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BAKER (MICHAEL) JR INC BEAVER PA

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NATIONAL DAM SAFETY PROGRAM. CANOE BROOK RESERVOIR NUMBER 3 DAM--ETC(U).

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LEVEL II

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PASSAIC RIVER BASIN
ESSEX COUNTY
NEW JERSEY

**CANOE BROOK RESERVOIR
NO. 3 DAM**

**CANOE BROOK RESERVOIR
NO. 3 DIKE**

**3 PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM.**

NJ 00527
NJ 00550

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**DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE - 2D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106**

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19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Dams - N.J. National Dam Safety Program Phase I. the Canoe Brook Reservoir Dam, N.J. → and Dike, N.J. Canoe Brook Reservoir Dike, N.J. Dykes - N.J. Phase I		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report cites results of a technical investigation as to the dam's adequacy of quacy. → The inspection and evaluation of the dam is as prescribed by the National Dam Inspection Act, Public Law 92-367. The technical investigation includes visual inspection, review of available design and construction records, and preliminary structural and hydraulic and hydrologic calculations, as applicable. An assessment of the dam's general condition is included in the report.		



IN REPLY REFER TO

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DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE-2 D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

28 JUL 1978

Honorable Brendan T. Byrne
Governor of New Jersey
Trenton, New Jersey 08621

Dear Governor Byrne:

Inclosed is the Phase I Inspection Report for Canoe Brook Reservoir No. 3 Dam and Dike in Essex County, New Jersey which has been prepared under authorization of the Dam Inspection Act, Public Law 92-367. A brief assessment of the dam's condition is given on the first two pages of the report.

Based on visual inspection, available records, calculations and past operational performance, Canoe Brook Reservoir No. 3 Dam and Dike is judged to be in generally good overall condition. To insure adequacy of the structure, the following actions, as a minimum, are recommended:

- a. The stone protection on the upstream face of the dam and the dike be rehabilitated by the owner within three months of the date of approval of this report.
- b. A general upgrading of the level of maintenance for both the dam and the dike be initiated within three months of the date of approval of this report.
- c. As a result of the field investigation and study, the hazard potential classification for the dam (I.D. No. NJ 00527) should be revised from "high" to "low". The dike (I.D. No. NJ 00550) previously not classified, should be a "high" hazard potential classification.
- d. Emergency warning and evacuation plans should be developed and implemented for the area downstream of the dike within two months of the date of approval of this report.

A copy of the report is being furnished to Mr. Dirk C. Hofman, New Jersey Department of Environmental Protection, the designated State Office

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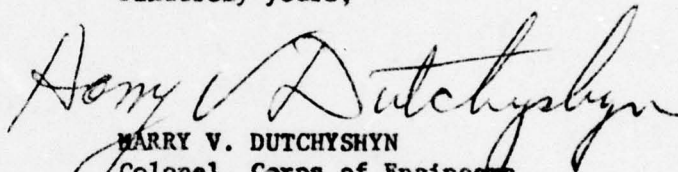
Honorable Brendan T. Byrne

contact for this program. Within five days of the date of this letter, a copy will also be sent to Congressman Joseph Minish of the Eleventh District. Under the provisions of the Freedom of Information Act, the inspection report will be subject to release by this office, upon request, thirty days after the date of this letter.

Additional copies of this report may be obtained from the National Technical Information Services (NTIS), Springfield, Virginia, 22161 at a reasonable cost. Please allow four to six weeks from the date of this letter for NTIS to have copies of the report available.

An important aspect of the Dam Safety Program will be the implementation of the recommendations made as a result of the inspection. We accordingly request that we be advised of proposed actions taken by the State to implement our recommendations.

Sincerely yours,


HARRY V. DUTCHYSHYN
Colonel, Corps of Engineers
District Engineer

1 Incl
As stated

Cy furn:
Mr. Dirk C. Hofman, P.E.
Department of Environmental Protection

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PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam and Dike - Canoe Brook Reservoir No. 3 (Cedar Ridge Reservoir), Essex County, New Jersey

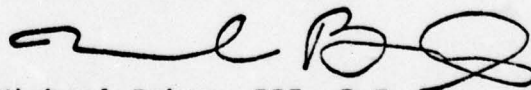
(Stream/River) - Pumped Storage from
Passaic River via Canoe Brook Reservoirs No. 1 and 2
Date of Inspection - 14 June 1978

ASSESSMENT OF
GENERAL CONDITIONS

Canoe Brook Reservoir No. 3 is a pumped storage water supply reservoir owned and operated by the Commonwealth Water Company of Short Hills, New Jersey. The reservoir is impounded by an earthfill dam and dike. The dam is an essentially homogeneous embankment with a crest length of 1280 feet and a maximum height of 57 feet. The dike is an essentially homogeneous embankment with a crest length of 5000 feet and a maximum height of 40 feet.

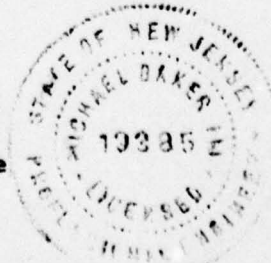
Visual inspections and review of engineering data in June 1978, indicate no serious deficiencies requiring emergency attention. The dam and dike were found to be in generally good overall condition at the time of inspection. It is recommended that slope protection be rehabilitated, the general level of dam and dike maintenance be upgraded, and emergency operation procedures be developed for the reservoir. Emergency evacuation plans should be developed for areas which will be affected in the event of a dike failure. In addition, the dam and dike should have a formal program of future periodic inspections.

MICHAEL BAKER, JR., INC.



Michael Baker, III, P.E.
Chairman of the Board and
Chief Executive Officer
Registration Number 13385

Based on visual inspection, available records, calculations and past operational performance, Canoe Brook Reservoir No. 3 and Dike are judged to be in



NAME OF DAM AND DIKE: CANOE BROOK RESERVOIR NO. 3

generally good overall condition. To insure adequacy of the structures, the following actions, as a minimum, are recommended:

a. The stone protection on the upstream face of the dam and the dike be rehabilitated by the owner within three months of the date of approval of this report.

b. A general upgrading of the level of maintenance for both the dam and the dike be initiated within three months of the date of approval of this report.

c. As a result of the field investigation and study, the hazard potential classification for the dam (I.D. No. NJ 00527) should be revised from "high" to "low". The dike (I.D. No. NJ 00550) previously not classified, should be a "high" hazard potential classification.

d. Emergency warning and evacuation plans should be developed and implemented for the area downstream of the dike within two months of the date of approval of this report.

