REPORT ON

FLOOD CONTROL
FRANKFORD CREEK

CITY OF PHILADELPHIA
PENNSYLVANIA

KNAPPEN ENGINEERING COMPANY
NEW YORK 18, N. Y.

OCTOBER 1947

HON. BERNARD SAMUEL

KNAPPEN ENGINEERING COMPANY
280 MADISON AVENUE
NEW YORK 16, N. Y.
MURRAY HILL 6-3180

THEODORE T. KNAPPEN
ERNEST F. TIPPETTS
ROBERT W. ABBETT
GERALD T. MCCARTHY
WILLIAM Z. LIDICKER

CABLE ADDRESS:
"KNAPENG NEW YORK"

December 30, 1947

Honorable Bernard Samuel
Mayor of Philadelphia
Philadelphia City Hall
Philadelphia, Pa.

Dear Mr. Mayor:

We take pleasure in handing you herewith a copy of our report on the Frankford Creek Flood Control project for your personal file. This report was recently completed by the Knappen Engineering Company under our contract with the City of Philadelphia.

With best wishes for the New Year.

Sincerely yours,

KNAPPEN ENGINEERING COMPANY

Robert W. Abbett

Robert W. Abbett

RWA:bc
Enc. copy of Frankford
Creek report.

REPORT ON FLOOD CONTROL

FRANKFORD CREEK

CITY OF PHILADELPHIA
PENNSYLVANIA

KNAPPEN ENGINEERING COMPANY
280 MADISON AVENUE
New York 16, N.Y.

OCTOBER 1947

TABLE OF CONTENTS

- - - - -

ILLUSTRATIONS

Drawing
No. R136-5 Plan, Profile and Sections - Delaware River to Penna. R.R.- Recommended Plan

R136-6 Plan, Profile and Sections - Delaware River to Penna. R.R.- Recommended Plan

R136-7 Plan, Profile and Sections - Delaware River to Penna. R.R.- Recommended Plan

R136-8 Plan, Profile and Sections - Penna. R. R. to Leiper St. - Recommended Plan

R136-9 Plan, Profile and Sections - Leiper Street to Juniata Park - Recommended Plan

R136-9A Plan, Profile and Sections - Leiper Street to Juniata Park - Recommended Plan

R136-10 Key Map For Alternate Schemes

R136-11 Plan, Profile and Sections - Delaware River to Penna. R.R. - Alternates Nos. 1 and 2

R136-12 Plan, Profile and Sections - Delaware River to Penna. R.R. - Alternates Nos. 1 and 2

R136-13 Plan, Profile and Sections - Delaware River to Penna. R.R. - Alternate No. 1

R136-14 Plan, Profile and Sections - Delaware River to Penna. R.R. - Alternate No. 1

R136-15 Plan, Profile and Sections - Delaware River to Penna. R.R. - Alternate No. 2

R136-16 Plan, Profile and Sections - Delaware River to Penna. R.R. - Alternate No. 2

R136-17 Plan, Profile and Sections - Penna. R.R. to Leiper St. - Alternate No. 1

R136-18 Plan, Profile and Sections - Leiper St. to Juniata Park - Alternate No. 1

R136-19 Plan, Profile and Sections - Leiper St. to Juniata Park - Alternate No. 2

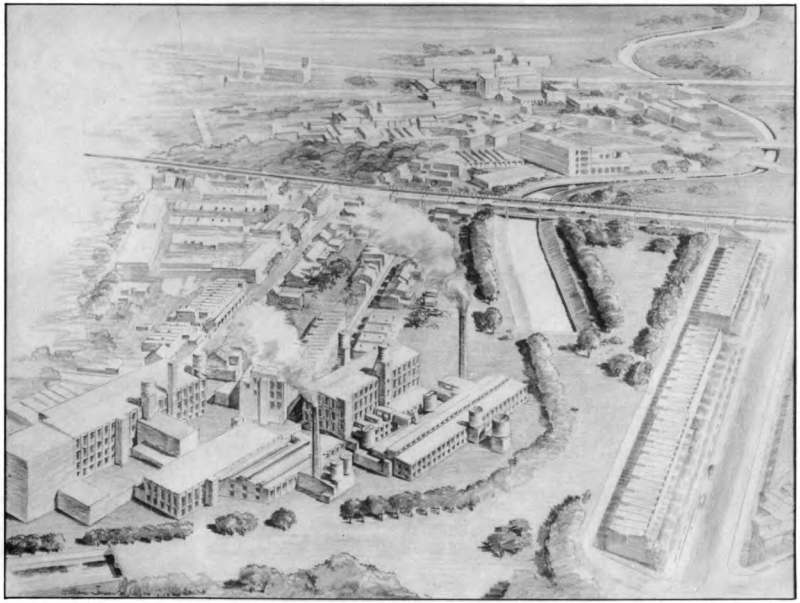
R136-20 Plan, Elevation and Section - Proposed Bridges at Richmond and Thompson Streets

R136-21 Plan, Elevation and Section - Proposed Bridge at Wingohocking Street

TABLES

APPENDICES

PLATE NO. I



KNAPPEN ENGINEERING CO.
CONSULTING ENGINEERS
NEW YORK CITY

PROPOSED FRANKFORD CREEK IMPROVEMENT
CONDUIT SECTION IN FOREGROUND
CITY OF PHILADELPHIA

PHOTO BY AERO SERVICE CORP. PHILA., PA.

EXISTING CONDITIONS ALONG FRANKFORD CREEK, LOOKING SOUTHEAST FROM LEIPER STREET

PLATE 2

October 20, 1947

Mr. Thomas Buckley, Director,
Department of Public Work,
City Hall Annex,
Philadelphia, Pennsylvania.

Dear Sir:

Submitted herewith is our report on flood control for Frankford Creek in the northeast section of the City of Philadelphia in accordance with our contract of November 12, 1946.

In arriving at the Recommended Plan and the various alternates thereto, we have made, insofar as practicable, a complete historical study of the creek, including water utilization, navigation, channel changes, maintenance difficulties and finally the flood history.

An intermittent record of floodmarks is available only for the last twenty years. No discharge measurements have ever been made of the flow of the creek, but hydraulic computations indicate that the greatest flood discharge was 6,500 cubic feet per second in July 1931. Studies indicate that development of the City has increased the frequency of the minor floods, but due to the throttling effect of the large trunk sewers and differences in timing of tributary flows, even with the loss in valley storage resulting from the filling program, floods in excess of 10,000 cubic feet per second are unlikely to occur. Accordingly, we recommend that the flood control improvements be designed to pass a peak discharge of 10,000 cubic feet per second with a freeboard of 2 feet. The improvements within the tidal reaches of the creek should be of sufficient capacity to pass the design discharge with the water level in the Delaware River at an elevation equivalent to that of mean high tide.

We find that two general plans of flood control are feasible for Frankford Creek. The first is a straight channel improvement and involves increasing

the discharge capacity of the present creek channel by deepening and widening and by removing restrictions caused by small bridge openings, encroachments and sharp bends. The second plan is a combination of channel improvement in the upper reaches and diversion of the lower third of the creek into a new channel that will take a more direct course to the Delaware River.

In studying the improvement of the existing channel we considered seven different types of open channel enlargement utilizing rectangular and trapezoidal sections stabilized by either bulkheads, walls, bottom paving, riprap or grass cover. For limited reaches, a covered conduit was considered.

The Recommended Plan, designated as Plan A, is outlined as follows:

(1) Provide a new cut-off channel to the Delaware River beginning at a point near Roxborough Street on the existing channel and extending south for a distance of 5,400 feet along the east side of the Pennsylvania-Reading Seashore Lines leading to New Jersey. The channel will discharge into the Delaware River at Five Mile Point, adjacent to the present steam plant of the Philadelphia Electric Company. New bridges will be required at intersections with Thompson Street, Richmond Street, The Belt Line Railroad and the Kensington & Tacony Railroad.

(2) Improve the existing channel from Roxborough Street upstream to the Pennsylvania Railroad bridge by an earth channel supplemental with low levees, except where building lines require sheet pile bulkheads. Enlarge or rebuild the present railroad siding bridges near Aramingo Avenue and Amber Street.

(3) Improve the existing channel from the Pennsylvania Railroad to Leiper Street by the following construction:

(a) 2,150 feet of concrete "T" walls;

(b) 2,280 feet of 5-foot concrete toe walls supporting grouted riprap side slopes, and

(c) 900 feet of concrete conduit consisting of two barrels 28 feet wide and 14 feet high.

All the existing bridges except that at Worrell Street would be incorporated in the new channel. Removal of the Worrell Street bridge is recommended.

(4) From Leiper Street to Castor Avenue construct 2,210 feet of concrete paved chute, 60 feet in width. Rebuild the bridge at Wingohocking Street on a new alignment. Construct a cut-off channel and debris weir in Juniata Park.

(5) Connect the present storm sewers in the existing channel between Roxborough Street and Wakeling Street to two collecting sewers, one leading west to the new cut-off channel and the other leading east to the Wakeling Street sewer. The old channel would then be filled in between the limits of the collecting sewers. The Bridge Street bridge could be replaced by a fill and culvert. When conditions justify the work the Wakeling Street sewer could be carried directly to the Delaware River along a line parallel to Pratt Street, where better foundation conditions exist. The remainder of the Frankford Creek channel could then be filled in.

The total estimated cost of the Recommended Plan, including lands, is $4,728,800. The estimate includes an allowance of 20 percent for contingencies in the construction costs and a further allowance of 10 percent for engineering and administration.

An alternate improvement, designated as Plan B, utilizes the existing channel below Roxborough Street. Above that point, the construction details are the same as for Plan A (Items 2 to 4, inclusive). Because of a high

degree of industrial development along the banks and because of poor foundation conditions, improvement of the existing channel from the Delaware River to Orthodox Street requires costly bulkheads of several different designs. New bridges are required at Bridge Street and Orthodox Street. The total estimated cost of Plan B is $5,629,700 or $900,900 more than the Recommended Plan.

Irrespective of which plan is adopted the initial step in the improvements should be the construction of check dams and a debris basin in Juniata Park. This work is particularly urgent as plans are going forward to construct a new cut-off channel in Juniata Park and the check dams should be an integral part of this work, as otherwise further erosion of the present creek channel in the park can be expected.

Very truly yours,

KNAPPEN ENGINEERING COMPANY

Theodore T. Knappen

Theodore T. Knappen

REPORT
ON
FLOOD CONTROL IMPROVEMENTS
FRANKFORD CREEK
PHILADELPHIA, PA.

AUTHORITY

In accordance with the provisions of an Ordinance of Council of the City of Philadelphia, approved by the Mayor on September 25, 1946, a contract was entered into on November 12, 1946, between the City and the Knappen Engineering Company for "the preparation of designs and plans for the construction of flood relief facilities along Frankford Creek and its tributaries". This report is submitted in accordance with the first item of the contract which requires engineering studies and the preparation of a project report that would outline the principal features of the project and serve as the basis for detailed design.

PREVIOUS INVESTIGATIONS

Reports by the City - The need for providing an adequate channel for Frankford Creek has been recognized for more than 60 years. Channel lines for the creek were established and confirmed upon the City plan as far back as 1885. Records show that these early lines were revised seven times in the period 1885 to 1902. Subsequent to 1902 attention appears to have been centered on the navigable portions between the mouth and Margaret Street. Surveys leading to dredging operations were made by the Department of Wharves, Docks and Ferries ten times in the period 1915-29.

A series of severe floods in 1931 again centered attention on the upper reaches of the creek. In that year the Bureau of Engineering made hydraulic studies of the channel capacity and reexamined the confirmed channel lines. A repetition of flooding in 1932 and 1933 resulted in suits against

the City to recover damages from the frequent flooding. The City's engineers made studies of the floods and the extraordinary storms causing them and these studies were presented as expert testimony in the court sessions in September 1932 and June 1933.

The current phase of flood investigations on Frankford Creek stems from an Ordinance of Council approved August 9, 1944, the purpose of which was "to authorize a revision of the City Plan so as to establish thereon a right-of-way for the channelization of Frankford Creek as a measure of flood control***". One of the provisions of this ordinance directed the Department of Public Works and the City Solicitor's Office to make a joint report on the project. The report was prepared and submitted to the City Council under date of February 8, 1945. This report gave a brief description of physical conditions along the creek, stressed the legal problems involved in obtained rights-of-way and made brief engineering recommendations.

Reports by the War Department - A preliminary examination and survey relative to the improvement of Frankford Creek for navigation was authorized by the River and Harbor Act of March 3, 1881. A favorable report was submitted by the War Department on January 25, 1882. This report, which was included in the Annual Report of the Chief of Engineers for 1882, recommended improvement for navigation from the mouth of the creek to Frankford Avenue at an estimated cost of $40,000. The project was adopted by the River and Harbor Act of August 2, 1882, and the sum of $10,000 was appropriated for a portion of the work.

In 1884 the Chief of Engineers reported that Frankford Creek was being regulated by the City of Philadelphia and recommended that no further appropriation be made by the Federal Government

The River and Harbor Act of August 17, 1894, provided the sum of $2,000 for straightening Frankford Creek in the vicinity of Aramingo Avenue. The District Engineer for the War Department reported that the proposed work had never been considered and was not justified by the prospective commerce. The work was never carried out by the Federal Government but was later undertaken by private interests. (See page 28).

A preliminary examination and survey was authorized by the River and Harbor Act of June 25, 1910. Pursuant to the authorization a report was submitted by the Chief of Engineers on November 7, 1912, and printed in 1913 as House Document No. 1260, 62nd Congress, 3d Session. It is interesting to note that this report found the actual and prospective commerce on the creek sufficient to justify improvement for navigation but that the Federal Government was not justified in undertaking the work because the benefits accrued only to the industries of Philadelphia.

The Committee on Rivers and Harbors of the House of Representatives directed on January 29, 1934, a review of the unfavorable report of 1913. The Chief of Engineers submitted a report on December 24, 1934, which was also unfavorable as regards improvements for navigation.

The final report by the War Department was authorized by Section 6 of the Flood Control Act approved June 28, 1938. This report, which was dated February 15, 1939, was a preliminary examination of flood conditions on that portion of the Frankford Creek watershed located in Philadelphia County. The conclusions of the report were that improvement for flood control or for flood control in conjunction with navigation was not economically justified. It should be emphasized that the authority for this survey only required comparison of past flood damages and probable future flood control and navigation benefits, and did not permit consideration of civic benefits to be

obtained from the reconstruction of obsolete bridges, from the correction of obnoxious and unsightly conditions, from the large potential increase in land and property valuations resulting from flood protection, and of the need for an adequate outlet for storm drainage.

