pennsylvania Department of Health, Delaware River Basin Commission and the United States Fish and Wildlife Service to discuss the continuing of the specific white water releases on the Lehigh River and formulate a policy that would best serve the needs of all sporting and recreational interests. It was concluded at the meeting that the Commonwealth of Pennsylvania, with the Department of Environmental Resources (DER) as its coordinating agency, would develop an operational plan of modified releases. These releases would be based on the natural characteristics of the Lehigh River below the dam and provide adequate conditions for canoeing without causing adverse impacts to the natural environment of the river.

In 1971, the DER provided a plan for limited releases to augment natural flows for canoeing. This plan was carried out on a trial basis for four 1971 events. The storage for releases was limited to avoid submerging an access road on the upstream embankment of the reservoir. This limited the releases to one day events. Pool elevations above 1309' prevented public and emergency services road access and impeded recreational boating on the lake. Photograph 2 shows F.E. Walter Dam & Reservoir at 1315' pool elevation. Photograph 3 shows F.E. Walter Dam & Reservoir at a 1300' pool elevation that allows boat launching from an undeveloped parking area and public use of the access road. The access road is used for boating, fishing, picnicking and travel along the upstream face of the dam.



Photograph 2. Photograph of F.E. Walter Dam & Reservoir at 1315' pool elevation.



Photograph 3. Photograph of the F.E. Walter Dam & Reservoir at a 1300' pool elevation.

In 1972, the District scheduled four, one day events under the same requirements as those established the previous year. From 1972-1979, on an annual basis, canoeing clubs submitted proposed release dates to the District. The District submitted these dates to the Pennsylvania DER for their review and approval. Many events were canceled or rescheduled after evaluations showed dry basin conditions with inflows insufficient to store the amount of water needed for releases.

In 1980-81, there was a basin-wide drought emergency and the Walter Reservoir was used for temporary water supply storage and all water release events were canceled. The 1982 schedule was also canceled at the request of the Delaware River Basin Commission (DRBC) due to lack of sufficient water in the Lehigh River Basin. DRBC had a water supply contract with USACE during this time period.

In January 1982, a meeting was convened by a Pennsylvania State Senator and the Director of the Pennsylvania Bureau of State Parks in Jim Thorpe, Pennsylvania to discuss the future of the Whitewater release program on the Lehigh River. This meeting was attended by all the key state agencies, the District, the Delaware River Basin Commission, organized canoe clubs and independent commercial outfitters groups. The meeting resulted in a recommendation to continue the four events per year. In addition, the Pennsylvania Fish and Boat Commission requested a defined constraint for storage to keep the access road on the upstream embankment from being inundated and accommodate boating interests and aquatic resources. This constraint limited storage of water prior to each white water event to approximately 9 feet (Elevation 1300 to 1309 ft. N.G.V.D).

The District evaluated basin hydrologic conditions prior to each event and decided whether to cancel or continue with the scheduled releases. Additional meetings were held in 1983 to review

and update the program. The release schedule was reviewed and adopted annually from 1983-1986. In 1987, an additional one-day October event was added.

With the passage of Public Law 100-676, Section 6, dated November 17, 1988 the F.E. Walter Dam and Reservoir was authorized to operate in such a manner to protect and enhance recreation associated with the project (Appendix A). This includes, but is not limited to, white water recreation (Photograph 1). There is no permanent storage authorized for water supply, water quality, recreation, or fish and wildlife conservation. However, the reservoir has been operated for recreation when feasible within the physical and operational limitations of the dam and reservoir.

The District, in coordination with the Pennsylvania Department of Conservation and Natural Resources (Bureau of State Parks), Pennsylvania Fish and Boat Commission, U.S. Fish & Wildlife Service, Delaware River Basin Commission and Lehigh River Sportsmen Groups set up an annual schedule of five weekend events for whitewater rafting that covered a total of seven days each summer and fall. Whitewater storage was limited to elevation 1309 feet. Storage began twelve days before the five scheduled events. This schedule was reviewed annually by the above agencies.

In 2004, a new road was constructed across the top of the dam that eliminated the need to limit pool levels to keep the lower access road open (Photograph 4). This also allowed for increased operational flexibility for temporary recreational water storage in the reservoir. Starting in 2005, increasing amounts of temporary storage were provided to expand recreational opportunities. These deviations were provided with Division approval. In 2005, the pool level was increased to 1335 ft N.G.V.D. for recreation, the following year it was increased to 1365 N.G.V.D. and it is now being raised to 1370 N.G.V.D. The pool is raised to 1370 ft. N.G.V.D. starting on or about April 1 and used to help support recreational needs until mid-October when any excess water is released and the pool is returned to elevation 1300 ft N.G.V.D. This volume is small enough to be released in advance of a large storm, yet sufficient to provide considerably enhanced recreational opportunities, but still relies on additional inflow during the season to fully meet the recreational plans. These plans are developed each season by a coordinated effort involving all interested parties to include public meetings and input.



Photograph 4. Photograph of the improved access road.

Historic Operation for In-lake Recreation

In-Lake Recreation was not an original congressionally authorized purpose of the F.E. Walter Dam & Reservoir Project and there is no storage specifically allocated for in-lake recreation. Most recreational area structures and access roads are located in the flood control storage area of the project. As a result, the type and magnitude of the facilities are not optimal. Utilization of flood control storage above elevation 1306 ft. N.G.V.D. began to eliminate boat launching capabilities, while storage above 1309 ft. N.G.V.D. covered the access road located on the upstream embankment (Photographs 2 and 3). In addition, storage for whitewater events, which became an authorized part of recreation in 1988 as part of Public Law 100-676, also impacted the boat launching area and access road. In July 2007, a boat turn-around was constructed on the east side along the lower road at approximately elevation 1390 ft. N.G.V.D. to facilitate boat launching from the roadway when the pool is elevated. In 2014, an expanded trailer and vehicle parking area was constructed in this area to meet public use demand.

Historic Operation for Fisheries

Fish and wildlife conservation is not a designated project purpose. No storage is specifically dedicated for this purpose at the project. The Fish and Wildlife Coordination Act of 1958 (PL 85-624), which amended the Act of March 10, 1934, required that fish and wildlife conservation receive equal consideration with other project purposes and be coordinated with other features of water resource development programs (Appendix A).

Prior to 2005, there were no formal fisheries management efforts, but the District maintained a stabilized pool elevation that encompassed shoreline fish habitat during the spring spawning and nursery cycles. The need for pool stability directly competed with natural weather events and the

need for pool adjustments frequently occurring in the spring season and during planned whitewater release events. Water control management needs took precedence over fishery and whitewater release accommodations, but attempts were made to adjust procedures to accommodate fishery purposes whenever possible. Releases were made to meet minimum release criteria to maintain and potentially enhance downstream fisheries. Criteria were developed to avoid abrupt gate changes during above normal releases for flood control regulation. Efforts were made to modify releases to minimize adverse shock effects on downstream fisheries.

Recreation and fisheries are now an important aspect of the reservoir due to public support and economic benefits to the region (explained in more detail in Section 6. Existing Conditions, Operation, and Facilities). Specifically authorized reservoir storage and modifications to the reservoir structure may be needed to enhance operation for these purposes.

Historic Operation for Drought

As constructed, the reservoir does not have any surplus storage in the flood control pool that may be permanently dedicated to water storage. The Water Control Manual for Francis E. Walter Reservoir includes a section that deals with declared drought emergencies by the Delaware River Basin Commission (DRBC) (USACE 1994). Since the completion of the Reservoir, the Corps has responded to periodic requests from the DRBC to impound water during drought emergencies. The Manual also included a copy of a draft agreement or impounding water during drought emergencies. This agreement included a cost to the DRBC for the impoundment. The agreement expired and no follow-on agreement has been reached. Section 4001 of the Water Resources Reform and Development Act (WRRDA) of 2014 provided authority to enter into an agreement with the DRBC to provide temporary water supply and conservation storage at the Francis E. Walter Dam during a drought warning or drought emergency (Appendix A). The agreement shall provide that the cost for water supply and conservation storage shall not exceed the incremental operating costs associated with providing the storage. Although this storage is not Municipal and Industrial or Agricultural Water Supply, it has been included in this category historically. Under Engineer Regulation 1110-2-8156, the Division Commander has the authority to approve planned deviations from the normal water control plan when necessary. A synopsis of drought storage history is displayed in the table below:

Table 2. Synopsis of drought storage history¹

Storage Start Date	Storage End Date	# of days of River flow affected	Approx. cfs Inflow During Storage	Outflow cfs During Storage	Starting Pool Elevation	Max. Storage Elevation	# of Days at Max. Storage Elevation
09/26/65	10/12/65	17	> or = 200	> or = 200	1300	1358	49
04/17/66	05/17/66	31	700	50	1306	1390	35
05/09/67	05/20/67	12	1000	> or = 200	1301	1358	119
01/26/81	02/07/81	10	500-6000	50	1300	1370	48
03/17/81	04/03/81	18	~ 400	50	1370	1392	146
11/--/81	04/--/82	0	-----	-----	1392	1370	151
05/14/85	06/17/85	35	100-500	43	1300	1392	146
11/09/85	12/25/85	0	-----	-----	1392	1358	47
08/04/99	09/15/99	44	< 100	50	1300	1383	30
02/01/02	03/11/02	38	200-700	156	1303	1370	14
03/25/02	04/05/02	11	500-2000	156-650	1374	1392	11
04/05/02	07/16/02	102	-----	-----	1392	1392	102
07/16/02	11/08/02	115	-----	-----	1370	1392	115

¹Table taken from Page 7 “Table 1 Historic Drought Operations” of the 2002 Environmental Assessment for Emergency Drought Storage at Francis E. Walter Reservoir, Carbon and Luzerne Counties.

5. Prior Studies and Reports

F.E. Walter Dam & Reservoir was completed in 1961 in direct response to flood control needs within the watershed. The project was developed as a flood control reservoir and not designed or authorized to directly benefit environmental resources, water supply, or to meet recreational needs. A timeline table was developed to summarize the numerous policy changes and Federal, state, and local actions and studies related to F.E. Walter Dam & Reservoir and the Lehigh River watershed (Appendix B).

As water supply, water quality, and recreational demands changed in the region, public interest increased in modifying the project to provide for these demands. Congress authorized modifications to the dam in the Flood Control Act of 1962, as part of the Corps’ Delaware River Basin Comprehensive Plan and this was described in detail in the 1962, House Document No.

522, 87th Congress, 2nd Session (see Appendix A). In that plan, the Philadelphia District proposed to turn the dam into a multipurpose dam used for flood control, water supply, and recreation.

In 1974, the Philadelphia District issued a general design memorandum for the Walter modifications (Godfrey, et al, 2012). In 1985, the District issued a revised General Design Memorandum, Main Report and Environmental Impact Statement for the Modification of the Francis E. Walter Dam and Reservoir that recommended significant modifications to the project. The recommendations were to add water supply and recreation to the existing flood control project by raising the dam 30 feet, raising the spillway 32 feet, and raising the permanent pool 127 feet. The pool would have been increased from 80 to 1,330 acres and this would have provided an additional 70,000 acre-feet of water supply storage. These recommendations included the construction of a new spillway, a new multigated control tower, and the relocation of three and a half miles of Bear Creek Road.

In 1985, the Delaware River Basin Commission (DRBC) informed the Philadelphia District that it was willing to serve as the non-Federal sponsor for the Walter Dam modification to address salinity and water supply concerns (Godfrey, et al, 2012). However, in the Water Resources Development Act of 1986, Congress modified cost-sharing provisions on flood control projects, stating that local interests would now be responsible for up to 50 percent of the cost of construction, operation, and maintenance. The legislation also stated that “local interests [were] required to pay all costs allocated to water supply” (Godfrey, et al, 2012). In the case of the Walter Dam modifications, this meant that the DRBC was responsible for approximately \$98.6 million in construction costs and \$84,000 a year for operation and maintenance (Godfrey, et al, 2012). In addition, the DRBC was responsible for half of the costs allocated for recreation, estimated at \$11.7 million, and an annual operation and maintenance charge of \$111,000.99 (Godfrey, et al, 2012). The DRBC was not able to cost-share construction due to other financial obligations and a limited ability to impose fees on water users and the project did not move forward (Godfrey, et al, 2012).

The 1988 congressional authorization (Appendix A) provided the Corps with the legal authority to tailor operations to better meet regional recreational and resource demands without modification to the structure. Operations for recreation were limited due to physical constraints (lower access road, operational tower design, etc.) and flood control operation requirements.

Increases in recreational (rafting and fishing), water supply, water quality and other demands in the region and watershed continued through the 1990's. In 2000, the Philadelphia District and the DRBC co-sponsored a Section 22 Planning Assistance to States study to collect water quality data in the watershed. This was the first step in developing a future water quality model for the system that would aid in operations of the F.E. Walter Dam & Reservoir and Beltzville Dam & Reservoir and to help identify what project changes are needed to meet regional goals and needs. This effort was widely supported and included a partnership with nearly 15 federal, state, and local agencies and interest groups. The data collection effort and study was completed in 2001.

In 2004, the Corps modified the upper access road for the project to act as the primary travel way past the dam under higher pool level conditions. The lower access road had been a physical constraint to operations at the project. This added operational flexibility was followed by the creation of a Lehigh River Work Group (Corps and applicable agencies) to work with the public

in understanding watershed needs and annually adjusting operations at the project to meet in-lake and downstream uses within the current limits of the project. This operational work group has met annually and held annual public meetings from 2005 through the present day. In addition, the Corps developed a project website to better coordinate with the public and allow easy access to project information and operations:
<http://www.nap.usace.army.mil/Missions/CivilWorks/FrancisEWalterDam.aspx>.

The Corps' flexibility in meeting current watershed and regional demands has been constrained by the physical aspects of the dam and reservoir, and lack of water quality, water supply, and in-lake storage authorization. In 2006, the Commonwealth of Pennsylvania co-sponsored a Section 22 Planning Assistance to States Study with the District to better understand the operational possibilities at F.E. Walter Dam & Reservoir and the effects on in-lake and downstream resources of different operating scenarios. The Corps used the water quality data collected during the 2001 Section 22 study and all other available data in the watershed to develop a CEQUAL-W2 water quality and flow model for the Lehigh River and the F.E. Walter Dam & Reservoir and Beltzville Dam & Reservoir. The study was divided into two phases. The agreement for Phase I was signed on August 4, 2006, and was completed in 2009. The study agreement for Phase II was signed on June 9, 2009 and was completed in 2014. A total of twelve operational scenarios were developed in cooperation with the angling and whitewater interests in the watershed along with the state agencies responsible for those recreational activities. Some of the model scenarios included modified operations under conceptual changes in pool elevations (depths) and operations utilizing existing authorizations, storage limits and dam and tower conditions. In addition, some of the scenarios included modified operations with conceptual changes in pool elevations (depths), authorizations, and storage and tower intake portal configurations. Model results showed, that under some of the model scenarios, changes or modifications in the dam structure, the operations, authorizations, and storage could positively benefit many miles of downstream water quality and recreation (whitewater rafting and angling) in the Lehigh River concurrently. Operating for one objective would not exclude benefits to the others.

The report concluded that the potential exists for F.E. Walter Dam & Reservoir to play a more direct positive role in improving in-lake and downstream aquatic resources while providing greater operational flexibility in meeting in-lake and downstream recreational demands. However, the model scenarios showed that in order to meet some of these scenario objectives, structural modifications, additional authority for storage and operation, and further study of regional existing and future demands is needed.

Numerous reports, studies, and National Environmental Policy Act (NEPA) documents have been prepared for the F.E. Walter Dam & Reservoir project. The Corps reports and studies listed below are a partial list with a brief summary of report content. These reports show the level of effort made by the Philadelphia District, numerous agencies, and the public to meet regional and resource demands while working within the constraint of authorized operations.

1970: Feasibility Study for increasing the permanent pool elevation to 1350 Ft, NGVD for the purpose of Recreation

The primary purpose of this study was to evaluate the benefits and effects on both the existing project and on expanded recreation facilities resulting from raising the conservation pool for recreational purposes. The secondary purpose of the study was to select from accumulated data

the options leading to the orderly development of the recreational resource. Scope of the study was the time period from 1969 level of development to roughly the 1989 authorized modification of the project. The study included discussion on the ramifications of a raised pool level on the operation, maintenance, hydrology, recreation development, and real estate requirements of the project.

1974: Design memorandum No. 10; Revised Master Plan

The revised master plan updated and provided additional information presented in two other documents. The first document was the feasibility study of increasing the permanent pool elevation to 1350 feet for recreation purposes of April 1970 and the second was the report on the comprehensive survey of the water resources of the Delaware River basin. The feasibility study proposed the raising of pool elevation to provide adequate landforms for interim-use recreational facilities prior to modifications and was abandoned. The need for the level of recreational and facility construction proposed was reduced to reflect present demands. Retained from the original plan was the acquisition of 1,300 acres of recreational lands and development of supportive features for recreational land use. This master plan also revisited the subject of visitation and rejected the original number of yearly visitors in favor of a new number of 341,000 which was up from the original 250,000 and based on two documents, the Pennsylvania State Comprehensive Outdoor Recreation Programs report and the North Atlantic Regional Water Resources Study both completed in 1972.

1974: Design memorandum No. 10 A; Appendices to the Master Plan; Recreation-Resource Management

The master plan included discussion concerning the present status of the project, planned short term utilization of project lands and waters, and contemplated long term development resulting from authorized major project modifications. Emphasis was placed on the direction of regional development and the role of the project on that expansion. The master plan centered on pre-modification development and management of the project and conceptually indicated post-modification development with details to follow in later master plan revisions.

1975: Design Memorandum No. 10 Master Plan

The master plan discussed several modifications to the project area which included; relocation of the spillway crest 31 ft, NGVD to elevation 1481, raising of the dam 29 ft, NGVD to elevation 1503, extending the outlet tunnel 70 ft, NGVD, raising 1700 ft, NGVD of existing dike and construction of 2900 ft, NGVD of new dike to fill a swale in the reservoir rim, relocation of over five miles of Bear Creek Road, acquiring 3250 acres of new lands for construction and related recreation areas, increasing of the pool size from 90 acres to 1280 acres, and lastly adding expanded recreation facilities to include swimming and camping areas.

1975: Environmental Assessment for the Operation and Maintenance of F.E. Walter Dam and Reservoir

In response to the National Environmental Protection Act (1969), this environmental assessment looked at positive and negative impacts from the operation of F.E. Walter Dam & Reservoir. Positive impacts included improved water quality due to releases during critical periods, maintenance of the fishery and recreation area, and flood protection. Negative impacts included increases in air and noise pollution due to equipment operation, public visitation, and debris burning. Additionally negative impacts to fish and wildlife were attributed to above average pool fluctuations. In conclusion to the environmental assessment and upon review of the operation

and maintenance activities, a finding of no significant adverse environmental impacts was reached.

1981: Preliminary Environmental Evaluation of Lehigh Basin Small Hydropower Projects

This study concluded that after modifications to the dam were complete, environmental screening criteria showed that no major obstacles exist to hydropower development. This conclusion was based on the assumption that modifications to the dam have been implemented and have not caused any uncorrectable detrimental environmental impacts.

1981: Environmental Assessment for the Proposed Modification of F.E. Walter Dam & Reservoir

This environmental assessment was conducted with the proposed modifications based on the congressionally authorized plan of improvement in the Flood Control Act of 1962 which provided for additional water supply capacity and recreation to the existing flood control project. This assessment determined that no severe long-term primary impacts would be incurred due to the proposed modifications, but secondary impacts involving accelerated development of the area may be substantial if sufficient planning and zoning was not conducted.

1983: Thermal Analysis of the Proposed F.E. Walter Dam & Reservoir Modification: Guidance on Selective Release

This report described the calibration and application of the one-dimensional temperature model, STRATFY, to F.E. Walter Dam & Reservoir and the use of STRATFY to develop the design rationale for the proposed selective withdraw structure. Conclusions from the study detailed that stratification would occur in the reservoir from early spring through fall dependant of hydrometeorological conditions, the selective withdrawal system should have a maximum capacity of at least 1200 cfs, and the review of existing water quality indicated potential pH issues which violated State water quality standards, and stratification periods would lead to anoxic water being released from the dam.

1984: Evaluation of Fish and Wildlife Habitats, Project Effects and Mitigation Needs for the Proposed Modification of F.E. Walter Dam & Reservoir Lehigh River, Pennsylvania

A technique known as Pennsylvania Modified Habitat Evaluation Procedure was used to assess the effect of the proposed enlargement of F.E. Walter Dam & Reservoir on fish and wildlife resources. In this procedure, baseline habitat conditions were contrasted against future with project conditions giving resulting change which could lead to the formulation of an appropriate mitigation plan. Lastly the future with project mitigation conditions was assessed to determine the effectiveness of the mitigation plan. In conclusion it was determined that the “with project” condition would result in a net loss of 1924 habitat units for the area. Further discussion recommended that terrestrial habitat loss could be offset by implementing habitat improvements on lands adjacent to the enlarged reservoir as the desired form of mitigation.

1985: General Design Memorandum, Modification of the Francis E. Walter Dam and Reservoir, Main Report and Environmental Impact Statement.

This study centered on confirming that the regional water supply and recreation needs for which the project was planned still existed, and evaluated if the authorized modification is still the best plan for meeting those needs. Upon confirmation of the plan to modify F.E. Walter Dam & Reservoir, alternative plans for accomplishing the modification were investigated and the best plan was recommended. The recommendation was to add water supply and recreation to the

existing flood control project by raising the dam 30 feet, raising the spillway 32 feet, and raising the permanent pool 127 feet. The pool would have been increased from 80 to 1,330 acres. These recommendations included the construction of a new spillway, a new control tower, and the relocation of three and a half acres of Bear Creek Road. For various reasons, including funding, the cost-sharing sponsor was not willing to cost-share construction and the plan did not move forward.

2000: Investigation of the Effect of White Water Boating Releases from the F.E. Walter Dam & Reservoir on Benthic Macroinvertebrates Communities in the Lehigh River

This study was a joint effort between the Pennsylvania Fish and Boat Commission and Philadelphia District Corps looking at the effects of recreational releases from the dam specifically for the purpose of white water boating. Conclusions and recommendations made by the Pennsylvania Fish and Boat Commission were that there were no deleterious effects to macroinvertebrates assemblages downstream from F.E. Walter Dam & Reservoir. The commission recommended that reservoir releases should follow the agreed upon maximum limits of water during summer and fall, avoid releasing peak levels of water on two consecutive days, and releases should not be made lesser than 144cfs or current inflow during storage events for white water releases.

2001: Lehigh River 2001 Water Quality Monitoring Report

In 2001, the Lehigh River Water Quality Monitoring Study was conducted by the Philadelphia District Corps of Engineers, Delaware River Basin Commission, the Pennsylvania Fish and Boat Commission, and the Pennsylvania Department of Environmental Protection. The project was accomplished under the Water Resources Development Act of 1974, Section 22, Planning Assistance to States authority. The project partners believed a predictive water quality computer model was needed to evaluate water flows and release scenarios from the F.E. Walter Dam & Reservoir and Beltzville Dam & Reservoir. The objective of this study was to collect water quality data throughout a portion of the Lehigh River watershed most influenced by Corps reservoir operations in anticipation of the future development of a water quality model.

2002: Final Environmental Assessment: Emergency Drought Storage at F.E. Walter Dam and Reservoir, Carbon and Luzerne Counties, Pennsylvania

This environmental assessment dealt with the emergency drought storage plan that was formulated between multiple state and federal agencies. The plan dictated that a recommended release rate be agreed upon by the agencies of 156cfs which was a change from the historical 43cfs. This volume was determined by a position paper released in 1992 by the Pennsylvania Department of Environmental Protection. Review of the environmental assessment determined that potential negative impacts associated with the project would not be significant.

2005: Environmental Assessment of Temporary Operations at F.E. Walter Dam & Reservoir: Temporarily raising the pool elevation from 1300' to 1335'

The 2005 Environmental Assessment determined that due to the previously disturbed nature of the area bordering the project and based on historical data for the project, that any negative effects to the environment are expected to be minor and temporary. Positive effects included increasing in-lake fishery habitat at the higher temporary pool, improved downstream water quality as a result of modified low flow fishery releases, and increased recreational opportunities as a result of more reliable whitewater release flows and schedules. The report further concluded that future evaluation and study may result in a more permanent change to operations at F.E.

Walter Dam & Reservoir. A finding of no significant adverse environmental impacts was reached.

2006: Environmental Assessment of Temporary Operations at F.E. Walter Dam & Reservoir: Temporarily raising the pool elevation from 1300' to 1365'

The 2006 Environmental Assessment determined that due to the previously disturbed nature of the area bordering the project and based on historical data for the project and experiences of the 2005 temporary operations plan success, that any negative effects to the environment are expected to be minor and temporary. Positive effects included increasing in-lake fishery habitat at the higher temporary pool, improved downstream water quality as a result of modified low flow fishery releases, and increased recreational opportunities as a result of more reliable whitewater release flows and schedules. These positive effects were expected to be incrementally greater than what was seen in 2005. The report further concluded that future evaluation and study may result in a more permanent change to operations at F.E. Walter Dam & Reservoir. A finding of no significant adverse environmental impacts was reached.

2008: Environmental Assessment of Temporary Operations at F.E. Walter Dam & Reservoir: Temporarily raising the pool elevation from 1300' to 1370'

The 2008 Environmental Assessment further evaluated raising the pool an additional 5 feet above 2006 and 2007 levels. It was determined that due to the previously disturbed nature of the area bordering the project and based on historical data, that any negative effects to the environment are expected to be minor and temporary. Positive effects included further increasing in-lake fishery habitat and providing a 5 foot pool fluctuation to enhance in lake fish spawning, improved downstream water quality as a result of modified release schedules and further preservation of in lake cool water, and increased recreational opportunities as a result of release and storage plans for whitewater releases downstream. The report further concluded that future evaluation and study may result in a more permanent change to operations at F.E. Walter Dam and Reservoir. A finding of no significant adverse environmental impacts was reached.

2009: Phase I- Temperature and Flow Model of F.E. Walter Dam & Reservoir and the Lehigh River: Evaluating the effects of changing the operational pool heights and release scenarios on the downstream fisheries conditions and recreational opportunities in the Lehigh River

In a follow up to the 2001 Section 22 water quality study, additional funding for water quality model development was secured under the Water Resources Development Act of 1974, Section 22, Planning Assistance to States authority. The model developed for this study is CE-QUAL-W2 Version 3, which is a two-dimensional hydrodynamic and water quality model for simulating surface water systems, including rivers, lakes, reservoirs, and estuaries. The U.S. Army Corps of Engineers' Engineer Research and Development Center (ERDC) developed the model for F.E. Walter Dam & Reservoir and 45 miles of the Lehigh River in cooperation with the Philadelphia District and the Commonwealth of Pennsylvania. The objective of the study was to model proposed operational scenarios at F.E. Walter Dam & Reservoir to enhance downstream and in-lake recreation and habitat. The Phase I study was focused on water temperatures and river flows.