APPROVED:

Harry V. Dutchyshyn

HARRY V. DUTCHYSHYN
Colonel, Corps of Engineers
District Engineer

DATE:

2-8 July 1978

LEVEL II

PASSAIC RIVER BASIN



Name of Dam: Canoe Brook Reservoir No. 3 - Dam and Dike
County and State: Essex County, State of New Jersey
Inventory Number: NJ 00527 (Dam)
Inventory Number: NJ 00550 (Dike)

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Prepared By: Michael Baker, Jr., Inc.
Consulting Engineers
4301 Dutch Ridge Road
Box 280
Beaver, Pennsylvania 15009

Prepared For: Department of the Army
Philadelphia District, Corps of Engineers
Custom House - Second and Chestnut Streets
Philadelphia, Pennsylvania 19106

Date: July 1978

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OVERALL VIEW OF DAM

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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

NAME OF DAM: CANOE BROOK RESERVOIR NO. 3, ID# NJ 00527
NAME OF DIKE: CANOE BROOK RESERVOIR NO. 3, ID# NJ 00550

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

- a. Authority - This report is authorized by the Dam Inspection Act, Public Law 92-367, 92nd Congress, H.R. 15951 enacted 8 August 1972.
- b. Purpose of Inspection - The purpose of this inspection is to evaluate the general condition of Canoe Brook Reservoir No. 3 with respect to safety of the facility based upon available data and visual inspection.

1.2 DESCRIPTION OF PROJECT

- a. Description of Reservoir, Dam and Dike - Canoe Brook Reservoir No. 3 (also called Cedar Ridge Reservoir) is a pumped storage water supply reservoir which was created by constructing dam and dike sections around a portion of a former glacial lake bed in an upland area adjacent to the Passaic River. The dam, which is located on the northwest side of the reservoir about 1500 feet east of the Passaic River, has a crest length of 1280 feet, a maximum structural height of 57 feet, an average crest width of 15 feet, and upstream and downstream slopes of 2.5:1. The dike around the east and south sides of the reservoir has a crest length of 5000 feet, a maximum structural height of 40 feet, an average crest width of 15 feet, 2:1 outer slopes, 2:1 inner slopes where heights are less than 30 feet, and 2.5:1 inner slopes where heights exceed 30 feet. The 2600 feet west and 2800 feet northeast sides of the reservoir are natural ridges covered with glacial soils.

The dam and dike are homogeneous embankments constructed in 1956 and 1957 from well graded, granular, and relatively impervious glacial soils obtained in the reservoir area. The dam and some of the higher dike sections have compacted soil foundation cutoffs on the order of five feet deep and 20 feet wide, as well as sand and gravel toe drains. The lower dike sections have no foundation cutoffs or toe drains. Gravel filled relief wells were installed in the dam foundation in 1959 and

NAME OF DAM AND DIKE: CANOE BROOK RESERVOIR NO. 3

similar relief wells were installed in the foundation of the highest dike section on the east side of the reservoir in 1961.

Surface runoff from the area east of the reservoir is carried beneath the reservoir by a 36 inch diameter lock joint pipe with anti-seepage rings. This pipe, which also carries drainage from the relief wells in the foundation of the east dike, discharges at the downstream toe of the dam into an unnamed stream which flows through a swampy area to the Passaic River. Outlet pipes for the dam's toe drains and relief wells also discharge into this stream and swampy area.

The reservoir, which has a surface area of 180 acres at dam and dike crest level (El. 225), a surface area of 165 acres at maximum pool (El. 220), and an additional drainage area of only 65 acres, has no spillway. The reservoir is filled by pumping water in through a 30 inch diameter lock joint pipe, with anti-seep rings that extends beneath the south dike. The maximum rate of inflow is 30 M.G.D. The reservoir is also drained through the 30 inch pipe. Outflow is by gravity with the pool above approximately El. 194 and by pumping with the pool below approximately El. 194. Maximum rate of outflow is 10 M.G.D. The maximum drawdown rate is approximately 0.2 feet per day in upper portions of the reservoir and somewhat greater in lower portions of the reservoir.

A 24 inch diameter lock joint pipe with anti-seep rings extends beneath the base of the dam and discharges into the stream which originally drained the area. This pipe, which was probably used for stream diversion during dam construction, now appears to convey water from the dam foundation relief wells and dam toe drain. The upstream end of the 24 inch pipe, located near the center of the upstream toe of the dam, has a 24 by 12 inch tee fitting. The tee fitting contains a 24 inch plug and a 12 inch gate valve. The handwheel on this gate valve must be operated by a diver unless the reservoir is practically empty. The 12 inch gate valve and 24 inch pipe, do however, provide an additional means of reservoir control. A gate valve on the downstream end of the 24 inch pipe was removed in 1959 when the downstream slope of the dam was flattened.

- b. Location - Canoe Brook Reservoir No. 3 is located in Livingston Township, New Jersey, about two miles east-southeast of the village of Livingston.

NAME OF DAM AND DIKE: CANOE BROOK RESERVOIR NO. 3

The reservoir is about one-half mile east of the Passaic River and one mile south of New Jersey Route 10. The Eisenhower Parkway lies about 100 feet east of the east dike of the reservoir.

- c. Size Classification - The maximum height of the dam is 57 feet and the maximum height of the dike is 40 feet. The reservoir volume to the dam and dike crest is 5800 acre-feet. Therefore, the dam and dike are in the "Intermediate" size category as defined by the "Recommended Guidelines for Safety Inspection of Dams."
- d. Hazard Classification - The channel downstream from the dam is an uninhabited swampy area extending approximately 1500 feet to a swampy area along the Passaic River. The dam is therefore considered in the "Low" risk category as defined by the "Recommended Guidelines for Safety Inspection of Dams."

Housing developments east of the east dike and Eisenhower Parkway are estimated to contain 50 houses and 300 people in areas that might be flooded if the dike failed. In addition, the heavily travelled Eisenhower Parkway lies just east of this dike; the Livingston Mall Shopping center is located southeast of the reservoir; and a school is located south of the reservoir. It is estimated that "more than a few" lives could be lost and property damage would be "excessive" in the event of a dike failure. The dike is therefore considered in the high risk category as defined in the "Recommended Guidelines for Safety Inspection of Dams."