The last action by Congress affecting Frankford Creek was taken on June 11, 1940, when an act was passed declaring the creek to be non-navigable within the meaning of the Constitution and the laws of the United States. By that time the creek was non-navigable in fact due to filling in of the channel.

ACKNOWLEDGMENTS

We wish to express appreciation for the cooperation of the Director of Public Works and the staff of the Bureau of Engineering, Surveys and Zoning of the City who made available all plans, records and technical studies of value in working out the plans presented herein. Mr. Thomas Buckley, Director of Public Works, and Mr. A. Zane Hoffman, Chief Engineer, and Mr. S. S. Baxter, Assistant Chief Engineer of the Bureau of Engineering, Surveys and Zoning, have followed closely the progress of the studies and have held frequent conferences which were helpful in formulating a plan which could best serve the needs of the City.

Many industries and individuals owning property along the creek have been exceedingly helpful in furnishing data on the flood history of the creek and on foundation conditions encountered in the construction of their buildings, bridges and bulkheads. The following organizations have been particularly helpful:

Engineer of Bridges & Buildings, Pennsylvania Railroad

Post Engineer, Frankford Arsenal

Barrett Division, Allied Chemical & Dye Corporation

Charles Lennig Company

Baxter, Kelly & Faust, Inc.

These organizations and their officials extended every courtesy to our representatives and furnished without question any available engineering data pertaining to the flood problem.

EXISTING CONDITIONS

Identifying Names - The headwaters of Frankford Creek are located in Abington and Cheltenham Townships in Montgomery County, Pennsylvania. In the townships the creek was formerly called Tacony Creek, but the name has been recently changed to Tookany Creek. From the Philadelphia city line to a point in Juniata Park opposite the former outlet of Wingohocking Creek, the name Tacony Creek is still used. The name Frankford Creek only applies to the reach between Juniata Park and the confluence with the Delaware River.

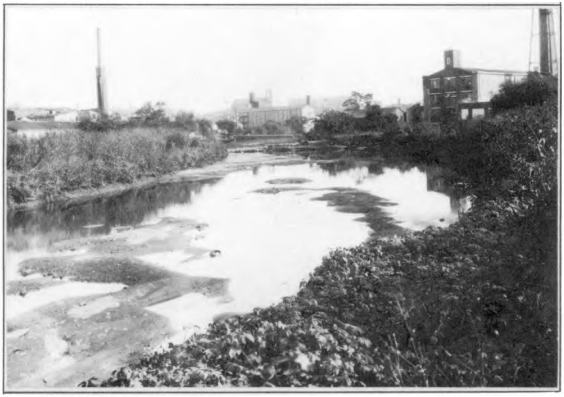
Geology and Physiography - Abington and Cheltenham Townships and the northern parts of Philadelphia lie in the Piedmont Plateau region of the Appalachian geologic province. The Piedmont Plateau in this locality is a dissected plain that slopes gently northeastward from about elevation 400 to elevation 100. The variations in relief are generally less than 100 feet and the hills and valleys are rounded. Drawing No. R136-1 shows the topography within the drainage area of Frankford Creek. The underlying geologic formation is Wissahickon mica gneiss that has a thick weathered zone at its surface and is overlain by a relatively thin layer of sand and gravel.

The main stem of Frankford Creek flows in a general southerly direction across the Piedmont Plateau for a distance of about 11 miles. In this region the profile of the stream is steep and the bed lies close to rock. Boulders that have weathered out of the Wissahickon gneiss are found

in portions of the stream bed.

About two miles above the mouth, in the general vicinity of the crossing of the Pennsylvania Railroad, the creek enters the Coastal Plain region. The general physiography of this region is that of a low-lying plain that slopes gently to the southeast. The variations in relief are very slight and the creek flows in an open valley. The Wissahickon gneiss occurs about 50 feet below the ground surface in this region. It is overlain by the Pensauken and Cape May formations that are recent geologic formations consisting primarily of sands and gravels. In the valley carved out by the stream, there are recent silt deposits in depths up to 45 feet near the mouth. Through the Coastal Plain there is very little natural slope to the bed of the creek and as a result tidal influence extends for a distance of two and a half miles above the mouth. The full range in tide at the mouth is normally 5.5 feet but that range extends only a short distance above Bridge Street.

Drainage Conditions - The total drainage area of Frankford Creek at its mouth is 37.2 square miles. Of this total about 15 square miles are in Montgomery County and 22 square miles within the City limits. The drainage subdivision does not follow the City boundary with the result that the City area both receives storm water from and discharges into natural channels within the County. The drainage area within the City has been subject to extensive industrial and residential development and includes a part or all of the districts known locally as Bridesburg, Frankford, Germantown, Ogontz, Olney, Logan, Oak Lane, Lawndale, Burholme and Fox Chase. The principal suburban communities within the drainage area are Cheltenham, Elkins Park, Ogontz, Jenkintown and Abington.



A – VIEW TAKEN NOVEMBER 10, 1932, SHOWING MILL POND FILLED WITH SEDIMENT

B – VIEW TAKEN APRIL 8, 1947, FOURTEEN YEARS AFTER REMOVAL OF THE DAM, SHOWING DEGRADATION OF THE STREAM BED AND BANK EROSION.

SITE OF OLD DAM ABOVE WINGOHOCKING STREET

The drainage boundary has remained as it was under natural conditions, but as the urban development progressed, storm water from the streets was directed into sewers which in turn emptied into the tributaries of Frankford Creek. As a final step in the drainage development, the principal tributaries were themselves inclosed in large storm sewers that discharge directly into Tacony and Frankford Creeks (See Drawing No. R136-1). Among the former tributaries which can no longer be seen as open streams are Lackawanna Run, Little Tacony Creek, Wingohocking Creek and Rock Run. In time of storm, Frankford Creek must now discharge the runoff from an area equal to more than one quarter of the total area of the City of Philadelphia. Thus it can be seen that the drainage capacity of the channel of the Creek is vital not only to the property owners along the creek but to the residents of a large section of the city who depend on the creek as a natural outlet for storm drainage.

Channel Conditions - Above Juniata Park the channel of Tacony Creek has not been materially changed from its original course. The banks have been improved as park areas for a distance of about four miles and a number of check dams and wall sections to stabilize the bottom and banks have been installed. Conditions in Frankford Creek proper are far from attractive. Evidence of the natural valley has been largely obliterated by the inroads of urban development. Old maps show that sections of the channel have been relocated to facilitate changes in streets and railroads. (See page 27).

At least two dams are known to have existed in Frankford Creek. The one furthest downstream was located just below Kensington Avenue and was used to furnish power for a mill. The date this dam was removed has not been definitely determined. The second dam, known as the Powder Mill Dam, was

located above Wingohocking Street. This dam was removed in July 1933 after being partly destroyed by floods. Removal of these dams, the existence of which extended back to colonial times, has had an important effect on channel maintenance in that their removal permitted the release of thousands of cubic yards of sediment that had been accumulating in the ponding areas (See Plate 3). The so-called "step profile" of the creek resulting from the dams was eliminated and the creek bottom, particularly in the reach through Juniata Park, dropped 6 to 8 feet. (See further comment on page 25). The eroded materials were carried downstream by floods and deposited in the slow-moving tidal reaches between the Pennsylvania Railroad and the mouth. A similar condition was experienced many years ago as indicated by the following statement in the Annual Report of the Chief of Engineers, U. S. Army, for 1882: "The tidal section ****** terminates at Frankford Avenue Bridge, below which considerable deposits were made some years ago by the bursting of dams formerly built across the creek at points above."

The periodic filling of the channel cannot be attributed alone to the removal of the dams because some trouble has always been experienced. Other sources of deposits, which will be discussed in more detail below, are as follows:

(a) Natural erosion of land areas and creek channels in the upper drainage area of Tacony Creek.

(b) Street washings from fully developed areas.

(c) Erosion of loosely placed and unprotected fills adjacent to the creek. (See Plates 4 and 5).

(d) Dumping of trash and industrial wastes in both liquid and solid form.

A- LOOKING UPSTREAM FROM KENSINGTON AVENUE. INADEQUATE LEVEE ALONG BANK AT RIGHT.

B- LOOKING DOWNSTREAM FROM LEIPER STREET TOWARDS KENSINGTON AVENUE. PROTECTION OF BANKS AT RIGHT REQUIRES HIGH WALLS OR A SECTION OF COVERED CONDUIT.

(e) Construction activities along the creek involving the placement of walls, bridges, sewers, etc.

(f) Suspended material brought in by tides from the Delaware River.

Bridges - In the three-mile reach from the Delaware River to Wingohocking Street, the channel of Frankford Creek is crossed by fourteen street, railroad and foot bridges. The age and condition of the bridges vary widely, the oldest, that of the Pennsylvania Railroad, being originally constructed in 1882 and the most modern, that at Margaret - Lefevre Street being constructed in 1940. The two bridges nearest the mouth, the Kensington & Tacony Railroad Bridge and the Bridge Street Bridge were formerly swing bridges to permit the passage of boats.

In their present condition, nine of the fourteen bridges seriously restrict the passage of flood flows, either because of narrow openings, poor alignment or deposition of sediments under the bridges (See Plates 5B, 7, 8A, 9A, and 11A). The most serious constriction is at Bridge Street where the opening is very narrow and further contracted by protective pile structures (See Plate 11A). This bridge is reported to be in an unsatisfactory structural condition and would normally be replaced in a short time. As will be pointed out later in this report, complete reconstruction is considered necessary for only five of the fourteen bridges and two of the five are relatively unimportant pile structures. One footbridge (Plate 6B) is now abandoned, so its removal will be relatively simple.

Encroachments - In common with conditions along many streams in the United States, the development adjacent to Frankford Creek has been carried forward without proper regard to the natural function of the creek. Growth of the city has increased land values adjacent to the creek, with the result that buildings have been erected in places normally occupied by the stream.

The demand for more land plus the need for dumping areas has resulted in filling of both the flood plain and the stream bed in reaches where the creek could normally spread out. In order to conform with the building lines, head walls of sewers have been brought out into the channel, causing constriction above and erosion below the outlets. The constriction caused by hundreds of feet of buildings, as in the reach from Kensington Avenue to the Pennsylvania Railroad, (See Plates 6, 7B and 8) results in a general raising of the water surface and also a loss of valley storage. Such storage, over long reaches, provides an effective reduction of flood peaks.

Since the greatest flood of record in 1931, there have been some changes and improvements in encroachment conditions. A horseshoe bend above Bridge Street was removed in 1934, resulting in the elimination of a narrow channel supported by timber bulkheads. At least one large wooden building located in the flood plain was also removed. Between the Pennsylvania Railroad and Frankford Avenue, a brick mill, 450 feet long, formerly located on the west bank, was removed (See Plate 6). In the same reach, several sheds on the east bank were also removed, thus causing some improvement in channel capacity in times of extreme flood.

Unfavorable encroachments from the standpoint of flood control have taken place in recent years as a result of filling the flood plain upstream from Orthodox Street and east of the Pennsylvania-Reading Seashore Lines (See Plate 9A). Much of this land was formerly an open meadow but has now been filled in with waste material from construction work and with refuse. The potential value of the land and inevitable growth of the City have brought about these operations, but the effect of them must be offset by flood control improvements. The fills have eliminated ponding areas that were effective

A— LOOKING DOWNSTREAM FROM BRISTOL STREET EXTENDED. ENCROACHMENTS ON LEFT BANK HAVE FORCED CREEK TO ERODE RIGHT BANK.

B— LOOKING DOWNSTREAM AT WINGOHOCKING STREET BRIDGE. POOR ALIGNMENT AND INADEQUATE WATERWAY REQUIRE RECONSTRUCTION OF THIS BRIDGE.

in reducing the flood peak discharges in the reaches from Orthodox Street to the mouth.

Above Kensington Avenue there have been a few isolated cases of new buildings jutting out into the creek channel (See Plate 5A). These have had the effect of forcing the stream into the opposite bank, where it picks up sediment to be deposited to the inconvenience of other property owners downstream.

Above Wingohocking Street, the old mill dam has been removed and the west bank at the dam site has been stabilized by grouted masonry (See Plate 3B). The mill races on both banks have been filled in and the present mills have given themselves partial flood protection by fills and levees (See Plate 5B). The net result of these changes has been to restrict the channel to such a small capacity that flood damage, generally on the west bank is very frequent.

Bank Revetment.- The existing system of bulkheads and walls along the creek is intermittent and unrelated in alignment, design and appearance. There has been no general plan and the work has been done by individual property owners in accordance with their particular needs. The longest wall is that belonging to Frankford Arsenal which extends 3,000 feet along the north bank from the mouth to Bridge Street (See Plate 10). This wall provides protection against the highest known tide in the Delaware River and except for a rather angular alignment, appears to be well able to withstand future floods. Opposite the Arsenal about three quarters of the bank is supported by a low wooden cribbing with concrete crib which has been overtopped several times by extraordinary tides.

Between Bridge Street and Margaret Street there is a 450-foot section of pile bulkhead on the north bank and several other short sections of timber,

or timber and concrete bulkheads (See Plate 11). Except for one or two short sections of timber cribbing, there is no protection in the 7,200-foot reach between Margaret Street and the Pennsylvania Railroad (See Plate 9). Between the Pennsylvania Railroad and Kensington Avenue, the construction of buildings has required almost a continuous line of concrete or masonry walls. Above Kensington Avenue the banks are unprotected (See Plate 4) except where foundation walls are required for the large mill in the vicinity of Leiper Street (See Plate 5A).

Dumping and Pollution - The present use of Frankford Creek as a channel for the disposal of wastes has already been mentioned in passing. Considerable material is washed into the channel unintentionally from loosely-placed fills which restrict the areas needed for flood flows and which are washed away by the resulting swift current. However, there is a practice on the part of some industrial and residential property owners to dump all types of trash into the creek with no thought of its ultimate destination or its effect on the capacity of the channel. Even if it were proper to use a natural stream for an open sewer, there would be little chance of effective disposal in Frankford Creek because the wasted material is only carried down to the junction with the tide. Flood flows may push the wastes along towards the mouth, but they eventually intermingle with the fine sediments to form immovable bars.

In the initial development of the sewer system of the city, both sanitary sewage and storm water were carried in the same pipes to outlets in Tacony and Frankford Creeks. About 20 years ago intercepting sewers were constructed to carry the dry-weather flow, which is largely sanitary sewage, to the Northeast Treatment Plant. Pollution of Frankford Creek downstrear

A – VIEW TAKEN ON OCTOBER 13, 1932

B – SAME REACH AS SHOWN ABOVE ON APRIL 8, 1947. ARCH BRIDGE IS CROSSING OF THE PENNSYLVANIA RAILROAD. STEEL TRUSS FOOTBRIDGE HAS BEEN ABANDONED.