2014: Phase II- Water Quality Model of F.E. Walter Dam & Reservoir and the Lehigh River: Evaluating the effects of changing operational pool heights and release scenarios on downstream fisheries conditions and recreational opportunities in the Lehigh River

In a follow up to the 2009 Phase I- F.E. Walter Dam & Reservoir and Lehigh River water quality model, additional funding for further development of the water quality model was secured under the Water Resources Development Act of 1974, Section 22, Planning Assistance to States authority. Phase II of the study focused on adding water quality and metal constituents to the existing model and the development of six new operational scenario runs. The U.S. Army Corps of Engineers' Engineer Research and Development Center updated the model and ran operational scenarios in cooperation with the Philadelphia District and the Commonwealth of Pennsylvania. A total of twelve operational scenarios were developed in cooperation with the angling and whitewater interests in the watershed along with the state agencies responsible for those recreational activities. Some of the model scenarios included modified operations under conceptual changes in pool elevations (depths) and operations utilizing existing authorizations, storage limits and dam and tower conditions. In addition, some of the scenarios included modified operations with conceptual changes in pool elevations (depths), authorizations, and storage and tower intake portal configurations. Model results showed, that under some of the model scenarios, changes or modifications in the dam structure, the operations, authorizations, and storage could positively benefit many miles of downstream water quality and recreation (whitewater rafting and angling) in the Lehigh River concurrently. Operating for one objective would not exclude benefits to the others.

Other Reports:

1975-2013: Annual Water Quality Sampling Reports for F.E. Walter Dam & Reservoir

1983: USGS Water Resource Investigation Report

2003: Categorical Exclusion for Francis E. Walter Dam and Reservoir Weir Repair

2003: Lehigh River Watershed Conservation Management Plan

2004: Categorical Exclusion for Francis E. Walter Dam and Reservoir Access Road Modification

2011: Final Environmental Assessment Forest Timber Management at F.E. Walter Dam and Reservoir

6. Existing Operation, Facilities, and Conditions

Current Operation

Current Operation for Whitewater Recreation

The current recreation plan has evolved over time with input from many agencies, outfitters and fishing interests to formulate a plan that attempts to maximize benefit to both fishing and boating interests throughout the recreation season. Current plans allow for a total of 24 whitewater releases spread throughout the season and fisheries augmentation releases every day that no whitewater is planned (based on hydrologic availability). Storage begins on/about 1 April with a target date of mid-May to reach elevation 1370 ft N.G.V.D. which is utilized as available to make releases thru mid-October at which time any remaining water would be released to return the pool to elevation 1300 ft. N.G.V.D. Flood control management needs will continue to take precedence over white water release accommodation but an attempt is made to adjust procedures for white water release purposes whenever possible under the current authorizations for the project.

Current operations address recreation within the limits of the authorization and physical limits of the dam. Recreation Operations Plans are developed annually with stakeholder input and approved as a planned deviation from the water control manual. Recreational demand has increased over time and future study is needed to investigate more permanent solutions to an annual recreation plan and evaluate future demands for services; evaluate existing infrastructure to support the current and future demand for services; and investigate opportunities to optimize operation to maximize benefits to current and future regional recreational needs. There is an opportunity to investigate modifying the current authorization to a higher pool level and/or structural modifications to allow for additional storage to improve existing whitewater recreation. The results from the CEQUAL-W2 water quality model completed for the project and Lehigh River showed that potential exists for significant water quality and recreational improvements (see Section 5 for details).

Current Operation for In-lake Recreation

Under the current regulation plan, the goal to maintain the pool elevation at elevation 1300 ft. N.G.V.D. in the winter months and at or near 1370 ft N.G.V.D. during the summer recreation season by regulating releases to equal inflow helps ensure in-lake recreation for boating and fishing and will keep the access road open for visitors to reach both picnic areas via the new road across the top of the dam. Fish are stocked in both the lake and below the dam by the Pennsylvania Fish and Boat Commission (Photograph 5). Lake boating is for non-power craft and power craft limited to 10 horsepower.

Current operations address recreation within the limits of the authorization and physical limits of the dam, but future study is needed to address increases in recreation use, and evaluate future demands for recreation services; evaluate existing infrastructure to support the current and future demand for services; and investigate opportunities to optimize operation to maximize benefits for current and future regional recreational needs. There is an opportunity to investigate modifying the current authorization to a higher pool level to maintain a stable pool and/or enhancing existing facilities, such as boat launches/ramps to improve in-lake recreation.

Current Operation for Fisheries

Since 2005, the District has worked in cooperation with State resource agencies to develop annual downstream release flow criteria that benefit the Lehigh River fishery and downstream aquatic resources.

The Pennsylvania Fish and Boat Commission stocks the reservoir area and the downstream Lehigh River channel three to four times a year with trout when the reservoir pool is at a higher elevation during the spring season (Photograph 5).



Photograph 5. Photograph of fish stocking in the F.E. Walter Dam & Reservoir.

Starting in 2005, increasing amounts of temporary storage have been provided to expand recreational fishing opportunities. The Pennsylvania Fish and Boat Commission works with the District to develop annual recreational plans. These plans contain recommendations on the best approaches to protect and improve the aquatic resources in the reservoir and downstream on the Lehigh River. The two primary goals include: creating optimal in-lake spawning areas in spring by limiting pool fluctuations to 5 feet during the May and June time period and maximizing cold water benefits in the Lehigh River during the summer months by augmenting flows to improve aquatic habitat availability and buffer higher summer river temperatures. Flood control management needs take precedence over fisheries management but the attempt is made to adjust operations whenever possible under the current authorizations for the project.

Current operations address recreation and fisheries needs within the limits of the authorization and physical limits of the dam. There is no authorized water quality storage and there are limited selective withdrawal capabilities. Future study is needed to address increases in recreation use, and evaluate future demands for recreation services; evaluate existing infrastructure to support the current and future demand for services; and investigate opportunities to optimize operation to maximize benefits for current and future regional recreational needs. Future study is also needed to identify ways to adequately address downstream water quality objectives using a combination of changes in authorization, operations, and structural modifications to maximize benefits for water quality and environmental conditions.

There are opportunities to investigate modifying the current authorization to a higher pool level to improve releases and/or structural modifications to allow for additional storage for existing tailwater fisheries, improve flow management for fish and wildlife resources, and/or add water quality storage and releases for “streamflow regulation” for fish and wildlife. The CEQUAL-W2 water quality model completed for the project and Lehigh River showed that potential exists for significant water quality and recreational improvements (see Section 5 for details).

Existing Public-Use Facilities

The recreational facilities at the F.E. Walter Dam and Reservoir project were developed in response to local pressure for recreational opportunities and, as a result, the type and magnitude of the facilities are not optimal. However, the area is heavily utilized for recreation and annual average visitation traffic counts from 1998-2013 were 321,299 vehicles. There are limited public-use facilities in and around the lake perimeter and there are opportunities for improvements. The existing facilities are as follows:

- Picnic Area #1 contains three picnic sites, two portable latrines, and parking space for five cars (elevation 1505ft N.G.V.D.).
- Picnic Area #2 contains ten picnic sites, two portable latrines and parking areas with a total of twenty-seven spaces (located at elevation 1420ft N.G.V.D).
- A pre-existing fire control access leads from the western side access road past a high point on the bluff to the northern Federal property line. An overlook has been provided on the high point and includes one picnic site and one thousand feet of access trail with selected vista clearing on the bluff above the impoundment.
- Although there is no existing boat ramp, the existing boat beach (mud/rock flat exposed at base pool operations) is adequate for boat launching because of its topography. Unfortunately, with flood produced rise in pool elevation of as little as six feet above normal, it becomes inundated and therefore unavailable.
- The downstream fishing site is located on the west bank downstream from the dam. There is no specific area designated for fishing, there are parking spaces for 25 vehicles for those using this area. The parking and boat launching area is available at pool elevation 1300 ft NGVD.
- Along the eastern bank, the trail which roughly parallels Cider Run tributary has a few picnic sites along its length. This is the only portion of the total 1.5 miles of existing trails that has any facilities other than the overlook on the west bank.
- A turn-around was constructed at approximately elevation 1390 ft. N.G.V.D. on the eastern approach of the lower road to facilitate boat launching from the road during higher pool elevations to accommodate recreational releases. In 2014, an expanded trailer and vehicle parking area was constructed in this area to meet public use demand.

There is an opportunity to investigate modifying the current authorization to a higher pool level to maintain a stable pool and/or enhancing existing facilities, such as boat launches/ramps to improve in-lake recreation. Current operations address recreation within the limits of the authorization and physical limits of the dam, but future study is needed to address increases in recreation use, and evaluate future demands for recreation services; evaluate existing infrastructure to support the current and future demand for services; and investigate opportunities to optimize operation to maximize benefits for current and future regional recreational needs.

Existing Conditions

Dam Safety

In 2006, the F.E. Walter Dam underwent a Screening for Portfolio Risk Analysis (SPRA) and the dam was classified as a “3” under the Dam Safety Action Classification (DSAC). This classification was the result of a combination of the potential for seepage and piping of embankment material into the right abutment and the associated level of downstream consequences. This potential failure mode was rated as “Probably Inadequate” for both the “Unusual and Extreme” hydrological loading conditions. In an effort to address this dam safety risk, the Philadelphia District conducted a grout curtain improvement program for the right abutment during December 2009 through May 2010. Assessments following the completion of the grouting program indicated an improved condition.

In 2012, the F.E. Walter Dam underwent a Periodic Assessment (PA). This assessment resulted in more in-depth evaluations of potential failure modes and risks than had occurred during the SPRA in 2006. As part of the PA, the DSAC for the dam and other structures are reviewed. Based on the more in-depth review, the classification of the main dam features were reduced from a DSAC 3 to a DSAC 4. All significant failure modes were judged to be sufficiently below tolerable risk guidelines.

Any future feasibility studies will ensure that the dam continues to provide flood risk management benefits to downstream communities. Recommendations will not have a negative impact on flood risk management benefits or the DSAC rating. Chapter 24 of ER 1110-2-1156, *Safety of Dams – Policy and Procedure*, states that a reallocation that would require raising the conservation pool is not permitted at a DSAC 1, 2, or 3 dam. Raising the conservation pool at a dam that is classified DSAC 4 will be considered by HQ USACE (USACE DSO and CECW-P) on a case by case basis. Reallocation reports that recommend pool raises must include review of the Potential Failure Mode Analysis (PFMA) for the dam and an analysis of the effects of a higher pool on the probability of failure and the consequences associated with the changed pool elevation.

Economics

In fiscal year 2014, flood control operations at F.E. Walter Dam and Reservoir prevented an estimated \$185,000 of damages downstream. Since the start of flood control operations at the reservoir in 1961 through fiscal year 2014, an estimated \$206,300,000 (September 2014 price levels) worth of cumulated damages have been prevented.

The Lehigh River is a popular destination water resource, which draws enthusiasts looking for a variety of angling experiences, white-water rafting opportunities and other outdoor recreation activities (hiking, biking, hunting, and sightseeing). From a regional perspective, annual reporting by the Pocono Mountains Visitor Bureau (2013) showed an estimated 25 million visitors to the four county areas, where the project is located, in 2013. This is 17 million more visitors to the region than what was seen in 2006 with visitor spending at \$2.4 billion. Water

based activities in 2012 alone accounted for \$13.85 million in economic impact in the Lehigh River regional area (Blockus G., 2013).

Recreational whitewater activities on the Lehigh River downstream of F.E. Walter Dam and Reservoir are directly affected by operations at the dam and have a direct effect on the local and regional economy. According to data collected by the Pennsylvania Department of Conservation and Natural Resources (D.M. Madl, Personal Communication, November 8th, 2013), commercial whitewater outfitter usage totals for the Pennsylvania Lehigh Gorge State Park located downstream of F.E. Walter Dam and Reservoir on the Lehigh River have averaged 56,535 users annually from 1986 through 2012. This does not take into account users further downstream and many private boaters not included in the monitoring data. A declining trend of whitewater rafting use was seen from 1986 (authorization for recreation occurred in 1988) through 2005 (beginning of temporary recreational operations plans at F.E. Walter Dam and Reservoir).

Since the implementation of temporary operations at F.E. Walter Dam and Reservoir (tailored to whitewater recreation and fishery enhancement) in 2005, whitewater outfitter use totals have raised dramatically. From 1986-2005, the average annual total was 50,072 recreational users. From 2006-2012, the average annual total was 75,000 recreational users with the top 5 annual usage totals for the 27 year period of record occurring between 2008 and 2012. In 2013 alone, one of the commercial outfitters downstream had 58,645 paying guests which correlate to over \$3.5 million in river sales with a conservative economic multiplier equating it to over a \$10 million impact in Carbon County alone. In addition, that single company employed 272 full and part time individuals in 2013 (P. Fogal, Personal Communication, December 16th, 2013).

The Pennsylvania Fish and Boat Commission conducted an angler use and harvest survey effort downstream of F.E. Walter Dam and Reservoir in 2006 (Pierce et. al, 2007). The goal of the survey was to determine the extent of angler use and harvest and the economic impact that occurs as a result of angling activity on Section 06 of the Lehigh River. Section 06 encompassed the tail waters of the Francis E. Walter Dam downstream 9.74 river miles to Sandy Run. This reach lies predominantly within the Pennsylvania Department of Conservation and Natural Resources Lehigh River Gorge State Park. The survey was also used to evaluate how modified temporary recreational flow release affects angler use.

Some of the findings of the survey include:

- Overall, the direct and secondary impacts of fishing on the White Haven and Frances E. Walter segments of the Lehigh River are estimated at \$293,613 in annual output, of which \$201,103 is value-added. From an employment standpoint, this translates into 6.0 jobs.
- Angler use and harvest, economic and job value ratings at the time of the survey reflect the fishery during the early development phases of the Lehigh River Flow Release plan started in 2005. The creel survey was conducted during the second year of flow modification with regard to hydrological management of outflows from the Francis E. Walter Dam for the enhancement of both fishing and boating recreational opportunities within Section 06. The plan was amended each successive year thereafter. The 2008 plan included a cap on releases for the first two weekends to maintain fishable flows (i.e., < 400 cfs outflow from Francis E. Walter Dam) through Section 06. Thus, angler behavior noted during the 2006 creel survey

would most likely reflect patterns more representative of flows prior to hydrological management plans than expected angler behaviors in the later years.

- Anglers utilizing the resource originated from the states of New Hampshire, New York, New Jersey, Virginia, Connecticut, Massachusetts, and Pennsylvania.

Current operations address recreation within the limits of the authorization and physical limits of the dam, but recreation use has increased and future study is needed to address increases in recreation use, evaluate future demands for recreation services; evaluate existing infrastructure to support the current and future demand for services; and investigate opportunities to optimize operation to maximize benefits for current and future regional recreational needs.

7. Plan Formulation

Problems and Opportunities

This report described the changing operation of the project over time and the District's historic and current attempts to meet watershed and regional needs within the constraints of the current congressional authorization and the physical limits of the dam and reservoir. A formal study is needed to evaluate these opportunities to better meet these needs and improve the sustainability the project.

The study would utilize collaborative planning efforts to examine how to better meet the needs associated with flood risk management, water quality, water supply, and recreation. The expected outcome of the study is an improved multi-purpose operational plan for F.E. Walter Dam and Reservoir along with recommended modifications to the existing infrastructure that would better support the project's congressionally authorized multi-purpose requirements and the evolving demands on the resources, both in-lake and downstream. The study would also evaluate whether the increases in the local economy described in Section 6 of this report would continue under the various alternatives.

The study would evaluate the current services provided by F.E. Walter Dam and Reservoir, including past and present operational plans; evaluate the existing demands for services from interested stakeholders, including flood control, water supply, water quality, and recreation; evaluate future demands for services; and evaluate existing infrastructure to support the current and future demand for services. The study will consider the Project's authorized purpose along with the public and environmental resource needs of the reservoir and Lehigh and Delaware River Basins. Table 3 summarizes considerations, problems and opportunities, and constraints that will be evaluated in a future Feasibility study.

Potential alternatives

Potential solutions include a combination of changes in authorization, operational changes, and structural modifications. There are many competing demands on the resource and these would be evaluated individually and collectively in a formal study.

Future without project conditions

If no additional study is performed, the operation will continue as authorized. Other needs such as water quality, water supply, and enhanced management for fisheries and recreation would not be evaluated.

Table 3. Considerations that will be evaluated in a future Feasibility Study

Considerations	Currently authorized at F.E. Walter?	Examples of Problems and Opportunities	Examples of Constraints	Path Forward/ Future Study
Flood Risk Management (FRM)	Yes (PL 79-526) ¹	Continue providing FRM to downstream communities.	Cannot have a negative impact to FRM benefits or decrease in DSAC rating.	Maintaining FRM benefits will be considered and evaluated in a future Feasibility Study.
Water Supply	Yes Temporary (PL 78-534) ¹ (See Section 4. Historic Operation for Drought)	WRRDA 14, Section 4001 provided authority to enter into an agreement with the Delaware River Basin Commission to provide temporary water supply and conservation storage at the Francis E. Walter Dam during a drought warning or drought emergency. Although this storage is not Municipal & Industrial or Agricultural Water Supply, it has been included in this category historically.	There is currently no agreement with DRBC for temporary water supply and conservation storage. Impacts to operation would need to be examined and there would be an incremental operating cost associated with providing the storage (water supply is 100% non-Federal). There is currently no watershed-wide multipurpose study that concludes that storage at F.E. Walter Reservoir is the best way to address watershed-wide water supply needs. If a water supply study only focuses on F.E. Walter, there may be different modifications recommended, as opposed to studying water supply in a watershed-wide context (considering the other reservoirs).	Need for a separate multipurpose watershed-wide study to address water supply, low flow augmentation, drought management, salinity control, and water quality issues. (See Section 9).

Considerations	Currently authorized at F.E. Walter?	Examples of Problems and Opportunities	Examples of Constraints	Path Forward/ Future Study
Water Quality	No	<p>Opportunity to add water quality storage and releases for “streamflow regulation” for fish and wildlife and the prevention of saltwater intrusion (to maintain the salt line in the Delaware Estuary) (ER 1105-2-100 App C, C-6, l., 2.a., page C-45)</p> <p>Compliance with Clean Water Act (CWA)</p>	<p>There is currently no water quality storage or authorization at the project. Constraints associated with operating for fish and wildlife in compliance with the CWA would have to be evaluated in future study.</p> <p>There is currently no watershed-wide multipurpose study that concludes that storage at F.E. Walter Reservoir is the best way to address saltwater intrusion. If a study to address saltwater intrusion only focuses on F.E. Walter, there may be different modifications recommended, as opposed to studying this issue in a watershed-wide context (considering the other reservoirs).</p>	<p>Improving water quality for fish and wildlife, specifically tailwater and inlake fisheries, will be evaluated with other alternatives in a future Feasibility Study.</p> <p>There is a need for a separate multipurpose watershed-wide study to address water supply, low flow augmentation, drought management, salinity control, and water quality issues. (See Section 9).</p>
Environmental considerations	Yes Fish and Wildlife Coordination Act (FWCA) 1958 requirement.	Opportunity to improve flow management for fish and wildlife resources.	Cannot have a negative impact on fish and wildlife resources. Constraints associated with operating for fish and wildlife in compliance with the FWCA would have to be evaluated in future Feasibility Study.	Consider improvements for fish and wildlife resources in a future Feasibility Study.

Considerations	Currently authorized at F.E. Walter?	Examples of Problems and Opportunities	Examples of Constraints	Path Forward/ Future Study
Recreation (whitewater)	Yes (PL 100-676) ¹	<p>Opportunity to investigate modifying the current authorization to a higher pool level and/or structural modifications to allow for additional storage to improve existing whitewater recreation.</p> <p>The CEQUAL-W2 water quality model completed for the project and Lehigh River showed that potential exists for significant water quality and recreational improvements.</p>	Cannot have a negative impact to whitewater recreation.	Improving whitewater recreation will be evaluated with other alternatives in a future Feasibility Study.

Considerations	Currently authorized at F.E. Walter?	Examples of Problems and Opportunities	Examples of Constraints	Path Forward/ Future Study
Recreation (tailwater fisheries)	Yes (PL 100-676) ¹	Opportunity to investigate modifying the current authorization to a higher pool level to improve releases and/or structural modifications to allow for additional storage for existing tailwater fisheries. The CEQUAL-W2 water quality model completed for the project and Lehigh River showed that potential exists for significant water quality and recreational improvements.	Cannot have a negative impact to tailwater fisheries.	Improving tailwater fisheries will be evaluated with other alternatives in a future Feasibility Study.
In-lake recreation	Yes (PL 100-676) ¹	Opportunity to investigate modifying the current authorization to a higher pool level to maintain a stable pool and/or enhancing existing facilities, such as boat launches/ramps to improve in-lake recreation.	Cannot have a negative impact to in-lake recreation.	Improving in-lake recreation will be evaluated with other alternatives in a future Feasibility Study.
Hydropower	No	A FERC preliminary permit exists for the study for hydropower development at the reservoir.	Hydropower is a 100% non Federal responsibility. No impact to FRM and minimal negative impact to recreation and fish and wildlife per the CWA and FWCA.	Keep hydropower option in mind when evaluating alternatives in a future Feasibility Study.

8. Views of Stakeholders and Resource Agencies

Since 2005, the U.S. Army Corps of Engineers has worked closely with the Pennsylvania Fish & Boat Commission, Pennsylvania Department of Conservation & Natural Resources (DCNR), and numerous stakeholders to develop the Francis E. Walter Dam Flow Management Plan each year. USACE Philadelphia District has hosted approximately 18 public meetings and received hundreds of formal public comments in addition to many more informal phone calls and verbal exchanges.

In October 2014, USACE hosted a public meeting in White Haven, PA with 42 participants from a wide variety of groups including public agencies such as Pennsylvania DCNR and Pennsylvania Fish & Boat Commission; non-profit groups such as Lehigh Coldwater Fisheries Alliance, Lehigh Valley Kayak Club, and Appalachian Mountain Club; and private entities such as Pocono Whitewater and Extreme Adventure Travel. These participants represent the interests of thousands of other recreational users. They provide feedback and recommendations on a variety of issues related to recreational water releases. Most of the stakeholders have a strong understanding of the Francis E. Walter Dam and have worked together in a principled and structured fashion to help create a balanced and equitable Flow Management Plan.

Several stakeholders have requested a formal investigation to determine the feasibility of pursuing changes to the congressionally authorized purposes and/or modifications to the dam itself to address these concerns. The Pennsylvania Fish and Boat Commission (PAFBC) requested that F.E. Walter Dam and Reservoir be operated more consistently to improve the downstream tailwater fishery. The PAFBC submitted a proposal to USACE Headquarters on December 1, 2014, pursuant to Section 7001 of WRRDA 14 requesting a Feasibility Study to evaluate the potential for the Francis E. Walter Dam on the Lehigh River to be a substantially greater asset in terms of aquatic resources and recreation to the Commonwealth, region, and nation. PAFBC specifically requested further study and implementation of the full reconstruction option identified in the Lehigh River Recreational Enhancement Study.

The Delaware River Basin Commission has expressed interest in optimizing storage to include water quality and low flow augmentation at F.E. Walter Dam and Reservoir. The New York City Department of Environmental Protection (NYCDEP) and Congressman Gibson requested that the District investigate whether F.E. Walter Dam and Reservoir could be used as an additional storage site to flush salt water from the Delaware River Estuary. They state that employing this concept would allow the NYCDEP the flexibility to deal with salt water intrusion and the requirement for equitable distribution downstream of all NYCDEP owned dams in the Upper Delaware River (Browne, 2014). The Philadelphia Water Department has also expressed interest in the use of storage at F.E. Walter Dam and Reservoir for low flow augmentation in the event of a drought as an additional storage site to flush salt water from the Delaware River Estuary. If a low flow augmentation study only focuses on F.E. Walter, there may be different modifications recommended, as opposed to studying low flow augmentation in a watershed-wide context (see Section 9).

The co-Chairs of the Delaware River Basin Task Force (Task Force), Representative Gibson, Representative Dent, and Representative Carney sent a letter to the Philadelphia District Commander on January 8, 2015 requesting that any study to optimize, expand, repurpose or reauthorize the storage volumes at F.E. Walter be shared with the Task Force and other key stakeholders. They also requested that any such reviews pay particular attention to local flood mitigation concerns, safe capacity optimization, and optimization of alternative uses of existing storage volumes to address down river water supply needs during drought and normal conditions as well as down river water supply needs to address flow management and salinity control concerns.

The potential sponsors are the Delaware River Basin Commission (DRBC), the State of Pennsylvania, and other interested stakeholders.

9. Future Study Requirements

The first step of the study process is identifying a cost-sharing non-Federal sponsor and beginning a cost-shared Feasibility Study to fully assess the need and potential alternatives in regard to current authorized uses and present and all future demands of the reservoir and the recommended changes needed to meet those demands.

A cost-shared Feasibility Study will evaluate the current services provided by F.E. Walter Dam and Reservoir, including past and present operational plans; evaluate the existing demands for services from interested stakeholders, including flood control, water supply, water quality and recreation; evaluate future demands for services; and evaluate existing infrastructure to support the current and future demand for services. The feasibility report would analyze whether proposed changes are sound from an engineering standpoint, environmentally acceptable, and economically justified.

There is also a need for a separate multipurpose watershed-wide study to address water supply, low flow augmentation, drought management, salinity control, and water quality. There is currently no watershed-wide multipurpose study that concludes that storage at F.E. Walter Reservoir is the best way to address watershed-wide water supply, low flow augmentation, drought management, salinity control, and water quality needs. If a water supply/low flow augmentation study only focuses on F.E. Walter, there may be different modifications recommended, as opposed to studying water supply/low flow augmentation in a watershed-wide context (considering the other reservoirs). The DRBC submitted a proposal to USACE Headquarters on December 3, 2014, pursuant to Section 7001 of WRRDA 14 requesting a study to optimize storage in the federal reservoirs in the Delaware Basin to meet and balance current and future needs including: flow management, low flow augmentation, water supply, flood loss reduction, drought management, salinity control, recreation and aquatic life support. DRBC also specifically requested that the study determine if existing storage volumes at F.E. Walter in combination with existing storage volumes in Beltzville and Blue Marsh can be more efficiently and effectively utilized and optimized to meet flow management objectives including management of salinity in the estuary. The co-Chairs of the Delaware River Basin Task Force (Task Force), Representative Gibson, Representative Dent, and Representative Carney sent a letter to the Philadelphia District Commander on January 8, 2015 supporting this proposal. This study could be completed using existing authority under Section 729 of WRDA 1986, as

amended, that allows USACE to conduct cost-shared watershed planning. The District will work with the DRBC and other stakeholders to implement this future study.

10. Conclusions/ Recommendations

This appraisal utilized only existing, readily-available data, and best professional judgment. This Initial Appraisal has shown that the initiation of a Feasibility Study is warranted.

The Lehigh River is a major tributary of the Delaware River in the northeast region of Pennsylvania supporting a diverse array of outdoor activities. This attraction provides annual and long term economic benefits to the region, state and local economy, and offers recreational opportunities for tens of thousands of people each year. In addition to recreational demand (angling and whitewater rafting) on the resource, other demands such as water quality, water supply and hydroelectric development interests persist. The Lehigh River downstream of F.E. Walter Dam and Reservoir is also used as a raw water supply for hundreds of thousands of watershed residents in riverside communities.