- e. Ownership - The reservoir is owned by the Commonwealth Water Company, 233 Canoe Brook Road, Short Hills, New Jersey 07080.
- f. Purpose of Reservoir - The reservoir is used for pumped storage water supply.
- g. Design and Construction History - The reservoir, dam, and dike and their various modifications were designed for Commonwealth Water Company by American Water Works Service Company, Inc., whose present address is 500 Grove Street, Haddon Heights, New Jersey 08035. Geotechnical investigations for the original design were done by Greer Engineering Associates of Montclair, New Jersey. Later geotechnical investigations were reportedly done by Woodward-Clyde Consultants.

Information on construction history is not readily available but may exist in the files of the Commonwealth Water Company. The dam and dike were reportedly constructed in 1956 with perhaps some work completed in 1957. Two small slides in the downstream slope of the dam were corrected in 1959. This work included installation of gravel filled relief wells in the dam foundation, extending the 24 inch reservoir outlet pipe and 36 inch storm drain pipe 30 feet downstream to a new concrete headwall, and flattening the downstream slope of the dam from 2:1 to 2.5:1.

After the Eisenhower Parkway was constructed along the east side of the reservoir, home owners in the housing development east of the Parkway apparently complained about groundwater problems in their yards and basements. In 1961, gravel-filled relief wells were installed in the foundation of the maximum height dike section along the east side of the reservoir. Since the installation of the relief wells, there reportedly have been no complaints on groundwater problems east of the Parkway.

The southwest corner of the reservoir overlies a pervious gravel-cobble-boulder stratum which extends southerly at a depth of several tens of feet beneath other, relatively impervious glacial soils. (This pervious soil was probably deposited along a natural saddle spillway by torrential outflow from the glacial lake which formerly occupied the reservoir site.) Some time ago, a one foot clay blanket was placed over the pervious soil in the southwest corner of the reservoir. This clay blanket reduced, but did not stop, the leakage. The owner estimates that this leakage could approach four M.G.D. at maximum pool El. 220 but notes that the leakage decreases substantially when the pool drops below El. 219. The water that is lost from the reservoir through the pervious soil stratum apparently recharges aquifers to the south and causes no problems. Present water losses are not of sufficient economic significance to the owner to justify mitigative measures.

- h. Normal Operational Procedures - The reservoir is filled by pumping water from the Passaic River via Canoe Brook Reservoirs No. 1 and 2 which are located two to three miles south of Canoe Brook Reservoir No. 3. Water discharged from Canoe Brook Reservoir No. 3 flows two miles south to Reservoir No. 1. Water levels in the three reservoirs are adjusted as necessary to balance water supply

NAME OF DAM AND DIKE: CANOE BROOK RESERVOIR NO. 3

and demand. Pumping water from the Passaic River is limited each year to the period from 1 October through 31 May. Reservoir No. 3 normally experiences filling each winter, drawdown each summer, and re-filling each autumn. In typical years, reservoir levels fluctuate between El. 220 (full pool) and about El. 190.

The entire reservoir is surrounded by a fence to keep out motorcyclists, vandals, fishermen, etc. Personnel of the owner's company inspect the reservoir each day to check its condition and take water samples. Other personnel make monthly inspections of the reservoir, dam and dike. Informal reports are prepared from these inspections. Routine maintenance is performed as necessary and/or when funds are available.

Additional operations and maintenance information may be available in the files of the Commonwealth Water Company. The information summarized above, which was obtained from the owner's representatives during the field inspection of the reservoir, are considered sufficient for purposes of this Phase I Inspection Report.

1.3 PERTINENT DATA

- a. Drainage Area - The drainage area of Canoe Brook Reservoir No. 3 is approximately 245 acres composed of the reservoir area of 180 acres at dam and dike crest level (El. 225) and a tributary drainage area of approximately 65 acres.
- b. Discharge at Damsite - The maximum known flow at the reservoir through the inlet pipe is 30 M.G.D.
- c. Elevation [feet above Mean Sea Level (M.S.L.)] -
 - Top of Dam and Dike - 225
 - Maximum Pool (Design Capacity) - 220
 - Bottom of Reservoir - 170+
 - Recreation Pool - Not applicable
 - Streambed at Centerline of Dam - 168+
 - Maximum Tailwater - Not applicable
- d. Reservoir -
 - Length of Maximum Pool - 4100 feet or 0.78 mile
 - Length of Recreation Pool - Not applicable

NAME OF DAM AND DIKE: CANOE BROOK RESERVOIR NO. 3

e. Storage -

At Maximum Pool (El. 220) - 5000 acre-feet
Top of Dam (El. 225) - 5800 acre-feet

f. Reservoir Surface (acres) -

Top of Dam - 180
Spillway Crest - Not applicable
Maximum Pool - 165
Normal Pool - 165

g. Dam -

Type - Homogeneous earthfill with sand and gravel
toe drain and gravel relief wells in
foundation.
Length - 1280 feet
Height - 57 feet
Top Width - 15 feet, typical
Side Slopes - Upstream - 2.5:1
Downstream - 2.5:1
Impervious Core - None
Cutoff Trench - About five feet deep by 20 feet
wide filled with compacted soil.

h. Dike -

Type - Homogeneous earthfill with gravel relief
wells in foundation for 550 feet of dike
on the east side of the reservoir.
Length - 5000 feet
Height - 40 feet (maximum)
Top Width - 15 feet typical
Side Slopes - Upstream - 2:1 for heights less than
30 ft., 2.5:1 for greater heights
Downstream - 2:1
Impervious Core - None
Cutoff - Generally none

i. Diversion and Regulating Tunnel - None

j. Spillway - None

k. Regulating Outlets - 30 inch diameter inlet/outlet
pipe.

NAME OF DAM AND DIKE: CANOE BROOK RESERVOIR NO. 3

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

The design data reviewed included the following:

Seven American Water Works Company, Inc.,
Drawings (included in this report)
Greer Engineering Associates Geotechnical report of
January 1956 (referenced in Appendix B).

2.2 CONSTRUCTION

Readily available construction information was summarized in paragraphs 1.2.a. and 1.2.g.