CHANGES IN ENCROACHMENT CONDITIONS BELOW FRANKFORD AVENUE.

from Wingohocking Street still continues because a large volume of industrial liquid wastes is still discharged into the creek. Besides being unsightly and obnoxious in odor, these wastes contain solids which settle out and, over a period of years, make an appreciable contribution to the filling up of the channel. The wastes in the creek water react with the sediments brought down by runoff from the drainage area above and brought in by the tide from the Delaware River in such a manner as to increase the normal rate of precipitation of the sediments.

Navigation.- The first official recognition that Frankford Creek was a useful waterway is contained in an Act of the General Assembly of the Commonwealth of Pennsylvania in 1799 which declared the creek to be a public highway from mouth "to Joseph I. Miller's land opposite the rail bridge across the Bristol road, or Main Street in Frankford." Early reports indicate that the creek was navigable at one time up to the bridge at Frankford Avenue. Traffic was limited to small barges and schooners and probably was carried on under adverse conditions because of the narrow, tortuous channel and shallow depths.

The availability of water transportation attracted early industries whose plants have since completely disappeared. In 1910 the value of capital investments along the navigable reach of the creek was reported to have been $6,850,000 and the total value of goods moved by water in the year 1909 was $983,000.

Even in the early days, constant maintenance was required to keep the channel from filling in. The Federal Government declined to maintain the channel subsequent to 1884 and although Congress in 1910 and 1934 authorized investigations leading towards possible improvements, the reports of the

War Department were always unfavorable. The City took on the responsibi lity of maintaining a navigable channel from the mouth to Margaret Street in the period 1915-29. It is said that funds totalling $2,500,000 were expended for the work in that period.

At a public hearing held by the War Department in Philadelphia on August 16, 1938, private interests along the creek indicated a desire to have the Federal Government again improve the lower reaches of the creek for navigation. Further inquiry revealed that the type of vessel that would now use the channel would draw 12 feet of water and would require a channel depth of 15 feet. The initial cost of such an improvement would have been prohibitive.

Commercial navigation on Frankford Creek ceased in 1929, and in 1940 and 1941 both the Federal Government and the Commonwealth of Pennsylvania passed acts declaring the creek to be non-navigable.

FLOOD HISTORY

Early Floods.- With steep narrow valleys and a drop in elevation of 400 feet from the headwaters to the mouth, it is probable that Frankford Creek was always subject to sudden flash floods. Early reports indicate this to be the case. The 1882 report of the Chief of Engineers, U. S. Army, has already been quoted with regard to damage by "the bursting of dams". The same source in 1884 mentioned that the creek was subject to sudden and violent floods. The report published in 1913 as House Document 1260, 62nd Congress, 3d Session, states that "the creek is subject to floods of considerable height at and above the head of navigation".

For this report more definite information has been pieced together from records of the Bureau of Engineering of the City of Philadelphia, from

A- LOOKING DOWNSTREAM AT FRANKFORD AVENUE BRIDGE. SEDIMENT DEPOSITS RESTRICT WATERWAY OPENING

B- LOOKING DOWNSTREAM AT TORRESDALE AVENUE BRIDGE. LOWER SECTION OF WINDOWS AT LEFT FILLED IN TO PREVENT FLOOD DAMAGE.

newspaper accounts of flood damage and from high water marks and other records preserved by property owners along the creek. The earliest flood for which there is a definite date was on September 15, 1904. No flood heights have been preserved for the flood, but rainfall records indicate that perhaps it was greater than any flood of recent years. Residents along the edge of Juniata Park recall a damaging flood in 1906, probably in June, which ruined the gardens of a nursery at Fisher's Lane. Floods of sufficient importance to be mentioned in records occurred on August 9, 1916, and August 12, 1918.

Recent Floods.- The first flood for which we have found a known elevation is that of July 23, 1927. Newspaper accounts say that it was the greatest flood in the previous ten years. From records of flood heights, it has been determined that the 1927 flood was exceeded at least 10 times in the subsequent 20 year period, indicating an abrupt increase in flood frequency in recent years.

Property owners along the creek were inconvenienced by floods from time to time prior to 1930, but beginning with the flood of June 26, 1930, they experienced a long series of disastrous inundations. In the summer of 1931 there were record breaking floods on July 10, July 14 and August 10. Floodmarks are available only for the flood of July 14. That flood had an estimated discharge of 6,500 cubic feet per second, and is quite certainly the greatest flood in the past 30 years. The second largest flood came on August 18, 1932, with a discharge of 5,800 cubic feet per second. In the 17 year period 1930-46, inclusive, only the three years 1940, 1942 and 1944 appear to have passed without flood damage. Because there has been no continuous record of the variations in stage of the creek, there may be some

omissions in the record as pieced together but the following chronological list of flood rises is believed to be quite complete:

July 23, 1927	-	June 30, 1935
Sept. 8, 1929	-	July 9, 1935
June 26, 1930	-	Sept. 6, 1935
July 10, 1931	-	Jan. 9, 1936
July 14, 1931	-	Aug. 26, 1937
Aug. 10, 1931	-	July 23, 1938
March 28, 1932	-	Sept. 23, 1938
July 22, 1932	-	July 27, 1939
Aug. 18, 1932	-	July 28, 1941
May 24, 1933	-	- - - - 1943*
Aug. 23, 1933	-	July 5, 1945
		- - - - 1946**

* Floods in May, June, July and October

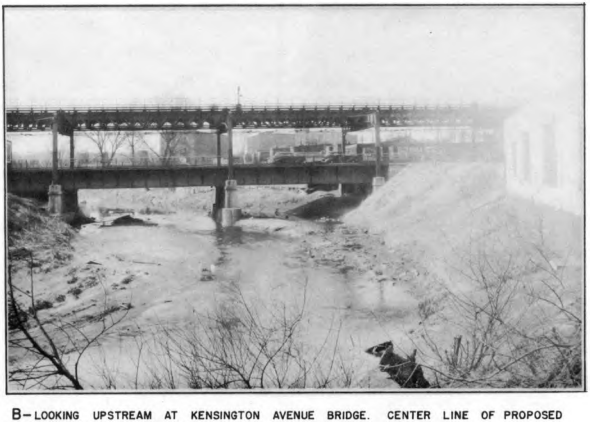
** " " June and July

Analysis of the above-listed flood occurrences indicates that discharges of various magnitudes can be expected with the probable frequency shown in the following table:

Discharge in Cubic Feet Per Second	Average Frequency of Recurrence in Years
3,000	1
4,000	3
6,500	18
8,000	40
10,000	100

Flood Characteristics.- The dates mentioned in the preceding paragraphs

A- LOOKING DOWNSTREAM AT WORRELL STREET BRIDGE. PROPOSED IMPROVEMENTS WILL REQUIRE REMOVAL OR REPLACEMENT OF THIS BRIDGE.



B- LOOKING UPSTREAM AT KENSINGTON AVENUE BRIDGE. CENTER LINE OF PROPOSED CHANNEL IS LOCATED IN LEFT HAND OPENING.

indicate that the greatest floods on Frankford Creek have not occurred in the spring and fall as on large rivers like the Delaware, but have occurred in the summer months as a result of intense thunderstorms or so-called cloudbursts. Thunderstorms are generally localized and may cover an area only a few miles in length and breadth. For example, summer floods have occurred on Frankford Creek when little or no rainfall was recorded in downtown Philadelphia. Local storms that moved across the drainage area in a direction from northwest to southeast appear to have caused the most severe floods. Some of the floods have been caused by general rains brought in by intense tropical storms or hurricanes. These latter storms occur in the summer or early fall. The present development of the Frankford Creek drainage area has undoubtedly changed the characteristics of the floods. Observations in the field and theoretical studies indicate that in time of flood the creek rises very rapidly, possibly 10 feet in an hour, and that it reaches an initial peak in one to two hours. This type of flash flooding is caused by the runoff from about 15 square miles of sewered area above Juniata Park. The flood runoff from the remaining drainage area in Montgomery County is slower and causes a second and lower peak about 3 hours later than the first peak.

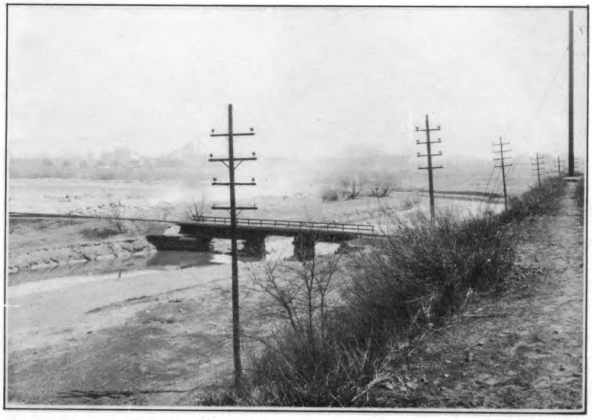
Although the construction of buildings, paved streets and storm sewers tends to increase the rapidity of runoff and the frequency of minor floods, it has certain advantages insofar as flood control for the creek is concerned. For example, it is not practicable from an engineering standpoint or justifiable from an economic standpoint to design sewer inlets and discharge lines to pass immediately the peak runoff from very rare storms. Following such storms the rate of discharge from a sewered area is limited by the capacity of the sewer system and as a result temporary ponding may occur in streets and at low points. Therefore, the peak rate of runoff from a developed area

may be less than from an equivalent undeveloped area. This condition exists in the lower portion of the Frankford Creek watershed where the total ultimate capacity of the sewer system will limit the peak discharge to 10,400 cfs. This is a large discharge compared with the greatest flood of record (6,500 cubic feet per second) but may ultimately occur.

A flood on the creek may result from contributions of runoff from both the City sewered area and the County suburban area but there is little chance of both areas contributing maximum discharges in coincidence. There is also little chance, that even if a severe storm centered on the suburban area, the resulting peak discharge from that area alone would exceed the maximum recorded flood on Frankford Creek. The reason for the latter statement is that there are three street bridges (Adams Avenue, Rising Sun Avenue, and Fisher's Lane) and one railroad culvert (Reading Railroad) with moderate sized waterway openings that would tend to throttle discharges of more than about 5,000 cubic feet per second. The throttling action of the bridges would cause ponding in the park areas upstream, further modifying the flood runoff and delaying the time of travel.

The above discussion indicates that, although the lower reaches of Frankford Creek will continue to have floods in excess of the present channel capacity, there are certain features of the present upstream development that act to reduce overwhelming floods such as can occur on natural areas of equivalent size.

Tidal Inundation.- High tides or a combination of high tides and flood flows in the Delaware River have several times caused flooding in the lower reaches of Frankford Creek below Orthodox Street. A combination of high tides and runoff from Frankford Creek have caused flooding between Orthodox Street and Frankford Avenue.



A- LOOKING DOWNSTREAM FROM ARAMINGO AVENUE. UPSTREAM END OF RECOMMENDED CUT-OFF CHANNEL TO DELAWARE RIVER WOULD BEGIN AT RIGHT OF PICTURE.

B - LOOKING UPSTREAM FROM ARAMINGO AVENUE. AN EARTH CHANNEL IS SUITABLE FOR THIS REACH

VIEWS OF UNDEVELOPED AREA BETWEEN ORTHODOX STREET AND PENNSLYVANIA RAILROAD

The highest tide of record occurred on August 24, 1933, at the time of a tropical hurricane. The crest of this tide at the mouth of the creek was 5.5 feet above normal high tide. The rains accompanying the hurricane caused one of the highest known floods in the upper reaches of Frankford Creek on August 23. It is estimated that the peak of the flood in the creek occurred when the tide was 3 feet above normal high tide. The flooding from the combination of causes was probably the worst ever experienced for a distance of about 2 miles above the mouth of the creek.

Two other periods of flooding at the mouth of Frankford Creek occurred at times of abnormal tides in combination with floods in the Delaware River. The peaks of these two floods occurred on October 11, 1903, and March 19-21, 1936, and reached elevations about 4 feet above normal high tide. Normally there is no slope in the Delaware River at the mouth of Frankford Creek, but there is appreciable slope during very high floods such as those mentioned above. Because of this absence of slope, the elevation of the tide at the mouth of the creek is normally the same as at Chestnut Street in downtown Philadelphia. The tide at Frankford Creek lags the tide at Chestnut Street by about half an hour.

Any plan of flood protection for the creek must take into account tidal effects and their combination with flood runoff in the upper creek.

FLOOD DAMAGES

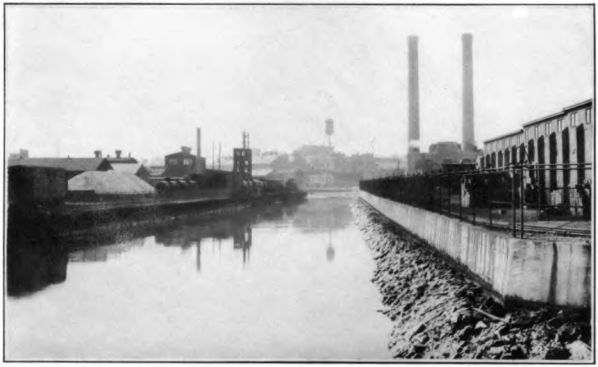
Industrial and Residential Areas.- On Drawing No. R136-2 are shown the approximate areas that have been inundated by flood runoff and tides or a combination of both. In general the entire area has not been flooded simultaneously although most of it was probably covered in the period August 23-24, 1933. It will be noted that many important industrial areas have been flooded. In the past Frankford Arsenal (on the north bank at the

mouth) has had considerable flooding from tides but is now protected (See Plate 10) and so is not shown as a shaded area. The large industrial area on the bank opposite the Arsenal received the inundation shown at the time of the record tide in 1933. The exact limits in the reach between Orthodox Street and the Pennsylvania Railroad crossing are very approximate because of the extensive filling that has taken place in recent years.

In addition to overbank flooding from the creek, additional flooding in basements and low areas at some distance from the creek has been caused by backwater in sewers and drains. Some of the industries have taken steps to protect themselves from this condition by placing gates on their discharge lines. Frequent flooding in low areas adjacent to Wheatsheaf Lane has been caused by backwater in Tunnell Ditch which passes through the fill of the Pennsylvania-Reading Seashore Lines.