The water quality and ecology of the Lehigh River has improved dramatically since the authorization and construction of the Project (Appendix B). These improvements are the result of public awareness, environmental regulations (Clean Water Act and National Environmental Policy Act), and the efforts and actions of numerous Federal, State, Local government agencies and interests groups within and outside of the region. As a direct result of improved health, the demands on use of the Lehigh River and the F.E. Walter Dam and Reservoir have increased over the lifetime of the Project. The District has adapted operations to meet these demands when feasible within the framework of the project's congressional authorizations, physical constraints, and operational limits. The Districts' flexibility in meeting current watershed and regional demands has been constrained by congressional authorization, physical aspects of the dam and reservoir, and lack of water quality, water supply, and other in lake storage authorities other than flood control. There is potential for F.E. Walter Dam & Reservoir to play a more direct positive role in improving in-lake and downstream aquatic resources while providing greater operational flexibility in meeting in-lake and downstream recreational demands. However, in order to meet some of these scenario objectives, structural modifications, additional authority for storage and operation, and further study of regional existing and future demands is needed.

Based on the consideration of potential increased recreational benefits (rafting and fishing), in-lake and downstream aquatic system improvements, and economic benefits to the region, there is sufficient reason to further investigate the feasibility of changes in authorization, operation, and physical modifications of the project to better serve the public interest.

11. References

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Appendix A: Authorization Language

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1946 Flood Control Act
House Document 79-587

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Prosecution of plans,
etc.

Initiation of proj-
ects.

Installation of pen-
stocks, etc.

Provided, That the necessary plans, specifications, and preliminary work may be prosecuted on any project authorized in this Act with funds from appropriations heretofore or hereafter made for flood control so as to be ready for rapid inauguration of a construction program: *Provided further*, That the projects authorized herein shall be initiated as expeditiously and prosecuted as vigorously as may be consistent with budgetary requirements: *And provided further*, That penstocks and other similar facilities adapted to possible future use in the development of hydroelectric power shall be installed in any dam authorized in this Act for construction by the War Department when approved by the Secretary of War on the recommendation of the Chief of Engineers and the Federal Power Commission:

DELAWARE RIVER BASIN

Lehigh River, Pa.

The project for flood protection on the Lehigh River, Pennsylvania, is hereby authorized substantially in accordance with the recommendations of the Chief of Engineers in House Document Numbered 587, Seventy-ninth Congress, second session, at an estimated cost of \$12,471,000.

POTOMAC RIVER BASIN

Cumberland and
West Cumberland,
Md.; Ridgeley, W.
Va.

49 Stat. 1574.
33 U. S. C. § 701a
et seq.; Supp. V, § 701b
et seq.
Act, p. 641.

The local flood-protection project at Cumberland and West Cumberland, Maryland, and Ridgeley, West Virginia, authorized in the Flood Control Act approved June 22, 1936 (Public, Numbered 738, Seventy-fourth Congress), is hereby amended to provide for completion of the project substantially in accordance with plans on file in the Office of the Chief of Engineers at an estimated cost to the United States of \$7,420,000 and subject to the conditions of local cooperation prescribed for that project in the Act approved June 22, 1936, as modified, now estimated at \$1,520,000.

Waynesboro, Va.

The project for flood protection at Waynesboro, Virginia, on South River is hereby authorized substantially in accordance with the recommendations of the Chief of Engineers in House Document Numbered 622, Seventy-ninth Congress, second session, at an estimated cost of \$1,431,000.

Washington, D. C.
Supra.

The project for protection at Washington, District of Columbia, on Potomac River, authorized by the Act of June 22, 1936, is hereby modified substantially in accordance with the recommendations of the Chief of Engineers in House Document Numbered 622, Seventy-ninth Congress, second session, at an estimated cost of \$500,000.

Savage River Dam,
Md.

Completion of the Savage River Dam on Savage River, Maryland, is hereby authorized substantially in accordance with the plan contained in House Document Numbered 622, Seventy-ninth Congress, second session, at a cost to the United States now estimated at \$1,900,000, subject to the conditions that local interests make a cash contribution of \$200,000 toward the cost of the work, and agree to hold and save the United States free from damages due to the construction works, and to maintain and operate all the works after completion in accordance with regulations prescribed by the Secretary of War.

RAPPAHANNOCK RIVER BASIN

Salem Church Res-
ervoir, Va.

The project for the Salem Church Reservoir on Rappahannock River, Virginia, is hereby authorized substantially in accordance with the recommendations of the Chief of Engineers in his report dated April 8, 1946, at an estimated cost of \$17,755,000: *Provided*, That the power pool shall be maintained at an elevation not to exceed two hundred and twenty feet.

LEHIGH RIVER, PA.

LETTER

FROM

THE SECRETARY OF WAR

TRANSMITTING

A LETTER FROM THE CHIEF OF ENGINEERS, UNITED STATES ARMY, DATED JANUARY 31, 1946, SUBMITTING A REPORT, TOGETHER WITH ACCOMPANYING PAPERS AND ILLUSTRATIONS, ON A REVIEW OF THE REPORT ON THE DELAWARE RIVER AND ITS TRIBUTARIES SUBMITTED TO CONGRESS ON AUGUST 4, 1941, WITH A VIEW TO DETERMINING WHETHER RECOMMENDATIONS CONTAINED THEREIN FOR THE LEHIGH RIVER, ESPECIALLY AT BETHLEHEM, ALLENTOWN, AND EASTON, PA., SHOULD BE MODIFIED AT THIS TIME IN THE LIGHT OF RECENT FLOODS IN THAT AREA, REQUESTED BY A RESOLUTION OF THE COMMITTEE ON FLOOD CONTROL, HOUSE OF REPRESENTATIVES, ADOPTED ON OCTOBER 20, 1942



May 13, 1946.—Referred to the Committee on Flood Control and ordered to be printed with three illustrations

UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON : 1946

86822

IV

CONTENTS

LIST OF APPENDIXES MADE IN CONNECTION WITH THE REPORT OF THE DISTRICT ENGINEER

(Only pls. 12 and 13 of appendix II are printed)

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 - II. Section 1. Precipitation, run-off, and floods.
 - Section 2. Reservoir design.
 - Section 3. Detail data and estimates.
 - Section 4. Flood losses and flood-control benefits.
- Plate No.
 - 1. Isohyetal map—storm of May 20-23, 1942.
 - 2. Watershed isohyetal map—storm of May 20-23, 1942.
 - Plate No.
 - 3. Mass-rainfall curves—storm of May 20-23, 1942.
 - 4. Composite rainfall and run-off curves—storm of May 20-23, 1942.
 - 5. Watershed isohyetal maps of notable storms.
 - 6. Discharge hydrographs—storm of May 20-23, 1942.
 - 7. Gage-rating curves.
 - 8. Stream profiles—Easton to Mauch Chunk.
 - 9. May 1942 flood peaks in Delaware River watershed.
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 - 15. Lehigh River, Easton to Mauch Chunk, sheet 1.
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LETTER OF TRANSMITTAL

WAR DEPARTMENT,
Washington, May 7, 1946.

THE SPEAKER OF THE HOUSE OF REPRESENTATIVES.
Dear Mr. Speaker: I am transmitting herewith a report dated January 31, 1946, from the Chief of Engineers, United States Army, together with accompanying papers and illustrations, on a review of the report on the Delaware River and its tributaries submitted to Congress on August 4, 1941, with a view to determining whether recommendations contained therein for the Lehigh River, especially at Bethlehem, Allentown, and Easton, Pa., should be modified at this time in the light of recent floods in that area. This investigation was requested by a resolution of the Committee on Flood Control, House of Representatives, adopted on October 20, 1942.

In accordance with section 1 of Public Law 534, Seventy-eighth Congress, the proposed report of the Chief of Engineers was furnished the Governor of Pennsylvania. A copy of the report was also furnished the Chairman of the Federal Power Commission for comment. The views of the State of Pennsylvania and of the Federal Power Commission are enclosed.

The Bureau of the Budget advises that while there would be no objection to the submission of the report of the Chief of Engineers to Congress or to the authorization of the recommended improvements, the submission of any estimate of appropriation for their construction under existing economic conditions and under presently established public-works policies would not be in record with the program of the President. The complete views of the Bureau of the Budget are set forth in the enclosed communication.

ROBERT P. PATTERSON,
Secretary of War.

COMMENTS OF THE STATE OF PENNSYLVANIA

COMMONWEALTH OF PENNSYLVANIA,
GOVERNOR'S OFFICE,
Harrisburg, November 14, 1945.

Maj. Gen. THOMAS W. ROBINS,
Acting Chief of Engineers,
War Department, Washington 25, D. C.

DEAR GENERAL ROBINS: I acknowledge receipt of a copy of the proposed report of the Chief of Engineers on a review of the Lehigh River, Pa., for improvements in the vicinity of Bethlehem, Allentown, and Easton.

Our engineers have given careful consideration to this report, and upon their recommendation, I can assure you that, upon favorable

VI LETTER OF TRANSMITTAL

action by Congress, the Commonwealth of Pennsylvania is prepared to give the necessary assurances of cooperation and to meet its obligation of the costs and conditions which this report presents.

As requested in your letter of November 5, the report will be considered as "not for public release."

Very sincerely,

EDWARD MARTIN.

COMMENTS OF THE FEDERAL POWER COMMISSION

FEDERAL POWER COMMISSION,
Washington 25, D. C., January 25, 1946.

Lt. Gen. R. A. WHEELER,
Chief of Engineers, War Department,
Washington 25, D. C.

DEAR GENERAL WHEELER: There are transmitted herewith, in response to your letter of November 5, 1945, the comments of the Commission on your Department's report on Delaware River and tributaries—Lehigh River, Pa. The report of the district and division engineers with appendix II on a review of the Lehigh River P., was transmitted to the Commission on July 13, 1945, and that of the Board of Engineers for Rivers and Harbors on this investigation with your letter of November 5.

Your reporting officers and the Board recommend improvement of Lehigh River, Pa., for flood control by construction of Bear Creek Reservoir and local protection works at Allentown and Bethlehem at an estimated cost of \$12,471,000. The proposed dam below the mouth of Bear Creek would be an earth or rock fill structure 2,900 feet long and rising 233 feet above the valley floor, creating a reservoir of 110,000 acre-feet storage capacity below the spillway at elevation 1,450. The Bear Creek Reservoir would be used for flood control and would not contain penstocks for the future generation of power.

The Commission staff has studied the Lehigh River in the vicinity of the proposed Bear Creek Reservoir extensively over the past several years and, during the past 2 years, in cooperation with your district and division engineers in the consideration of the potentialities for the development of power in connection with improvements on this river.

The report of the district engineer covers only very briefly the possibilities for the development of power and the studies thereon which were made in collaboration with the Commission staff. The apparent attractiveness of the plan of development studied and the magnitude of the power which could be produced warrant a brief description here of the plan which was developed by the staff. Staff memoranda describing the plan in some detail and discussing its various features have been forwarded to the district engineer.

The plan includes the Bear Creek Reservoir, with the storage capacity proposed in your Department's report which would be used in conjunction with another reservoir immediately upstream from Bear Creek and just below the confluence of Lehigh River and Tobyhanna Creek. Part of the Bear Creek flood-control storage capacity would be transferred to Tobyhanna and used for conservation. Water thus stored in Bear Creek would be pumped into the conservation pool in

Tobyhanna through a lift of about 150 feet, using off-peak power for that purpose.

From Tobyhanna water would be conveyed by gravity through a tunnel to an intermediate reservoir on Mud Run, and from there to a regulating reservoir, on the lower Bear Creek, above a powerhouse near Mauch Chunk. The flow between Tobyhanna and the regulating reservoir would be practically continuous throughout the year, lending economy in tunnel sizes. A larger tunnel and conduit between the regulating reservoir and the surge tank would permit peaking operation, the capacity of the regulating reservoir being sufficient for that purpose.

The water would be conveyed from the surge tank to the powerhouse through three steel penstocks supplying three impulse-type water wheels direct connected to generators having an aggregate capacity of 150,000 kilowatts and operating under an average head of about 1,020 feet. On the average about 325,000,000 kilowatt-hours would be generated annually.

Preliminary estimates of cost show that the development described would be economic, the benefit-cost ratio being 1.22. The studies were made having consideration for mandatory releases of water for water supply and other purposes. The plan is also susceptible of modifications which might be required for the operation and use of storage for navigation and other purposes with no serious detriment to power values.

The district engineer reports that power could not be generated economically at the Bear Creek Dam and that provision for penstocks is not necessary. The Commission staff concurs in this conclusion and also with that of the district engineer that the Bear Creek project as proposed could be incorporated into the plan described for hydroelectric development of the Lehigh River.

The Commission agrees with these conclusions and recommends for your further consideration at such time as may be appropriate the plan suggested by its staff for hydroelectric development of the Lehigh River. Attached for your information is a copy of drawing¹ indicating the development.

Sincerely yours,

Leland Olds, *Chairman.*

COMMENTS OF THE BUREAU OF THE BUDGET

EXECUTIVE OFFICE OF THE PRESIDENT,
BUREAU OF THE BUDGET,
Washington 25, D. C., April 19, 1946.

The Honorable the Secretary of War.

(Through the Budget Officer for the War Department).

My Dear Mr. Secretary: This will acknowledge receipt of your letter, dated February 14, 1946, submitting the proposed report of the Chief of Engineers on the Delaware River and tributaries—Lehigh River, Pa., authorized by resolution of the Committee on Flood Control, House of Representatives, adopted October 20, 1942, and requesting information as to the relationship of the report to the program of the President.

¹ Not printed.

The Chief of Engineers recommends improvement of the Lehigh River, Pa., for flood control by construction of the Bear Creek Reservoir, and local protection works at Allentown and Bethlehem, at an estimated cost to the United States of \$12,471,000. In the accompanying reports, it is indicated that the cost estimates are based on 1940 prices and the benefits on normal industrial activity. The ratio of annual benefits to annual costs for the Bethlehem improvement, including allocated reservoir costs and benefits, is stated to be 0.93. At Allentown the comparable economic ratio is 0.91. For the over-all project, the ratio of benefits to costs is 1.03. In addition, intangible social and economic benefits are expected through the elimination of flood hazards.

The report indicates that the comprehensive plan of improvement of the Chief of Engineers as presented in the report, when considered as a whole, is economically justified by a margin of about 3 percent. The estimates for the local improvements at Allentown and Bethlehem show that these projects, by themselves, are not warranted. Since the estimates of total evaluable benefits for the combined project exceed the estimates of cost, it would appear that the improvement should be, in accordance with law, a Federal responsibility. However, since this is a marginal project, I would not expect that any estimates of appropriation for construction of these facilities would be submitted until (a) sufficient funds have been appropriated for accomplishment of other authorized improvements having greater economic justification, (b) adequate evidence has been presented warranting prosecution of the work on the basis of urgent social need, or (c) until expanded public-works programs are specifically initiated by the Federal Government for employment purposes.

In view of the above, you are advised that, while there would be no objection to the submission of the report of the Chief of Engineers to Congress or to the authorization of the recommended improvements, the submission of any estimate of appropriation for their construction under existing economic conditions and under presently established public-works policies, would not be in accord with the program of the President.

Very truly yours,

PAUL H. APPENBY,
Acting Director.

LEHIGH RIVER, PA.

WAR DEPARTMENT,
OFFICE OF THE CHIEF OF ENGINEERS,
Washington, January 31, 1946.

THE CHAIRMAN, COMMITTEE ON FLOOD CONTROL,
House of Representatives, Washington, D. C.

My Dear Mr. Chairman: 1. The Committee on Flood Control of the House of Representatives, by resolution adopted October 20, 1942, requested the Board of Engineers for Rivers and Harbors to review the report on the Delaware River and its tributaries submitted to Congress on August 4, 1941, with a view to determining whether recommendations contained therein for the Lehigh River, especially at Bethlehem, Allentown, and Easton, Pa., should be modified at this time in the light of recent floods in that area. I enclose the report of the Board in response thereto.

2. After full consideration of the reports secured from the district and division engineers, the Board recommends improvements of Lehigh River, Pa., for flood control by construction of Bear Creek Reservoir and local protection works at Allentown and Bethlehem substantially in accordance with the plan outlined in the report of the district engineer, and with such modifications thereof as in the discretion of the Secretary of War and the Chief of Engineers may be advisable, at an estimated cost of \$12,471,000 for construction, and \$10,000 annually for operation and maintenance of the dam and reservoir; provided that no money shall be expended on the construction of the local protection works in Allentown and Bethlehem until responsible local interests have given assurances satisfactory to the Secretary of War that they will provide without cost to the United States all lands, easements, and rights-of-way necessary for the construction of the improvement, hold and save the United States free from damages due to the construction works, and maintain and operate the works after completion in accordance with regulations prescribed by the Secretary of War.

3. After due consideration of these reports, I concur in the views and recommendations of the Board.

Very truly yours,

R. A. WHEELER,
Lieutenant General,
Chief of Engineers.

REPORT OF THE BOARD OF ENGINEERS FOR RIVERS AND HARBORS

WASHINGTON, October 16, 1946.

Subject: Delaware River and tributaries, Lehigh River, Pa.
To: The Chief of Engineers, United States Army.

1. This report is in response to the following resolution adopted October 20, 1942:

Resolved by the Committee on Flood Control, House of Representatives, That the Board of Engineers for Rivers and Harbors created under section 3 of the River

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LEHIGH RIVER, PA.

and Harbor Act approved June 13, 1902, be, and is hereby requested to review the report on the Delaware River and its tributaries submitted to Congress on August 4, 1941, with a view to determining whether recommendations contained therein for the Lehigh River, especially at Bethlehem, Allentown, and Easton, Pennsylvania, should be modified at this time in the light of recent floods in that area.

2. The Lehigh River, a tributary of the Delaware River, rises in Wayne County, Pa., flows southwesterly 33 miles to White Haven, thence southeasterly 54 miles to Allentown and thence 16 miles northwesterly to enter the Delaware River at Easton, Pa. The drainage area of 1,370 square miles embraces portions of nine counties in northeastern Pennsylvania. The headwater portion of the basin above White Haven, Pa., lies within the Appalachian Plateau, with elevations ranging from 1,500 to 2,000 feet above sea level and contains numerous lakes and swamps. The remainder lies within the Appalachian Valley province, where the course of the main river is in general transverse to the numerous steep mountain ridges. Tributaries of the Lehigh River are small streams, the largest, with drainage areas, being Little Lehigh Creek, 107.0 square miles; Aquashicola Creek, 81.2 square miles; Pohopoco Creek, 111.7 square miles; and Polythanna Creek, 128.3 square miles. The basin had a population of 393,000 in 1940, nearly half of which was concentrated in the 3 largest cities, Allentown, population 97,000; Bethlehem, population 58,300; and Easton, population 33,600. The lower part of the basin in Lehigh and Northampton Counties is highly developed both agriculturally and industrially, with most of the land devoted to raising farm and truck crops. Lehigh County is one of the most important cement-producing areas in the country, while Northampton County produces nearly half of the slate quarried in the United States. Large quantities of steel, textiles, ceramics, glass, paper, and food products are also manufactured. Monroe and Wayne Counties, in the upper part of the basin, are sparsely populated, the most important resources being game, fish, limestone, and sandstone, whereas Carbon and Luzerne Counties constitute the principal anthracite-producing center of the basin. There are no existing Federal projects for improvement of Lehigh River for navigation or flood control. Canalization of the river between the mouth and White Haven was completed by local interests in 1838 and served as an important artery of commerce for many years. However, water-borne traffic has now ceased. Twelve small dams in the basin are maintained principally to supply water for industrial purposes and for development of hydroelectric power at 14 small plants having a combined installed capacity of 2,064 horsepower. The basin is served by a network of railroads and highways.

3. The average annual precipitation on the Lehigh River watershed is 45.2 inches. The average annual snowfall is 45 inches. The region is subject to severe rainstorms which cause frequent flooding of portions of the trough-like valley. Flood problems are caused by Monocacy Creek drainage area 49.6 square miles, which flows through Bethlehem and enters the Lehigh River within the city; Jordan Creek, drainage area 81.0 square miles, which enters Little Lehigh Creek in Allentown, about $\frac{1}{2}$ mile above the mouth of the latter; Mauch Chunk Creek, drainage area 8.9 square miles, which flows through the town of Mauch Chunk in an inadequate, closed flume, about 5,000

feet in length; and Black Creek, drainage area 62.6 square miles, which flows through the town of Weatherly, located 5 miles above the mouth. Five outstanding floods have occurred since the beginning of reliable stream-flow records in 1902, of which the flood of May 1942 was the largest known in the basin. It inundated 2,800 acres of developed land, involving property valued at more than one-half billion dollars, disrupted all means of travel and communication, stopped all commerce, and caused estimated direct and indirect damages of \$11,800,000. Other serious floods occurred in 1933, 1935, and 1936. The average annual preventable flood damage in the entire basin is estimated at \$722,100.

4. Local interests desire that a comprehensive flood-control project be developed for the entire Lehigh River basin which will provide relief from damages caused by floods on the main stream, as well as on the tributaries. The Lehigh Valley Flood Control Council suggests construction of reservoirs in the upper reaches of the stream as the most economical means of accomplishing the purpose. The State of Pennsylvania proposes to establish the necessary floodways and to keep them free from encroachments or obstructions. No definite offers of local cooperation have been made, but the district engineer believes that such will be forthcoming.

5. The district engineer has investigated various means of providing the desired relief from flood damage. He finds that the most practical plan of improvement consists of (a) construction of a flood-control reservoir having a storage capacity of 110,000 acre-feet at spillway level, with the dam in Lehigh River below the mouth of Bear Creek; (b) local protection at Allentown by means of channel rectification and enlargement, and construction of a training dike levees, and incidental structures; and (c) local protection at Bethlehem by means of flood walls or levees with incidental structures and the necessary pumping plants, both on the main river and Monocacy Creek. The proposed dam below the mouth of Bear Creek would be an earth-or-rock-fill structure 2,900 feet long and rising 233 feet above the valley floor. A natural saddle $\frac{3}{4}$ mile from the right end of the dam would serve as the spillway, with crest elevation of 1,450 feet above sea level. The 110,000 acre-feet of storage capacity in the reservoir is equivalent to 7.2 inches of run-off from the 288 square miles of drainage area above the dam site. The estimated Federal and non-Federal first cost of the entire plan is \$12,471,000 and \$514,000, respectively. The total annual cost is estimated as \$572,000, including \$10,000 for operation and maintenance of the reservoir. The proposed improvement would eliminate the most serious flood damage along the river between the proposed dam and Easton, and would provide average annual tangible direct and indirect benefits of \$589,000, which gives a ratio of annual cost to benefits of 1.00 to 1.03. Resulting intangible benefits would materially improve the economic ratio. The major portion of flood damages at Easton is caused by floods on Delaware River and the district engineer finds that improvement for flood protection is not warranted at this time because of the high cost. The cost of protective measures at Mauch Chunk, Weatherly, and other damage centers is also much greater than warranted by the resulting benefits.

6. The district engineer recommends authorization of a flood-control project for Lehigh River, Pa., consisting of a reservoir formed by

a dam on the main river below the mouth of Bear Creek, and local protective works in Allentown and Bethlehem, substantially as described in his report, with such modifications as may be advisable in the discretion of the Secretary of War and the Chief of Engineers, at an estimated first cost to the United States of \$12,471,000, with \$10,000 annually for maintenance and operation of the reservoir; provided that responsible local interests give assurances satisfactory to the Secretary of War, regarding the local improvements, that they will provide without cost to the United States all lands, easements, and rights-of-way necessary for their construction, hold and save the United States free from damages due to the construction of these works, and maintain and operate them after completion in accordance with regulations prescribed by the Secretary of War. The division engineer concurs.

7. Local interests were advised as to the conclusions of the division engineer and were invited to submit additional data to the Board of Engineers for Rivers and Harbors. The Board has given careful consideration to the views expressed by local interests in communications received.

VIEWS AND RECOMMENDATIONS OF THE BOARD OF ENGINEERS FOR RIVERS AND HARBORS

8. The Board of Engineers for Rivers and Harbors has carefully considered the reports of the district and division engineers and the data submitted by local interests. It finds that there is urgent need for improvements to protect the communities, commerce, and industry along the Lehigh River from recurring flood damage which is becoming more serious from year to year. The proposed Bear Creek Reservoir would materially reduce damage from floods along the Lehigh River between the proposed dam and Easton. The local protection works at Allentown and Bethlehem would greatly reduce residual flood damages at Allentown and would provide complete protection for practically all of Bethlehem from floods up to one 20 percent greater than that of 1942. The cost of the improvement is warranted by the estimated resulting tangible direct and indirect benefits. Improvements for flood control at Easton and other damage centers are not warranted at this time.

9. The Board recommends improvement of Lehigh River, Pa., for flood control by construction of Bear Creek Reservoir and local protection works at Allentown and Bethlehem substantially in accordance with the plan outlined in the report of the district engineer, and with such modifications thereof as in the discretion of the Secretary of War and the Chief of Engineers may be advisable, at an estimated cost of \$12,471,000 for construction, and \$10,000 annually for operation and maintenance of the dam and reservoir; provided that no money shall be expended on the construction of the local protection works in Allentown and Bethlehem until responsible local interests have given assurances satisfactory to the Secretary of War that they will provide without cost to the United States all lands, easements, and rights-of-way necessary for the construction of the improvements, and hold and save the United States free from damages due to the con-

struction works, and maintain and operate the works after completion in accordance with regulations prescribed by the Secretary of War.

For the Board:

THOMAS M. ROBINS,
Major General,
Senior Member.

REVIEW REPORT ON LEHIGH RIVER, PA.

SYLLABUS

The Lehigh River, a tributary of the Delaware River in eastern Pennsylvania, is subject to recurring, disastrous floods that rise suddenly and jeopardize the lives, property, and social security of the valley inhabitants.

The district engineer finds that the construction of a flood-control reservoir on the upper Lehigh is feasible and will afford substantial protection to flooded areas along Lehigh River. He recommends this construction, and in addition, channel improvements at Allentown and protective works at Bethlehem. Local works to supplement the protection of the reservoir at other places are not found economically justifiable at this time.

The cost of the entire recommended project is \$12,985,000, of which \$514,000 is the cost of rights-of-way for local improvements and of alterations to existing utilities. The ratio of annual benefits to annual costs is 1.03 to 1.

UNITED STATES ENGINEER OFFICE,
Philadelphia, Pa., November 15, 1944.

Subject: Review of flood control report on Delaware River and its tributaries (Lehigh River), Pa.
To: The Chief of Engineers, United States Army (through the division engineer, North Atlantic division).

AUTHORITY

1. This review report is submitted in response to the following resolution adopted October 20, 1942:

Resolved, by the Committee on Flood Control, House of Representatives, That the Board of Engineers for Rivers and Harbors created under section 3 of the River and Harbor Act approved June 13, 1902, be, and is hereby requested to review the report on the Delaware River and its tributaries submitted to Congress on August 4, 1941, with a view to determining whether recommendations contained therein for the Lehigh River, especially at Bethlehem, Allentown, and Easton, Pennsylvania, should be modified at this time in light of recent floods in that area.

2. *Scope.*—This report of survey scope presents the results of a detailed investigation respecting flood control on that portion of the Delaware River watershed which is drained by the Lehigh River. It reviews the recommendations in a previous report in the light of the flood of 1942. It shows the measure of protection which can be secured by the construction of a reservoir and local improvements and the results which may be expected therefrom.