2.3 OPERATION

Readily available operations and maintenance information was summarized in paragraphs 1.2.a. and 1.2.h.

2.4 EVALUATION

- a. General - Much of the engineering information used in this report was verbally reported by owner's representatives in interviews that occurred immediately prior to the field inspection and during the field inspection. It is likely that considerably more engineering data, reports, etc., exist in the owner's files and attempts could be made to obtain and review such information if it is considered necessary by the Corps of Engineers or agencies of the State of New Jersey.
- b. Adequacy - The engineering information obtained from the owner's representatives, plus observations made during field inspection of the reservoir, are considered sufficient for this Phase I Inspection Report.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

- a. General - The reservoir and its appurtenant structures, including the dam and dike, were found to be in generally good overall condition at the time of inspection. Most of the problems noted during the visual inspection are considered minor and do not require immediate remedial treatment. Noteworthy deficiencies observed are described briefly in the following paragraphs. The complete visual inspection check list is given in Appendix A.
- b. Dam - A seepage area was noted along the junction of the downstream slope and right abutment from approximately El. 192 (the slide area corrected in 1959) down to stream level, El. 170+. Sand boils one inch in diameter were observed in well graded sandy fill at El. 190+. There was no evidence of piping. This was inferred to be an area of long-term, steady seepage which is probably occurring through pervious outwash, ice contact, and/or glacial lake beach soil deposits along the right abutment. A wet, marshy area with cattails extends from the top of the seepage area to stream level along the downstream toe of the dam. The estimated total flow in the seepage area was on the order of 10 to 20 G.P.M.

There was considerable vegetation, i.e., grass, weeds, brush, small trees, on the downstream slope of the dam and in the area of its downstream toe. This vegetation made inspection of seepage areas and toe drain discharge pipes difficult.

The two eight inch diameter toe drain outlets on the right side of the downstream toe of the dam were both functioning. The toe drain outlet about 40 feet east of the headwall at the downstream toe of the dam was, however, partially filled with sediment. The locations of the eight inch diameter toe drain outlets on the left side of the downstream slope were not known by the owner's representatives. These outlets were not observed during the inspection.

The 24 inch diameter relief well and reservoir outlet pipe discharging from the headwall at the downstream toe of the dam was functioning but it was about one-half full of sediment. No other deficiencies were observed in the visible section of this pipe.

NAME OF DAM AND DIKE: CANOE BROOK RESERVOIR NO. 3

A scour pit several feet in length and breadth and about two feet deep had developed in the stream channel immediately downstream from the headwall from which the above-mentioned 24 inch pipe and the 36 inch storm drain discharge. No deficiencies were observed in the visible section of the 36 inch pipe.

Riprap failures were noted at several locations along the upstream slope of the dam.

- c. Dike - A seepage area approximately 70 feet long was noted along the outer dike toe extending easterly from a point about 30 feet east of the 30 inch diameter inlet/outlet pipe and pump vault. No sand boils or piping evidence were observed. This was inferred to be an area of long-term steady seepage along the natural ground line beneath the dike. Total estimated flow in the seepage area was on the order of two to three G.P.M.

There was considerable vegetation, i.e., grass, weeds, brush, small trees, along the outer dike slope.

Several groundhog burrows were observed in the outer dike slope.

Riprap failures were noted at numerous locations in the inner dike slope. The most severe of these were along the south dike where the most severe wave action occurs.

3.2 EVALUATION

- a. General - Maintenance of the dam and dike in recent years has been less than adequate. Michael Baker, Jr., Inc., strongly suggests that the level of maintenance be upgraded. Specific recommendations are included in the following paragraphs.
- b. Dam - The seepage area on the right side of downstream slope is not considered to be indicative of conditions which endanger the structural stability of the downstream slope at the present time. This seepage area should be visually monitored by the owner's personnel and any others who make future inspections of the dam. Also, the owner should consider installation and monitoring of open standpipe piezometers in the right abutment area to clarify seepage patterns.

Large vegetation consisting of brush and trees should be removed from the downstream slope and downstream toe area. Small vegetation such as grass and weeds should be mowed periodically. These measures will significantly facilitate future dam inspections by the owner's personnel and other authorities.

The toe drain and relief well outlet pipes are not considered indicative of conditions which endanger the structural stability of the dam at the present time. However, the following remedial work should be performed:

- 1) The toe drain outlet(s) on the left side of the downstream slope should be immediately located and cleaned as necessary.
- 2) The eight inch toe drain outlet located about 40 feet east of the headwall should be cleaned.
- 3) The 24 inch relief well and reservoir outlet pipe should be cleaned, inspected, and repaired as necessary.

The scour pit located downstream from the headwall at the downstream toe is a relatively minor erosional problem which certainly does not endanger the structural stability of the dam. Riprap consisting of moderate to large size boulders should be placed in this scour pit to dissipate energy of the water discharged from the 36 inch drain pipe, thereby preventing additional scour.

Riprap failures along the upstream slope of the dam are relatively superficial but they should be repaired as soon as possible. Riprap stone used in the repairs should be of adequate size and free of decomposable rocks such as shales.

- c. Dike - The seepage area located along the outer toe of the south dike, east of the pump vault, is not considered to be indicative of a condition which endangers the structural stability of the dike at the present time. This seepage area should be visually monitored by the owner's personnel and any others who make future inspections of the dike. A small ditch might be excavated to collect seepage water and a drain pipe might be installed to carry the water south under the driveway.

Large vegetation, i.e., brush and trees, should be removed from the downstream slope of the dike and

small vegetation, i.e., grass and weeds, should be mowed periodically. These measures will significantly facilitate future dike inspections by the owner's personnel and others.

Groundhog burrows in the outer dike slopes are not considered detrimental to dike stability at the present time. However, a groundhog control program should be implemented to prevent potential future problems.

Several of the riprap failures along the inside of the south dike slope are considered severe enough to require immediate attention. Other riprap failures along the inner dike slope were relatively superficial and have a lower priority for repairs. Riprap stone used in the repairs should be of adequate size, i.e., larger than much of the present riprap and free of decomposable rocks, such as shales. It may also be necessary to include appropriate granular bedding beneath the riprap in some of the more severely eroded areas.