From the standpoint of inconvenience to the community as a whole the most serious flooding has taken place at the junction of Torresdale and Frankford Avenues. Street car and other traffic has been held up for several hours at a time. Flooding of the adjacent industrial area has sometimes been 3 or more feet above the ground surface.

Another area of frequent damage is in the vicinity of the Wingohocking Street bridge. Downstream from the bridge on the west bank mills and residences adjacent to Adams Avenue have been flooded often. Fills and low levees have been placed in this section but their effectiveness is doubtful. Upstream from Wingohocking Street the mills on both banks have been flooded many times. Some protective fill has been placed on the east bank but overbank flooding and backwater in drains continues at the mill on the west bank (See Plate 5B). An example of the seriousness of conditions at this point is given by the following record of interference by floods:



A-LOOKING UPSTREAM FROM MOUTH OF CREEK. ARSENAL WALL ON RIGHT. PRIVATELY-OWNED BULKHEAD ON LEFT.

B - LOOKING DOWNSTREAM FROM BRIDGE STREET. ARSENAL WALL ON LEFT.

FRANKFORD CREEK BETWEEN DELAWARE RIVER AND BRIDGE STREET

Year	No. of Work Stoppages by Floods
1943	5
1944	0
1945	5
1946	2

Juniata Park. - Prior to the removal of the Powder Mill Dam (See Plate 3A), the golf course in Juniata Park was frequently flooded. This flooding resulted in the deposition of debris and additional maintenance costs for clean up. A nursery located at Fisher's Lane suffered several thousand dollars damage in the flood of July 10, 1931, and in earlier floods. Removal of the dam reduced the frequency of flooding in the Park, because the channel was deepened by erosion of the stream bed. This erosion has in turn led to damage probably more costly than that produced by overbank flooding. For example, the abutments of three footbridges and one vehicular bridge have been seriously undermined, so that all are in an unsafe condition. The banks of the stream have been undermined causing caving and loss of land, trees, and shrubs. The trees and brush which have fallen into the stream have been washed further downstream and contributed to the partial blocking of the bridge opening at Wingohocking Street. Additional erosion is caused by the discharge of the huge sewer at Ramona Street which carries the flow from the former Wingohocking Creek. This sewer, which is 21 feet wide and 24 high, is capable of an ultimate discharge of 6,700 cubic feet per second. At present there is no structure to dissipate the energy of the outflow which leaves the sewer at a velocity of about 25 feet per second and causes erosion for some distance downstream.

Evaluation of Damages.- During the first unexpected floods in 1930 and 1931, there was great damage to goods and equipment in basements and first floors of buildings. As floods continued to occur, floors in low-lying buildings were abandoned. In other buildings windows were bricked up (See

Plate 7B). Some industries obtained partial protection by the construction of low earth levees. Damage to stock and equipment was thereby reduced but losses continued to occur from the closing down of operations at intervals more often than once a year in some places. The general loss of use of buildings results in a permanent depreciation and perhaps ultimate abandonment. Flood damage and flood hazard probably was one of the reasons for abandonment and removal of some buildings in the reach between Kensington Avenue and the Pennsylvania Railroad (See Plate 6).

Flood damages and the benefits for protection are difficult to evaluate. Direct losses for the replacements of goods and repair of equipment and certain indirect losses such as loss of wages due to shutdown can be evaluated in dollars. However, other indirect losses resulting from delays in production, loss of goodwill, loss of customers because of production uncertainties and depreciation of property values because of flood hazards cannot be evaluated readily. All of these losses have been experienced by the industries along Frankford Creek. The War Department in its survey in 1939 and the Northeast Philadelphia Chamber of Commerce both compiled data on the value of flood damages in the period 1930-38. The annual industrial and commercial losses by years are given by the War Department as follows:

Year	Loss
1930	$ 8,800
1931	54,100
1932	14,500
1933	48,800
1934	1,200
1935	1,900
1936	500
1937	4,100
1938	8,100
	$ 142,000

The above-listed losses are believed to be very conservatively estimated. For example in 1932 the Chamber of Commerce sent out a questionnaire

A— LOOKING DOWNSTREAM AT BRIDGE STREET SHOWING SMALL WATERWAY OPENING.

B— PRIVATELY OWNED BULKHEAD LOCATED ON NORTH BANK BETWEEN BRIDGE STREET AND MARGARET STREET. THIS BULKHEAD CAN BE INCORPORATED IN THE IMPROVED CHANNEL.

on which to report losses. Fourteen industrial concerns replied and reported a total loss of $175,000 for the previous year. In addition to the industrial losses, several dozen residences have suffered damage up to the first floor. There has been at least one loss of life. Damage to truck gardens in the lower reaches were so severe that the owners attempted to recover damages from the City.

The War Department estimated property depreciation losses at $12,000 based on a real estate value of $2,000,000 for property adjacent to the creek. Here again the estimate appears to be much too small inasmuch as the capital investment in industries along the tidal reaches of the creek was $6,850,000 in 1910 and in 1932 the Chamber of Commerce reported capital investments of $9,000,000 exclusive of residences and public buildings. In addition to other losses there are the costs to the City of periodic dredging from the channel of material brought down in floods. If all these various economic losses were corrected for present conditions, it is quite certain that the loss due to the flood hazard on Frankford Creek would be several times the estimate of $22,000 per year made by the War Department in 1939.

PREVIOUS PROJECTS FOR IMPROVEMENT

General Plan. - Excepting the establishment of confirmed channel lines, there has been no authorized plan for coordinated improvement of the entire length of Frankford Creek. Dredging operations undertaken by the City were of an emergency nature to relieve particular sections of the channel that were choked with debris and sediment. The benefits from much operations were short lived because of the continued abuses already discussed.

Changes in Alignment. - There is evidence that, over a period of 40 to 50 years, there have been several changes in alignment of portions of the

channel of Frankford Creek. The most recent change was in 1934, when a cut-off was made across the former horseshoe bend above Bridge Street. This would have been a considerable improvement in the lower reaches except for the fact that the Bridge Street bridge opening was a bottleneck in itself (See Plate 11A) and therefore nullified to some extent the gains made as a result of the cut-off.

In the tidal reach below the main line of the Pennsylvania Railroad about 2,500 feet of channel was relocated to avoid a bridge crossing for the Pennsylvania-Reading Seashore Lines leading to New Jersey (See Plate 9). This change, which was believed to have been made about 40 years ago, had little beneficial effect on the flood carrying capacity of the channel. In fact the construction of the railroad fill blocked off a portion of the valley storage that was available under natural conditions for the reduction of flood peak discharges.

Between Kensington Avenue and Frankford Avenue the channel formerly swung in a wide curve to the east and crossed the line of Frankford Avenue 400 feet from the present location. Removal of this bend reduced the length of the channel and probably improved flow conditions. The change was made about 45 years ago.

The present channel paralleling Adams Avenue between Leiper and Church Streets was formerly about 100 feet further east. The old channel was filled in to make room for the extension of Adams Avenue.

The above-mentioned changes in alignment, except that above Bridge Street, were not intended primarily as channel improvements. They were made to facilitate development of the City and its utilities, and as that development went forward along the relocated channel the resulting structures had a very adverse effect on the flood carrying capacity of the channel.

Levee Protection. - The frequent overbank flooding of Frankford Creek created a demand on the part of property owners for relief and protection. As a result the City initiated several projects in the period 1931-42 for dredging reaches above the former navigation channel. The sand and gravel excavated from the creek bottom were spoiled along the banks in low levees particularly at low places between buildings (See Plate 3A). Following the floods of 1930-33, several industrial plants took steps to protect themselves with levees. These levees are located immediately above Torresdale Avenue on the east bank and above Wingohocking Street on both banks.

All the existing levees on Frankford Creek constitute an emergency type of protection and are not considered a permanent solution to the flood problem. For example, the levees are not based on a coordinated hydraulic design and although they may appear to exclude the water at one point the chances are that flood waters may get behind them through a vulnerable point upstream. Furthermore, the levees are made of pervious material on steep and unprotected slopes with the result that they are gradually decreasing in effective height. The final objection to them is that they do not increase the channel capacity, but merely raise the water level and increase backwater conditions in the sewers. When they are overtopped, as they eventually will be, the property owners will suffer more damage than before because of a false sense of security.

Removal of Encroachments. - Except for the encroachments adjacent to the cut-off made above Bridge Street in 1934, no attempt to remove encroachments has been effective. There has been some improvement in encroachment conditions, as mentioned on page 14, but this improvement has been accidental and not as a result of deliberate efforts on the part of property owners. Buildings that were eliminated from the flood plain were torn down because

it was in the best interests of the owners to remove them.

The old dam above Wingohocking Street was removed by the owners in July 1933 after it had been seriously damaged by floods (See Plate 3). This change had considerable benefit in the immediate vicinity in that overbank flooding through headraces was eliminated. However, the filling in of both banks that took place after the dam was removed decreased the effective width of the channel between the damsite and Wingohocking Street (See Plate 5B).

Dredging to Increase Flood Capacity. - Projects by the City to improve the capacity of the channel for flood flows were previously mentioned under "Levee Protection". These dredging operations were of an emergency nature to relieve conditions where portions of the channel were filling in. Without a comprehensive plan for lowering the entire channel and for controlling sedimentation, bank erosion and dumping, such dredging operations would have to be repeated from time to time.

Dredging to Improve Navigation. - In accordance with Congressional authorization in 1882 a sum of $10,000 was expended in dredging a channel 50 feet wide and 7 feet deep from the mouth of Frankford Creek to the horseshoe bend above Bridge Street. A total of 35,200 cubic yards of material was removed. The project was to have been extended to Frankford Avenue with depths decreasing to 3 feet at the upper end but the Chief of Engineers, U. S. Army, recommended in 1884 that no further appropriation be made. Although reports on the improvement of Frankford Creek were made from time to time no further work was ever undertaken by the Federal Government.

The Department of Wharves, Docks and Ferries later took up the problem of maintaining a navigable channel to Margaret Street. In the period 1915-29 the channel was dredged 10 times and a total of 270,000 cubic yards of material was removed. The channel is again filled in and except at the mouth, most

of the bottom is exposed at low tide.

POSSIBLE METHODS OF FLOOD CONTROL

General Principles. - Flood protection of a single community can be achieved by several different methods or by a combination of methods. The methods are in general:

(a) reservoir storage
(b) levees or walls
(c) channel improvements
(d) diversion

The selection of an ultimate plan can only be made after extensive hydraulic, structural and economic analyses. In the case of Frankford Creek certain methods can be readily eliminated without undertaking complete studies.

Reservoir Storage. - From the standpoint of topography and foundation conditions it would be feasible structurally to build a dam across the valley of Frankford Creek in the vicinity of Castor Avenue. There are also other possible sites on Tacony Creek but dams at these sites would not be effective in controlling the discharge from the largest sewer, that at Ramona Street. The objections to a flood control reservoir near Castor Avenue are quite readily apparent, but are listed below:

(a) The reservoir area would occupy a considerable portion of Juniata Park, and would eliminate an important recreational facility.

(b) The reservoir level necessary to obtain effective flood control storage would cause backwater in the existing sewer system, particularly in the sanitary intercepting system.

(c) Flood control by reservoir storage would not eliminate the need for considerable expenditures in Frankford Creek below Juniata Park. The reconstruction of some bridges, bank stabilization and protection against

excessive tide and flood levels in the Delaware River would still have to be undertaken.

Levees and Walls. - Some of the objections to depending entirely on levees or high walls for flood protection on Frankford Creek have already been mentioned in discussing past emergency protection (See page 29). On large rivers where extensive levee systems are commonly used, there are wide overbank flood plain areas where levees can be built some distance back from the normal river channel, thereby leaving a large but still somewhat restricted floodway. Although most levee systems have a restrictive effect and tend to raise water levels for equivalent discharges, a levee and high wall system along a developed creek like Frankford Creek would have a particularly unfavorable effect. Water levels would be raised causing increased back pressure in sewers and drains and increased flooding in basements and low spots. A more serious effect of raising the flow lines would be the difficulty of passing flood discharges through existing bridges without raising the structures and probably raising existing street levels. In addition to the hydraulic objections to a levee and high wall scheme, there is the further objection that such a scheme requires a relatively large amount of right-of-way for construction purposes.

Channel Improvements. - The term channel improvements is applied to any project for increasing the discharge capacity of a stream by deepening and widening the channel and by removing bottlenecks caused by small bridge openings, encroachments, sharp bends or natural gorges. A channel improvement may also involve increasing the freeboard by the construction of low levees or walls. The ideal channel improvement includes sufficient stabilization of the bed and banks to insure that the improvement will be permanent. Frankford Creek in its present state of development is best adapted to the channel im-

provement type of protection.

Diversion. - In some river basins it is possible to divert a stream away from a damage center into a floodway or channel where rights-of-way are relatively inexpensive. In other cases the course of a stream may be diverted so as to decrease its length of travel and increase its rate of fall, thus either carrying the stream away from the damage center or merely effecting a lowering of flood levels.

A theoretical example of the above-mentioned procedure can be illustrated in the case of Tacony Creek. In Cheltenham the course of this creek is located within 4,500 feet of the drainage divide between Tacony and Pennypack Creeks. If it had been determined that the principle source of Frankford Creek floods was from Tacony Creek then it might be entirely feasible from an engineering and economic viewpoint to consider diversion of the flood flows of Tacony Creek into a tributary channel of Pennypack Creek. As it has been definitely established that the first and major flood peak on Frankford Creek comes from the sewered area within the City, any scheme for the diversion of Tacony Creek is not worthy of complete engineering study.

A scheme that has equal merit with a channel improvement in the lower reaches would be one in which a cut-off channel is constructed directly to the Delaware River along the east side of the Pennsylvania-Reading Seashore Lines leading to New Jersey (See Drawing No. R136-3). The channel would discharge into the Delaware River at Five Mile Point, adjacent to the present steam-electric station of the Philadelphia Electric Company. By taking a course about 5,500 feet in length compared with about 8,500 feet by the present confirmed channel, such a channel has a considerable hydraulic advantage as well as economic advantages.

A channel in this location was given preliminary study by the Bureau of

Engineering of the City in 1935. The scheme was also proposed to the War Department in 1938. In these earlier investigations, the plan was to use the cut-off channel only as a floodway, and to continue the use of the existing channel for normal flows. Due to the fact that the tidal reaches of Frankford Creek were then classified as a navigable stream, there might have been legal objections to diversion of all runoff from the existing creek channel. However, the creek is no longer navigable, therefore there appears to be an advantage in abandoning at least a part of the present channel, thus making considerable land available for reclamation.