PRIOR REPORTS

3. Prior reports that gave consideration to control of floods on Delaware River and its tributaries are listed in Table 1. Four of

these reports that are relevant to a study of floods on the Lehigh River watershed are here summarized:

(a) House Document No. 245, Seventy-second Congress, first session, is a survey report on Lehigh River, Pa., authorized by section 1 of the River and Harbor Act approved January 21, 1927, in accordance with the provisions of House Document No. 308, Sixty-ninth Congress, first session, and was submitted to Congress February 4, 1932. After review of the report by the Board of Engineers for Rivers and Harbors, the Chief of Engineers concurred in the recommendation that no improvement of Lehigh River for navigation, power development, flood control, irrigation, or any combination thereof, was justified at that time.

(b) House Document No. 179, Seventy-third Congress, second session, is a survey report on the Delaware River watershed above Trenton, N. J., authorized by section 1 of the River and Harbor Act approved January 21, 1927, in accordance with the provisions of House Document No. 308, Sixty-ninth Congress, first session, and was submitted to Congress October 9, 1933. After review of the report by the Board of Engineers for Rivers and Harbors, the Chief of Engineers concurred in the finding that no improvement of Delaware River for navigation, except as authorized by existing projects, or that had been recommended to Congress, was advisable, and that no improvement for navigation, power development, flood control, irrigation, water supply, or any combination thereof, should be undertaken at that time.

(c) A report on preliminary examination of Delaware River made in accordance with authorizations in Public No. 468, Seventy-fourth Congress, second session, Public No. 738, Seventy-fourth Congress, second session, and Public No. 406, Seventy-fifth Congress, first session, found that sufficient data on Delaware River were already available to indicate that it was not possible to justify the construction of a general system of reservoirs, either for flood control alone or for flood control in conjunction with power and water-supply developments; but that there was a possibility of providing local protection for certain localities at a cost commensurate with the benefits to be expected. After review of the report by the Board of Engineers for Rivers and Harbors, the Chief of Engineers, on June 11, 1938, directed a survey to determine the degree and extent of local protection that could be provided economically.

(d) The latest prior report, submitted to Congress August 4, 1941, is the report under review. It was made under the directive issued by the Chief of Engineers on June 11, 1938, cited in (c) above. This report presented a survey of the Delaware River watershed, made for the purpose of determining the need and justification for control of floods in that basin. After review of the report by the Board of Engineers for Rivers and Harbors, the Chief of Engineers found that floods in the Delaware River Basin are relatively infrequent, but cause substantial damage; that flood losses are widely distributed throughout the watershed, and comprehensive measures for their prevention would be very costly; and that protection for certain urban areas could be provided by dikes and flood walls, but the cost of such works would be excessive. It was reported, accordingly, that construction of works for flood protection in the Delaware River watershed, exclusive of the basins of Schuylkill River, Pottest River, and Hancock Creek, which were reported upon separately, was not advisable at that time.

DESCRIPTION

4. The watershed of Lehigh River is portrayed in geographic and topographic detail on United States Geological Survey quadrangle sheets for Pennsylvania as follows: Allentown, Ariel, Boyertown, Easton, Hamburg, Hazleton, Mauch Chunk, Pecono, Scranton, Slatington, Stoddardsville, Wilkes-Barre, and Wind Gap. Aerial photographs of the Lehigh Valley are available in files of the Agricultural Adjustment Administration, United States Department of Agriculture, at a scale of 1:12,500. Plates 1 and 2 of this report are an index map and a watershed map, respectively.

5. Lehigh River drains an area of 1,370 square miles in the northeastern part of Pennsylvania, embracing portions of Wayne, Lackawanna, Monroe, Luzerne, Carbon, Schuylkill, Berks, Northampton and Lehigh Counties. It has its source in southwestern Wayne County, and flows southwesterly for 33 miles to White Haven, forming the boundary of Lackawanna and Luzerne Counties to the northwest and Monroe and Carbon Counties to the southeast; thence 50 miles southeasterly in an irregular course, through Carbon and between Northampton and Lehigh Counties, to Catasauqua; thence 4 miles southeasterly into Lehigh County to Allentown; thence 5 miles northerly, into Northampton County to Bethlehem, thence 11 miles northeasterly in Northampton County to Delaware River at Easton. The total length is 103 miles and the watershed comprises one-quarter of the Delaware River drainage area above Easton.

6. The Lehigh Basin lies within two physiographic provinces. The northernmost, known as the Appalachian Plateau province, contains that portion of the watershed above White Haven. This region is glaciated and contains numerous lakes and swamps at 1,500 to 2,000 feet above sea level. Below White Haven the basin lies within the Appalachian Valley province, which is recognized as consisting of two sections, the ridge and valley section and the Appalachian Valley section. The ridge and valley section, which adjoins the plateau province, is a broad band of long narrow ridges and intermontane valleys whose axes lie in a northeast-southwest direction, transverse to the general course of the river. The ridges and steep slopes are moderately wooded. Elevations of the terrain range from 400 to 1,400 feet above sea level. The southernmost ridge, Blue Mountain, is cut by the river at Lehigh Gap. The Appalachian Valley section, of broad rolling terrain, extends northeast to the mouth of the Lehigh at Easton, on Delaware River, and to the southwest across Pennsylvania.

7. Geological formations in the mountainous regions are predominantly shale and sandstone. Rich deposits of anthracite occur in Luzerne, Carbon, and Schuylkill Counties. In the Appalachian Valley section, the stream first enters a slate formation, which is extensively quarried; thence it traverses a limestone formation which is especially adapted to the manufacture of cement.

TABLE 1.—Prior reports on Delaware River connected pertaining to flood control

Locality	Authority	Reports		Surveys		Chief of Engineers		Compendious documents		When published	
		Date of report	Special examination	Date of report	Special examination	Date of report	Special examination	No. of sheets	Year	Year	Page
Northampton and Delaware Rivers, N. Y.	River and Harbor Act of March 3, 1897	Apr. 20, 1907	Feasibility	Mar. 20, 1908	Not made	Dec. 5, 1908	Feasibility	114	6th, 2d, 1st	1908	150
Lehigh River, Pa.	Act of June 22, 1902	Sept. 21, 1903	Feasibility	Sept. 21, 1903	Not made	Feb. 4, 1904	Feasibility	212	7th, 1st, 1st	1907	187
Delaware River (Lower Division, N. J.)	Act of June 22, 1902	Jan. 27, 1903	Feasibility	Mar. 20, 1908	Not made	Apr. 20, 1908	Feasibility	131	7th, 2d, 1st	1907	123
Delaware River (Upper Division, N. J.)	Act of June 22, 1902	Jan. 27, 1903	Feasibility	Mar. 20, 1908	Not made	Apr. 20, 1908	Feasibility	0		1907	22
Delaware River, Tidewater Division, N. J.	Act of June 22, 1902	Nov. 20, 1903	Feasibility	Mar. 20, 1908	Not made	Apr. 20, 1908	Feasibility			1907	142
Delaware River (Lower Division, N. J.)	Act of June 22, 1902	Nov. 20, 1903	Feasibility	Mar. 20, 1908	Not made	Apr. 20, 1908	Feasibility			1908	28
Delaware River and its tributaries as far as the State of Pennsylvania, Pa.	Act of June 22, 1902	Feb. 28, 1904	Feasibility	Mar. 20, 1908	Not made	Apr. 20, 1908	Feasibility			1907	142
Delaware River (Lower Division, N. J.)	Act of June 22, 1902	Feb. 28, 1904	Feasibility	Mar. 20, 1908	Not made	Apr. 20, 1908	Feasibility			1907	142

1. River and Harbor Act of June 22, 1902, authorized the War Department to study the problem of flood control on the Delaware River and its tributaries in the State of Pennsylvania, Pa. The authorization was not made until June 1, 1903, when the War Department issued a report on the subject. The report was published in the form of a pamphlet, "Report on the Delaware River and its Tributaries in the State of Pennsylvania, Pa., for Application in Connection with Power Development," and was distributed to the States of New Jersey, New York, and Pennsylvania. The report was published in the form of a pamphlet, "Report on the Delaware River and its Tributaries in the State of Pennsylvania, Pa., for Application in Connection with Power Development," and was distributed to the States of New Jersey, New York, and Pennsylvania. The report was published in the form of a pamphlet, "Report on the Delaware River and its Tributaries in the State of Pennsylvania, Pa., for Application in Connection with Power Development," and was distributed to the States of New Jersey, New York, and Pennsylvania.

LEHIGH RIVER, PA.

8. In the upper part of the watershed the effects of glacial action are marked in the smoothing down of summits, the scouring of valley walls, and the deep accumulation of rock waste at irregular intervals. The course, erosion-resisting glacial deposits have frequently interrupted the preglacial drainage channels, forming ponds and some overflowed land and marshland. The river has eroded its channel progressively deeper from its source to its exit from the mountains at Lehigh Gap. From White Haven to Mauch Chunk, a distance of 30 miles, it flows through a gorge and rapids are frequent. The steep gradients of the river bed and the narrow gorges indicate that the formations resist erosion to an extent that has prevented the river from carving its channel to full maturity. The river has not developed waterfalls for the reason that the rock formations in its bed do not present sufficient variation in hardness. Nearly all outcrops are limestone, sandstone, and metamorphosed strata. Below Lehigh Gap, the subterranean structure is cavernous where soluble limestone deposits were disintegrated by ground-water flow. Existence of the cavities is manifested during low flows by dry reaches in the river's tributaries.

9. Gradients in the main stem of the river average 26.2 feet per mile above White Haven (32 miles), 17.8 feet per mile for 54 miles between White Haven and Allentown, and 4.1 feet per mile for 17 miles from Allentown to the mouth. The total fall in 103 miles from the source at elevation 2,050 feet to the mouth at 160 feet above sea level is 1,890 feet. Slopes in the tributary streams average 50 feet per mile.

10. The river has high and rocky banks in the upper courses; drainage into the streams is rapid, and in consequence the streams are subject to sudden rises. The river bed is rock throughout most of its length and in places is covered by a thin layer of drift. In the early part of the nineteenth century the river was improved by the construction of dams, locks, and canal channels as a private enterprise, primarily for the transportation of lumber from the headwaters and anthracite from Mauch Chunk to Delaware River at Easton and thence to tidewater. In the lower courses, some of the pools above the navigation dams have accumulated silt and fine anthracite to such an extent that the canal operators have found it profitable to dredge and recover anthracite fines for marketing.

11. The width of the river channel generally increases progressively downstream to Allentown; from that point to its mouth at Easton it varies irregularly from 200 to 500 feet. The maximum depth in the pools above the dams is approximately 10 feet at normal stages. The discharge of the river varies from an average of 450 cubic feet per second in April. The channel-flow capacities, in cubic feet per second, at seven points between the mouth and Mauch Chunk are: At Easton, 24,000; at Bethlehem, 34,000; at Allentown, 28,000; at Northampton, 23,000; at Palmerton, 48,000; at Lehighton, 13,000; and at Mauch Chunk, 39,000.

12. Data on the 15 principal tributaries of Lehigh River are tabulated below:

Stream	Enters river miles above mouth	Drainage area	Length	Elevation at source	Elevation at mouth
Sasson Creek	10.2	68.2	18.0	710	206
Little Lehigh Creek	16.2	107.0	24.0	830	224
Jordan Creek	31.0	81.0	22.0	740	228
Hockanigua Creek	22.0	42.6	15.0	790	232
Aquashicola Creek	26.7	81.2	22.5	1,300	339
Northampton Creek	40.5	101.7	28.0	1,820	413
Pohopoco Creek	40.8	57.3	14.0	1,640	480
Mauch Chunk Creek	42.1	8.0	8.0	1,120	517
Nequehoning Creek	46.5	8.0	13.0	1,440	568
Black Creek	48.4	62.6	14.6	1,720	704
Bear Creek	67.6	50.2	13.0	2,020	729
Tobyhanna Creek	83.5	128.3	22.0	2,680	1,410

Four of the tributaries contributing to local flood problems are as follows: Monocacy Creek, which flows through the city of Bethlehem and joins the Lehigh after passing under the Lehigh Navigation Co.'s canal; Jordan Creek, which joins Little Lehigh Creek in the city of Allentown about 3/4 mile above its confluence with Lehigh River; Mauch Chunk Creek, the flow of which is carried under the town of Mauch Chunk for a distance of 5,000 feet above the junction of the creek with the Lehigh; and Black Creek, which flows through the town of Weatherly 5 miles above its mouth, in the right bank of Lehigh River about 8 miles above Mauch Chunk.

13. In respect to its drainage pattern, the Lehigh watershed consists of contrasting areas which differ in their run-off characteristics. In the area that lies downstream from Lehigh Gap, and comprises one-third, or more, of the entire watershed, the stream channels and basin surfaces have moderate slopes and correspondingly moderate rate of run-off. Between Lehigh Gap and the vicinity of Mauch Chunk is an area composed of ridges and valleys extending entirely across the watershed and drained by four principal tributaries, viz. Aquashicola and Pohopoco Creeks, which enter from the northeast; with Lizard and Mahoning Creeks which enter from the southwest. The watersheds of the streams that enter from the southwest are much smaller and shorter in extent than those which enter from the northeast. The tributaries in this area are characterized by moderate slopes in their main channels and steep slopes in the basin surfaces and in the channels of their feeders and headwater streams. Upstream from the ridge and valley area lies the southeastern escarpment of the Appalachian Plateau, on which the terrain and the stream channels, including Bear Creek Basin, slope steeply and deliver the run-off rapidly. On the plateau penneplain which is drained by Tobyhanna Creek and the extreme upper part of the main stem of Lehigh River, slopes are moderate and there are many ponds and swamps, conducive to slow run-off.

14. The climate in the area drained by Lehigh River is typical of the northern Appalachian highlands. The mean annual temperature is approximately 47° F., varying from 103° to -21°. Mean

summer and winter temperatures are approximately 68° F. and 25° F., respectively. The prevailing winds are from the northwest in winter and west in summer. Thunderstorm winds reach high velocities and occasionally cause considerable local damage to standing field crops.

15. Additional climatological data from records of dispersed stations are tabulated below.

Station	Length of record	Highest temperature	Lowest temperature	Average annual temperature	Days above 90°	Days below 32°	Average growing season	Approximate date of latest killing frost	Approximate date of earliest killing frost
Easton	Year 25	° F. 105	° F. -16	° F. 52.7	48.9	134	186	May 9	Sept. 11
Northampton	Year 39	° F. 104	° F. -20	° F. 48.9	48.9	134	186	May 25	Sept. 8
Mount Pocono	Year 25	° F. 103	° F. -35	° F. 44.4	12	180	128	June 17	Sept. 4

ECONOMIC DEVELOPMENT

16. Occupation and industrial development in the Lehigh watershed have been influenced strongly by the physiographic and geological characteristics of the area. Early growth in the valley resulted from the development of its many natural resources in combination with the canalization of the river to transport finished products. With the advent of railroads, this growth was accelerated and expansion has been continuous to reach the present high state of development. A wide diversity is found between the upper watershed areas that lie in the Appalachian Plateau and the ridge and valley section, and the lower watershed areas that lie in the Appalachian Valley section.

17. In the upper watershed the arable lands are mostly in small scattered areas. The eastern part, in Monroe and Wayne Counties, is rugged, sparsely populated, and wooded with small mixed growth. Game and fish abound. Its mineral resources are sandstone and limestone. The western part, in Carbon and Luzerne Counties, is mountainous; only one-seventh of the area is susceptible of cultivation, and agriculture is of minor importance. This is the anthracite-producing area of the Lehigh Basin. Its mineral resources also include sand and gravel, stone used in the construction industry, and shale used in producing bricks.

18. The lower watershed areas in the Appalachian Valley section are largely agricultural lands of high quality, intensively worked for farm and truck crops. The chief mineral resource in Lehigh County is limestone which is valuable for numerous industrial purposes, but is used mainly in the manufacture of cement. This locality has become one of the most prominent cement-producing areas in the country. It is also noteworthy that Northampton County produces nearly half the slate quarried in the United States. Iron ore, which once was a basic resource, is now unimportant.

19. The upper watershed areas, with rugged terrain, have not been developed industrially as in the case of the lower Lehigh Valley. Nearly one-half the population of the basin is concentrated in the cities of Allentown, Bethlehem, and Easton, which are the industrial

centers of the basin and are all situated on the river within 16 miles of its mouth. The population of the watershed, as shown by census data, was approximately 206,000 in 1910, 329,000 in 1920, 384,000 in 1930, and 393,000 in 1940.

20. Pertinent data on the cities of Allentown, Bethlehem, and Easton are given in the following tabulation:

	Allentown	Bethlehem	Easton
Area	17 square miles	18	33.89
Population	86,004	88,400	33,897
Banks	31	31	31
Income tax returns, 1940	\$54,835,000	\$12,796,000	\$30,790,000
Income tax returns, 1940	12,533	11,497	7,068
Hotel sales, 1939	\$48,880,000	\$21,737,000	\$30,460,000

21. Other communities in the watershed that had populations of more than 2,500 in 1940 are as follows:

	Population	Population	
Hazleton	38,009	Stakington	4,062
Northampton	9,622	Bethlehem	88,400
Palmerton	7,475	Fullerton	4,031
Lehighon	6,615	Manch Chunk	3,076
Catsasquaga	4,764	Weatherly	2,754

22. The population, industrial, and agricultural statistics of the Lehigh watershed for the year 1940, which is considered a normal year, are shown in table 2.

TABLE 2.—Normal economic data, Lehigh River watershed, 1940

Population	392,704
Employees, industrial and manufacturing	77,638
Wages, industrial and manufacturing	\$94,306,400
Value of products	\$301,026,500
Number of farms	6,027
Total acreage of farms	362,132
Value of crops	\$6,270,400
Value of dairy products	\$2,001,600
Value of livestock	\$2,986,137

23. Cement and steel production are the prominent basic industries of the lower Lehigh Basin. Other activities of importance include the production of textiles, miscellaneous metal products, ceramics, glass, paper, and food products, and the quarrying of limestone and slate.

24. Initial use of anthracite early in the nineteenth century, and subsequent increase in demand for this fuel, led to the development of the Lehigh Navigation Canal as a means for transportation down the river to Easton, where it connected with the Pennsylvania Canal (Delaware division) that paralleled Delaware River downstream to tide-water. The canal was put in operation from March Chunk to Easton in 1829, and from White Haven in 1838. The transportation facility thus provided was a cogent factor in the early industrial development of the Lehigh Valley. Eventually the demand that accompanied expansion of anthracite mining and other industries exceeded the capacity of the waterway, and this means of transportation was supplemented by a railroad on each bank of the river. As the rail lines took over the burden of transportation, traffic on the canal

declined, and now has ceased. The only portions that are now usable are from Weissport to Downstown, from Treichlers to Bethlehem, and through the terminal reach at Easton. The Pennsylvania Canal which connected with tidewater in Delaware River is completely closed in its lower courses.

25. There are 12 dams in Lehigh River, 10 of which are owned by the Lehigh Coal & Navigation Co.; and 2 by industrial plants which depend on the pools for their water supply. These dams are maintained in a reasonably good state of repair. The pools of the Lehigh Coal & Navigation Co. serve chiefly to supply water for industrial operations and for the development of power by 14 minor installations. The total power developed is reported as 2,054 horsepower. There is no other hydro power in the Lehigh Basin. Most of the water drawn from the river for industries and for power production is returned to the stream within a short distance from the point of diversion. The Lehigh Coal & Navigation Co. has been engaged in recent years in the recovery of small sizes of anthracite from their pools below Mauch Chunk by dredging. This anthracite has been washed down the tributaries which drain the mining areas. The average quantity recovered from 1933 to 1941 was 75,000 tons annually. In 1934, which is the maximum year reported, the recovery was approximately 117,000 tons.

26. The western part of the Lehigh River Basin, above Mauch Chunk, contains the northeastern extremity of the coal measures known as the southern anthracite field, most of which lies within the watersheds of the Schuylkill and Susquehanna Rivers. The number of mining operations and their output vary under the influence of labor conditions and the demand for this fuel. With the increased demand occasioned by wartime conditions the output has been unusually high, and in marked contrast to the steady decline in production that had been in evidence through more than 10 years prior to 1939. In 1943 the output was approximately 3,500,000 tons, which was approximately 6 percent of the entire output of Pennsylvania anthracite. At prevailing market prices it had a value of approximately \$20,000,000 on board cars at the breakers. The anthracite industry in the Lehigh Basin is of major economic importance in the Mauch Chunk locality. Elsewhere in the basin it is of interest as a readily accessible source of domestic heating fuel.

27. The Lehigh Basin is served by a comprehensive net of rail lines, principally those of the Central Railroad of New Jersey and the Lehigh Valley Railroad, that give excellent service both as to branch-line and trunk-line movements of the products of industry. Both railroad and bus-line transportation for passengers is available. The area is well covered by a highway network that provides for local communication and for connection with outside areas by State and Federal routes.

PRECIPITATION

28. The eastern Pennsylvania area that is drained by Delaware River and its tributaries receives an average annual precipitation of approximately 45 inches. Precipitation in amounts greater than 7 inches in 24 hours has been recorded on several occasions at individual gauging stations. The snowfall is moderately heavy, averaging 45 inches a year in the area that is drained by Lehigh River. The snow-

fall in the headwaters area is considerably heavier than in the lower portion of the watershed. This is indicated by the Weather Bureau snowfall records for the period 1926-43 (table 2; appendix II) which show an average snowfall of 54 inches at Bethlehem in the headwaters, as compared with 25 inches at Bethlehem in the lower basin.

29. United States Weather Bureau data on rainfall that are pertinent to a study of the Lehigh River watershed are recorded at 20 stations within or adjacent to the watershed. List of rainfall stations is shown in table 1 of appendix II. The annual average precipitation over the watershed, derived from the records of 9 selected stations each having more than 25 years of record, is 45.2 inches. The maximum was 70.65 inches, recorded at Mauch Chunk in 1933, and the minimum was 28.86 inches, recorded at Bethlehem in 1932. The average monthly mean precipitation ranges from 4.8 inches in July to 3.0 inches in February. Annual precipitation over the upper portion is approximately 5 inches greater than over the lower portion. Tables 2¹ and 3¹ of appendix I show the annual rainfall and mean monthly precipitation over the watershed.

30. The five storms which produced the most damaging floods in Lehigh River during the period for which authentic stream-flow data are available occurred in 1942, 1902, 1933, 1935, and 1936. The storms are listed in order of flood magnitudes produced, the greatest being in 1942. Data on these storms are given in paragraphs that follow and on maps and graphs included as plates 1, 2, 5, and 18¹ of appendix II.

31. The storm of May 16-23, 1942, traveled generally northeastward across eastern Pennsylvania and into New York and produced the greatest flood recorded on Lehigh River. This storm was described by the United States Weather Bureau, in part, as follows:

The storm of May 16-23 belongs to the category of storms of which May 30-June 1, 1889 (Johnstown flood) is the most famous, and May 18-22, 1894, about the most extreme in westward extension of the heavy rainfall. In all cases the rainfall came out of a moist current from the Atlantic curving northwestward about an upper cold cyclonic circulation.

The isohyetal map of the entire storm indicates several centers of heavy precipitation, the greatest in the Lehigh watershed being at Mauch Chunk where a total of 7.52 inches was measured, of which 6.52 inches fell in 24 hours.

32. The data indicate that an average total of 2 1/4 inches of rain fell on the Lehigh watershed in the 36 hours between noon, May 20, and midnight, May 21; that only 1/2 inch fell in the ensuing 16 hours; and that this was followed by unusually heavy rainfall for approximately 10 hours, in which 3 inches fell. Although this storm was the main cause of the destructive flood, a storm of May 16-17 had contributed substantially to antecedent flood conditions when nearly 2 inches of rain fell on the watershed. Mass rainfall curves shown on plate 3¹ of appendix II reveal that unusually heavy rainfall occurred in the upper portion of the Lehigh watershed several hours prior to the second period of heavy rainfall in the Allentown-Bethlehem area. This combination of circumstances was favorable to the production of high flood stages in the lower reaches of the river. A detailed analysis of this storm, which shows the intensity and distribution of the rainfall, has been completed by the Department and is now available for reference.

¹ Not printed.

33. In February 1902, rainfall and snowfall in eastern Pennsylvania were intense throughout the month, a severe snowstorm amounting to about 12 inches occurring on the 16th and 17th. The temperatures were generally below freezing from the 5th to the 19th. More than 2 inches of precipitation, in the form of rain, snow, and sleet, fell on the 21st and 22d, from which there was no appreciable run-off. An average of ¾ inch of rain and sleet fell over the Lehigh watershed during the 25th and 26th; the precipitation on the lower portion of this watershed during this period was considerably greater than on the upper portion. This rainfall, accompanied by above-freezing temperatures in the lower area, resulted in an estimated peak flow of 14,000 cubic feet per second at Bethlehem on the 26th. Heavy rainfall amounting to more than 2 inches fell on the 28th of February, during which the heavier precipitation occurred on the upper portion of the watershed, 2.4 inches being recorded at Manch Chunk. Total precipitation over the Lehigh Basin between the 16th and 28th of February, which contributed to the flood of the 28th, amounted to about 6 inches.

34. In August 1933, a period of moderate rainfall, beginning on the 21st, was followed by a tropical disturbance on the 23d which moved in a northerly direction across the Middle Atlantic States from North Carolina to Massachusetts. The rainfall accompanying this disturbance was of high intensity and relatively long duration. The average rainfall over the Lehigh watershed for the 3-day period was approximately 6½ inches. The period of heavy precipitation occurred first in the lower reaches of the basin and progressed in a northerly direction. The rainfall was generally of uniform intensity during this period and amounted to approximately 4 inches.

35. In July 1935, heavy rain occurred over eastern Pennsylvania for a period of about 48 hours, beginning on the 8th and ending during the morning of the 16th. The total rainfall was 9.32 inches in Bethlehem, in the lower watershed, 7.21 inches at Manch Chunk, in the middle area, and 7.26 inches at Gouldsboro, in the headwaters. The period of the most intense rainfall occurred during the afternoon of the 9th, and it appears that this period of rainfall took place simultaneously throughout the watershed. During this period of intense rainfall nearly 3 inches of rain fell over the entire basin in 12 hours.

36. In March 1939, a storm having two periods occurred in the Lehigh watershed, the first on the 11th and 12th, and the second on the 17th to 21st. During the first period the total precipitation was 1.46 inches at Bethlehem, 2.23 inches at Manch Chunk, and 2.50 inches at Gouldsboro. At the beginning of this period there was an estimated average of 4 inches of water over the watershed above Bethlehem in the form of snow, the bulk of it being at the higher elevations; in the headwaters; above Tannery it was 6.6 inches. Most of the snow melted during this period, resulting in floods throughout the basin. There was light intermittent rainfall between the two storm periods.

37. The rainfall during the second period was 3.47 inches at Bethlehem, 4.60 inches at Manch Chunk, and 4.80 inches at Gouldsboro, most of which occurred prior to noon on the 18th. The period of occurrence of the maximum intensity in the headwaters was in the morning of the 18th. The flood peaks resulting from this rainfall were lower in the Lehigh Basin than those of the first period.

38. The pattern of the maximum possible storm that could occur on the Lehigh watershed has been derived from data furnished by the

Hydrometeorological Section, Office of the Chief of Engineers, on the maximum possible precipitation applicable to the Lackawaxen River watershed, which adjoins the Lehigh watershed on the northeast. The extent and characteristics of the Lehigh watershed are such that a 36-hour storm would be of sufficient duration to produce maximum flow at Bethlehem. The above-mentioned data indicate that the maximum possible 36-hour rainfall for the drainage area above Bethlehem would amount to 18.6 inches. The rainfall pattern was arranged in six 6-hour periods, with a maximum 6-hour precipitation of 8.5 inches occurring in the fifth period. It is considered that this distribution of rainfall will produce the maximum possible flood peaks.