SECTION 4 - OPERATIONAL PROCEDURES

Operational procedures are generally discussed in paragraphs 1.2.a. and 1.2.h.

There is no formal written procedure for emergency evacuation in the event of impending catastrophe. However, the owner is reportedly developing such emergency plans at the present time as part of requirements for insurance coverage.

Rapid emergency drawdown of the reservoir is virtually impossible due to the nature of the outlet works as described in paragraph 1.2.a.

It is recommended that a formal emergency procedure be prepared and prominently displayed and furnished to all operating personnel. This should include:

- 1) How to operate the reservoir during an emergency.
- 2) Methods of draining the reservoir under emergency conditions.
- 3) Who to notify, including public officials, in case evacuation from adjacent areas is necessary.

In addition, the owner should assist public officials in developing an emergency evacuation plan for areas which will be affected in the event of a dike failure.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 OVERTOPPING POTENTIAL

Hydraulic and hydrologic considerations of importance to this pumped storage water supply reservoir have been described in paragraphs 1.2.a. and 1.2.h. It is obvious that, with five feet of freeboard storage in a 165 acre reservoir (maximum pool El. 220) with a tributary drainage area of less than 100 acres, the dam and dike will not be overtopped even during rainfall equivalent to the Probable Maximum Precipitation (P.M.P.) which is approximately two feet of rain in six hours for this area.

5.2 EMERGENCY DRAWDOWN OF RESERVOIR

An elevation-storage curve provided by the owner indicates a reservoir storage of 1650 million gallons at maximum pool El. 220 and a reservoir storage of 500 million gallons at El. 194, the approximate lower limit of gravity outflow (paragraph 1.2.a.). Using the maximum outflow rate of 10 M.G.D. furnished by the owner (paragrph 1.2.a.), 115 days would be required to draw the reservoir down from El. 220 to El. 194. As indicated in Section 4, rapid emergency drawdown of the reservoir is virtually impossible due to the nature of th outlet works.

NAME OF DAM AND DIKE: CANOE BROOK RESERVOIR NO. 3

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

- a. Visual Observations - No structural inadequacies were noted during the visual inspection of the dam or dike.
- b. Design and Construction Data - Calculations of embankment slope and foundation stability were not available for review. However, the January 1956 geotechnical report by Greer Engineering Associates noted that the minimum safety factor of the upstream dam slope and inner dike slope during rapid drawdown was 2.5.

Except for information about the 1959 dam modifications and 1961 dike relief well installations described in paragraphs 1.2.a. and 1.2.g., construction data were not available for review. These modifications obviously improved dam and dike stability., but the improvement cannot be quantified.

General experience with slopes of heights, inclinations, materials, and hydraulic conditions similar to those of the dam and dike slopes indicates that these slopes could be shown to satisfy the stability requirements of the "Recommended Guidelines for Safety Inspection of Dams." This inference is supported by empirical guidelines on stable slope inclinations given by the U.S. Bureau of Reclamation (1973) Design of Small Dams, 2nd ed., pp. 265-267. In view of the modest heights and inclinations of the dam and dike slopes, their histories of satisfactory performance, and the fact that no indications of instability were observed during the field inspection of 14 June 1978, no further stability assessments are justified for this Phase I Inspection Report.

- c. Operating Records - Nothing in the readily available operating information indicates cause for concern relative to structural stability of the dam or dike.
- d. Post-Construction Changes - As noted above in paragraph 6.1.b., the 1959 and 1961 dam and dike modifications obviously improved stability.
- e. Seismic Stability - The dam and dike are located in Zone 1 on the Seismic Zone Map of the contiguous United States (Figure 1, p. D-30, "Recommended Guidelines for Safety Inspection of Dams"). This

NAME OF DAM AND DIKE: CANOE BROOK RESERVOIR NO. 3

is an area of very low seismic activity. Seismic stability of small embankment dams with conservative slopes located in areas of low seismic activity need not be evaluated because experience has shown that such dams have adequate seismic stability as long as they have adequate static stability. Thus, there is no need for further consideration of seismic stability of the Canoe Brook Reservoir No. 3 Dam and Dike.

NAME OF DAM AND DIKE: CANOE BROOK RESERVOIR NO. 3

SECTION 7 - ASSESSMENT, RECOMMENDATIONS/REMEDIAL MEASURES

7.1 DAM AND DIKE ASSESSMENT

- a. Safety - There are no detrimental findings, as a result of this inspection, from which an unsafe assessment can be rendered. Freeboard storage is adequate for the P.M.P. even if the reservoir is at maximum pool.
- b. Adequacy of Information - The available information and the observations made during field inspection of the reservoir are considered sufficient for this Phase I Inspection Report.

7.2 RECOMMENDATIONS/REMEDIAL MEASURES

The inspection revealed certain items of rehabilitation or other work which should be given high priority by the owner. These are:

- 1) Repair of riprap failures along the upstream dam slope and inner dike slope, particularly the severe riprap failures along the south dike.
- 2) General upgrading of maintenance of the dam and dike, including:
 - a) Removal of large vegetation and periodic mowing of small vegetation on downstream dam slope and outer dike slope.
 - b) Location and cleaning as necessary of the eight inch toe drain outlet pipe on left side of downstream dam slope.
 - c) Cleaning of the eight inch toe drain outlet pipe located about 40 feet east of the head-wall of the downstream dam slope.
 - d) Cleaning, inspection and repair as necessary of 24 inch relief well and reservoir outlet pipe at downstream toe of dam.
 - e) Placement of boulder size riprap in scour pit downstream from headwall at downstream toe of dam.
 - f) Implementation of groundhog control program for dike and dam slopes.

- 3) Development of emergency operations procedures, including:
 - a) How to operate the reservoir during an emergency.
 - b) Methods of draining the reservoir under emergency conditions.
 - c) Who to notify, including public officials, in case evacuation from adjacent areas is necessary.
 - d) Assistance of public officials with development of emergency evacuation plans for areas which will be affected in the event of a dike failure.
- 4) Periodic inspections of the reservoir, dam, and dike with particular attention directed to:
 - a) Seepage areas on the right side of downstream dam slope and along the outer toe of the south dike east of the pump vault.
 - b) Wave damage and riprap deterioration.
 - c) Condition and behavior of the toe drain and relief well outlet pipes.