REQUIRED FLOOD CONTROL CAPACITY

Definition. - The channel capacity as used in this report is the rate of discharge in cubic feet per second that can be passed in any reach without causing damage through overbank flooding or backwater in sewers.

Capacity of Existing Channel. - The capacity of the existing channel from the mouth to the Pennsylvania Railraod bridge varies with the height of tide. To be conservative the capacity studies were based on conditions at mean high tide. However, at intervals of about once a year the tide may reach levels 2 feet or more above the mean high point but coincidence of an unusual tide with flood flows is a rare occurrence. The following table gives approximate existing channel capacities by reaches:

Reach	Capacity in C.F.S.
Mouth to Bridge St.	4,500
Bridge St. to Orthodox St.	3,500
Orthodox St. to Penna. R.R.	2,000
Penna. R. R. to Frankford Ave.	2,200
Frankford Ave. to Kensington Ave.	5,000
Kensington Ave. to Wingohocking St.	1,800
Wingohocking St. to Castor Ave.	2,000

It is apparent from the above table that the channel capacity varies widely

from reach to reach. The low capacity of 2,000 cfs between Orthodox Street and the Pennsylvania Railroad (See Plate 9) is not of particular consequence at the present time as there is little development in the reach and much of the land is being filled in. Above the Pennsylvania Railroad the minimum capacity varies between 1,800 and 2,000 cfs, except for the section between Frankford Avenue and Kensington Avenue where protective works have increased the capacity to about 5,000 cfs. Serious damage does not begin at critical points in the upper reaches until the discharge exceeds about 3,000 cfs.

Previous Studies. - Several years ago the Bureau of Engineering of the City made a study of channel capacity requirements for Frankford Creek. The method of making the runoff computations was in accordance with standard practices in the design of storm sewers and differed from that used in this report and presented in detail in Appendix II. The City's investigations indicated that in a storm of intensity equivalent to that adopted for storm sewer design the peak discharge at the head of Frankford Creek would be 5,260 cfs and at Wakeling Street it would be 5,470 cfs. It was considered that these discharges would not give a sufficient factor of safety for the design of extensive channel improvements, therefore a runoff computation was made using rainfalls recorded in the storm of September 14, 1904. This storm was believed to have caused one of the greatest floods on the creek. Under runoff conditions prevailing at the time of the study, it was estimated that such a storm would have produced a discharge of 7,800 cfs at Wakeling Street. It was further estimated that the same storm under the ultimate development anticipated for the Frankford Creek drainage area would produce a discharge of 10,000 cfs at the head of the creek and 11,000 cfs at Wakeling Street. These discharges were recommended for channel requirements in the report to the City Council mentioned on page 6.

Appraisal of Flood History. - The selection of an adequate discharge capacity should be based on consideration of both the past flood history and estimates of future floods that may be affected by changes in development. The results of the studies of past floods have been summarized on pages 18 to 20, and are given in more detail in Appendix II. The greatest flood in the 20-year period for which data are available occurred on July 14, 1931, and had an estimated discharge of 6,500 cfs. The second largest flood had a discharge of 5,800 second-feet and occurred on August 18, 1932. The next six floods in order of magnitude had discharges varying between 4,800 and 4,000 cfs. In comparison with the flood history of an equivalent drainage area that has not been disturbed by urban development, the range in magnitude of the floods on Frankford Creek is relatively small. For example, the flood discharge that will be equalled or exceeded at least once a year is estimated to be 3,000 cfs or 46 percent of the maximum recorded flood of 6,500 cfs. This is a very extraordinary relationship and results from the effect of urban development on the runoff as discussed on pages 21 and 22. It would be incorrect to assume from this relationship that an adequate channel capacity can be obtained by providing for only small percentage increase over the greatest flood of record, because additional relief sewers to discharge directly into the creek are being planned for the reach between Juniata Park and the City line. Furthermore, it is probable that development within the County may increase the speed of runoff from that area and increase the degree of coincidence with flood runoff within the City, thus resulting in greater peak discharges in Frankford Creek. In view of the probable future changes it would be reasonable to allow for an increase of 50 percent in the magnitudes of future floods from an area as small as 30.6 square miles. Such an increase applied to the discharges of the two largest floods of record would result in discharges of 9,750 and 8,700 cfs, respectively.

Theoretical Rainfall-Runoff Analysis. - Because of incompleteness of the historic record and the relatively short period of years for which any flood heights are available, it was considered advisable to make a theoretical rainfall-runoff analysis. This study, which is presented in detail in Appendix II, was made in accordance with the most advanced hydrologic techniques that have been applied with success in flood control problems involving larger natural streams. Briefly this method required a complete analysis of rainfall frequencies for the Philadelphia area and the establishment of storm patterns of various frequencies. The runoff characteristics of the sub-areas were appraised and typical runoff hydrographs were computed for rainfalls of different durations. Through a combination of the storm analysis and the typical runoff hydrographs, estimates were made of complete flood hydrographs having a frequency of occurence corresponding to the storms. The results of these studies are summarized and compared with the study of the historic floods, in the following table:

Flood Frequency in years	Discharge in C.F.S.	
	Theoretical Analysis	Historic Flood Study
1	2,800	3,000
5	5,300	4,700
10	6,900	5,700
25	8,900	7,100
50	10,900	8,400
100	12,000	10,000

The theoretical runoff analysis takes into account the fact that the trunk sewers will limit the peak discharge from the area within the City to their total ultimate hydraulic capacity of about 10,400 cfs. Discharges greater than that amount represent contributions from the area within the County. It is considered that results of the two studies presented above are in unusually close agreement in view of the very meagre basic data available. The theoretical study indicates considerably higher discharges for the rarer floods,

probably because this study assumed that the sewer system would develop the full hydraulic capacity of existing and proposed outfalls, a condition that may never be reached. The study of historic floods probably does not include a number of intermediate floods the addition of which would result in higher discharge estimates for all frequencies. Thus the true discharge-frequency relation probably lies between the results of the two studies.

Summary. - The greatest discharge on Frankford Creek under the existing development has been computed to be 6,500 c.f.s. Hydrologic analysis indicates that critical flood peaks come from the 15.2 square miles of sewered area within the City and that due to a longer time of peaking, the part of the total drainage area within the County does not contribute appreciably to the peak at the present time, but may make greater contributions with changes in development in the County. Considering the historical record alone, a factor of safety of 50 percent added to the discharge of the greatest flood would not be unduly conservative for an estimate of future floods for a total drainage area of 30.6 square miles and would result in a discharge of 9,750 cfs. An extension of the frequency curve for the 20-year record of flood peaks indicates that a discharge of about 10,000 cfs could be expected on the average of once in a hundred years under present conditions. It is known that additional relief sewers will be constructed in the near future, therefore, that change, combined with the possibility of development in the County, should appreciably increase the frequency of a discharge of 10,000 cfs. The theoretical rainfall-runoff analysis indicates that a discharge of 10,000 cfs can be expected about once in 35 years, but appreciably greater discharges will not occur because of limited capacity of the sewers.

In addition to purely hydraulic and hydrologic factors, the following economic considerations must receive weight in selecting the capacity of the channel improvement:

(a) The several plans considered require the construction of three to four street and two to four railroad bridges for which waterway openings should be adequate for a period equivalent to their economic life.

(b) The flood protection will encourage valuable industrial development up to the right-of-way lines and as a result future expansion of the channel will be prohibitively expensive.

(c) A discharge of 10,000 cfs has been found to be the critical point in the cost-capacity relationship for the proposed improvements.

Recommended Channel Capacity. - In view of the results of the several studies discussed in the preceding paragraphs, we recommend that a channel capacity of 10,000 cfs be adopted for the Frankford Creek Flood Control Project and that the walls, bulkheads and levees be of sufficient height to provide a freeboard of 2 feet above the water surface under the design discharge. No increase in capacity above 10,000 cfs for the lower reaches of the improvement is recommended if the water surface computations are based on conditions at mean high tide.

FLOOD CONTROL SCHEMES INVESTIGATED

Types of Flood Channel. - The various schemes that we have investigated include several designs for increasing the discharge capacity of the present stream and a scheme for diversion of a portion of the stream into a new channel or "cut-off" below Aramingo Avenue extended. As mentioned above, a satisfactory design of a flood channel must provide for passing the maximum anticipated discharge without damage, and must, in addition, provide sufficient stabilization of the bed and banks of the channel to insure that the construction will be permanent. The types of construction considered for accomplishing these ends were as follows:

Type A: Earth channel with graded and seeded side-slopes and low levees where needed.

Type B: Channel with earth bottom and vertical sides supported by driven sheet-pile bulkheads of steel or concrete.

Type C: Channel with earth bottom and vertical sides supported by concrete walls.

Type D: Channel with earth bottom and sloping banks protected by low concrete toe-walls and grouted riprap paving on the banks above the walls.

Type E: Channel with concrete bottom and sides. If built on a steep enough gradient, this type of channel is often called a "chute" as the water would flow at high speed.

Type F: Covered channel consisting of a twin-barrel concrete conduit.

In order to determine the dimensions and construction costs for the above types of channel, hydraulic, structural and economic analyses were made. Not all of the above types of channel are feasible at a given location although generally more than one type is possible, requiring development of alternate schemes in various portions of the creek. To simplify consideration of these alternates the creek has been subdivided into reaches as follows:

(1) Delaware River to Pennsylvania Railroad Bridge

(2) Pennsylvania Railroad Bridge to Leiper Street

(3) Leiper Street to Juniata Park

The recommended and the alternate schemes for each of the above reaches are described in the following paragraphs. The respective construction and right-of-way costs are shown in Table 1. The recommended scheme in each reach was selected by us after considering such factors as construction and right-of-way costs, present and ultimate land use, and appearance.

Data on the construction quantities and unit costs are compiled in Appendix V. The unit prices are our best estimate of current prices for equivalent types of work. To the total construction cost we have added 10 percent for costs of engineering and administration. The land costs have been based

TABLE 1. - SUMMARY OF RECOMMENDED AND ALTERNATE SCHEMES IN EACH REACH

Reach	Description	Construction Cost	Land Cost
Delaware River to Penna. Railroad (8,700 ft.) 1/	Recommended Scheme: 5,400' of earth cutoff channel; 4,800' of earth dike; 1,510' of steel bulkhead; 4,290' of storm sewers; new railroad bridges at Delaware Ave. and Carbon St.; new bridges at Richmond St. and Thompson St.; railroad bridges at Aramingo Ave. and Amber St. enlarged	$2,148,000	$147,500 2/
	Alternate No. 1: 19,640' of concrete or steel bulkhead; new bridges at Bridge St. and Orthodox St.; railroad bridges at Aramingo Ave. and Amber St. enlarged; sheet pile sill across creek at mouth	4,304,600	127,800
	Alternate No. 2: Same as Alt. No. 1 except that 9,000 feet of bulkheads are replaced by earth dikes	3,031,400	165,000
Penna. Railroad to Leiper St. (3,400 ft.)	Recommended Scheme: 2,150 of concrete "T" walls; 2,280 ft. of 5-ft. concrete toe-walls and grouted riprap side slopes; 900 ft. of concrete conduit; remove Worrell St. bridge.	1,387,000	28,900 3/
	Alternate No. 1: 6,230' of concrete "T" walls; remove Worrell St. bridge	1,359,000	24,250
	Alternate No. 2: Same as Alt. No. 1 except 2,280' of "T" walls replaced by 5' concrete toe-walls and grouted riprap side slopes	1,252,000	30,300
	Alternate No. 3: Same as Alt. No. 1, except 4,060' of "T" walls replaced by concrete conduit	1,768,000	22,100 4/
Leiper St. to Juniata Park (2,200 ft.)	Recommended Scheme: Concrete paved chute; new bridge at Wingohocking St.; cut-off channel and debris weir in Juniata Park	1,003,600	13,810
	Alternate No. 1: 4,400' of concrete "T" walls; new bridge at Wingohocking St.; cut-off channel and debris weir in Juniata Park	1,205,600	13,750
	Alternate No. 2: 5' concrete toe-walls and grouted riprap side slopes; new bridge at Wingohocking St., cut-off channel and debris weir in Juniata Park	1,034,600	24,150

1/ 11,700 ft. for Alternates Nos. 1 and 2.

2/ Reduce by $53,000 for estimated value of land created by filling in the old creek bed.

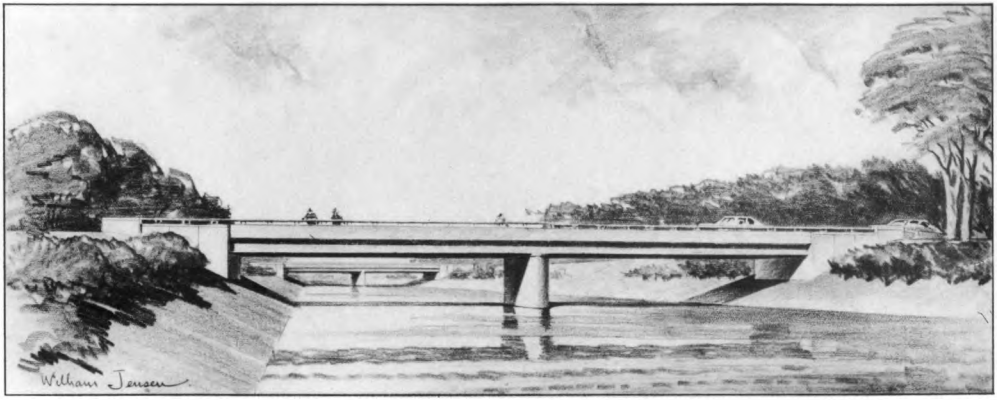
3/ Reduce by $4,800 for estimated value of land created by filling over the conduit.

4/ Reduce by $12,000 for estimated value of land created by filling over the conduit.

on an average figure of $3500 an acre furnished to us by the City.

Delaware River to Pennsylvania Railroad Bridge. - The Recommended Scheme, shown on Drawings Nos. R136-5, 6 and 7 provides for an earth cut-off channel (Type A), beginning at the present bend in the creek at Roxborough Street and paralleling the Pennsylvania-Reading Seashore Lines for a distance of 5,400 feet to the Delaware River. An architectural rendering of a section of this channel is shown in Plate 12. From the beginning of the cut-off upstream to the Pennsylvania Railroad bridge, a distance of 3,300 feet, 4,800 feet of earth banks and 1,510 feet of steel sheet-pile cantilever type bulkhead would be used. Existing storm sewers between Roxborough Street and Wakeling Street would be connected to two collecting sewers to be constructed in the existing channel. One sewer would flow west to the new cut-off channel and the other would flow east to the present Wakeling Street sewer. The present channel from Roxborough Street to Wakeling Street would then be filled in. When conditions justify it, the Wakeling Street sewer could be extended directly to the Delaware River in a line parallel to Pratt Street where good foundation conditions could be expected. It would be prohibitively costly to extend the sewer in Frankford Creek where deep pile foundations are required. When the sewer extension is made, the remainder of the creek channel could be filled in.