RUN-OFF

39. The locations and other pertinent data pertaining to six stream gaging stations that are operated by the United States Geological Survey in the Lehigh watershed are given in table 3.

TABLE 3.—Stream-gaging stations, Lehigh River watershed

Stream and location	Drainage area	Type of gage	Period of record	Years of record	Daily discharge in cubic feet per second per square mile	
					Mean	Maxi- mum
Lehigh River at—	Sq. mi.	None recording		22	1.76	62.1
Bethlehem.....	1,280	Recording	September 1902 to February 1903; April 1909 to September 1928.	16	1.96	64.7
Do.....	222	None recording	June 1914 to September 1928.	14	1.91	36.7
Tannery.....	322	Recording	October 1928 to date.	15	1.85	32.7
Do.....	92.5	None recording	October 1928 to date.	4	2.21	32.4
Stoddardville.....	110	Recording	September 1943 to date.	3	1.85	32.7
Pohopoc Creek at Ferryville.....	10.6	do	February 1941 to date.	3	2.21	32.4
Wild Creek at Halseyville.....	77.0	do	October 1939 to date.	8	1.85	32.7
Aquashicola Creek at Falmerton.....						.18

40. Records obtained at the Bethlehem gage, which controls the greatest drainage area (1,280 square miles) and longest period of record, established mean, maximum, and minimum monthly discharges of 1.76, 9.31, and 0.25 cubic feet per second per square mile, respectively. The maximum run-off occurred in March and the minimum in October. The mean, maximum, and minimum values of annual run-off in inches over the watershed were 23.72, 39.60, and 13.37, respectively. The mean, maximum, and minimum percentages of annual precipitation that appeared as run-off were 52.1, 67.4, and 36.9, respectively. Run-off during floods of record is shown in the following section.

FLOODS

41. Floods that were evidently of magnitude that would produce extensive damage under present-day conditions of development along Lehigh River are mentioned in old manuscripts and publications as having occurred as early as 1675. Evidence is found that only the

records of phenomenal floods have been preserved, consequently it is probable that a considerable number of floods occurred that were noteworthy but for which no data are available. Prior to the establishment of the first stream gage on the Lehigh at Bethlehem in 1902, nine floods occurred for which the peak discharges at Bethlehem can be estimated with reasonable certainty. These discharges are based on the most recent data of the United States Geological Survey, and the values previously reported for these floods are now revised to agree with the latest available rating curve. The years in which the floods occurred, and their estimated peak flows, are as follows:

Year	Cubic feet per second	Cubic feet per second
1786	43,000	74,000
1839	32,000	54,000
1841	79,000	56,000
1850	54,000	88,000
1862	79,000	

While the floods that occurred in 1901 and 1902 antedate the gage at Bethlehem, reliable, although unofficial, data on their discharges warrant their inclusion with the floods of record.

42. Four of the five outstanding floods resulting from the storms described in previous paragraphs (30 to 37), have occurred subsequent to the establishment of the stream gage at Bethlehem. Permanent data relating to these floods on the Lehigh River at Bethlehem and Tannery are tabulated below. The hydrographs for the 1942, 1933, 1935, and 1936 (first period) floods are shown in plate 18¹ of appendix II.

BETHLEHEM

Date of flood	Elevation of water feet above mean sea level	Maximum rate of discharge		Average rainfall inches over watershed	Surface run-off inches over watershed	Percent run-off	Interval between peaks at Bethlehem and Tannery (hours)	Duration of flooding (hours)
		Cubic feet per second	Cubic feet per square mile					
Mar. 1942	223.1	92,000	71.9	6.6	3.1	65	10	24
August 1933	227.3	64,800	50.6	6.6	2.6	38	4	18
July 1935	227.1	63,700	49.8	6.5	2.6	40	7	24
Mar. 12, 1936	227.6	65,700	46.3	1.6	1.2	180	8	24
Mar. 18, 1936	224.3	49,000	38.2	4.3	3.2	75	8	13

TANNERY

Date of flood	Elevation of water surface, feet above mean sea level	Maximum rate of discharge		Average rainfall inches over watershed	Surface run-off inches over watershed	Percent run-off	Contribution to peak at Bethlehem, cubic feet per second
		Cubic feet per second	Cubic feet per square mile				
Mar. 1942	1,058.3	29,600	91.9	6.0	3.6	60	24,000
August 1933	1,054.3	17,500	64.3	6.3	2.8	45	12,400
July 1935	1,054.9	19,500	60.9	6.1	2.7	44	12,800
Mar. 12, 1936	1,054.9	20,000	60.9	1.7	1.1	29	15,800
Mar. 18, 1936	1,054.8	19,100	59.4	4.9	4.6	52	15,800

¹ Includes snow melt.

² Not printed.

The flood flow whose peak occurred on March 12, 1936, had not subsided entirely before the arrival of the rise that peaked on the 18th of March. The total volume of the surface run-off of the two periods was equivalent to 6.0 inches over the watershed above Bethlehem.

43. The flood of May 1942 is the greatest flood known on Lehigh River. The storm that produced this flood occurred in two phases; the rainfall of the second phase was much heavier than the first. The rainfalls, discharges, and run-off percentages for each phase of the storm, and the total for 5 gaging stations in the watershed are tabulated below:

Station	Drainage area, sq. mi.	First storm phase			Second storm phase			Total storm		
		Rain-fall	Run-off	Pct. run-off	Rain-fall	Run-off	Pct. run-off	Rain-fall	Run-off	Pct. run-off
Lehigh River at Bethlehem	126	2.3	0.5	22	3.3	2.6	79	5.6	3.1	65
Tannery	222	2.4	0.6	25	3.6	3.0	83	6.0	3.6	60
Polopow Creek at Perryville	110	1.8	0.6	33	3.3	2.2	67	5.1	2.8	55
Wild Creek at Hatcher's	10.6	1.8	0.3	17	3.3	1.9	58	5.1	2.2	49
Washington Creek at Tannery	77	2.0	1.2	40	2.4	1.9	51	5.0	2.2	49

44. It will be noted from the table in paragraph 42 that the flood of 1942, which produced the greatest peak of record at Bethlehem, had the longest time interval, 10 hours, between the peaking at Bethlehem and Tannery. It was determined from the routing computations that the travel time of the floodwaters from Tannery to Bethlehem was approximately 13 hours. The relatively short time between the observed peaking at Bethlehem and the arrival of the Tannery peak-flow waters to Bethlehem is indicative of a substantial contribution from the headwaters to the 1942 peak at Bethlehem. The smaller intervals between times of peaking at the two locations shown for the other, lesser, floods were partially caused by the run-off from the lower areas. The table in paragraph 42 also shows the computed contributions from the drainage area above Tannery to the peaks at Bethlehem for the floods of 1942, 1936, 1935, and 1933.

45. Peak discharge records for the flood of May 1942, obtained by the United States Geological Survey at gages on the Lehigh and on several of its tributaries, with comparable data on previous maximum discharges, are given in table 4.

46. The maximum gage height at Bethlehem that is estimated to result from the maximum possible storm (par. 38) would exceed the maximum gage height of the 1942 flood by approximately 30 feet, and the peak discharge is estimated at more than 4 times the peak discharge of the 1942 flood.

47. The estimated frequency of floods in Lehigh River is shown graphically on plate 3.¹ It will be noted that the plotted position of the 1942 flood does not conform closely to the smooth curve passed through the plotted positions of other floods. Since the discharge of this flood is well established, its position in relation to the curve is taken to indicate that its frequency of recurrence should be accepted as approximately once in 100 years, in preference to its plotted position obtained by computation.

¹ Not printed.

TABLE 4.—Peak discharges, flood of May 1942

Stream and location	Drainage area	Date of earliest record	Maximum previously recorded				Maximum May 22-23, 1942				Method of measurement ¹
			Date	Gage height (feet)	Discharge		Gage height (feet)	Discharge			
					Cubic feet per second	Cubic feet per second per square mile		Cubic feet per second	Cubic feet per second per square mile		
Lehigh River at—											
Bethlehem	1,290	1902	Feb. 28, 1902	22.8	88,000	69	23.3	47,020,000	72	D	
Stoudersville	322	1914	Mar. 12, 1915	13.3	20,000	62	22.16	51,292,800	92	D	
Honey Lake at Onda-boro	82.8					22		9,780	105	C	
West End Pond at West End	3.6					22		281	78	B	
Wildcat Creek at Bowmanstown	16.6					22		367	22	B	
Wildcat Creek at Paryville	311					22		25,400	82	B	
Poliopee Creek at Paryville	742		July 8, 1941	4.85	2,280	23	7.42	6,300	73	B	
Wild Creek at Hatcher's	110		do	6.30	1,000	21	8.00	1,280	48	D	
Auntie's Creek at Easton	18.6					23		8,102,910	75	D	
Toboggan Creek at Blakeslee	77	1899	Mar. 15, 1940	10.03	4,550	68	8.10	12,910	38	D	
Bear Creek at—	118					23		7,070	60	A	
Rear Creek	43					22		6,010	172	B	
Caldwell	52					22		6,160	142	B	
Wild Creek at Wild Creek	22.2					22		1,480	65	B	

¹ Method of determination: A—slope area; B—flow over spillway; C—contracted opening; D—rating curve from current meter observations.
² Exceeded on Sept. 26, 1942, when the discharge was 3,650 cubic feet per second, gage height 9.08.

EXTENT AND CHARACTER OF FLOODED AREA

48. Lehigh River has not developed an extensive flood plain. The floodway is a trough, narrow and steep-sided where it traverses the ridges between White Haven and Lehigh Gap, but broader and with sides of gentler slope from Lehigh Gap to the mouth. The chief centers of industrial and residential occupation have developed on moderately sloping areas close to the river, as at Easton, Bethlehem, and Allentown.

49. The extent of areas that are subject to inundation by floods, and the type and extent of improvements in those areas, are given in paragraphs that follow.

50. At Easton approximately 100 acres bordering 2½ miles of the Lehigh River were inundated by the 1942 flood to an average depth of 6 feet. The width of the inundated area varied from zero to 800 feet, the maximum width occurring on the north bank at the west line of the city of Easton. In this area are extensive industrial developments, including iron foundries, electric-power plants, ice plants, coal yards, and lumber yards, also retail business establishments and residences. There are two highway bridges, two railroad bridges, and one navigation dam in this reach of the river. Easton is subject to flooding by high stages in Lehigh River and by high stages in Delaware River, independently of flows in the Lehigh. Extreme stages in the Delaware produce corresponding stages of backwater in the Lehigh. Delaware floods, in addition to affecting damage centers along the Lehigh, inundate considerable areas in Easton adjacent to

the Delaware and cause corresponding stages of backwater in Bushkill Creek which enters the Delaware along the north edge of the town. Records indicate that at Easton, Delaware River floods occur more frequently and cause more extensive damage than Lehigh River floods.

51. In the 6 miles of river next above Easton there are 390 acres in the flooded area, which is mostly wooded and grass land, of which 85 acres are island area. These lands are undeveloped, except for canal improvement and a few farm buildings. There is one highway bridge and one navigation dam in this section of the river.

52. The residential and industrial centers of Premaunburg, Bethlehem, and Allentown follow in order upstream, all within a 9-mile reach, and constitute an almost continuous development along the river. The total flooded area during the May 1942 flood, within these limits, was approximately 1,400 acres, which includes inundated areas on Monocacy Creek, Jordan Creek, and Little Lehigh Creek.

(a) The flooded area at Premaunburg amounts to 45 acres, mostly residential, but including areas occupied by commercial establishments and utilities. A part of the flooded area lies on Nancy Run which enters the river from the north at this point.

(b) In Bethlehem the area that is subject to flooding lies on both the north and south sides of the river. Within this area, Monocacy Creek enters the Lehigh River from the north. While extremely high discharges in this creek produce some damage in its floodway, the high stages that result from flood flows in the creek combined with backwater from floods in the Lehigh inundate lands that extend 1½ miles up the creek. These lands are occupied to some extent by residences but mostly by industrial and commercial buildings. On the south side of the river the plant of the Bethlehem Steel Co. occupies 150 acres that are subject to flooding, and the losses experienced in this plant are the chief industrial damage in Bethlehem and a major part of the entire flood damages in the city. The areas subject to flooding include 20 acres occupied by residences, 15 acres in park, and 18 acres in railroad yards, also several miles of main line trackage. In the flood of 1942, the inundated area was 1,200 feet wide and the depth of water was 3 to 5 feet.

(c) At Allentown, the May 1942 flood inundated 175 acres of improved land on Lehigh River, 100 acres on Jordan Creek, and 75 acres on Little Lehigh Creek or 350 acres in all. The major part of this area (about 80 percent) is occupied by commercial and industrial establishments, the balance by utilities and residences. Within the flooded area at Allentown there are approximately 50 large industries, 50 small business establishments, 200 residences, and 5 hotels.

53. In the 6 miles of river upstream of Allentown are the industrial centers of Catasauque, Hokendangun, and Northampton. In these communities the area that is subject to flooding totals 225 acres, of which 90 acres are improved and occupied by industrial and residential areas.

54. Along the remaining 48 miles of river to White Haven are located Larrys, Treichlers, Slatington, Wahnunport, Lehigh Gap, Palmerton, Bowmanstown, Paryville, Weissport, Leighton, and Mauch Chunk. The valley being narrow and steep-sided along this part of the river, the majority of these communities have relatively small areas that are subject to flooding. In the occupied areas the effects of the 1942 flood consisted principally of industrial and residential damages in approximately equal amounts. The greatest item of damage on this part of the river in the flood of 1942 was experienced by the railroads.

55. Main-line tracks of the Central Railroad of New Jersey and the Lehigh Valley Railroad, on opposite sides of Lehigh River, are at most points close to the high-water elevations reached by the floods of 1902 and 1942, and consequently, washouts and other damages are to be

expected in major floods. Certain low bridges also are subject to damages.

56. Although the main highways in the Lehigh Valley generally are above flood level and are not subject to serious damage, numerous bridges carrying Federal and State routes across the river and its tributaries are imperiled during floods.

57. There are 44 railroad and highway bridges spanning Lehigh River between the mouth and White Haven, 71 miles upstream. Their location, type, and clearances are shown in table 5.

Table 5.—Bridges on Lehigh River (Easton to White Haven)

No.	Miles above mouth	Location and name of owner	Type	Use	Number of spans		Total length in feet		Vertical clearance in feet
					River	Approach	River	Approach	
1	0.26	Easton, Central R. R. of New Jersey	Deck truss	Railroad	3	—	518	65	
2	.28	Easton, Pennsylvania Electric Co.	Concrete arch	Highway	3	266	296	34	
3	.85	Easton, Easton & Northern R. R.	Deck truss	Railroad	2	1,260	1,440	47	
4	1.06	Easton, Pennsylvania Electric Co.	Suspension	Foot	1	440	610	74	
5	2.28	Clendon, Pennsylvania Electric Co.	Through truss	Highway	1	327	357	26	
6	3.59	Smith Island, Pennsylvania Electric Co.	Suspension	Tow path	1	327	357	26	
7	4.20	Smith Island, Pennsylvania Electric Co.	Through truss	Highway	1	327	357	26	
8	10.74	Bethlehem, National Trail	Deck truss	Interurban	10	772	493	32	
9	11.80	Bethlehem, National Trail	Deck truss	Interurban	3	662	399	31	
10	12.12	Bethlehem, Hill to Hill	Through truss	Interurban	2	290	354	19	
11	12.17	Bethlehem, Central R. R. of New Jersey	Through truss	Railroad	3	—	438	47	
12	16.48	Easton, Central R. R. of New Jersey	Deck girder	do	4	—	338	19	
13	16.48	West Channel, Central R. R. of New Jersey	do	do	1	185	266	30	
14	16.78	Allentown, 2d St., West Channel	Steel truss	Highway	1	172	110	14	
15	17.00	Allentown, Hamilton St.	Through truss	do	1	200	250	50	
16	16.26	Allentown, Central R. R. of New Jersey	Through truss	Railroad	10	—	600	18	
17	20.02	Catsasquaque, Philadelphia & Reading R. R.	Deck girder	Highway	1	2	65	32	
18	20.11	Catsasquaque, Philadelphia & Reading R. R.	do	do	2	—	354	24	
19	20.08	Hohenshon, Philadelphia & Reading R. R.	Deck truss	Highway	19	783	413	35	
20	21.31	Coplay, Northampton	Concrete arch	do	6	383	474	24	
21	22.61	Coplay, Northampton	Steel truss	do	5	740	385	61	
22	23.82	Coplay, Northampton	Through truss	do	1	103	480	25	
23	23.18	Trochters, W. Amstrup	Through truss	do	1	103	388	21	
24	33.24	Stratton, W. Amstrup	Through truss	do	1	103	388	21	
25	33.24	Stratton, W. Amstrup	Through truss	do	1	103	388	21	
26	33.80	Land R. R., Lehigh & New England R. R.	Through truss	Railroad	2	1,580	1,600	83	
27	33.80	Land R. R., Lehigh & New England R. R.	Through truss	Railroad	2	1,580	1,600	83	
28	39.97	Boymanstown, Bowman	Through truss	Highway	3	—	402	18	
29	43.00	Wassport, Forge St., R. of New Jersey	Deck truss	do	3	—	400	20	
30	43.14	Wassport, Forge St., R. of New Jersey	Through truss	do	1	—	432	16	
31	43.14	Wassport, Forge St., R. of New Jersey	Deck girder	Railroad	6	—	432	16	
32	46.25	Mauch Chunk, Lehigh Valley R. R.	Through truss	do	2	292	226	20	
33	47.67	Mauch Chunk, Lehigh Valley R. R.	Through truss	do	3	392	235	20	
34	48.90	Nesquehoning Junction, Central R. R. of New Jersey	Deck girder	Highway	1	476	476	17	
35	49.09	Jersey, Central R. R. of New Jersey	do	do	3	—	240	22	
36	50.00	do	do	do	2	—	236	19	
37	50.05	Orxon Bend, Lehigh Valley R. R.	Suspension	do	1	—	234	17	
38	52.52	do	do	do	1	—	351	17	
39	53.13	Lehigh Valley Junction, Lehigh Valley R. R.	Through girder	Railroad	1	—	351	17	
40	53.92	Lehigh Valley Junction, Lehigh Valley R. R.	Suspension	Foot	2	—	360	17	
41	58.89	Lehigh Valley Junction, Lehigh Valley R. R.	Deck girder	Railroad	1	—	360	17	
42	70.08	Lehigh Valley Junction, Lehigh Valley R. R.	Steel truss	Highway	3	—	290	22	
43	71.20	White Haven, East Side	Steel girder	Railroad	2	—	204	22	
44	71.20	White Haven, East Side	Steel truss	Highway	2	—	246	22	

1 No data.

58. Throughout the length of the Lehigh Navigation Canal, from Easton to Mauch Chunk, the dikes, banks, lock walls, and similar elements of this waterway were submerged 5 to 12 feet by the crests of the floods of 1902 and 1942.

59. The susceptibility of the Lehigh Valley to damage by floods is exemplified in the data on the effects of the flood of 1942, given in the following tabulation:

Community	Number of persons affected	Number of businesses affected	Number of houses affected	Number of commercial businesses affected
Easton	191	59	15	50
Freemansburg	95	169	15	10
Bethlehem	174	201	15	43
Allentown	213	233	17	72
Northampton	177	177	1	10
Northampton Township	210	210	2	3
White Haven	48	72	1	3
Stratton	15	14	2	4
Wassport	15	15	2	4
Mauch Chunk	—	—	—	—
Lehigh Valley	3	3	3	1
Parryville	3	3	3	1
Wassport	188	214	6	17
Lehigh Valley	14	14	3	10
Mauch Chunk	100	100	3	3
White Haven	12	12	2	10
Weatherly	5	8	2	5
Total	1,292	1,288	110	342

This flood disrupted all means of travel and communication. Commerce and industry were brought to a standstill. The interruption of operations throughout this highly and intensively industrialized area with a great number of plants producing diversively in support of the war effort, was disastrous. More than 2,800 acres of developed and occupied areas were inundated, in which the investments in property are reported to be as follows:

Industrial	\$529, 579, 000
Commercial	10, 040, 000
Utilities and municipalities	29, 840, 000
Residential and personal	8, 153, 000
Total	577, 612, 000

The employees in the commerce and industry affected are reported as 35,000 in number, drawing an annual pay roll of \$67,774,000.

FLOOD DAMAGES

60. The flood of May 1942 caused damages in the amount of \$14,300,000, according to the data furnished by local interests at the public hearing and subsequently. Local interests cooperated extensively in obtaining and making available these data on the losses experienced. Appraisal of their estimates in the light of information obtained after the flood resulted in revising this figure to \$11,800,000. It was revealed during the course of the investigation that some items had been overestimated, and that others, representing losses that would not be repeated should a similar flood occur, had been included. The estimate prepared by local interests also presented data on losses

61. The high ratio of indirect to direct industrial damages at Bethlehem reflects the highly interrelated activities at that locality. This high ratio is mainly attributable to the nature of the losses suffered at the Bethlehem steel plant. There were relatively moderate direct losses, as the damage to buildings, machinery, and raw materials was small in proportion to the loss resulting from the interruption of production. The plant organization is complex, and those units which were not directly damaged were unable to produce while other parts of the plant were inundated and while resulting damages were being repaired. The indirect losses allowed in this case were carefully computed from operating statistics made available by the Bethlehem Steel Co. The computation of indirect losses is given in detail in appendix II.¹

62. The damages that were caused by the floods of 1936, 1935, and 1933 are estimated from the best information now obtainable and are based on data submitted by local interests during the survey of 1942 damages supplemented by damage surveys made by district office personnel at Allentown and Bethlehem following the 1936 flood. These figures are greater than those given in the latest prior report, and are so reported only after careful investigation and evaluation. It appears that local interests, particularly large industries, were not as cooperative as they were for the present study, nor was the damage survey as comprehensive. It is concluded that the damage data thus obtained were not complete, and that the figures now reported are closer approximations of the true losses. Table 7 summarizes these damages.

Table 7.—Total damages, towns and utilities along Lehigh River, secondary floods

TOWN OR REACH	DOLLARS		
	AUGUST 1933	JULY 1935	MARCH 1936
Easton.....	\$121,690	\$166,900	\$548,600
Fredensburgh.....	9,100	6,100	34,800
Bethlehem.....	1,028,700	1,012,100	344,600
Allentown.....	384,900	287,400	158,000
Northampton.....	66,500	3,300	7,800
Treblechters and Cementon.....	10,900	5,000	6,800
Stratington and Walnutport.....	18,000	7,200	1,000
Fabrication and Howmestown.....	12,200	7,200	1,000
Lehighport.....	17,300	22,200	21,000
Lehigh Valley.....	17,300	14,400	20,700
March Chunk.....	21,800	400	20,400
Subtotal.....	1,721,400	1,655,400	1,117,400
UTILITIES			
Easton to Allentown.....	18,200	38,400	19,200
Above Allentown to Lehighton.....	25,600	10,600	43,700
Above Lehighton to White Haven.....	38,600	7,300	131,800
Total utilities.....	82,100	62,300	194,700
Grand total.....	1,803,500	1,627,600	1,314,100

63. The annual values of preventable flood damages, exclusive of nonrecurring damages, are estimated by localities in table 8. These values were derived by employing stage-damage-frequency relations. The damages for various flood stages were estimated on the basis of existing river conditions and state of development in the floodway and for normal industrial activity. Details of the derivation of annual damages are given in appendix II.¹

¹ Not printed.

DAMAGES ALONG PRETREATERS NOT AFFECTED BY LEHIGH RIVER

NAME OF CHURCH	1933	1935	1936	1933	1935	1936	1933	1935	1936
Methodist Episcopal Church, Bethlehem	11,600	2,400	2,400	11,600	2,400	2,400	11,600	2,400	2,400
Methodist Episcopal Church, Lehighport	11,600	2,400	2,400	11,600	2,400	2,400	11,600	2,400	2,400
Methodist Episcopal Church, Allentown	11,600	2,400	2,400	11,600	2,400	2,400	11,600	2,400	2,400
Methodist Episcopal Church, Northampton	11,600	2,400	2,400	11,600	2,400	2,400	11,600	2,400	2,400
Methodist Episcopal Church, Treblechters and Cementon	11,600	2,400	2,400	11,600	2,400	2,400	11,600	2,400	2,400
Methodist Episcopal Church, Stratington and Walnutport	11,600	2,400	2,400	11,600	2,400	2,400	11,600	2,400	2,400
Methodist Episcopal Church, Fabrication and Howmestown	11,600	2,400	2,400	11,600	2,400	2,400	11,600	2,400	2,400
Methodist Episcopal Church, Lehighport	11,600	2,400	2,400	11,600	2,400	2,400	11,600	2,400	2,400
Methodist Episcopal Church, Lehigh Valley	11,600	2,400	2,400	11,600	2,400	2,400	11,600	2,400	2,400
Methodist Episcopal Church, March Chunk	11,600	2,400	2,400	11,600	2,400	2,400	11,600	2,400	2,400
Total	116,000	24,000	24,000	116,000	24,000	24,000	116,000	24,000	24,000

Note.—The damages listed for the Bethlehem Steel Co. were derived by adjusting the reported amount to represent the estimated amount of 1933-1936 flood based on 1942-1936. Subsequent investigation and analysis indicate that tangible damages suffered by the Bethlehem Steel Co. would approximate \$2,000,000.

FLOOD PROBLEM

72. The Lehigh flood problem is primarily due to the role of the river valley as a transportation gateway. Two main line railway routes that provide access to all parts of the Nation follow the river on opposite banks, frequently within reach of its major floods. The many industries of the Lehigh area, located here because of locally available raw materials and the excellent transportation facilities, are logically sited as close to the railroads as possible. Locations where the valley slopes are not prohibitively steep are few, and accordingly, great concentrations of industrial, residential, and commercial property are found at such points. Encroachments that add to the natural flood hazards are frequent due to the industrial value of land in the extensively developed areas. The total value of property subject to recurring floods of the Lehigh is more than \$577,000,000, and the great bulk of flood damages in the watershed occur to these properties located along the main stem of the river.

73. Only one community not on the main stem has reported a flood problem. Weatherly, located on Black Creek 5 miles above its junction with the Lehigh, is subject to relatively minor floods as a result of inadequate drainage facilities and encroachments on the channel of Black Creek and those of small tributary streams. The town of Manuch Chunk, located on the Lehigh River generally above its flood plain, experiences damages due to overflow of Manuch Chunk Creek, a tributary of the Lehigh. Rural damages in the watershed are small; on the main stem, there is practically none, as the few relatively flat areas of the floodway that are suitable for agriculture topographically are occupied by industry.

74. At Allentown, the extensive flooding is due to Lehigh backwater in two streams, the Little Lehigh and the Jordan. The flood problem at Bethlehem is complicated by the Monocacy, which is also subject to Lehigh backwater throughout that portion of its course lying within the city limits. At Easton, located at the confluence of the Lehigh with the Delaware, the flood problem is complicated by backwater from the Delaware. The maximum flood of record (1942) in the Lehigh was 10 feet lower than the greatest flood of record (1903) in the Delaware. Delaware floods back up the Lehigh in its lower reaches, along the Easton frontage, to produce stages as high or higher than that of the Delaware.