PLATES

NO DRAWINGS OF REPRODUCIBLE QUALITY WERE AVAILABLE
FOR INCLUSION IN THIS REPORT. IF DRAWINGS ARE
DESIRED, PLEASE CONTACT THE OWNER.

PHOTOGRAPHS

PHOTOGRAPH DESCRIPTIONS

Overall View of Dam - View Northeast from Crest of Downstream Slope at Center of Dam; Seepage and Sand Boil Area (Close-up of Photo 2) is in Upper Center of Photo at Junction of Downstream Slope with Right (Northeast) Abutment - 14 June 1978.

Photo 1 - View Upstream (Southeast) at Dam Showing Center of Downstream Slope; Concrete Headwall has 36 Inch Storm Drain Outlet on Left, 24 Inch Outlet for Reservoir and Foundation Relief Wells on Right - 14 June 1978.

Photo 2 - Close-up of Seepage and Sand Boil Area at Approximately El. 190 on Right Side of Downstream Slope of Dam (Center of Overall View of Dam); Pencil at Boil in Silty Sand - 14 June 1978.

Photo 3 - Close-up of Eight Inch Toe Drain Outlet Partially Plugged with Sediment and Debris, Downstream Toe of Dam About 40 Feet Northeast of Headwall Shown in Photo 1 - 14 June 1978.

Photo 4 - View Downstream from Top of Headwall Shown in Photo 1 - 14 June 1978.

Photo 5 - View Northwest Across Eisenhower Parkway at Maximum Height Dike Section; Curb Inlet Between Two Cars Marks Inlet of 36 Inch Storm Drain Extending Beneath Reservoir to Outlet Shown in Overall View of Dam; Crest of Dam is in Center of Photo, Above Dike Crest and Below Tree Line - 14 June 1978.

Photo 6 - View Southeast From Crest of Maximum Height Dike Section (Photo 5) Across Eisenhower Parkway to Housing Area; Curb Inlet on Far Side of Parkway is Opposite Curb Inlet in Right Side of Photo 5; Concrete Manhole at Inlet of 36 Inch Storm Drain is in Bottom Center of Photo - 14 June 1978.

Photo 7 - View Southwest Along Inside Dike Slope from North End of East Dike Section; Areas of Riprap Damage and Riprap Repair on Right Side of Photo - 14 June 1978.

Photo 8 - Close-up of Severe Riprap Failure and Wave Erosion on Inside Slope of South Dike Section About 40 Feet East of Reservoir Inlet/Outlet Pipe; Tape Segment in Photo is 3.5 Feet Long - 14 June 1978.

PHOTOGRAPH DESCRIPTIONS
(Cont.)

Photo 9 - View South From Crest of South Dike Section Over
Pump Vault on Reservoir Inlet/Outlet Pipe; Livingston
Mall Behind Eisenhower Parkway at Top of Photo -
14 June 1978.

Photo 10 - Seepage Area at Outside Toe of South Dike About
50 feet East of Pump Vault (Photo 9) - 14 June 1978.



PHOTO 1



PHOTO 2



PHOTO 3



PHOTO 4

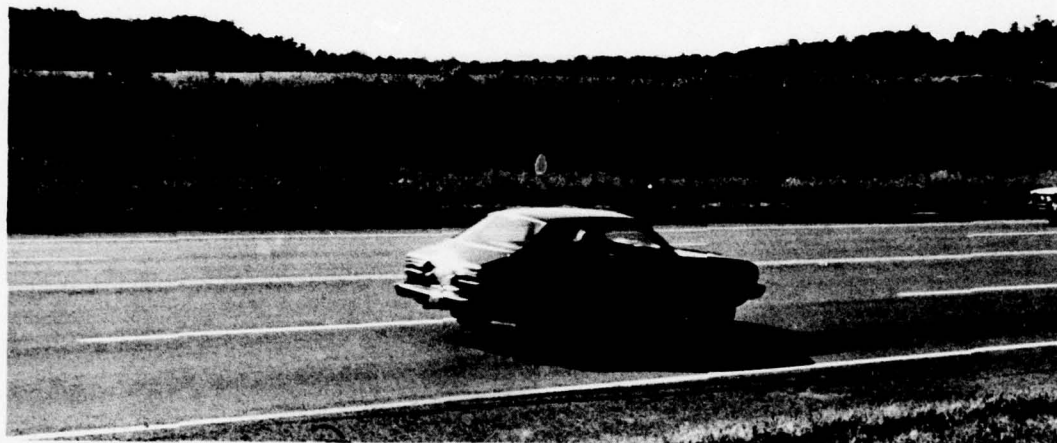


PHOTO 5



PHOTO 6



PHOTO 7



PHOTO 8



PHOTO 9



PHOTO 10

APPENDIX A

CHECK LIST - VISUAL INSPECTION

Check List
Visual Inspection
Phase 1

Name Dam Canoe Brook Reservoir No. 3 County Essex State New Jersey Dam Coordinates N 4047.3°
and Dike (Cedar Ridge Reservoir) W 7421.9°

Dike Coordinates N 4046.7°
W 7421.5°

Date Inspection 14 June 1978 Weather Sunny and Breezy Temperature 75°

Pool Elevation at Time of Inspection 217.8 M.S.L. Tailwater at Time of Inspection M.S.L.
is (Pool elevation furnished by owner) No tailwater as such; pumped storage water supply reservoir.
Dam toe drains discharge to stream through swampy area --
El. 168+

Inspection Personnel:

MICHAEL BAKER, JR., INC.:

E. U. Gingrich
T. J. Dougan
J. V. Hamel

COMMONWEALTH WATER COMPANY:

K. Lutz
G. Moran

AMERICAN WATER WORKS SERVICE CO.:

W. Pearce
D. Edwards

J. V. Hamel Recorder

CONCRETE/MASONRY DAMS

Canoe Brook Reservoir No. 3

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SEE PAGE ON LEAKAGE	Not Applicable	
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS	Not Applicable	
DRAINS	Not Applicable	
WATER PASSAGES	Not Applicable	
FOUNDATION	Not Applicable	

CONCRETE/MASONRY DAMS

Canoe Brook Reservoir No. 3

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES	Not Applicable	
STRUCTURAL CRACKING	Not Applicable	
VERTICAL AND HORIZONTAL ALIGNMENT	Not Applicable	
MONOLITH JOINTS	Not Applicable	
CONSTRUCTION JOINTS	Not Applicable	

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	None observed	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None observed	Trees and brush should be cleared from outer slopes and toe areas of dam and dike sections. Lower vegetation (grass, weeds) should be mowed periodically.
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	None observed, except as noted below on riprap erosion.	Several groundhog holes in outer dike slopes. Groundhog control program should be implemented.
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	No problems observed	
RIPRAP FAILURES	Several areas of riprap failure on upstream slope of dam and inner slopes of dikes. Most riprap too small to provide adequate protection and some riprap of poor quality (decomposable shale). Extensive wave damage at several locations along inside of dike around southern part of reservoir. Evidence of numerous riprap repairs (apparently continuing problem).	Riprap should be repaired as soon as possible, particularly in areas of severe wave damage along south dike, using durable stone of adequate sizes underlain by appropriate granular bedding, where the latter is required.