With the Recommended Scheme the present bridges at Orthodox Street and Margaret Street could be abandoned, while the Bridge Street bridge could eventually be replaced by a relatively small culvert. The railroad bridge below Aramingo Avenue would be enlarged by the addition of two spans and two abutments. The railroad bridge at Amber Street extended would be lengthened. Four bridges would be required over the cut-off proper as follows: Thompson Street, Richmond Street, Belt Line Railroad and Kensington & Tacony Railroad. For sketches of the proposed highway bridges see Drawing No. R136-20 and Plate No. 12.



KNAPPEN ENGINEERING CO.
CONSULTING ENGINEERS
NEW YORK CITY

PROPOSED CUT-OFF CHANNEL & RICHMOND STREET BRIDGE

FRANKFORD CREEK FLOOD CONTROL PROJECT
CITY OF PHILADELPHIA

PLATE 12

In Alternate No. 1 (Drawings Nos. R136-11, 12, 13 and 14) and Alternate No. 2 (Drawings Nos. R136-11, 12, 15 and 16) Type B channel, consisting of driven sheet-pile bulkheads, has been used in the portion of the existing channel from the Delaware River to Orthodox Street. This type of construction is required primarily because of the industrial development bordering the creek. Type A channel (earth banks) is not feasible because of prohibitive right-of-way cost. Types C and D are ruled out because of soil conditions. There is not sufficient slope to cause the high-speed flow necessary for Type E nor the moderate-speed flow necessary for Type F.

In the portion from Orthodox Street to the Pennsylvania Railroad bridge, Alternate No. 1 continues use of bulkheads (Type B channel) while Alternate No. 2 substitutes the Type A channel, consisting of a sloping bank and low earth dikes, wherever feasible.

The bulkheads required for both Alternates No. 1 and No. 2 vary considerably in design from place to place because of changes in subsurface conditions, as indicated by borings and laboratory tests. For the most part, designs utilizing precast concrete sheet piling, tied back to precast concrete anchor piles, were found to be the most economical to resist lateral thrusts and insure structural stability (See Section 10-10, Dwg. No. R136-11). Where buildings are close to the creek, tie-backs are not feasible, and a design for a steel bulkhead, with batter piles on the channel side, was used (See Section 9-9, Dwg. No. R136-11). A third type of bulkhead, known as the "relieving platform" type, was used near the mouth of the creek where subsurface explorations indicate the presence of a deep layer of soft silt (See Section 8-8, Dwg. No. R136-11). Finally, a fourth type of bulkhead, called the "cantilever type"--consisting of steel sheet piling without tie-backs or batter piles--was used where there are favorable subsurface conditions (See

Section 13-13, Dwg. No. R136-14). Plans of existing bulkheads or walls were examined and, if the structures were considered adequate they were incorporated in the proposed improvement. For example, the 430-foot bulkhead adjoining the plant of the Barrett Division of the Allied Chemical & Dye Corporation can be used with a minor addition consisting of a 3½-foot parapet wall (See Plate 11B and Drawing No. 136-12, Section 11-11). The existing concrete wall on the Frankford Arsenal side of the creek between the Delaware River and Bridge Street is in good condition although the alignment is irregular (See Plate 10). However, as hydraulic studies indicate that only minor benefits can be obtained from rectification and as the elevation of the top of the wall is adequate to protect against either the Design Discharge or the highest tide of record, it is proposed that this wall be left untouched. To resist anticipated scour near the mouth of the creek in times of major floods, a sheet-pile barrier sill would be placed across the creek as shown in Drawing No. R136-11.

Changes to bridges proposed under Alternates No. 1 and No. 2 are as follows:

(a) Remove the upstream fender piling of the railroad bridge at the mouth of the creek. No further change to this bridge is proposed.

(b) Construct new bridge at Bridge Street as the present bridge constitutes a serious bottleneck to the passage of floods, (See Plate 11A).

(c) Construct a new bridge at Orthodox Street where there would be a cut-off in accordance with the so-called "confirmed channel" laid out by the City.

(d) Construct a new bridge at the railroad crossing below Aramingo Avenue where a longer span and greater vertical clearance are needed.

(e) Remove and lengthen one span of the railroad bridge at Amber Street extended.

The Recommended Scheme is lower in cost than Alternates Nos. 1 and 2 for the following reasons: (1) The total length of reach from the Pennsylvania Railroad bridge to the Delaware River is reduced from 11,700 feet to 8,700 feet; and (2) the costly bulkheads required in Alternates Nos. 1 and 2 below Orthodox Street are eliminated. The Recommended Scheme, besides being lower in cost, has an additional advantage in that water levels would be lower than with Alternates Nos. 1 and 2, due to the shorter length of channel to the Delaware River. This is of importance in the vicinity of Paul Street where two large storm sewers, that drain the low-lying area at Paul and Vandyke Streets, discharge into the creek. With Alternates Nos. 1 and 2, self-closing backwater gates are needed to prevent backing up of the storm sewers into the low area. While backwater gates have been used successfully in many instances, their maintenance is always a problem and their use should be avoided if possible. With the Recommended Scheme the backwater gates would not be needed.

Pennsylvania Railroad Bridge to Leiper Street.- Subsurface soil conditions in this reach are adequate for support of a wall-type of bank protection (Type C channel). The channel slope and the character of development are such as to warrant consideration also of channel Types D, E and F for various portions of this reach. The resulting schemes are described briefly in the following paragraphs. Construction and land costs are shown in Table 1.

The Recommended Scheme utilizes channel Types D, E and F as shown in Drawing No. R136-8. From the Pennsylvania Railroad to the proposed stabilizing sill just above Torresdale Avenue, Type E channel, consisting of vertical

concrete walls and a paved concrete bottom, is used. The channel width in this portion would vary from 70 feet to 100 feet, with the channel walls tying in to the present abutments of the Frankford Avenue and Torresdale Avenue bridges. The resulting waterway area, which is much smaller than that used in the channel below the Pennsylvania Railroad, provides for a much higher velocity of flow. The available slope of the creek is sufficient to produce the required velocities, as revealed by hydraulic computations. The considerable economy achieved by leaving the Frankford and Torresdale Avenue bridges intact is obvious.

From the stabilizing sill near Torresdale Avenue, Station 99 + 50 (See Drawing No. R136-8) to Station 111 + 50, Type D channel, consisting of 5-foot concrete toewalls supporting sloping earth banks paved with grouted riprap (See Section 4-4) would be used. The absence of development along the west bank will permit a slight shift in alignment toward that bank, thus providing ample width of right-of-way. This alignment will also avoid costly underpinning of the buildings on the east bank between Torresdale and Kensington Avenues (See Plate 8A), but removal of the Worrell Street bridge is required. However, replacement of this bridge is considered unnecessary in view of the proximity of the Kensington and Torresdale Avenue crossings and the fact that Worrell Street is not a through street. The concrete stabilizing sill at Station 99 + 50 is located at a change in the bottom slope and is for the purpose of minimizing erosion of the channel bottom.

From Station 111 + 50 to Station 142 + 50, Type F channel, consisting of a twin concrete conduit as shown in Section 5-5, Drawing No. R136-8, is proposed. This type of channel was selected because of the restricted right-of-way in this portion of the channel caused by the industrial buildings on the east bank (Plate 5A) and the high ground on the west bank (Plate 4B).

There is insufficient width of right-of-way for a Type D channel in this place. A Type C channel with vertical walls is also feasible and has been considered in Alternates Nos. 1 and 2 described below. An architectural rendering showing the proposed construction in this portion of the improvement is shown in Plate 1.

Alternate No. 1, shown in Drawing No. R136-17, provides a rectangular channel 100 feet wide to Frankford Avenue and 70 feet wide above Torresdale Avenue, with reinforced concrete "T" walls (Type C construction) having a total length of 6,230 feet. The existing bridges at Pennsylvania Railroad, Frankford Avenue, Torresdale Avenue and Kensington Avenue would be retained. Sediment deposits under these bridges would be removed and the channel bottom under the upper three bridges would be paved with concrete. As with the Recommended Scheme, the Worrell Street bridge would be removed to provide better hydraulic conditions and to permit a change of alignment that would avoid underpinning of existing buildings.

Alternate No. 2 is similar to the Recommended Scheme except that instead of the 900-foot long Type F covered section, Type C channel (high vertical walls) would be used.

Alternate No. 3 would consist of a 2,020-foot concrete conduit extending downstream from a point about halfway between Leiper Street and Bristol Street to 200 feet above Torresdale Avenue. From the latter point to the Pennsylvania Railroad the construction would be the same as in Alternates Nos. 1 and 2. The conduit would have two barrels each 28 feet wide and 14 feet high. As shown in Table 1, this alternate requires the least land-taking and, as in the case of the Recommended Scheme, additional land would become available after construction by filling over the conduit.

It would be possible to extend the covered channel of Alternate No. 3 to the Pennsylvania Railroad. However, as the channel slope becomes flatter

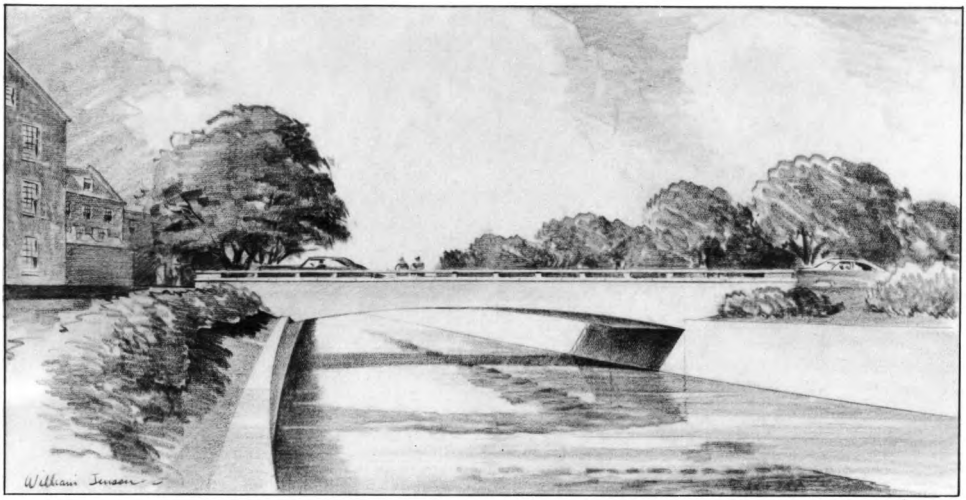
below Torresdale Avenue, a larger conduit would be required resulting in a marked increase in cost. Therefore, consideration of a covered channel from Torresdale Avenue to the Pennsylvania Railroad was not carried any further and is not presented as an alternate at this time. If additional development of this part of the city takes place or if it becomes necessary to replace or widen the bridges at Frankford and Torresdale Avenues, appropriate portions of the creek could be covered over as desired.

The total costs for the Recommended Scheme in this reach are $133,600 more than Alternate No. 2, which is the most economical scheme. The difference in costs results from the use of 900 feet of conduit section in place of walls up to 19 feet in height. The additional costs to eliminate the walls are believed justified as such walls create a hazardous condition for children and others who might gain access to the right-of-way. A further advantage of the conduit is that 70,000 sq. ft. of additional land would become available after construction by filling over the conduit. This land could be used for a playground or leased to adjacent property owners.

Alternate No. 1 would cost $100,950 more than Alternate No. 2 and would not overcome the objections to the latter alternate.

Leiper Street to Juniata Park. - All the schemes for this reach include the costs for a creek cut-off at and above Castor Avenue. The cut-off had been previously proposed by the City as a necessary adjunct to the extension of Castor Avenue, now under construction.

In developing a suitable design for the project, it was necessary to study the hydraulic characteristics of the creek channel above the head of the cut-off channel insofar as they relate to maintenance of the improvements below. As pointed out above (See pages 12 and 25) much erosion and deposition of sediment has occurred and the creek bottom through Juniata Park has dropped 6 to 8 feet in recent years. As a means of arresting this erosion



KNAPPEN ENGINEERING CO.
CONSULTING ENGINEERS
NEW YORK CITY

PROPOSED CHANNEL & WINGOHOCKING STREET BRIDGE

FRANKFORD CREEK FLOOD CONTROL PROJECT
CITY OF PHILADELPHIA

PLATE 13

and at the same time preventing accumulations of debris and sediment from being carried down to the improved channel below, it was found advisable to provide a weir and debris basin at the head of the cut-off. This weir is considered the head of the project covered by this report.

The Recommended Scheme for this reach, shown in Drawing No. R136-9 and R136-9A, utilizes a Type E channel from Leiper St. to Castor Avenue. The channel will be a concrete high-speed flume or "chute", 60 feet wide and 9 feet deep from the top of the walls. An architectural rendering of a section of this channel is shown in Plate 13. A new bridge (See sketch, Drawing No. R136-21, and Plate 13) would be required at Wingohocking Street as the existing bridge has an inadequate opening, is subject to flooding up to the street level and has an unsatisfactory alignment. This scheme has practically the same construction cost as Alternate No. 2, described below, but is recommended because of the smaller right-of-way requirements that may be an important consideration in future development of the adjacent lands.

Alternate No. 1 for the portion of the reach from Leiper Street to Castor Avenue, as shown on Drawing No. R136-18, provides the same type of bank protection as Alternate No. 1 in the preceding reach. The channel would be 70 feet wide and the concrete "T" walls would have a height of 15 feet above the channel bottom. The total length of walls is 4400 feet. A low weir is required at a point midway between Bristol and Leiper Streets to limit velocities and stabilize the channel bottom. As with the Recommended Scheme a new bridge would be required at Wingohocking Street.

Alternate No. 2 shown in Drawing No. R136-19 would be a continuation of Alternate No. 2 in the previous reach and would provide for 5-foot concrete walls connecting with sloping earth banks paved with grouted riprap. As with the Recommended Scheme a new bridge would be required at Wingohocking Street.

OVERALL PLANS

In the previous section, the improvement of the creek was considered reach by reach. The most desirable schemes for each reach have been combined in four overall plans designated as Plans A, B, C, and D. The costs of these plans are summarized in Table 2.