75. Study of the configuration of the flooded area leads quickly to the conclusion that the best plan of improvement would consist of detention reservoirs. The flood zones are long in comparison with their areas, and local improvements would have to be correspondingly extensive. The volume of overbank flood waters is comparatively small due to the characteristic trough-like shape of the floodway, and therefore reservoirs would be very effective in lowering flood stages. Easton is the only community that would not receive an appreciable measure of protection as a result of reservoirs on the Lehigh, for the reasons stated previously.

76. Unfortunately, reservoir sites that can be economically developed and that control a significant proportion of the drainage area above the damage centers are few. The economic development of the

valley below White Haven and the two main line railroads that closely follow the river to that point eliminate sites on the main stem that control a sufficiently large area to provide complete protection. Slugs above White Haven control less than 30 percent of the area above Allentown, and the largest tributary between White Haven and Allentown, the Pohopoco, has a drainage area amounting to only 10 percent of the area of the basin above the principal damage centers.

77. Although these circumstances peculiar to the Lehigh preclude complete protection by reservoirs, partial protection by this method would be beneficial and desirable. The most feasible plan would then consist of a reservoir or reservoirs, supplemented by local improvements through the damage centers wherever further protection can be justified.

PLAN FOR IMPROVEMENT

78. The most practicable plan for controlling floods on Lehigh River comprises the items that follow:

- (a) A reservoir on Lehigh River, the dam to be located a short distance downstream from the mouth of Bear Creek. It would have a controlled outlet discharging through a tunnel in rock at the east abutment of the dam, and a natural spillway discharging through a saddle in the west margin of the pool, about 7/8 mile from the dam. No improvements to the saddle are contemplated. See plate II, appendix II.
- (b) Channel improvement and local protective works:
 - (1) At Allentown: Improvement of the channel by widening, deepening, and casing of the abrupt turn and approaches thereto at the mouth of Little Lehigh Creek; also a training dike and levees, and incidental structures. See plate 12, appendix II.
 - (2) At Bethlehem: Flood walls, or slope-ruled levees and incidental structures on Lehigh River and on Monocacy Creek; also pumping facilities to remove storm water from protected areas during flood periods. See plate 13, appendix II.

Each unit of the proposed plan was found by investigation to be feasible and economically advantageous. The flood walls and levees that are proposed would be of moderate height, and have been so designed that interference with local activities or communication will be very slight.

79. The following table shows the estimated effect of the proposed reservoir in reducing flood stages at Bethlehem and other important damage centers for four major floods. These stage reductions were arrived at by, first determining by flood routing the reduced peak discharges at the selected locations for each of the floods considered, and then applying the respective derived discharge-stage rating curves to the peak flows as experienced and as reduced by the proposed reservoir.

Location	Reduction in discharge, percent				Reduction in stage, feet			
	May 1942	Mar. 12, 1950	July 1953	August 1953	May 1942	Mar. 12, 1950	July 1953	August 1953
Bethlehem (U. S. Geological Survey, 1942)	20	26	14	18	3.2	2.4	1.7	2.0
Allentown (Hamilton, S. C.)	24	34	19	20	4.1	4.0	2.1	2.4
Catsaquog	25	34	19	21	4.0	4.0	2.2	2.4
Northampton	26	36	20	22	6.0	5.5	3.4	3.7
Easton	32	40	20	28	3.0	3.7	2.3	3.0
Weatherly-Lehigh	41	60	36	39	4.0	5.3	3.6	4.5

1 Not printed.

This tabulation shows that the reductions vary with the distances from the reservoir of the various localities as well as with the characteristics of the storms causing the flood. Plate 18, appendix II, shows graphically the effect that the proposed reservoir would have had on the peak flows at Bethlehem during the storms of 1942, 1936, 1935, and 1933. Based on the analysis of the 1902 storm (see par. 33) it appears that the flood run-off from the headwaters was relatively heavy. If the 1902 flood should recur with the proposed reservoir in operation, it is reasonable to expect that the reductions in discharges and flood stages effected at Bethlehem would approximate those anticipated for a flood of the magnitude and type of that of 1942.

80. The channel improvement as proposed at Allentown results in additional stage reductions on the lower reaches of the tributaries as well as on the main stream. The estimated combined effect of reservoir control and channel improvement on stages to be anticipated in Allentown for the recurrence of these floods is as follows:

Location	Reduction in stage, feet			
	May 1942	Mar. 12 1936	July 1935	August 1933
Allentown, Hamilton St.	5.1	6.4	4.0	4.2
Allentown, lower end of Xhinas Island	4.3	6.1	3.6	3.9
Allentown, existing mouth of Little Lehigh Creek	6.6	6.7	4.6	4.6

The stages and consequent damages attending greater floods would be reduced substantially. The further reduction of damages in Allentown by more extensive protective works was investigated, but was found not economically justified at this time. Protection for this locality can be augmented in the future.

81. In Bethlehem, with the reduction in flood levels that would be accomplished by the proposed reservoir control, the proposed levees and walls would give the vital portions of this locality complete protection against all floods of magnitudes up to that of a flood 20 percent greater than the flood of 1942. The elevations planned for the levees and walls will provide a freeboard of 2 feet above the stage produced by the design flood. It was found uneconomical to provide complete protection for floods of greater magnitude throughout the valley.

82. The proposed plan provides negligible protection for Easton. This city, located at the junction of the Lehigh with the Delaware, is subject to far more damaging inundations from the Delaware than it experiences from Lehigh floods. The Delaware flood of October 1903 attained an elevation of 193.5 feet causing an inundation more than 10 feet deeper in the damage areas than that which occurred as a result of the 1942 Lehigh flood, the greatest of record in that stream. Thus, even if it were feasible to protect the city from Lehigh River floods, Easton would remain in jeopardy of inundations. The cost of channel improvement in the Delaware below and through Easton to carry the 1903 discharge of 272,000 cubic feet per second would be out of proportion when compared with any possible benefits, and the only remaining alternate is flood walls or slope-protected levees.

¹ Not printed.

Reservoir control of the Delaware was considered in the Survey Report for Flood Control on the Delaware River submitted to Congress August 4, 1941, and found to be unjustifiable. No reason is seen for modifying that conclusion at the present time, as the 1942 flood on the Delaware was of lesser magnitude than the 1936 flood, which prompted the Survey investigation referred to. The problem is complicated not only by Delaware backwater extending up the Lehigh, on the south side of the city, but also by backwater reaching far up the Bushkill, a tributary of the Delaware along the north side of the city. Accordingly, protection of Easton from a flood of the magnitude experienced in 1903 requires more than 17,000 feet of wall or levee averaging 17 feet in height, as shown on plate 14, appendix II. The estimated cost of this construction, including facilities for drainage, is \$2,500,000, which is not found warranted at this time.

83. Studies were also made of local improvements to supplement the protection afforded by the proposed reservoir at numerous smaller communities where there would be appreciable residual damages. In these studies it was assumed that the top of levees and flood walls would be 3 feet above the flow line resulting from the recurrence of the 1942 flood with the reservoir in operation. The localities considered were Northampton, Catasauqua, Slatington, Pfrementsburg, and Hokendauqua. The additional improvements were not found justifiable. Pertinent data for these areas are listed below.

Community	Description of Improvement	Length Feet	Average height Feet	Cost	Area that would be protected Acres
Northampton	Walls, levees, and drainage, 1 stop-log opening	4,900	6	\$46,000	21½
Catasauqua	Walls, levees, and drainage, 5 stop-log openings, 2 gates, 1 canal	4,600	12	686,000	6¼
Slatington	Levees and drainage	1,100	8	75,000	1½
Pfrementsburg	Walls, levees, and drainage	4,650	8	590,000	25
Hokendauqua	Walls and drainage, 1 stop-log opening	1,300	14	107,000	2

84. The residual damages in other communities such as Palmerton, Lehighton, Weissport, Walnutport, Bowmanstown, Parryville, and White Haven due to a recurrence of the 1942 storm after the reservoir is constructed, will be minor and serious consideration of supplemental works was not found warranted.

85. Plans that would provide protection for Mauch Chunk from flood flows in Mauch Chunk Creek were considered and dismissed because they were found to be economically infeasible. The creek passes through the entire length of the town, a distance of approximately a mile, in a masonry flume of inadequate cross section. By far the greater part of the flume is covered, and it frequently passes under buildings. Reconstruction of the flume as a pressure conduit with dimensions adequate to carry the potentially intense rainfall on the 9 square miles of basin above the town would be a solution, but the cost greatly outweighs the prospective benefits, and construction would be very difficult. Residual damages in this community from floods in the Lehigh, including recurrence of the 1942 flood, will be slight after construction of the proposed reservoir.

¹ Not printed.

86. Alternate plans of improvement that were investigated are outlined in subparagraphs (a), (b), and (c), that follow:

(a) Control by 2 reservoirs, plus local protection: Includes a reservoir on Pohopoco Creek in conjunction with the proposed reservoir on Lehigh River below the mouth of Bear Creek and local protective measures at Allentown and Bethlehem that are comparable in degree of protection to these damage centers to that provided by the proposed plan. It was found that under this plan the cost would be approximately 20 percent greater without a commensurate increase in benefits.

(b) Control by reservoirs alone: Consists of a combination of the proposed reservoir with reservoirs on Pohopoco Creek, Aquashicola Creek, and Jordan Creek, also an alternate plan replacing the proposed reservoir with a reservoir on the Lehigh below Tobyhanna Creek. The flood protection given by either combination would not be as complete as the principal damage centers as that provided by the proposed plan, since flood heights would not be reduced below the no-damage stage. The cost would exceed the cost of the proposed plan by more than 20 percent with benefits lower than those of the proposed plan.

(c) Protection without reservoirs: Consists of channel improvement in conjunction with levees and walls. Investigation revealed that a degree of protection similar to that furnished by the proposed plan could not be obtained by this method at a lower cost. Moreover, levee and flood-wall protection possesses serious disadvantages. It would not be susceptible of incorporation into plans for future conservation of the river's water. The high walls would impede activities in the towns. A large number of openings in the walls and levees would be needed to maintain communications, and the closing of these openings in every flood emergency would involve a human function with its inevitable element of uncertainty. The benefits from this plan would not be as widely felt as would the effect of the proposed reservoir in reducing the crest heights of future floods.

87. The proposed plan of improvement for controlling floods on the Lehigh River will not adversely affect the development of the river for navigation, domestic and industrial water supply, abatement of stream pollution, conservation pools for wildlife preserves and recreation, or for hydroelectric power development, nor will such ultimate development reduce the degree of flood protection.

88. Preliminary studies made in collaboration with representatives of the Federal Power Commission indicate that the proposed flood-control reservoir near the mouth of Bear Creek can be made a part of a future power development on the Lehigh, if and when such a plan is found desirable. In addition to Bear Creek Reservoir, the tentative power-development scheme would require a dam on the Lehigh below the junction of Tobyhanna Creek, a reservoir on Mud Run, and a regulating reservoir above a powerhouse located near Mauch Chunk. Tunnels and conduits would convey the water from Tobyhanna Reservoir to Mud Run Reservoir and from there to the regulating pool above Mauch Chunk. A pumping plant may be provided to lift Bear Creek Reservoir water into Tobyhanna Reservoir, thus augmenting the base flow available for power. It is estimated that such a project would provide approximately 272,000 acre-feet of usable storage and develop an effective net head of between 1,000 and 1,100 feet. The installation would be approximately 150,000 kilowatts.

89. The only work required to make Bear Creek Reservoir an integral part of such a water-power project consists of the construction of a pumping plant. Power could not be generated economically at the dam; therefore, provision for penstocks is not necessary.

90. The dam for the reservoir proposed would be approximately 2,900 feet long and rise 233 feet above the valley floor. Suitable gate-controlled outlet works would be provided. The reservoir would

control 288 square miles of drainage area, which is approximately 20 percent of the total area drained by Lehigh River. The capacity of the reservoir at spillway level, would be 110,000 acre-feet which is equivalent to 7.2 inches of run-off from the drainage area above the dam.

91. The capacity given above for the reservoir is its storage capacity, exclusive of any volume discharged while water is accumulating back of the dam. Depending on the type of storm that is anticipated, the outlet would be open during either the entry or the late portion of the run-off. Accordingly, the volume controlled in a single filling and emptying of the reservoir might exceed the storage capacity by as much as 20 percent. In the event that this reservoir should be incorporated into a project for developing power on Lehigh River, the interests of flood control would require that the total capacity reserved for flood-control storage in this reservoir and other reservoirs upstream be maintained at not less than 92,000 acre-feet.

92. The height of the dam as proposed is approximately 20 feet greater than the height that would be required to give the minimum adequate storage for flood-control purposes. It was found less costly to increase the height of the dam, and take advantage of the natural spillway site, than to construct the dam with less height and provide a spillway adjacent to the dam. The proposed location of the dam is the site that was found to be most advantageous of all the sites which appeared to be feasible.

93. The plan of improvement proposed will involve the following:

(a) At Allentown, the relocation of approximately 500 feet of inverted-siphon sewer under the river, moving one steel tower of an electric transmission line, also highway and other utility alterations; (b) At Bethlehem, furnishing a new superstructure for a bridge at Main Street over Monocacy Creek and miscellaneous utility alterations. A bituminous-surfaced secondary highway passes through the upper part of the reservoir site, but its relocation is not considered necessary since it is located high above the valley floor and would not be submerged except in the occurrence of a flood of magnitude approaching the maximum possible flood.

94. The total first costs of construction of the improvement are estimated as follows:

Reservoir:		
Dam and appurtenances (estimated as rock-fill construction)-----	\$8,796,000	
Lands-----	100,000	\$8,896,000
At Allentown:		
Channel relocation, 8,700 feet; levees and dike		
2,500 feet; and revetment-----	741,000	
Lands and buildings-----	3,000	
Utility alterations-----	15,000	759,000
At Bethlehem:		
Earth levee, 1,000 feet; concrete wall, 13,500 feet-----	1,884,000	
Pump houses-----	223,000	
Pumping equipment, 4 installations-----	727,000	
Intercepting sewers-----	379,000	
New superstructure, bridge-----	42,000	
Lands and buildings-----	25,000	
Highway and utility alterations-----	50,000	3,330,000
Total first cost-----		12,986,000

The costs shown are based on prices in effect in 1940, estimated to be applicable under anticipated postwar conditions. The quantities involved are reasonable estimates based on accepted engineering practice.

95. Assuming that local interests will bear the cost of land required for local improvements, the cost of highway and utility alterations, and the cost of the superstructure of a new bridge crossing Monocacy Creek at Main Street in Bethlehem, the Federal and non-Federal costs will be as follows:

Federal first cost:	\$8,896,000
Reservoir: dam and appurtenances, also land:	
At Allentown: Deepening and widening channel, also earth levees, dikes, and revetment:	741,000
At Bethlehem:	
Earth levees, concrete walls:	1,884,000
Pump houses:	223,000
Pumping equipment:	727,000
Total Federal first cost:	12,471,000
Non-Federal first cost:	
At Allentown: Lands and buildings, also utility alterations:	18,000
At Bethlehem:	
New bridge superstructure, lands and buildings, also highway and utility alterations:	117,000
Intercepting sewers:	379,000
Total non-Federal first cost:	514,000

96. The Federal and non-Federal annual carrying charges on the proposed improvement, based on the assumptions that the construction period for the reservoir will not exceed 2 years, that the construction period for local improvement will not exceed 1 year, that the cost of pumping equipment in Bethlehem should be amortized in 25 years, and all other costs in 50 years, are as follows:

Federal investment:	\$12,471,000
Total Federal first cost:	\$12,471,000
Interest during construction of reservoir (2 years), 3 percent of \$8,896,000:	267,000
Total Federal investment:	12,738,000
Federal annual charges:	
Interest, \$12,738,000 at 3 percent:	382,000
Amortization:	
Pumping equipment, \$727,000 times 0.02743:	20,000
Other costs, \$12,011,000 times 0.00887:	107,000
Maintenance and operation of reservoir:	10,000
Total Federal annual charges:	519,000
Non-Federal investment (as the construction period for local improvements does not exceed 1 year, interest during construction is not charged, and the non-Federal investment equals the non-Federal first cost):	
Non-Federal annual charges:	
Interest, \$514,000 at 3 percent:	21,000
Amortization, \$514,000 times 0.00635:	3,000
Maintenance and operation of local protective works:	
At Allentown:	10,000
At Bethlehem:	19,000
Total non-Federal annual charges:	53,000
Total Federal and non-Federal annual charges:	572,000

ANNUAL BENEFITS—JUSTIFICATION OF PROJECT—LOCAL COOPERATION

97. The average tangible annual benefits to accrue to the credit of the improvement proposed are the flood losses and damages that the improvement would prevent. They are evaluated as the difference between the losses and damages that are reasonably anticipated if flood protection is not provided and the losses and damages that must reasonably be expected after the improvements have been accomplished. They include both the direct and indirect flood damages prevented. After careful analysis of the data on flood flows and flood losses and damages, the total tangible benefits to result from the proposed improvements are estimated at \$589,000 a year. In developing the annual damages it was assumed that one design flood would occur during the economic life of the proposed improvement. The design flood is of the magnitude of the protection provided at Bethlehem, and has a reasonable probability of occurrence. The derivation of those benefits, by localities, is explained in detail in Appendix II and the results are summarized in the table that follows. The estimated damages shown are based on normal industrial activity.

TABLE 9.—Summary of annual damages and benefits

Damage area	Damage without improvements		Damage with proposed improvements		Annual benefits
	Recurrence of 1932 flood	Annual	Recurrence of 1932 flood	Annual	
Pascon:	\$285,700	\$77,600	\$1,233,600	\$1,777,600	\$3,700
Pennsboro:	106,300	8,100	57,000	2,400	282,700
Arden:	6,037,400	281,200	10,000	800	280,700
Carlsboro:	287,800	45,200	178,000	15,600	281,700
Northington:	216,700	12,800	120,000	3,600	6,300
Remainder of area, Catawunga to above Bear Run:		85,300	212,000	14,000	71,300
Property to North Church, including Perry's Mill:	1,455,700	74,200	108,000	7,000	67,200
Property to North Church and Hershberg White Haven:	716,700	33,100	0	0	33,100
Total:	10,406,800	722,100	1,310,600	133,000	689,100

¹ Although the proposed reservoir at Bear Creek would have affected the stage at upper Eastern of the 1942 flood, no credit was applied for the reduction of annual damages because of the backwater effect of Delaware River floods on this area.

Total annual cost of improvement: Bear Creek \$366,000
 Reservoir on Lehigh River below Bethlehem and Allentown 206,000
 Additional local improvement at Bethlehem and Allentown 206,000
 Total 572,000

Ratio of benefits to costs = $\frac{589,000}{572,000} = 1.03$.

98. The improvements proposed have been planned with a view to reducing the effects anticipated for future floods in Lehigh River to the greatest degree that is justified, for the purpose of providing reasonable social security for the population of the valley and raising commerce and industry from the constant threat of interruption and loss. The over-all ratio of estimated tangible annual benefits (\$589,000) to the estimated annual cost of the improvement (\$572,000) is 1.03. The total worth of the proposed project is greater, as the

¹ Not printed.

intangibles and property enhancement benefits due to increased usage made possible are not considered in this monetary evaluation. At Bethlehem, the economic ratio found for the proposed improvements, including allocated reservoir costs and benefits, is 0.93. At Allentown, where the proposed improvements would reduce the estimated damages resulting from the recurrence of the 1942 flood from \$986,500 to \$296,000, the comparable economic ratio is 0.91.

99. If a project is adopted for flood control in the Lehigh River in accordance with the recommended plan, local interests, consistent with existing Federal policy on flood-control improvements, should meet the following requirements of local cooperation with respect to channel improvement and local protective works:

- (1) Furnish without cost to the United States all lands, easements, and rights-of-way necessary for their construction.
- (2) Hold and save the United States free from damages due to the construction of these works.
- (3) Maintain and operate them after completion in accordance with regulations prescribed by the Secretary of War.

Among other provisions for Bethlehem, local interests should provide a new superstructure and new road approaches to Main Street Bridge, construct new road approaches to Lehigh Avenue Bridge and construct necessary intercepting storm water sewers.

100. No definite assurances of local cooperation have been received. However, the General Assembly of Pennsylvania enacted laws during the extraordinary session of 1936, empowering and directing the Water and Power Resources Board of the Department of Forests and Waters, in addition to the powers previously granted and conferred upon it, for and in behalf of the Commonwealth and its subdivisions, to aid, assist, and cooperate in the carrying out of any Federal flood-control program or plans. The board has the power to require adequate bridge openings, to prevent encroachments, and to make surveys and studies connected with flood control and related subjects. Laws were enacted by the general assembly in March 1937, empowering and directing the board to cooperate with local interests in the formation of flood-control districts for the purpose of assisting in obtaining rights-of-way by condemnation or otherwise, and for cooperation with the Federal Government in prosecuting flood-control plans and projects. The board has all other powers, consistent with the State laws, necessary or required, in order to enable the Commonwealth to participate in, and receive the benefits from any Federal flood-control program or plans in Pennsylvania. The board has power to assist and cooperate in the construction, erection, financing, maintaining, using, and operating of any Federal public flood-control works and improvements.

101. In view of the interest and activities of local groups and the authority vested in the State board, it is expected that the requirements of local cooperation will be met. The Commonwealth of Pennsylvania has assisted local interests in furnishing the necessary lands and rights-of-way required for flood-control projects prosecuted in the State.

FLOOD CHANNEL DELINEATIONS

102. To secure the anticipated degree of protection from the proposed improvement will require that the hydraulic capacity of existing channels through the damage control areas be maintained unimpaired.

To accomplish this purpose, the Pennsylvania Department of Forests and Waters proposed to establish in these areas channel lines beyond which no encroachment will be permitted. This action will indicate the intent of the State to enforce its ruling regarding encroachments throughout the life of the project recommended herein. Final action of this plan is in abeyance, pending Federal action on the proposal to provide flood protection for the area.

DISCUSSION

103. An intense concentration of commerce and industry has been developed on Lehigh River. The valley is relatively narrow and troughlike, and the centers of occupation and activity, of which Allentown and Bethlehem are the most prominent, are located on the banks of the river. Flooding is frequent, and major floods produce great damage. In the flood of May 1942, the direct and indirect damages attributable to high water in the main river amounted to approximately \$11,800,000.

104. The need and justification for flood control on this stream has increased greatly in recent decades. The flood that occurred in 1902 produced stages that were approximately equal to those of the 1942 flood. The damages produced, however, were estimated at \$2,850,000. The difference of nearly \$9,000,000 in the damages produced by these floods of approximately equal magnitudes indicates the increase in productive development and economic importance of the subject area since the turn of the century, although wartime conditions are responsible for a portion of the present development. It is estimated, however, that recurrence of the 1902 flood under average economic conditions would now cause damages amounting to approximately \$10,000,000. The total value of property subject to the damaging effects of major floods is over half a billion dollars.

105. The proposed plan of improvement, consisting of a reservoir on the main river a short distance below the mouth of Bear Creek, supplemented by channel improvement in Allentown and walls and levees in Bethlehem, is found to be the most practicable plan for alleviating flood conditions in the Lehigh Valley. Control of floods by reservoirs alone, by local protective works along the river without benefit of reservoirs, or by two reservoirs supplemented by local protection were investigated and found to be less advantageous economically than the plan advocated.

106. The reductions in crest stages that would be accomplished by the proposed reservoir (par. 79) would eliminate the most serious damages for those areas along the river above Easton. The location of the headwaters, mostly on the eastern slope of the mountains, is conducive to greater intensity of rainfall in the upper parts of the basin than in the lower portions. Analysis of the major storms indicates that in the 1936 and 1942 storms both the precipitation and the run-off were greater in the headwaters than in the lower watershed, and that the proposed reservoir, had it been in operation, would have been effective in lowering the flood stages due to these two storms and in reducing substantially the amount of damage caused along the Lehigh. Available data on the 1902 flood indicate that this storm also was a headwaters storm with resulting heavy run-off from the upper watershed, and it is reasonable to expect that the proposed reservoir con-

trof would be just as effective in the recurrence of this storm as in the case of the 1942 storm. The effect of the reservoir on the 1933 and 1935 storms would also have been substantial. From what is known of the various floods that have occurred in the Lehigh Basin, the reductions in flood stages expected from reservoir control are considered representative of future conditions which are likely to obtain in the watershed. It is pertinent to note that the three greatest floods of record in the Lehigh Valley resulted from storms which had their greatest intensity in the upper watershed. It is the opinion of a prominent hydraulic engineer, who was retained as a consultant in the preparation of this report, that a reservoir on the headwaters of the Lehigh, as proposed, should be an integral part of any comprehensive plan for controlling floods on this river.

107. All flood damage in the vital areas in Bethlehem will be prevented unless the design flood is sufficiently exceeded to overflow the walls or endanger the levees. Increased height of local protection works was found to be not economically justified.

108. Local conditions at Allentown preclude protection by walls and levees, but the proposed improvements, consisting, in addition to Bear Creek Reservoir, principally of channel improvement, would lower all flood stages on the Lehigh River and lessen backwater effects along the tributaries resulting in substantial reduction in flood damages. In case of the recurrence of the 1942 flood, damages would be reduced by approximately 70 percent. The large part of this residual damage in Allentown would occur along Little Lehigh River and Jordan Creek. Protective measures for the further reduction of the damage on the tributaries were not considered warranted at this time.

109. Local protective works to supplement the protection afforded by the reservoir were considered for communities in addition to Allentown and Bethlehem as follows:

(a) *Easton*.—This city is located at the junction of the Lehigh with the Delaware. It is subject to inundations caused by flood discharges of either or both of these rivers, but the experienced peak stages that produce serious damage have come more frequently from the Delaware than from the Lehigh. The Delaware attained a discharge of 272,000 cubic feet per second at Easton in October 1903, and rose more than 10 feet above the stages reached during the flood of May 1942, although the latter flood was the greatest of record on the Lehigh. The Delaware River floods cause backwater effects in both the Lehigh and the Bushkill, a tributary of the Delaware which flows along the northern limits of the industrial and commercial area of the city. It is clear that complete protection from the Lehigh alone, even if feasible, would not prevent flooding of Easton. Previous investigations of Delaware River flood problems have revealed that construction of a flood-control reservoir, or system of reservoirs, could not be justified by the prospective benefits. No reason is seen to warrant a change in this finding. The most practicable plan of improvement would consist of walls or slope-ripped levees along approximately 17,000 feet of the Delaware, Lehigh, and Bushkill frontage. The walls would necessarily average 17 feet in height, with a maximum of 25 feet, to protect against the 1903 flood with adequate freeboard. The cost of the improvement, including necessary facilities for drainage, is estimated at \$2,500,000. The area which is relatively small when compared by the walls amounts to 83 acres, which is relatively small when compared from the length of wall required. Ground surface elevations rise rapidly away from the three streams, the Delaware, Lehigh, and Bushkill, and the great bulk of the city is free from floods. As a result, the annual costs of the improvement are approximately twice as great as the annual benefits that may be anticipated. According to hydrologic investigation and search of historical files, it was found that the 1903 flood is the greatest of record in a period of over a hundred years. The standing damages from a recurrence, under existing conditions, of the 1903 flood have been generously estimated at approximately \$2,000,000. The damages recorded for the 1903 flood at Easton amounted to only \$200,000.