EMBANKMENT

Canoe Brook Reservoir No. 3

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	Seepage observed at two locations:	Mow vegetation on downstream dam slope; visually monitor seepage areas during periodic inspections for evidence of piping; consider monitoring of open standpipe piezometers to clarify right abutment seepage pattern.
ANY NOTICEABLE SEEPAGE	1. Junction of downstream slope of dam and right abutment from approximately El. 192 (area of slide corrected in 1959) down to stream level (El. 170+); 1 inch diameter sand boils in well graded sandy fill--El. 190+; no evidence of piping; inferred long term steady seepage, probably through pervious outwash, ice contact, and/or glacial lake beach soil deposits along right abutment; wet, marshy area with cattails extends from top of seepage area to stream level along downstream toe of dam; total estimated flow--10 to 20 GPM. 2. Outer toe of south dike, extending from 30 to 100 feet east of 30 inch inlet/outlet pipe and pump vault; no sand boils or piping evidence; inferred long term steady seepage along natural ground line beneath dike; estimated flow--two to three GPM.	Mow vegetation on outer dike slope; visually monitor seepage during periodic inspections; install ditch to collect seepage water and drain-pipe to carry it south under drive-way.

None

STAFF GAGE AND RECORDER

DRAINS

Dam:

Two eight diameter toe drain outlets on right side downstream toe both functioning but rather inaccessible in heavy vegetation; eight inch outlet located approximately 40 feet east of headwall partially filled with sediment; 24 inch diameter toe drain relief well outlet in headwall partially filled with sediment but functioning; eight inch diameter toe drain outlet(s) on left side downstream toe were not observed [location(s) unknown to owner's representatives].

Vegetation should be cut to provide access to dam toe drain outlets. Eight inch outlet approximately 40 feet east of headwall should be cleaned; 24 inch outlet in headwall should be cleaned, inspected, and repaired as necessary next time the reservoir is drawn down; drain outlet(s) on left side downstream toe should be located and cleaned as necessary.

(Continued on next page)

EMBANKMENT

Canoe Brook Reservoir No. 3

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
DRAINS (Continued)	Dike: Relief wells in foundation of east dike section were functioning adequately.	Drain performance should be checked in all future dam inspections; drain maintenance should be upgraded significantly.

OUTLET WORKS

Canoe Brook Reservoir No. 3 . (See following page)

<u>VISUAL EXAMINATION OF</u>	<u>OBSERVATIONS</u>	<u>REMARKS OR RECOMMENDATIONS</u>
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT		
INTAKE STRUCTURE		
OUTLET STRUCTURE		
OUTLET CHANNEL		
EMERGENCY GATE		

OUTLET WORKS

Canoe Brook Reservoir No. 3

NOTES:

1. A 36 inch diameter lock joint storm drain with anti-seepage rings carries surface runoff from an area located east of the reservoir, beneath the reservoir to a discharge point at the headwall at the downstream toe of the dam. Boulder-size riprap should be placed in the scour area downstream from headwall.
2. A 24 inch diameter lock joint outlet pipe with anti-seepage rings extends from the reservoir through the base of the dam to a discharge point at the headwall at the downstream toe of dam. Upstream end of the 24 inch pipe has a 24 inch x 12 inch tee with 24 inch plug and 12 inch valve. Handwheel on 12 inch valve must be operated by diver unless reservoir is essentially empty.
3. Reservoir regulation is with 30 inch diameter lock joint water pipe with anti-seepage rings which passes through base of dike on south edge of reservoir. Water is pumped into and drained from the reservoir via this pipe. Drainage is by gravity flow for approximately the upper half of the reservoir storage (above approximately El. 194), then by pumping for lower half of reservoir storage.
4. There is no spillway for the reservoir which has an insignificant tributary drainage area and adequate freeboard storage for the P.M.P.

UNGATED SPILLWAY

Canoe Brook Reservoir No. 3

<u>VISUAL EXAMINATION OF</u>	<u>OBSERVATIONS</u>	<u>REMARKS OR RECOMMENDATIONS</u>
CONCRETE WEIR	Not Applicable	
APPROACH CHANNEL	Not Applicable	
DISCHARGE CHANNEL	Not Applicable	
BRIDGE AND PIERS	Not Applicable	

GATED SPILLWAY

Canoe Brook Reservoir No. 3

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
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CONCRETE SILL		
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	Not Applicable	
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APPROACH CHANNEL		
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	Not Applicable	
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DISCHARGE CHANNEL		
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	Not Applicable	
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BRIDGE AND PIERS		
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	Not Applicable	
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GATES AND OPERATION EQUIPMENT		
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	Not Applicable	
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INSTRUMENTATION

Canoe Brook Reservoir No. 3
(No Instrumentation)

VISUAL EXAMINATION	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	Not Applicable	
OBSERVATION WELLS	Not Applicable	
WEIRS	Not Applicable	
PIEZOMETERS	Not Applicable	
OTHER	Not Applicable	

RESERVOIR

Canoe Brook Reservoir No. 3

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	This pumped storage water supply reservoir is located in an upland area on a portion of a former glacial lake bed. More than half of the reservoir perimeter consists of dam and dike sections (see location maps and plans). Remainder of reservoir perimeter consists of moderately steep natural ridges covered with glacial till, ice contact, and/or glacial lake beach soil deposits. Slopes are well vegetated and stable from both soil mechanics and hydraulics (erosion) standpoints.	
SEDIMENTATION	Sedimentation is negligible. (Tributary drainage area, outside of reservoir itself, is insignificant).	