Plan A: Plan A, the Recommended Plan, is the most economical plan, even though the land costs are slightly higher than in Plans C and D. Plan A (See Drawings Nos. R136-3 and 4 for general plan and profile) utilizes the Recommended Scheme in each of the three reaches. A recapitulation of the features of the plan is given below. In the first reach, a new cut-off channel below Roxborough Street and an earth channel above that point is proposed. In the second reach, beginning at the Pennsylvania Railroad, three types of channel are used. From the lower end of the reach to a point immediately above Torresdale Avenue vertical concrete walls and concrete bottom paving are proposed for a distance of 1075 feet. The next section would utilize 5-foot concrete toe walls supporting grouted riprap side slopes for a distance of 1140 feet. The last section, 900 feet long, would be inclosed in a concrete conduit. In the last reach from Leiper Street to Juniata Park the concrete-lined chute is adopted because of the lower construction costs and smaller land taking. The profile of Plan A in Drawing No. R136-4, shows the lowering of flood levels accomplished with this plan, by comparing the high-water marks left by the 1931 flood, when the discharge was 6,500 cubic feet per second, with the lower water levels to be expected for the same discharge after completion of this plan. The total cost of Plan A, including lands, is $4,728,800.

Plan B: This plan utilizes the existing channel throughout and is the most economical plan for that course. As in both of the schemes that follow the existing channel, bulkheads are used up to Orthodox Street but beyond that

point the earth channel (Alternate No. 2) is used. Above Torresdale Avenue, this plan is identical with Plan A. Drawing No. R136-4 shows the lowering of flood levels achieved by Plan B. It will be noted that the expected flood levels below Torresdale Avenue are higher for Plan B than for Plan A. The total cost of Plan B, including lands, is $5,629,700.

Plan C: This plan is similar to Plan A, except that Alternate No. 3 (the 2,030-foot conduit scheme) is used from the Pennsylvania Railroad to Leiper Street. This modification of Plan A results in a saving of $6,800 in estimated land costs plus an estimated benefit of $12,000 in reclaimed land but adds $381,000 to the construction costs. The total costs are $5,103,000.

Plan D: This plan again uses the existing channel. It is set up as the plan having the least land takings, as it utilizes bulkheads the entire length of the first reach from the Delaware River to the Pennsylvania Railroad. The total cost, including lands, is $7,239,900.

Recommended Plan: We recommend that Plan A with a total estimated cost of $4,728,800 be adopted as the most feasible and economical plan for the control of floods in Frankford Creek. If the city does not desire to abandon the lower reaches of Frankford Creek then we suggest the adoption of Plan B with a total estimated cost of $5,629,700.

In addition to the estimated saving of $900,900 in total cost compared with Plan B, Plan A has the following advantages, all of which lie in the reach from the Delaware River to Frankford Avenue.

(a) No interference with the operations of important industries, claims from whom will probably far exceed the average estimated land costs furnished to us by the City. Conditions to be encountered with Plan "B" are shown in Plate 10.

(b) Lower flood levels opposite critical areas below Frankford Avenue, eliminating the need for backwater gates on storm sewers.

TABLE 2.-COSTS OF OVERALL PLANS

Reach	Plan A (The Recommended Plan) Scheme Used*	Construction Cost	Land Cost	Plan B (Recommended if the Cut-off Scheme is not desired) Scheme Used*	Construction Cost	Land Cost	Plan C (Requires the least right-of-way with Cut-off) Scheme Used*	Construction Cost	Land Cost	Plan D (Requires the least right-of-way without the Cut-off Scheme) Scheme Used*	Construction Cost	Land Cost
Delaware River to Penna. RR	R	$2,148,000	$147,500	2	$3,031,400	$165,000	R	$2,148,000	$147,500	1	$4,304,600	$127,800
Penna. RR to Leiper Street	R	1,387,000	28,900	R	1,387,000	28,900	3	1,768,000	22,100	3	1,768,000	22,100
Leiper St. to Juniata Park	R	1,003,600	13,800	R	1,003,600	13,800	R	1,003,600	13,800	R	1,003,600	13,800
TOTALS...	-	$4,538,600	$190,200	-	$5,422,000	$207,700	-	$4,919,600	$183,400	-	$7,076,200	$163,700

* The Recommended Scheme for the reach is designated by R; alternate schemes are designated by number

(c) Filling in of the old channel will result in additional benefits from reclaimed land and saving in costs of future bridges.

MAINTENANCE

Inspection. - Any type of channel improvement requires periodic inspection to guard against surface deterioration, settlement and vandalism. In a hydraulic structure subject to the force of flowing water, small surface breaks in sod, riprap or concrete due to weathering, or breaks in general alignment due to unforeseeable causes may lead to deterioration of adjacent sections of the channel. Therefore, periodic inspection three or four times a year is well worth the small cost.

Care of Levees and Earth Channels. - In the Recommended Plan an earth channel with seeded side slopes, with and without supplemental levees, is proposed for a distance of 8,400 feet above the outlet. To protect the channel sides and levees against scour from flood flows in the channel and from rain wash a good grass cover is required. Effective maintenance requires frequent cutting through the summer to keep down weeds. Bare spots and eroded areas should be repaired whenever necessary. Refertilization of the cover is also desirable from time to time as the slopes facilitate removal of plant foods. Once a good stand of grass is established, the channel will have a pleasing appearance and will maintain its form indefinitely. The average annual maintenance costs of the seeded slopes is estimated to be about $1000 per year. This does not include the cost of mowing equipment.

Control of Dumping and Pollution. - Need for correcting the present pollution of the creek cannot be emphasized too strongly. Dumping of trash should be stopped and city ordinances prohibiting dumping should be rigidly enforced. A high fence is proposed along the entire improvement, but such a fence will

not in itself prevent all dumping.

The industrial liquid wastes that now enter the creek should be disposed of through the existing sanitary sewers or should be treated separately at their point of origin. These wastes contribute considerable solid matter and also react with other materials in suspension and increase the rate of precipitation of the latter. If the use of Frankford Creek for waste disposal continues, maintenance costs for the flood control project proposed herein will be excessive and the effectiveness of works to cost ultimately several millions of dollars will be impaired to a considerable extent.

Maintenance Dredging. - On page 12 there were listed six principal causes of deposition in the present channel. Of these items, the following will be entirely eliminated by construction and policing of the improvements:

Item (c): Erosion of loosely placed and unprotected fills adjacent to the creek.

Item (d): Dumping of trash and industrial wastes in both liquid and solid form.

Item (e): Construction activities along the creek involving placement of walls, bridges, sewers, etc.

Item (a), which was erosion of land areas and creek channels in the upper drainage area of Tacony Creek will continue but the transportation of material will be largely intercepted after construction of the recommended check dams and debris basin in Juniata Park. Only fine particles in suspension will come down the creek in time of flood, but some of these will settle out in the lower tidal reaches of the improvement.

Street washings (Item b) will enter the creek as before but the coarser materials will find their way to the existing grit chamber through which the present intercepting sewer passes.

The last source of sediments (Item f) is suspended material brought in by tides from the Delaware River. Nothing can be done to exclude this material from the lower reaches, but it is believed that if the Frankford Creek waters are kept free from pollution, the tendency for this material to precipitate will be reduced.

The debris basin in Juniata Park may require dredging after major floods until conditions become stabilized in the channel above. If this basin is properly maintained, no maintenance dredging in the improved channel will be required in the reach from Juniata Park to the head of tide in the vicinity of Frankford Avenue. Fine sediments will accumulate slowly in the 10,000 feet of tidal reach between Frankford Avenue and the mouth. However, it is believed that with the improved alignment, uniformity of section, steeper average slope, and relatively clear water, flood flows will remove some of the sediments that have accumulated during low flows. It is difficult to predict when dredging will be required in the tidal reach, but we estimate that such dredging may be required after a period of 5 to 10 years. Average annual dredging costs, including cleaning of the debris basin, is estimated to be $6,000 per year.

Access. - Maintenance equipment may require access to various portions of the improved channel for cleaning or repair of structures, outfall sewers or other appurtenances. Access could be accomplished in several different ways. The chute could be entered from the golf course by passing under the Castor Avenue bridge. Entry into the conduit could be provided by one or two manholes or equipment could be driven in from either end. The riprapped channel section between Leiper Street and Torresdale Avenue could be entered at Worrell Street where abandonment of the existing bridge is recommended. Access to the earth channel section from Amber Street to the Delaware River would be accomplished from the top of the bank. Where low levees are proposed,

they will have a top width of 8 to 10 feet which should be sufficient for access purposes. Where there are no levees along the earth channel a permanent easement 10 feet wide from the top of the bank should be secured for access purposes. Where fences are recommended, removable sections or gates should be provided to permit access. A strip of land at least 6 feet wide should be provided for access to and maintenance of the fences.

CONSTRUCTION PROGRAM

General Procedure. It is our understanding that it will not be practicable to undertake the construction of either Plan A or Plan B as one contract due to budgetary limitations. We accordingly recommend certain steps that will bring partial relief from flood damage until the entire program of improvements can be carried out.

Plan A. - The following order of construction is proposed:

(1) Construct the cut-off above Castor Avenue, together with the weir and debris basin in Juniata Park to prevent additional sediments from collecting in the lower reaches of Frankford Creek. The estimated cost of the construction is $333,600, including an allowance for engineering and administration.

(2) Construct the concrete channel from the proposed cut-off at Castor Avenue to Leiper Street, including a new bridge at Wingohocking Street. Flood damage above Wingohocking Street is frequent under present conditions. The estimated cost of this work is $693,000.

(3) Improve the following bottlenecks below Kensington Avenue at an estimated cost of $117,000:

(a) Remove abandoned steel footbridge at Paul Street.

(b) Enlarge railroad siding bridge at Amber Street.

(c) Remove and reconstruct the railroad spur-track bridge below Aramingo Avenue.

(d) Remove Worrell Street Bridge including west abutment.

(4) Make preliminary channel excavation from Kensington Avenue to the Pennsylvania Railroad to relieve present choked conditions. The estimated cost is $16,000.

(5) Construct the 900-foot conduit below Leiper Street at an estimated cost of $374,000.

(6) Construct channel from end of conduit to Amber Street at an estimated cost of $1,047,000.

(7) Construct two highway and two railroad bridges in the proposed cut-off channel below Roxborough Street. These bridges can be built "in the dry". The estimated cost is $550,000.

(8) Excavate cut-off channel except for short sections at each end to act as cofferdams. Excavations will have to be spoiled along Frankford Creek until intercepting sewers can be built. The estimated cost is $911,000.

(9) Complete earth channel from Amber Street to the cut-off at an estimated cost of $332,000.

(10) Divert Frankford Creek into cut-off. The cost is included in Item (9).

(11) Block off existing channel at Roxborough Street and in vicinity of Wakeling Street and construct collecting sewers at an estimated cost of $355,000.

(12) Fill existing channel. This cost is included in Item (8).

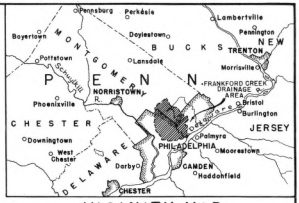
Plan B. - The first six steps listed above for Plan A should be followed except that reconstruction of the Bridge Street bridge should be initiated almost at once to afford some relief from backwater in the lower reaches in

time of floods. The bridge and bulkheads in the cut-off at Orthodox Street could be constructed in the dry and the channel cut through as an early step following the work at Bridge Street. The order of construction of the final channel should be in a downstream direction.

RECOMMENDATIONS

It is our recommendation that the City adopt Plan A for flood control in Frankford Creek at a total estimated cost of $4,728,800, and that the construction be carried out in accordance with the program outlined above.


WILLOW GROVE TURNPIKE
SUSQUEHANNA RD
CHURCH RD
CHELTENHAM AVE
BEAVER MILL ROAD
OLD YORK RD
READING
SUSQUEHANNA ROAD
MEETING HOUSE ROAD
FOX CHASE
ROCKLEDGE BORO
FOX CHASE
GLENSIDE
JENKINTOWN
WYNCOTE
MC KINLEY
WYNDMOOR
STENTON AVE
MT AIRY
LAMONT
MELROSE
ASHBURNE
CHELTENHAM
LAWNDALE
GERMANTOWN
OLNEY
ADAMS AVE
FRANKFORD
TIOGA AVE
ALLEGHENY AVE
LEHIGH AVE
KENSINGTON
BROAD