(b) *Northampton*.—Construction of the proposed reservoir will reduce the stage in the Lehigh due to a recurrence of the 1942 storm approximately 6 feet at this town. This reduction would reduce the 1942 damages of \$216,000 to \$126,000. To provide complete protection against floods up to the magnitude of the May 1942 flood would involve the construction of nearly 5,000 feet of wall and levee averaging 6 feet in height, including 3 feet of freeboard. The ratio of annual benefits to be derived from such works to the annual cost thereof would be only 0.07.

(c) *Coatsburg*.—The works necessary to prevent all damage in this community due to recurrence of the 1942 storm, after the proposed reservoir is constructed, would cost \$669,000. The plan includes five stop log openings, two canal gates, and 4,600 linear feet of walls and levees to protect only 8½ acres of marginal property. The incremental benefits would be small compared with the cost of the improvement.

(d) *Stirlington*.—The proposed reservoir will reduce the damages due to recurrence of the 1942 storm to \$12,000 confined to only 1½ acres. Prevention of this damage would require the construction of approximately 1,100 feet of levee averaging 8 feet in height at a cost of \$75,000. The incremental benefit-cost ratio is only 0.03.

(e) *Frazerburgh*.—The plan of improvement required to avoid damages which will amount to \$57,000 due to recurrence of the storm of 1942, with the proposed reservoir in operation, consists of approximately 4,500 feet of levee and walls having an average height of 8 feet, including the required 3 feet of freeboard. The estimated cost of this work is \$550,000. The benefits applicable to this supplemental construction give a benefit-cost ratio of only 0.03.

(f) *Hokendauqua*.—The remaining area in this town that is subject to inundation from a recurrence of the 1942 storm, after the proposed reservoir is in operation, amounts to only 2 acres. The work necessary to prevent the inundation consists of 1,300 feet of wall with one stop-log opening, the cost of which is estimated at \$197,000. The ratio of the incremental benefit to the incremental cost is only 0.10.

110. Other communities in the valley of the Lehigh such as Trevilians, Palmerton, Lehighton, Weissport, Bowmanstown, Paryville, and White Haven, all of which suffered damages in the 1942 flood, will have a substantial degree of protection from a recurrence of a similar storm, and supplemental works are unnecessary. At Mauch Chunk, damages due to Lehigh River floods will be minor, and no economically feasible plan for protection against floods caused by March Chunk Creek was found. In Weatherly, the flood damages are due in part to the inadequacy of a simple drainage structure and partially to the obstruction on the left bank of Black Creek upstream from the mouth of Doney Run. As this obstruction consists of a mound of industrial waste material which is being enlarged steadily, it appears to be in order for local authority to take the necessary action to correct this condition. The entrance of the Federal Government into this flood problem is considered inappropriate.

111. The tangible annual benefits that are anticipated for the proposed improvement amount to \$589,000 compared to annual costs of \$572,000. Other certain, though intangible, benefits would accrue to the credit of the improvement. They include the enhancement in values of real estate in the areas heretofore subject to flooding which, through a positive prospect, have not been included with the tangibles because of the elements of uncertainty and speculation involved. A further and large measure of intangible benefit would accrue through diminution of the ever-present threat of flooding and the attendant disruption of social and economic order.

112. Had the proposed improvements been in operation during the past 50 years, they would have effectively reduced the peaks and resulting damages of the two largest floods experienced, one of which occurred during the critical period of wartime production activity.

113. The improvement proposed would not interfere with future developments for beneficial use of the river's water, and the reservoir which is included in the plan could be incorporated into a project for multiple purpose development of the upper watershed without reducing the value of the improvement for flood control. The proposed reservoir would not interfere with a project for hydroelectric development of the Lehigh River.

114. Objection to the proposed improvement is not probable, as local interests have indicated their desire for such a plan.

115. In the latest prior flood-control report on Lehigh River, submitted August 4, 1941 (Par. 3), economic justification was not found for reduction of flood stages by reservoir control nor for local protective works outside of Bethlehem, whereas the instant report proposes that reservoir control and a major item for the protection of Allentown be provided, together with local protective works for Bethlehem that are closely similar to those studied in the prior report. The conspicuous difference between these reports is attributable to the fact that when the earlier report was in preparation local interests were not aware of the full import of the investigation and the effect their cooperation would have on the results that would be forthcoming. Consequently, personnel of the district office were unable, at that time, to secure complete damage figures, particularly those from large industrial concerns. Accordingly, the direct damages estimated were based on meager information, and indirect damages, mostly industrial, were estimated to be equal to the direct damages. The cooperation of local interests in the present study was much more satisfactory, and the scope of the investigation of flood losses greatly exceeded that of the previous report. Establishments that suffered damages submitted signed questionnaires listing the experienced losses, those that they anticipate if certain floods of the past were to recur under present conditions and those that would be suffered from floods even greater than that of 1942. Much of these data were estimated by district personnel in the previous investigation, and the differences have been a major factor in establishing the economic justification of the project herein considered. It is believed that the present estimate of average annual flood damages is sound and that the benefits found are likely to obtain if the project is constructed.

CONCLUSIONS

116. An urgent need is found for protecting commerce, industry, and residential occupation in the valley of Lehigh River from recurring damage by floods. The measures that have been found most practicable for accomplishing this objective, as incorporated in the plan of improvement proposed, consist of a reservoir with a dam on the main river a short distance below the mouth of Bear Creek, and local works to give additional protection in Allentown and Bethlehem where additional benefits that would be secured justify additional improvements. The control of flood flows that would be effected by the reservoir would be beneficial throughout the entire populated length of the river, and in Allentown the local improvements proposed would substantially reduce the remaining damages. In the city of Bethlehem, which is the center of greatest damage along the river, the combined effects of reservoir control and local improvements would

protect substantially all of this locality against damage by any flood of magnitude up to 20 percent above that of the flood of 1942. It is estimated that this flood has a percent chance of occurrence of 0.29.

117. The tangible annual benefits that are in prospect exceed the annual cost of the improvements proposed. Intangible social and economic benefits also would accrue through the elimination of flood hazards. The total value of the tangible and intangible benefits is regarded as sufficient to warrant Federal participation in the project.

118. In view of the local character of a major part of the prospective benefits, the State or local interests should cooperate to a reasonable extent in providing the improvement, maintain and operate the local works after construction is completed, and assure that the United States will be immune from any claims for damages arising from or attributable to the improvement.

RECOMMENDATION

119. Authorization is recommended for a flood-control project for Lehigh River, Pa., consisting of a reservoir formed by a dam on the main river a short distance below the mouth of Bear Creek, and local protective works in Allentown and Bethlehem, substantially as described in this report, and with such further modifications as may be advisable in the discretion of the Secretary of War and the Chief of Engineers, at an estimated first cost to the United States of \$12,471,000 with \$10,000 annually for maintenance and operation of the reservoir. If a project is adopted, it should require that responsible local interests give assurances satisfactory to the Secretary of War regarding the local improvements, that they will provide without cost to the United States all lands, easements, and rights-of-way necessary for their construction; hold and save the United States free from damages due to the construction of these works; and maintain and operate them after completion in accordance with regulations prescribed by the Secretary of War.

CLARENCE RENSHAW,
Colonel, Corps of Engineers,
District Engineer.

(First endorsement)

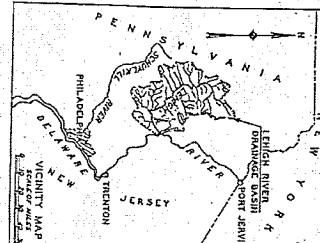
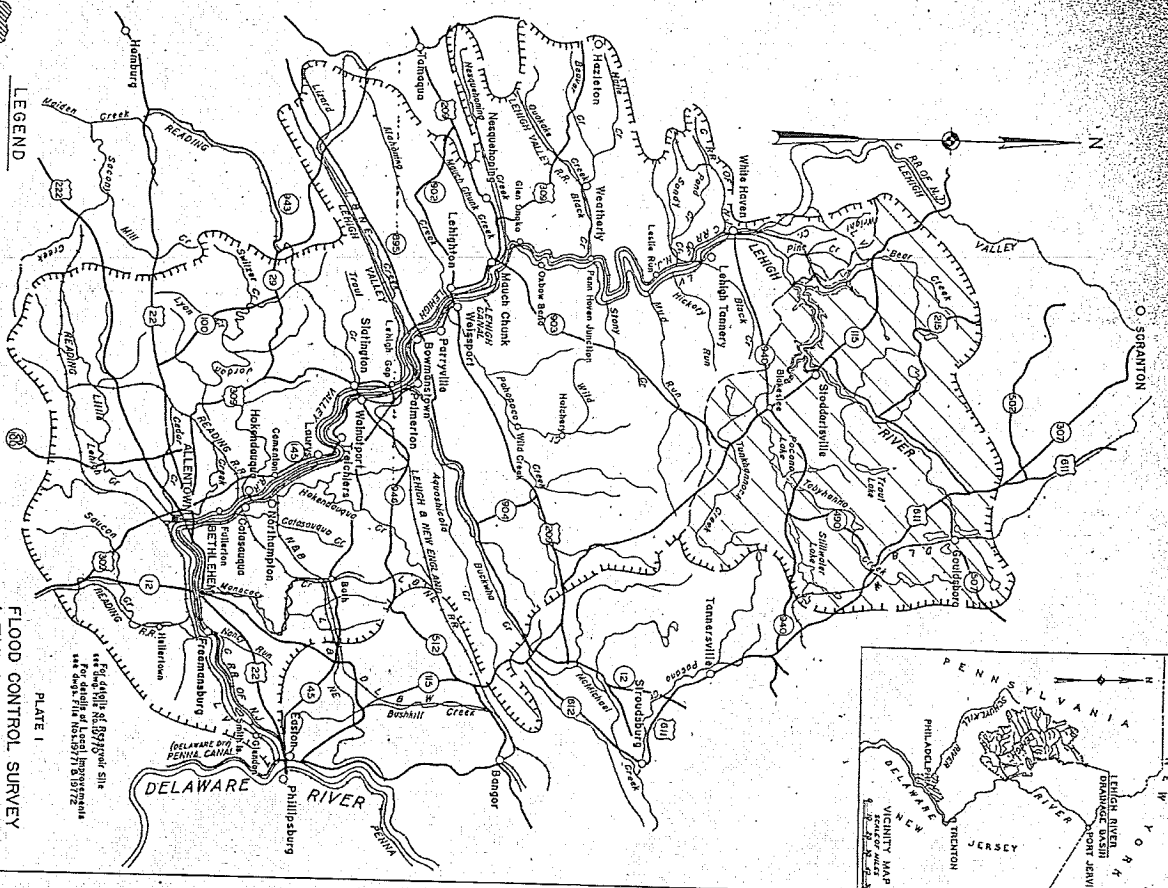
OFFICE, DIVISION ENGINEER,
NORTH ATLANTIC DIVISION,
New York, N. Y., June 25, 1945.

To: The Chief of Engineers, United States Army.

I concur in the views, conclusions, and recommendation of the district engineer.

ALBERT H. BURTON,
Colonel, Corps of Engineers,
Division Engineer.

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LEGEND

- Recommended Reservoir—showing drainage area and reservoir area
- Local Improvements recommended
- Local Limits of Drainage Basin

U.S. Highway

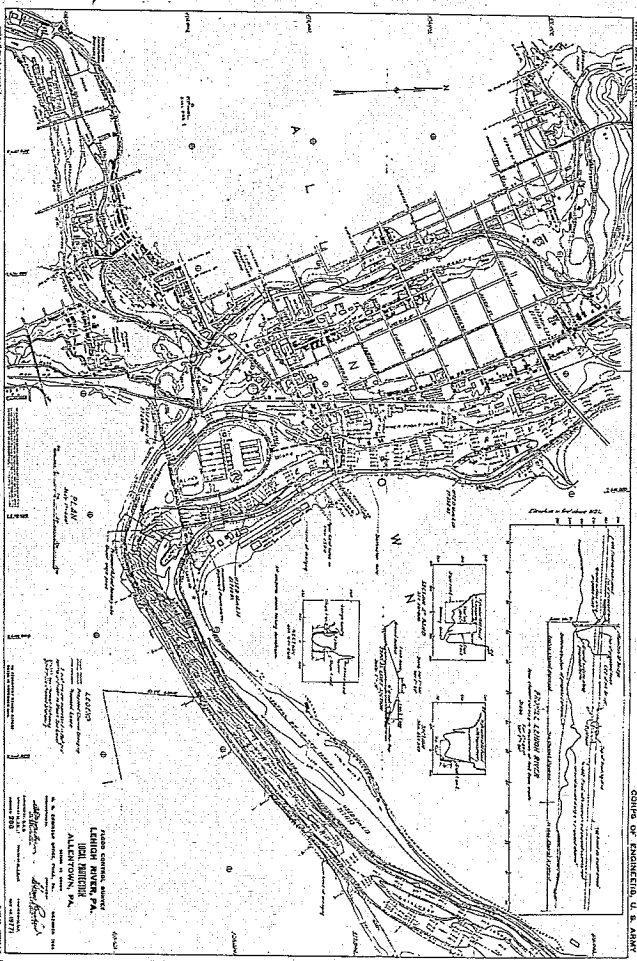
State Highway

TO ACCOMPANY REPORT DATED 15 NOVEMBER 1944

FLOOD CONTROL SURVEY
LEHIGH RIVER, PA.
INDEX MAP

SCALE OF MILES

U.S. ENGINEER OFFICE, PHILA., PA. OCTOBER 1944
 RECOMMENDED APPROVED FOR THE DISTRICT ENGINEER
 [Signature] [Signature]
 CHIEF, DISTRICT ENGINEER CHIEF, DISTRICT ENGINEER
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River and Harbor Act of 1962

"House Document 87-522

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SUSQUEHANNA RIVER BASIN

The project for construction of the Fall Brook and Ayleworth Creek Reservoirs, and local flood protection works on the Lackawanna River at Scranton, Pennsylvania, is hereby authorized substantially as recommended by the Chief of Engineers, in Senate Document Numbered 141, Eighty-seventh Congress, at an estimated cost of \$3,596,000.

The project for the Juniata River and tributaries, Pennsylvania, is hereby authorized substantially in accordance with the recommendations of the Chief of Engineers in House Document Numbered 565, Eighty-seventh Congress, at an estimated cost of \$32,150,000: *Provided*, That installation of the power generating facilities shall not be made until the Chief of Engineers shall submit a reexamination report to the Congress for authorization.

DELAWARE RIVER BASIN

The project for the comprehensive development of the Delaware River Basin, New York, New Jersey, Pennsylvania, and Delaware, is hereby authorized substantially in accordance with the recommendations of the Chief of Engineers, in House Document Numbered 522, Eighty-seventh Congress, at an estimated cost of \$192,400,000.

POTOMAC RIVER BASIN

The project for the North Branch of the Potomac River, Maryland and West Virginia, is hereby authorized substantially in accordance with the recommendations of the Chief of Engineers, in House Document Numbered 469, Eighty-seventh Congress, at an estimated cost of \$50,965,000.

MIDDLE ATLANTIC COASTAL AREA

The project for hurricane-flood protection at Norfolk, Virginia, is hereby authorized substantially in accordance with the recommendations of the Chief of Engineers in House Document Numbered 354, Eighty-seventh Congress, at an estimated cost of \$1,537,000.

The project for hurricane-flood protection and beach erosion control at Wrightsville Beach, North Carolina, is hereby authorized substantially in accordance with the recommendations of the Chief of Engineers in House Document Numbered 511, Eighty-seventh Congress, at an estimated cost of \$345,000.

The project for hurricane-flood protection and beach erosion control at Carolina Beach and vicinity, North Carolina, is hereby authorized substantially in accordance with the recommendations of the Chief of Engineers in House Document Numbered 418, Eighty-seventh Congress, at an estimated cost of \$739,000.

APALACHICOLA RIVER BASIN, GEORGIA

The project for the West Point Reservoir, Chattahoochee River, Georgia, is hereby authorized substantially in accordance with the recommendations of the Chief of Engineers in House Document Numbered 570, Eighty-seventh Congress, at an estimated cost of \$52,900,000.

CENTRAL AND SOUTHERN FLORIDA

The comprehensive plan for flood control and other purposes in central and southern Florida approved in the Act of June 30, 1948,

11. BEAR CREEK PROJECT.

a. Description. The Bear Creek Project is a modification of the single-purpose flood control project with incidental recreation use now under construction, which is located on Lehigh River 75 miles above its confluence with Delaware River and about 5 miles north of White Haven, Pennsylvania. The proposed project would be a multiple-purpose development to provide for supplies of water and recreation in addition to the present flood control purpose. Reservoir capacity to spillway crest level would be 180,000 acre-feet; 2,000 acre-feet inactive, 70,000 acre-feet for supplies of water and recreation, and 108,000 acre-feet for flood control. The proposed modification would require alteration of the spillway, increasing the height of the dam, extending the outlet tunnel by the addition of a concrete conduit, and constructing new and raising the heights of existing dikes. The modified dam would rise 263 feet above the river bed and be 3,500 feet long. The modified project would contribute to: (1) the satisfaction of the future water supply needs of downstream areas especially the Allentown-Bethlehem and the Trenton-Philadelphia areas; (2) the reduction in flood damages in the downstream areas of especial importance to the highly industrialized Allentown, Bethlehem, and Easton areas; and (3) the satisfaction of the desire for nonurban recreation facilities of the surrounding population. The Bear Creek Project would be required by the year 1989.

b. Economic life. The economic life of the Bear Creek Project from the time modifications are completed and including features of the existing project as used in project analysis is 50 years.

c. Project costs. The estimated cost of construction, excluding \$875,000 for indirectly related recreation, is \$20,100,000, which is made up of \$11,100,000 for the cost of the project now under construction and \$8,990,000 for the cost of modifications for multiple-purpose development. The total new construction expenditure required, including \$4,460,000 for rehabilitation of the existing project would be \$13,400,000. The estimated annual operation and maintenance cost is \$117,000 and the estimated major replacement cost is \$3,000 annually. All costs are computed on the basis of 1959 price levels.

d. Benefit-cost ratios. Benefit-cost ratios were computed using total tangible benefits and total costs reflecting various interest rates applied to Federal and non-Federal interests for 50 years and 100 years. The economic justification for the Bear Creek Project was based on the premise that the modification constituted a second stage of development and rehabilitation to provide feasible comprehensive development with a 50-year life expectancy. The benefit-cost ratio of the Bear Creek Project for a 50-year economic life is 2.6 and for a 100-year economic life it is 3.3. Capital costs,

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operation and maintenance costs, replacement costs and benefits for 50 years and 100 years are as follows:

	Amortization Period	
	50 Years	100 Years
NEW CONSTRUCTION EXPENDITURES	\$ 13,400,000	\$ 13,400,000
ANNUAL CHARGES		
Interest and Amortization (including interest during construction)	577,000	467,000
Operation and Maintenance	117,000	117,000
Major Replacements	3,000	4,000
Economic Cost of Land	17,000	16,000
Total Annual Charges	714,000	603,000
ANNUAL BENEFITS		
Reduction of Flood Damages	427,000	427,000
Recreation, directly related	161,000	161,000
Supplies of Water	1,290,000	1,380,000
Total Annual Benefits	1,880,000	1,970,000
BENEFIT-COST RATIO	2.6	3.3

Notes: Costs and benefits for indirectly related recreation are excluded.

All amounts rounded; totals may not agree with sums of individual items due to rounding.

Interest rate of 2-5/8% used in determination of annual costs, where applicable, and discounting of future benefits.

e. Intangible project effects. Intangible project effects of the Bear Creek Project would include: a contribution to the prevention of loss of life, which amounted to 99 lives lost throughout the Delaware River Basin in the August 1955 flood; assurance values from assigning adequate flood control storage capacity at the Bear Creek Project to completely control the standard project flood to non-damaging proportions so as to avoid a false sense of security from floods among the residents in the urban downstream reaches; and the value of the provision for sufficient site development at Bear Creek Project to insure the realization of optimum recreation benefits. Adverse effects resulting from the Bear Creek Project essentially would be a consequence of the damages expected to fish and wildlife resources in the project area. There is presented in appendix J to this report a discussion of how such damages attributable to other projects in the plan of development might be mitigated. No monetary equivalent for means of recovering such damages is presented.

f. Physical feasibility and cost of providing for future needs. The Bear Creek Project has been formulated to contribute to the satisfaction of current and future needs for reduction of flood

damages, recreation, and supplies of water over the economic life of the project. No provision has been made for further modification at the Bear Creek Project to satisfy known additional future requirements in the area served by this project since it was found uneconomic to do so.

g. Allocation of costs. Allocation of costs were computed by (1) the separable costs-remaining benefits method, (2) the priority of use method, and (3) the incremental cost method on two time periods for amortization, 50 years and 100 years. The cost allocation data are shown in table AA-8. In the incremental cost method of allocation, supply of water was considered the basic function because the scheduled date for development of the project is based on the anticipated need for supplies of water.

h. Extent of interest in project. In order to take into account the desires and views of Federal agencies, affected states and municipalities, during the survey and the preparation of the survey report, the District Engineer formally established the Delaware Basin Survey Coordinating Committee. This Committee was comprised of representatives of the States of Pennsylvania, New York, New Jersey, and Delaware; of the cities of Philadelphia and New York; and of the various Federal agencies concerned with water resources. Ten meetings of the Committee, which were open to the public, were held at about four-month intervals from April 1957 to March 1960 at various points throughout the Delaware River Basin and service area. Federal agencies, states and municipalities were informed at these various meetings as to the progress of the study and given the opportunity to review and comment on the features of the comprehensive plan. Also, a formal review procedure assured each member of the Coordinating Committee ample time to comment on the major features of the studies as they were reported on in the 24 appendices to the report. At the conclusion of the studies four public hearings were held in the basin to advise local interests of the findings of the study and afford them opportunities to express their views. It is believed that these interests are in general agreement with the plan presented. Under the review procedures prescribed for this survey report, local interests will have additional opportunity for comment on the features of the plan and cost sharing arrangements. Federal participation in this project has been estimated at \$4,330,000 for new construction expenditures, and \$85,000 annually for operation, maintenance, and replacement costs during the period of deferred use of future water supplies and a total of \$55,000 annually after use of the future water supplies is initiated.

i. Repayment schedules for reimbursable costs. The reimbursable cost for the Bear Creek Project would include a construction cost of \$9,110,000 for supplies of water. Alternates

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TABLE AA-8
 ALLOCATIONS OF COST FOR BEAR CREEK PROJECT 1/
 (All amounts rounded; totals may not agree with sums of individual items due to rounding)

	Amortization Period - 50 Years				Amortization Period - 100 Years			
	Reduction of Flood Damages	Recreation (Directly Related)	Supplies of Water	Total	Reduction of Flood Damages	Recreation (Directly Related)	Supplies of Water	Total
SEPARABLE COSTS - REMAINING BENEFITS METHOD								
1. BENEFITS	\$1,060,000	\$ 161,000	\$ 1,300,000	\$ 2,520,000	\$ 1,060,000	\$ 161,000	\$ 1,390,000	\$ 2,610,000
2. ALLOCATION OF COSTS:								
a. Annual Economic Costs	409,000	60,000	404,000	872,000	323,000	53,000	330,000	706,000
b. Annual O & M and Replacement Costs	31,000	295,000	64,000	120,000	31,000	26,000	65,000	121,000
c. Specific Use Construction Expenditures	-	595,000	-	595,000	-	595,000	-	595,000
d. Joint-Use Facility Constr. Expenditures	10,100,000	229,000	9,110,000	19,500,000 ^{2/}	10,100,000	210,000	9,170,000	19,500,000 ^{2/}
e. Total Const. Expenditures (First Cost)	10,100,000	824,000	9,110,000	20,100,000 ^{2/}	10,100,000	805,000	9,170,000	20,100,000 ^{2/}
PRIORITY OF USE METHOD 3/								
1. BENEFITS	1,060,000	161,000	1,300,000	2,520,000	1,060,000	161,000	1,390,000	2,610,000
2. ALLOCATION OF COSTS:								
a. Annual Economic Costs	454,000	105,000	313,000	872,000	361,000	96,000	248,000	706,000
b. Annual O & M and Replacement Costs	53,000	30,000	37,000	120,000	53,000	32,000	36,000	121,000
c. Specific Use Construction Expenditures	-	595,000	-	595,000	-	595,000	-	595,000
d. Joint-Use Facility Constr. Expenditures	10,700,000	1,340,000	7,400,000	19,500,000 ^{2/}	10,600,000	1,530,000	7,310,000	19,500,000 ^{2/}
e. Total Const. Expenditures (First Cost)	10,700,000	1,940,000	7,400,000	20,100,000 ^{2/}	10,600,000	2,120,000	7,310,000	20,100,000 ^{2/}
INCREMENTAL COST METHOD 4/								
1. BENEFITS	1,060,000	161,000	1,300,000	2,520,000	1,060,000	161,000	1,390,000	2,610,000
2. ALLOCATION OF COSTS:								
a. Annual Economic Costs	398,000	49,000	425,000	872,000	316,000	44,000	346,000	706,000
b. Annual O & M and Replacement Costs	30,000	23,000	67,000	120,000	30,000	24,000	67,000	121,000
c. Specific Use Construction Expenditures	-	595,000	-	595,000	-	595,000	-	595,000
d. Joint-Use Facility Constr. Expenditures	9,920,000	-	9,570,000	19,500,000 ^{2/}	9,920,000	-	9,570,000	19,500,000 ^{2/}
e. Total Const. Expenditures (First Cost)	9,920,000	595,000	9,570,000	20,100,000 ^{2/}	9,920,000	595,000	9,570,000	20,100,000 ^{2/}

1/ Fish and wildlife benefits and costs discussed in Appendix J. No monetary equivalent given.
 2/ Includes existing flood control project cost of \$11,100,000.
 3/ Priority for assigning remaining costs: (1) reduction of flood damages, (2) directly related recreation, (3) supplies of water.
 4/ Supplies of water considered the basic function to which all remaining costs are assigned.
 NOTE: Interest rate of 2% used in determination of annual costs and discounting of future benefits.

repayment schedules acceptable to the Federal government for the recovery of this cost are shown below:

<u>Function</u>	<u>Construction Expenditure</u>	<u>Lump Sum</u>	<u>Annual Payment</u> ^{1/}	<u>Deferred Lump Sum</u>	<u>Deferred Annual Payment</u> ^{1/}
Supplies of Water	\$9,110,000 (rounded)				
Current Supply	3,087,000	\$3,087,000	\$116,000	N. A.	N. A.
Deferred Supply	6,026,000	6,026,000	226,000	\$6,026,000 ^{2/}	\$226,000

^{1/} Assumes Federal financing of such costs at 2-5/8%, amortization period 50 years.

^{2/} Initiation of use of deferred supply within ten-year interest free period.

N. A. = not applicable.

In addition, non-Federal interests would be required to contribute \$34,000 annually for the cost of operation, maintenance and replacement during the period of deferred use of future water supplies and \$64,000 annually after use of the future water supplies is initiated.

j. Effect of project on state and local governments.

There are no major changes expected in the cost of state and local government services as a result of the Bear Creek Project. Any increased costs of state and local services associated with the project have been taken into account in the estimate of annual operation and maintenance costs for the project. While there may be reductions in the revenues resulting from Federal acquisition of lands in the Bear Creek Project area, it is expected that such reductions would be more than compensated for through increased activity, directly and indirectly associated with the multiple-purpose development features of the Bear Creek Project.