DOWNSTREAM CHANNEL

Canoe Brook Reservoir No. 3

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	Channel downstream from dam is uninhabited swampy area (along unnamed tributary of Passaic River) which extends approximately 1500 feet westerly to swampy area along Passaic River. There is no channel as such adjacent to the dike section along Eisenhower Parkway--just a low swale-like area extending to housing developments east of the Parkway.	
SLOPES	All flat (i.e., swampy area downstream from dam and low swale-like area east of Eisenhower Parkway).	
APPROXIMATE NO. OF HOMES AND POPULATION	No homes downstream from dam in swampy area extending to Passaic River. Estimate of approximately 50 houses and approximately 300 people in lower portions of housing developments east of dike section along Eisenhower Parkway. (Need more detailed survey of housing developments to establish elevations and populations). A shopping center (Livingston Mall) is located southeast of reservoir and a school is located south of reservoir.	

APPENDIX B

CHECK LIST - ENGINEERING DATA

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

Canoe Brook Reservoir No. 3

ITEM	REMARKS
PLAN OF DAM AND DIKES	See American Water Works Service Co., Inc., (AWWSC) drawings available from owner.
REGIONAL VICINITY MAP	See the Location Plan--U.S.G.S. Caldwell, NJ, 7.5 min. topographic quadrangle (photo revised 1970).
CONSTRUCTION HISTORY	Dam and dikes constructed in approximately 1956-1957. Slides in downstream slope dam corrected and foundation relief wells added 1959. Relief wells in east dike foundation added 1961 after Eisenhower Parkway was constructed. No other construction history readily available.
TYPICAL SECTIONS OF DAM AND DIKES	See AWWSC drawings available from owner.
HYDROLOGIC/HYDRAULIC DATA	None available
OUTLETS - PLAN	See AWWSC drawings available from owner.
- DETAILS	See AWWSC drawings available from owner.
- CONSTRAINTS	Refer to "Notes" in Appendix A on "Outlet Works" sheet.
- DISCHARGE RATINGS	Pumping rate for inflow is approximately 30 MGD. Outflow rate (gravity or pumping) is approximately 10 MGD.
RAINFALL/RESERVOIR RECORDS	Contact Commonwealth Water Company.

Canoe Brook Reservoir No. 3

ITEM	REMARKS
DESIGN REPORTS	"Investigation and Design, Cedar Ridge Reservoir, Livingston, New Jersey" by Greer Engineering Associates, Montclair, New Jersey, January 1956 6 pp and 20 plates (geotechnical aspects). Other design and geotechnical reports may be available from Commonwealth Water Co.
GEOLOGY REPORTS	Geology information is included in January 1956 geotechnical report. Other geology reports may be available from Commonwealth Water Co.
DESIGN COMPUTATIONS	None available
HYDROLOGY & HYDRAULICS	None available, but design report mentions minimum safety factor of 2.5 for inner dam and dike slopes during rapid drawdown.
DAM STABILITY	
SEEPAGE STUDIES	Several flow nets included in above referenced geotechnical report; other report(s) on investigations of seepage losses from pervious glacial soil zone at southwest corner of reservoir may be available from Commonwealth Water Co.
MATERIALS INVESTIGATIONS	
BORING RECORDS	Some boring records and laboratory soil test data are included in January 1956 geotechnical report. Other geotechnical information may be available from Commonwealth Water Co.
LABORATORY	
FIELD	
POST-CONSTRUCTION SURVEYS OF DAM	None available
BORROW SOURCES	Glacial soil deposits adjacent to reservoir.

Canoe Brook Reservoir No. 3

ITEM	REMARKS
MONITORING SYSTEMS	None
MODIFICATIONS	1959 - Two slides in downstream slope of dam corrected, slope flattened to 2.5:1, foundation relief wells installed. 1961 - Foundation relief wells installed along east dike section after Eisenhower Parkway constructed.
HIGH POOL RECORDS	Pumped storage water supply reservoir with maximum design pool El. 220 which according to owner's representatives has never been exceeded.
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POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	None readily available Reports on 1959 and 1961 modifications (described above) may be available from Commonwealth Water Co.
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	Owner's representatives also mentioned (but did not provide reports on) investigation(s) of leakage through pervious (gravel, cobbles, boulders) glacial soil zone extending from southwest corner of reservoir beneath west end of dike. This leakage reportedly recharges groundwater system (glacial soil aquifers) several tens of feet below ground surface south of reservoir. Leakage reportedly approaches 4 MGD with maximum pool El. 220 and decreases substantially with pool below El. 219. The leakage is not presently of economic significance to the owner.
MAINTENANCE OPERATION RECORDS	Available from Commonwealth Water Co.

Canoe Brook Reservoir No. 3

ITEM	REMARKS
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SPILLWAY PLAN Not Applicable

SECTIONS

DETAILS

OPERATING EQUIPMENT See AMWSCI drawings available from owner.
PLANS & DETAILS

CHECK LIST
HYDROLOGIC AND HYDRAULIC DATA
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: Total drainage area of about 245 acres includes only 65 acres tributary to 180 acre reservoir (El. 225)

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 220 (5000 acre-feet)

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): 220 (5000 acre-feet)

ELEVATION MAXIMUM DESIGN POOL: 220

ELEVATION TOP DAM: 225

CREST: _____

- a. Elevation Dam and Dike - 225
- b. Type Homogeneous Earthfill
- c. Width Dam and Dike - 15 feet average
- d. Length Dam - 1280 feet, Dike - 5000 feet
- e. Location Spillover None
- f. Number and Type of Gates None

OUTLET WORKS: See "Notes" in Appendix A on "Outlet Works" sheet

- a. Type 30 inch diam. reservoir inlet/outlet pipe
- b. Location center of south dike at pump valut
- c. Entrance inverts gravity outflow for pool above El. 194
- d. Exit inverts pumped outflow for pool below El. 194
- e. Emergency draindown facilities 12 inch gate valve below pool on up-stream end 24 inch pipe in center of dam base

HYDROMETEOROLOGICAL GAGES: No information available

- a. Type _____
- b. Location _____
- c. Records _____

MAXIMUM NON-DAMAGING DISCHARGE Not Applicable