Fish and Wildlife Coordination Act of 1958 (PL 85-624)

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(1) to civilian or Armed Forces supply or procurement officers and employees of the Federal Government ordering, procuring, or purchasing such knives in connection with the activities of the Federal Government;

(2) to supply or procurement officers of the National Guard, the Air National Guard, or militia of a State, Territory, or the District of Columbia ordering, procuring, or purchasing such knives in connection with the activities of such organizations;

(3) to supply or procurement officers or employees of the municipal government of the District of Columbia or of the government of any State or Territory, or any county, city, or other political subdivision of a State or Territory, ordering, procuring, or purchasing such knives in connection with the activities of such government; and

(4) to manufacturers of such knives or bona fide dealers therein in connection with any shipment made pursuant to an order from any person designated in paragraphs (1), (2), and (3).

The Postmaster General may require, as a condition of conveying any such knife in the mails, that any person proposing to mail such knife explain in writing to the satisfaction of the Postmaster General that the mailing of such knife will not be in violation of this section."

Sec. 6. This Act shall take effect on the sixtieth day after the date of its enactment.
Approved August 12, 1968.

Public Law 85-624

AN ACT

To amend the Act of March 10, 1934, to provide for more effective integration of a fish and wildlife conservation program with Federal water-resource developments, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Act of March 10, 1934, as amended, and as further amended by this Act may be cited as the "Fish and Wildlife Coordination Act";

Fish and Wildlife Coordination Act
48 Stat. 401.

For the purpose of recognizing the vital contribution of our wildlife resources to the Nation, the increasing public interest and significance thereof due to expansion of our national economy and other factors, and to provide that wildlife conservation shall receive equal consideration and be coordinated with other features of water-resource development programs through the effectual and harmonious planning, development, maintenance, and coordination of wildlife conservation and rehabilitation for the purposes of this Act in the United States, its Territories and possessions, the Secretary of the Interior is authorized (1) to provide assistance to, and cooperate with, Federal, State, and public or private agencies and organizations in the development, protection, rearing, and stocking of all species of wildlife, resources thereof, and their habitat, in controlling losses of the same from disease or other causes, in minimizing damages from overabundant species, in providing public shooting and fishing areas, including

Wildlife conservation.

Cooperation of agencies.

Modification of projects.

Surveys and investigations.

Donations.

Interagency water control coordination.

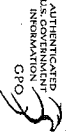
Reports and recommendations.

assessments across public lands for access thereto, and in carrying out other measures necessary to effectuate the purposes of this Act; (2) to make surveys and investigations of the wildlife of the public domain, including lands and waters or interests therein acquired or controlled by any agency of the United States; and (3) to accept donations of land and contributions of funds in furtherance of the purposes of this Act.

"Sec. 2. (a) Except as hereafter stated in subsection (h) of this section, whenever the waters of any stream or other body of water are proposed or authorized to be impounded, diverted, the channel deepened, or the stream or other body of water otherwise controlled or modified for any purpose whatever, including navigation and drainage, by any department or agency of the United States or by any public or private agency under Federal permit or license, such department or agency first shall consult with the United States Fish and Wildlife Service, Department of the Interior, and with the head of the agency exercising administration over the wildlife resources of the particular State wherein the impoundment, diversion, or other control facility is to be constructed, with a view to the conservation of wildlife resources by preventing loss of and damage to such resources as well as providing for the development and improvement thereof in connection with such water-resource development.

"(b) In furtherance of such purposes, the reports and recommendations of the Secretary of the Interior on the wildlife aspects of such projects, and any report of the head of the State agency exercising administration over the wildlife resources of the State, based on surveys and investigations conducted by the United States Fish and Wildlife Service and such State agency for the purpose of determining the possible damage to wildlife resources and for the purpose of determining means and measures that should be adopted to prevent the loss of or damage to such wildlife resources, as well as to provide concurrently for the development and improvement of such resources, shall be made an integral part of any report prepared or submitted by any agency of the Federal Government responsible for engineering surveys and construction of such projects when such reports are presented to the Congress or to any agency or person having the authority or the power, by administrative action or otherwise, (1) to authorize the construction of water-resource development projects or (2) to approve a report on the modification or supplementation of plans for previously authorized projects, to which this Act applies. Recommendations of the Secretary of the Interior shall be as specific as is practicable with respect to features recommended for wildlife conservation and development, lands to be utilized or acquired for such purposes, the results expected, and shall describe the damage to wildlife attributable to the project and the measures proposed for mitigating or compensating for these damages. The reporting officers in project reports of the Federal agencies shall give full consideration to the report and recommendations of the Secretary of the Interior and to any report of the State agency on the wildlife aspects of such projects, and the project plan shall include such justifiable means and measures for wildlife purposes as the reporting agency finds should be adopted to obtain maximum overall project benefits.

"(c) Federal agencies authorized to construct or operate water-control projects are hereby authorized to modify or add to the structures and operations of such projects, the construction of which has not been substantially completed on the date of enactment of the Fish and Wildlife Coordination Act, and to acquire lands in accordance with section 3 of this Act, in order to accommodate the means and measures for such conservation of wildlife resources as an in-



legal part of such projects: *Provided*, That for projects authorized by a specific Act of Congress before the date of enactment of the Fish and Wildlife Coordination Act (1) such modification or land acquisition shall be compatible with the purposes for which the project was authorized; (2) the cost of such modifications or land acquisition, as means and measures to prevent loss of and damage to wildlife resources to the extent justifiable, shall be an integral part of the cost of such projects; and (3) the cost of such modifications or land acquisition for the development or improvement of wildlife resources may be included to the extent justifiable, and an appropriate share of the cost of any project may be allocated for this purpose with a finding as to the part of such allocated cost, if any, to be reimbursed by non-Federal interests.

"(4) The cost of planning for and the construction or installation and maintenance of such means and measures adopted to carry out the conservation purposes of this section shall constitute an integral part of the cost of such projects: *Provided*, That such cost attributable to the development and improvement of wildlife shall not extend beyond those necessary for (1) land acquisition, (2) modification of the project, and (3) modification of project operations; but shall not include the operation of wildlife facilities nor the construction of such facilities beyond those herein described: *And provided further*, That, in the case of projects authorized to be constructed, operated, and maintained in accordance with the Federal reclamation laws (Act of June 17, 1902, 32 Stat. 388, and Acts amendatory thereof or supplementary thereto), the Secretary of the Interior, in addition to allocations made under section 9 of the Reclamation Project Act of 1939 (53 Stat. 1187), shall make findings on the part of the estimated cost of the project which can properly be allocated to means and measures to prevent loss of and damage to wildlife resources, which costs shall not be reimbursable, and an appropriate share of the project costs may be allocated to development and improvement of wildlife resources, with a finding as to the part of such allocated costs, if any, to be reimbursed by non-Federal fish and wildlife agencies or interests.

"(5) In the case of construction by a Federal agency, that agency is authorized to transfer to the United States Fish and Wildlife Service, engineering, or construction, such funds as may be necessary to conduct all or part of the investigations required to carry out the purposes of this section.

"(6) In addition to other requirements, there shall be included in any report submitted to Congress supporting a recommendation for authorization of any new project for the control or use of water as described herein (including any new division of such project or new supplemental works on such project) an estimation of the wildlife benefits or losses to be derived therefrom including benefits to be derived from measures recommended specifically for the development and improvement of wildlife resources, the cost of providing wildlife benefits (including the cost of additional facilities to be installed or hands to be acquired specifically for that particular phase of wildlife conservation relating to the development and improvement of wildlife), the part of the cost of joint-use facilities allocated to wildlife, and the part of such costs, if any, to be reimbursed by non-Federal interests.

"(7) The provisions of this section shall be applicable with respect to any project for the control or use of water as prescribed herein, or any unit of such project authorized before or after the date of enactment of the Fish and Wildlife Coordination Act for planning

Project costs.

43 USC 371 and note.

43 USC 485b.

Transfer of funds.

Estimation of benefits.

Applicability.

Exceptions.

Wildlife resources.

or construction, but shall not be applicable to any project or unit thereof authorized before the date of enactment of the Fish and Wildlife Coordination Act if the construction of the particular project or unit thereof has been substantially completed. A project or unit thereof shall be considered to be substantially completed when sixty percent or more of the estimated construction cost has been obligated for expenditure.

"(4) The provisions of this Act shall not be applicable to those projects for the impoundment of water where the maximum surface area of such impoundments is less than ten acres, nor to activities for or in connection with programs primarily for land management and use carried out by Federal agencies with respect to Federal lands under their jurisdiction.

"Sec. 3. (a) Subject to the exceptions prescribed in section 2 (1) of this Act, whenever the waters of any stream or other body of water are impounded, diverted, the channel deepened, or the stream or other body of water otherwise controlled or modified for any purpose whatever, including navigation and drainage, by any department or agency of the United States, adequate provision, consistent with the primary purposes of such impoundment, diversion, or other control, shall be made for the use thereof, together with any areas of land, water, or interests therein, acquired or administered by a Federal agency in connection therewith, for the conservation, maintenance, and management of wildlife resources thereof, and its habitat thereon, including the development and improvement of such wildlife resources pursuant to the provisions of section 9 of this Act.

"(b) The use of such waters, land, or interests therein for wildlife conservation purposes shall be in accordance with general plans approved jointly (1) by the head of the particular department or agency exercising primary administration in each instance (2) by the Secretary of the Interior, and (3) by the head of the agency exercising the administration of the wildlife resources of the particular State wherein the waters and areas lie. Such waters and other interests shall be made available, without cost for administration, by such State agency, if the management of the properties relate to the conservation of wildlife other than migratory birds; or by the Secretary of the Interior for administration in such manner as he may deem advisable, where the particular properties have value in carrying out the national migratory bird management program: *Provided*, That nothing in this section shall be construed as affecting the authority of the Secretary of Agriculture to cooperate with the States or in making lands available to the States with respect to the management of wildlife and wildlife habitat on lands administered by him.

"(c) When consistent with the purposes of this Act and the reports and findings of the Secretary of the Interior prepared in accordance with section 2, land, waters, and interests therein may be acquired by Federal construction agencies for the wildlife conservation and development purposes of this Act in connection with a project as reasonably needed to preserve and assure for the public benefit the wildlife potentials of the particular project area: *Provided*, That before properties are acquired for this purpose, the probable extent of such acquisition shall be set forth, along with other data necessary for project authorization, in a report submitted to the Congress, or in the case of a project previously authorized, no such properties shall be acquired unless specifically authorized by Congress, if specific authority for such acquisition is recommended by the construction agency.

Report to Congress.

"(d) Properties acquired for the purposes of this section shall continue to be used for such purposes, and shall not become the subject of exchange or other transactions if such exchange or other transaction would defeat the initial purpose of their acquisition.

"(e) Federal lands acquired or withdrawn for Federal water-resource purposes and made available to the States or to the Secretary of the Interior for wildlife management purposes, shall be made available for such purposes in accordance with this Act, notwithstanding other provisions of law.

"(f) Any lands acquired pursuant to this section by any Federal agency within the exterior boundaries of a national forest shall, upon acquisition, be added to and become national forest lands, and shall be administered as a part of the forest within which they are situated, subject to all laws applicable to lands acquired under the provisions of the Act of March 1, 1911 (36 Stat. 981), unless such lands are acquired to carry out the National Migratory Bird Management Program.

"Sec. 4. Such areas as are made available to the Secretary of the Interior for the purposes of this Act, pursuant to sections 1 and 3 or pursuant to any other authorization, shall be administered by him directly or in accordance with cooperative agreements entered into pursuant to the provisions of the first section of this Act and in accordance with such rules and regulations for the conservation, maintenance, and management of wildlife, resources thereof, and its habitat thereon, as may be adopted by the Secretary in accordance with general plans approved jointly by the Secretary of the Interior and the head of the department or agency exercising primary administration of such areas: *Provided*, That such rules and regulations shall not be inconsistent with the laws for the protection of fish and game of the States in which such area is situated (16 U. S. C. sec. 664): *Provided further*, That lands having value to the National Migratory Bird Management Program may, pursuant to general plans, be made available without cost directly to the State agency having control over wildlife resources, if it is jointly determined by the Secretary of the Interior and such State agency that this would be in the public interest: *And provided further*, That the Secretary of the Interior shall have the right to assume the management and administration of such lands in behalf of the National Migratory Bird Management Program if the Secretary finds that the State agency has withdrawn from or otherwise relinquished such management and administration."

Sec. 2. The Watershed Protection and Flood Prevention Act, as amended (16 U. S. C. secs. 1001-1007, inclusive), is amended by adding at the end thereof the following new section:

"Sec. 12. When the Secretary approves the furnishing of assistance to a local organization in preparing a plan for works of improvement as provided for in section 3:

"(1) The Secretary shall so notify the Secretary of the Interior in order that the latter, as he desires, may make surveys and investigations and prepare a report with recommendations concerning the conservation and development of wildlife resources and participate, under arrangements satisfactory to the Secretary of Agriculture, in the preparation of a plan for works of improvement that is acceptable to the local organization and the Secretary of Agriculture.

"(2) Full consideration shall be given to the recommendations contained in any such report of the Secretary of the Interior as he may submit to the Secretary of Agriculture prior to the time the local organization and the Secretary of Agriculture have agreed on a plan for works of improvement. The plan shall include such of

National forest lands.

16 USC 480-563, *passim*.

Rules and regulations.

50 Stat. 1080.

Watershed Protection and Flood Prevention Act, 16 USC, 966.

Report with recommendations.

Works of improvement.

the technically and economically feasible works of improvement for wildlife purposes recommended in the report by the Secretary of the Interior as are acceptable to, and agreed to by, the local organization and the Secretary of Agriculture, and such report of the Secretary of the Interior shall, if requested by the Secretary of the Interior, accompany the plan for works of improvement when it is submitted to the Secretary of Agriculture for approval or transmitted to the Congress through the President.

"(3) The cost of making surveys and investigations and of preparing reports concerning the conservation and development of wildlife resources shall be borne by the Secretary of the Interior out of funds appropriated to his Department."

Sec. 4. There is authorized to be appropriated and expended such funds as may be necessary to carry out the purposes of this Act. Approved August 12, 1958.

Public Law 85-625

AN ACT

To amend the Interstate Commerce Act, as amended, so as to strengthen and improve the national transportation system, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That this Act may be cited as the "Transportation Act of 1958".

AMENDMENT TO INTERSTATE COMMERCE ACT, RELATING TO LOAN GUARANTIES

Sec. 2. The Interstate Commerce Act, as amended, is amended by inserting immediately after part IV thereof the following new part:

PART V

PURPOSE

"Sec. 501. It is the purpose of this part to provide for assistance to common carriers by railroad subject to this Act to aid them in acquiring, constructing, or maintaining facilities and equipment for such purposes, and in such a manner, as to encourage the employment of labor and to foster the preservation and development of a national transportation system adequate to meet the needs of the commerce of the United States, of the postal service, and of the national defense.

DEFINITIONS

"Sec. 502. For the purposes of this part—

"(a) The term 'Commission' means the Interstate Commerce Commission.

"(b) The term 'additions and betterments or other capital expenditures' means expenditures for the acquisition or construction of property used in transportation service, chargeable to the road, property, or equipment investment accounts, in the Uniform System of Accounts prescribed by the Interstate Commerce Commission.

"(c) The term 'expenditures for maintenance of property' means expenditures for labor, materials, and other costs incurred in maintaining, repairing, or renewing equipment, road, or property used in transportation service chargeable to operating expenses in accordance with the Uniform System of Accounts prescribed by the Commission.

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Public Law 100-676, Section 6, November 17, 1988
Water Resources Development Act of 1988

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SEC. 6. OPERATION OF CERTAIN PROJECTS TO ENHANCE RECREATION.

(a) Enhancement of Recreation.--The Secretary shall ensure, to the extent compatible with other project purposes, that each water resources project referred to in this subsection is operated in such manner as will protect and enhance recreation associated with such project. The Secretary is authorized to manage project lands at each such project in such manner as will improve opportunities for recreation at the project. Such activities shall be included as authorized project purposes of each project. Nothing in this subsection shall be construed to affect the authority or discretion of the Secretary with respect to carrying out other authorized project purposes or to comply with other requirements or obligations of the Secretary which are legally binding as of the date of the enactment of this Act. The provisions of this subsection shall apply to the following projects:

- (1) Beechfork Lake, West Virginia.
- (2) Bluestone Lake, West Virginia.
- (3) East Lynn Lake, West Virginia.
- (4) Francis E. Walter Dam, Pennsylvania.
- (5) Jennings Randolph Lake (Bloomington Dam), Maryland and West Virginia.
- (6) R.D. Bailey Lake, West Virginia.
- (7) Savage River Dam, Maryland.
- (8) Youghiogheny River Lake, Pennsylvania and Maryland.
- (9) Summersville Lake, West Virginia.

(10) Sutton Lake, West Virginia.

(11) Stonewall Jackson Lake, West Virginia.

(b) Recreation Defined.--As used in this section, in addition to recreation on lands associated with the project, the term "recreation" includes (but shall not be limited to) downstream whitewater recreation which is dependent on project operations, recreational fishing, and boating on water at the project.

Water Resources Reform and Development Act (WRRDA) 2014, Section 4001

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REPLY TO
ATTENTION OF

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS
441 G STREET, NW
WASHINGTON, DC 20314-1000

FEB 19 2015

CECW-NAD

MEMORANDUM FOR COMMANDER, North Atlantic Division

SUBJECT: Implementation Guidance for Section 4001 of the Water Resources Reform and Development Act (WRRDA) of 2014 – River Basin Commissions.

1. Section 4001 of WRRDA 2014 amends Section 5019 of the Water Resources Development Act (WRDA) of 2007 and directs the Secretary to allocate funds to the Susquehanna and Delaware River Basin Commissions and the interstate Commission on the Potomac River Basin. The amount allocated should be equal to that determined by each commission in accordance with the respective interstate compact approved by Congress. Further, if funding is not allocated, the Secretary is directed to submit a notice to the Committee on Environment and Public Works of the Senate and the Committee on Transportation and Infrastructure of the House of Representatives with the Agency's Annual Budget submission. The notice shall describe the rationale for and impact of not allocating such funds. A copy of Section 5019 of WRDA 2007, as amended, is enclosed.

2. Funding for the River Basin Commissions may be considered for inclusion in the budget in accordance with the annual budget engineering circular. If funding is not allocated to these Commissions, the District Engineer will prepare a draft notice describing the impact on water supply allocation, water quality protection, regulatory review and permitting, water conservation, watershed planning, drought management, flood loss reduction, recreation and energy development and forward the draft to the NAD RIT for review and coordination with the Secretary for submission to Congress as part of the Budget submission.

Encl

EDWARD E. BELK, JR., P.E.
Chief, Operations and Regulatory Division
Directorate of Civil Works

SUBJECT: Implementation Guidance for Section 4001 of the Water Resources Reform and Development Act (WRRDA) of 2014 - River Basin Commissions.

**SEC. 5019. WATER RESOURCES DEVELOPMENT ACT OF 2007.
SUSQUEHANNA, DELAWARE, AND POTOMAC RIVER BASINS, DELAWARE,
MARYLAND, PENNSYLVANIA, AND VIRGINIA as amended by Section 4001 of
WRRDA 2014**

(a) EX OFFICIO MEMBER.—Notwithstanding section 3001(a) of the 1997 Emergency Supplemental Appropriations Act for Recovery From Natural Disasters, and for Overseas Peacekeeping Efforts, Including Those in Bosnia (Public Law 105–18; 111 Stat. 176), section 2.2 of the Susquehanna River Basin Compact to which consent was given by Public Law 91–575 (84 Stat. 1512), and section 2.2 of the Delaware River Basin Compact to which consent was given by Public Law 87–328 (75 Stat. 691), beginning in fiscal year 2002, and each fiscal year thereafter, the Division Engineer, North Atlantic Division, Corps of Engineers—

(1) shall be—

(A) the ex officio United States member of the Susquehanna River Basin Compact and the Delaware River Basin Compact; and

(B) one of the 3 members appointed by the President under the Potomac River Basin Compact to which consent was given by Public Law 91–407 (84 Stat. 856);

(2) shall serve without additional compensation; and

(3) may designate an alternate member in accordance with the terms of those compacts.

“(b) AUTHORIZATION TO ALLOCATE.—

“(1) IN GENERAL.—The Secretary shall allocate funds to the Susquehanna River Basin Commission, the Delaware River Basin Commission, and the Interstate Commission on the Potomac River Basin to fulfill the equitable funding requirements of the respective interstate compacts.

“(2) AMOUNTS.—For each fiscal year, the Secretary shall allocate to each Commission described in paragraph (1) an amount equal to the amount determined by the Commission in accordance with the respective interstate compact approved by Congress.

“(3) NOTIFICATION.—If the Secretary does not allocate funds for a given fiscal year in accordance with paragraph (2), the Secretary, in conjunction with the subsequent submission by the President of the budget to Congress under section 1105(a) of title 31, United States Code, shall submit to the Committee on Environment and Public Works of the Senate and the Committee on Transportation and Infrastructure of the House of Representatives a notice that describes—

“(A) the reasons why the Secretary did not allocate funds in accordance with paragraph (2) for that fiscal year; and

SUBJECT: Implementation Guidance for Section 4001 of the Water Resources Reform and Development Act (WRRDA) of 2014 - River Basin Commissions.

“(B) the impact of that decision not to allocate funds on each area of jurisdiction of each Commission described in paragraph (1), including with respect to—

- “(i) water supply allocation;
- “(ii) water quality protection;
- “(iii) regulatory review and permitting;
- “(iv) water conservation;
- “(v) watershed planning;
- “(vi) drought management;
- “(vii) flood loss reduction;
- “(viii) recreation; and
- “(ix) energy development.”.

(c) WATER SUPPLY AND CONSERVATION STORAGE, DELAWARE RIVER BASIN.—

(1) IN GENERAL.—The Secretary shall enter into an agreement with the Delaware River Basin Commission to provide temporary water supply and conservation storage at the Francis E. Walter Dam, Pennsylvania, for any period during which the Commission has determined that a drought warning or drought emergency exists.

(2) LIMITATION.—The agreement shall provide that the cost for water supply and conservation storage under paragraph (1) shall not exceed the incremental operating costs associated with providing the storage.

(d) WATER SUPPLY AND CONSERVATION STORAGE, SUSQUEHANNA RIVER BASIN.—

(1) IN GENERAL.—The Secretary shall enter into an agreement with the Susquehanna River Basin Commission to provide temporary water supply and conservation storage at Federal facilities operated by the Corps of Engineers in the Susquehanna River basin for any period for which the Commission has determined that a drought warning or drought emergency exists.

(2) LIMITATION.—The agreement shall provide that the cost for water supply and conservation storage under paragraph (1) shall not exceed the incremental operating costs associated with providing the storage.

(e) WATER SUPPLY AND CONSERVATION STORAGE, POTOMAC RIVER BASIN.—

(1) IN GENERAL.—The Secretary shall enter into an agreement with the Interstate Commission on the Potomac River Basin to provide temporary water supply and conservation storage at Federal facilities operated by the Corps of Engineers in the Potomac River basin for any period for which the Commission has determined that a drought warning or drought emergency exists.

SUBJECT: Implementation Guidance for Section 4001 of the Water Resources Reform and Development Act (WRRDA) of 2014 - River Basin Commissions.

(2) LIMITATION.—The agreement shall provide that the cost for water supply and conservation storage under paragraph (1) shall not exceed the incremental operating costs associated with providing the storage.

Appendix B: Historic Timeline

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Dates		Description
Start	End	
	1940	Project Authorized in Flood Control Act of 1940
	1955	Hurricane Diane devastates the region
	1955	The Lehigh River Restoration Association is established
1956	1961	Construction of the Francis E. Walter Dam and Reservoir (Bear Creek Reservoir)
	1966	Pennsylvania State Representative Samuel Frank is instrumental in returning the ownership of the Lehigh River to the Commonwealth after 144 years of ownership by the Lehigh Coal & Navigation Company
	1968	The Pennsylvania Fish and Boat Commission studies the Lehigh and Delaware rivers determining that the American shad could not survive in their polluted waters
1968	1970	Start of whitewater releases on 1 weekend a month July-October with no access road infringement
	1970	State and Federal resource agency coordination to discuss canoeing and whitewater release plans
1971	1979	Release plan implemented to include canoe interests
	1974	F.E. Walter construction project environmental assessment completed per NEPA 1969
	1980	Pennsylvania Lehigh Gorge State Park is created downstream of the F.E. Walter Reservoir
1980	1982	Regional drought conditions resulted in cancelation of recreation releases and implementation of F.E. Walter Reservoir water supply storage at the request of DRBC
	1982	Meeting convened by PA State Senator to discuss release program viewpoints amongst agencies and interests
	1982	The Lehigh River Scenic Rivers Act adds a portion of the Lehigh River to the state Scenic Rivers System
	1983	Improved water-quality conditions enable programs to reintroduce breeding populations of bald eagle, osprey, and river otter in Pennsylvania that are dependent on aquatic resources
1983	1987	Newly developed release plan implemented to include access road restrictions
1981	1986	Corps F.E. Walter Reservoir Feasibility study for adding water supply, water quality & recreation
	1988	The Lehigh River Foundation is established
	1988	Congressional authorization for Recreation at F.E. Walter Reservoir
1989	2004	Coordination with resource agencies and interests with modification of release plan to include access road restriction
	1990	4,000 acres of the Lehigh Upper Watershed is Protected
	1991	Trout stocking begins in the Upper Lehigh by the State of Pennsylvania
	1994	A migratory fish Passage is constructed on the lower Lehigh River for shad and other species
	1997	The first annual Lehigh River sojourn
	1999	The first Lehigh River Watershed Conference
	2001	Corps and Pennsylvania Section 22 Lehigh River Comprehensive Watershed WQ Study
2001	2002	Drought storage performed at F.E. Walter Reservoir and recreational releases cancelled
	2003	Wildlands Conservancy Comprehensive Lehigh Mgt. Plan
	2003	The Lehigh River Water Trail is established
	2003	The Lehigh River is placed on the Pennsylvania River's Registry
	2004	Completion of new access road across the top of the F.E. Walter Reservoir dam
2005	Present	Temporary Annual Recreation Operations Plan in cooperation with resource agencies
	2005	Temporary recreation pool level modified storage to elevation 1335'
	2006	Temporary recreation pool level modified storage to elevation 1365'
	2006	Pool height of record at F.E. Walter Reservoir following severe storm event
2006	2014	Corps and Pennsylvania Section 22 Reservoir and Lehigh River Water Quality model (Twp phases)
	2007	Water Resources Development Act (WRDA) of 2007
	2007	Pennsylvania State Lehigh Fishery Management Plan developed
	2007	Lehigh Named Pennsylvania River of the Year
	2008	Temporary recreation pool level modified storage to elevation 1370'
2009	2009	Completion of Phase I and Startup of Phase II of the Section 22 Reservoir and Lehigh River Water Quality Model
	2014	Water Resources Development Act (WRDA) of 2014
	2014	Completion of Phase II of the Section 22 Reservoir and Lehigh River Water Quality Model
2014	---	Section 216 IAR for F.E. Walter Reservoir

Corps Action or Federal Policy Change ◇

Corps and Local Partner Action or Study ◇

State, Local or Watershed Interest Study or Action ◇

Other Relative Watershed Activity ◇