VICINITY MAP

LEGEND

DRAINAGE BOUNDARY
SEWERS
PROPOSED SEWERS
COUNTY LINE
RESIDENTIAL OR INDUSTRIAL AREAS

NOTES

CONTOUR INTERVAL 20FEET
DATUM IS MEAN SEA LEVEL

CITY OF PHILADELPHIA
DEPARTMENT OF PUBLIC WORKS
BUREAU OF ENGINEERING, SURVEYS AND ZONING

REPORT ON
FRANKFORD CREEK FLOOD CONTROL

DRAINAGE AREA MAP

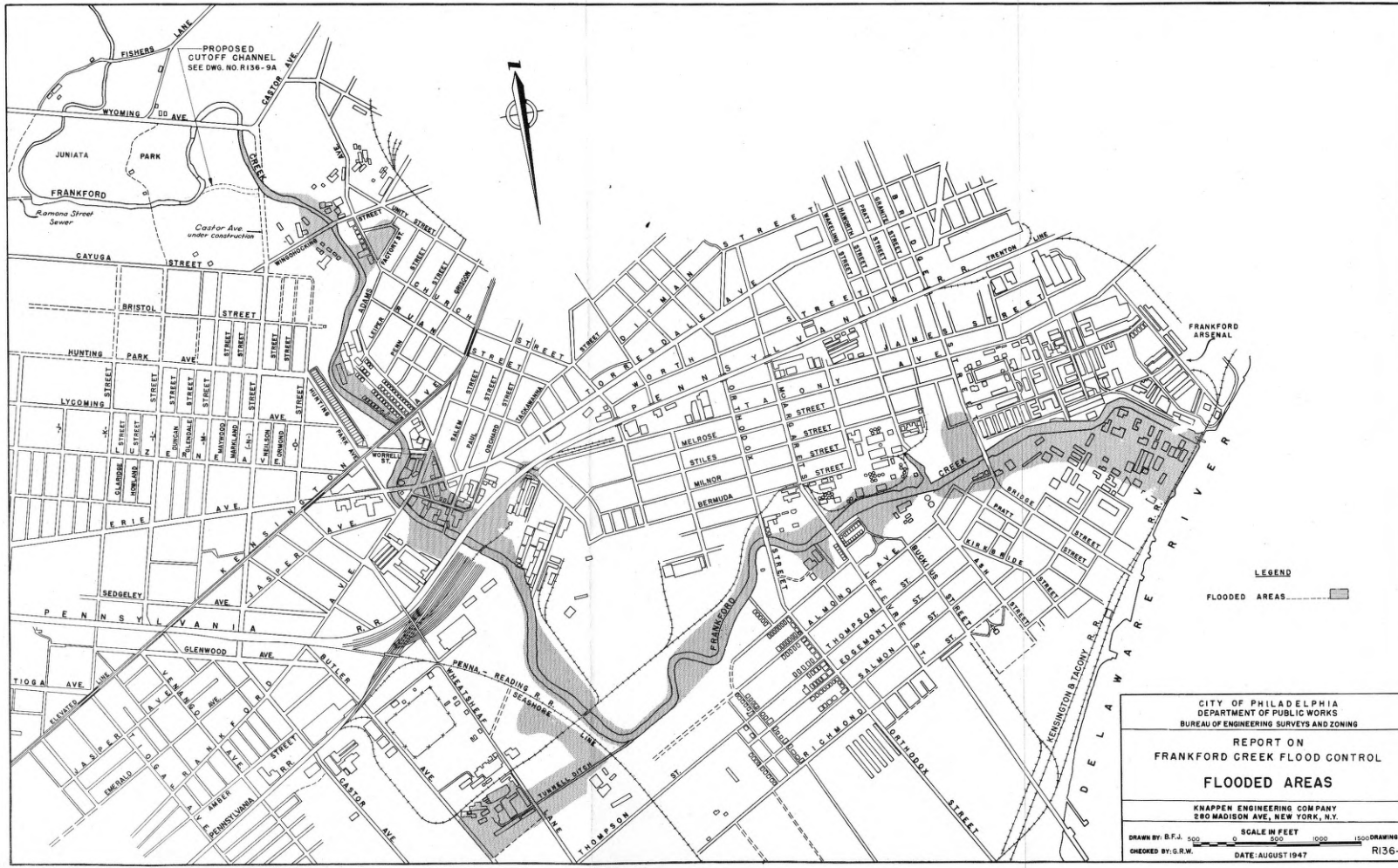
KNAPPEN ENGINEERING COMPANY
280 MADISON AVE. NEW YORK, N.Y.

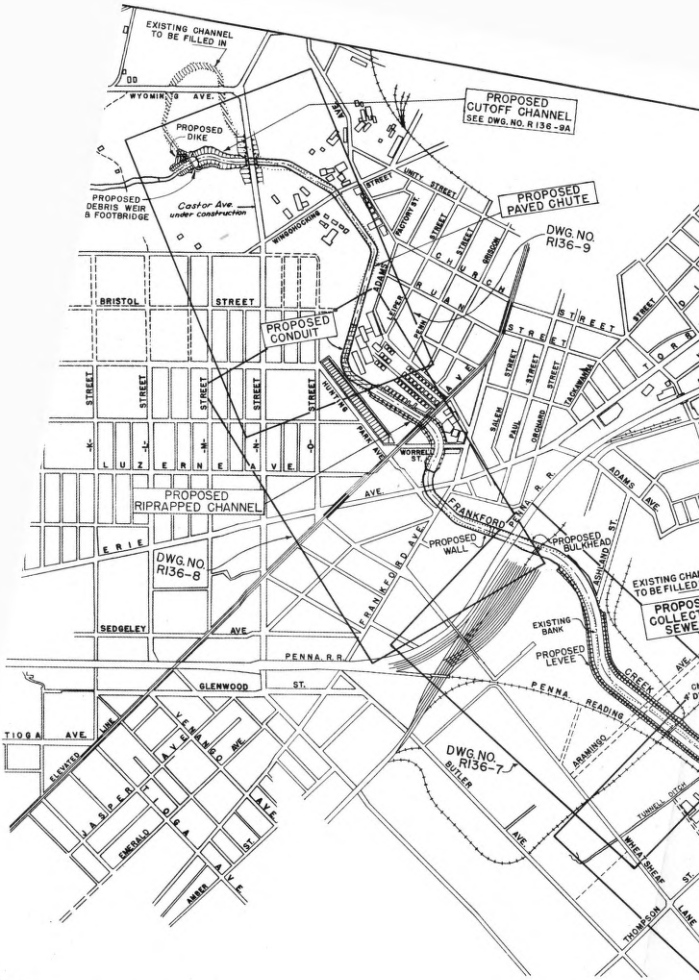
DWN. BY: B.F.J.
CHKD. BY: G.R.W.

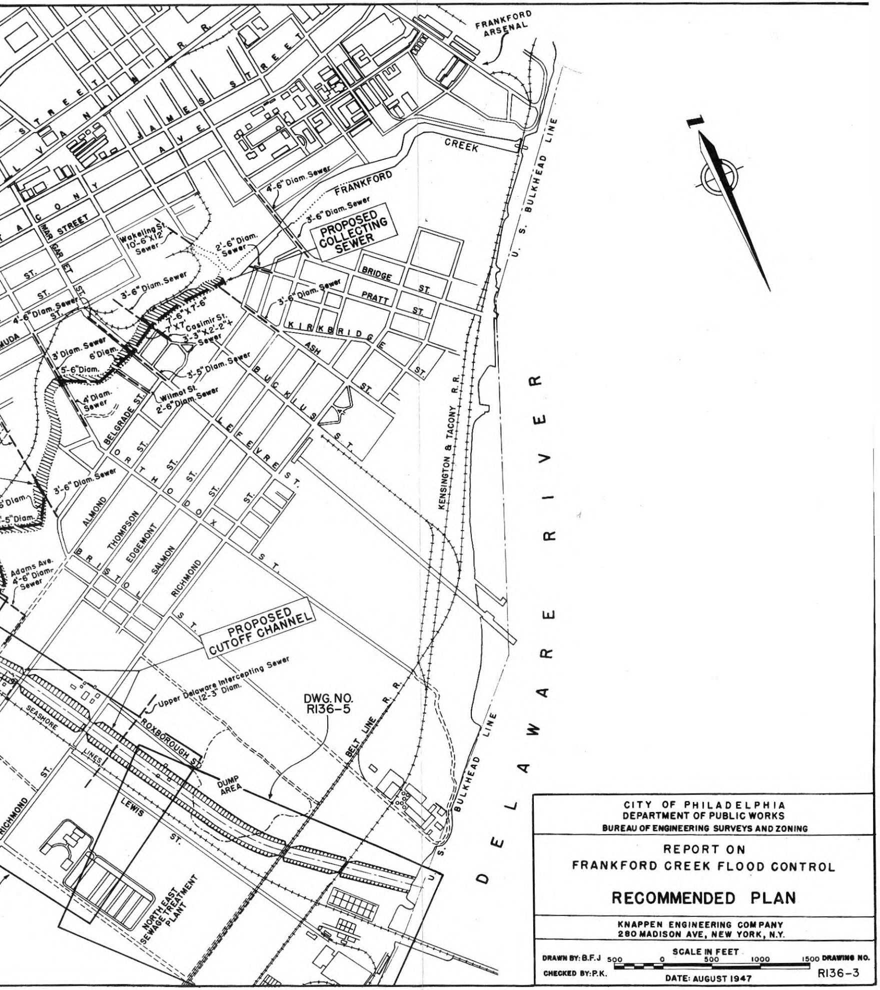
SCALE IN FEET
2500 0 2500 5000 7500

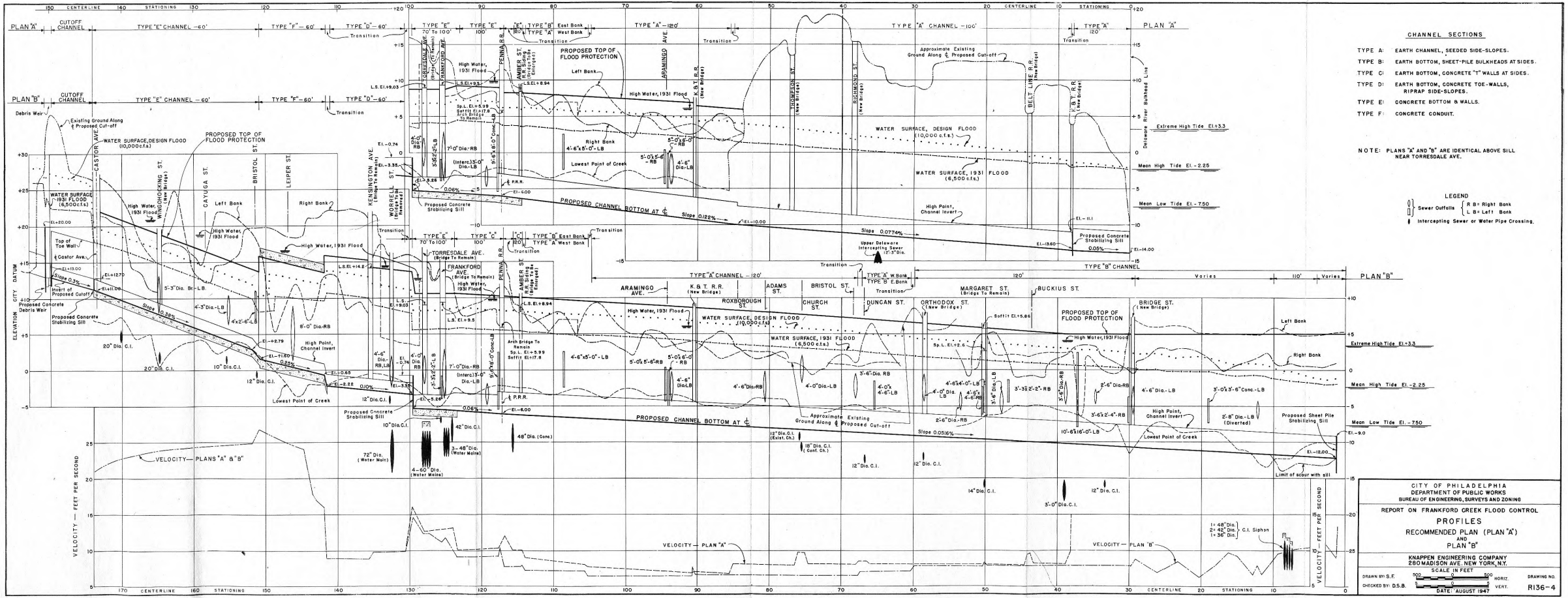
DRAWING NO. R136-1

DATE: AUGUST 1947


PROPOSED CUTOFF CHANNEL SEE DWG. NO. R136-9A
FISHERS LANE
WYOMING AVE
CASTOR AVE
JUNIATA PARK
FRANKFORD CREEK
FRANKFORD
Ramona Street Sewer
Castor Ave under construction
WINDRIDGE RD
CAYUGA STREET
BRISTOL STREET
HUNTING PARK AVE
LYCOMING AVE
ERIE AVE
SEDGELEY AVE
GLENWOOD AVE
TIOGA AVE
ELEVATED LINE
VENANGO AVE
PENNSYLVANIA AVE
EMERALD STREET
AMBER STREET
CASTOR AVE
THOMPSON ST
THORNELL DITCH
PENNA. — READING R.R.
WEAVERSHEAD SEAGHORE LINE
KENSINGTON AVE
JASPER STREET
MARTIN PARK AVE
WORRELL ST
ADAMS AVE
UNITY STREET
HARTWELL AVE
LEVICK STREET
PENN STREET
CHURCH STREET
SALEM STREET
PARK STREET
ORCHARD STREET
TACKAWANNA STREET
DIAMOND STREET
WORTH STREET
PENNSYLVANIA R.R.
TRENTON LINE
MELROSE
STILES
MILNOR
BERMUDA
FRANKFORD AVE
ALMOND STREET
THOMPSON STREET
EDGEMONT STREET
SALMON STREET
RICHMOND STREET
LORTHROOP STREET
JAMES STREET
FRANKFORD ARSENAL
BRIDGE STREET
PRATT STREET
KIRKBRIDE STREET
DELAWARE RIVER
KENSINGTON & TACONY R.R.
LEGEND
FLOODED AREAS
CITY OF PHILADELPHIA
DEPARTMENT OF PUBLIC WORKS
BUREAU OF ENGINEERING SURVEYS AND ZONING
REPORT ON
FRANKFORD CREEK FLOOD CONTROL
FLOODED AREAS
KNAPPEN ENGINEERING COMPANY
280 MADISON AVE, NEW YORK, N.Y.
SCALE IN FEET
500 0 500 1000 1500
DRAWN BY: B.F.J.
CHECKED BY: G.R.W.
DATE: AUGUST 1947
DRAWING NO
R136-2


EXISTING CHANNEL TO BE FILLED IN
WYOMING AVE.
PROPOSED DIKE
PROPOSED CUTOFF CHANNEL
SEE DWG. NO. R136-9A
PROPOSED DEBRIS WEIR & FOOTBRIDGE
Castor Ave under construction
PROPOSED PAVED CHUTE
DWG. NO. R136-9
BRISTOL STREET
PROPOSED CONDUIT
LUZERNE AVE.
PROPOSED RIPRAPPED CHANNEL
ERIE
DWG. NO. R136-8
SEDGELEY AVE.
PENNA. R.R.
GLENWOOD ST.
TIOGA AVE.
ELEVATED LINE
JASPER ST.
EMERALD ST.
AMBER ST.
FRANKFORD AVE.
PROPOSED WALL
PROPOSED BULKHEAD
EXISTING BANK
PROPOSED LEVEE
DWG. NO. R136-7
ADAMS AVE.
ASHLAND ST.
EXISTING CHA
TO BE FILLED
PROPOS
COLLECT
SEWE
CREEK
PENNA. READING
ARAWOGO
WHEATSHEAF ST.
THOMPSON LANE
DWG. NO. R136-6


FRANKFORD ARSENAL
CREEK
FRANKFORD
4'-6" Diam. Sewer
3'-6" Diam. Sewer
PROPOSED COLLECTING SEWER
Wakeling St. 10'-6"X12' Sewer
2'-6" Diam. Sewer
3'-6" Diam. Sewer
4'-6" Diam. Sewer
7'-6"X7'-6"
7'X7'
Casimir St. 3'-3"X2'-2"+ Sewer
3' Diam. Sewer
6' Diam.
5'-6" Diam.
3'-5" Diam. Sewer
4' Diam. Sewer
Wilmot St. 2'-6" Diam. Sewer
3'-6" Diam. Sewer
Adams Ave. 4'-6" Diam. Sewer
PROPOSED CUTOFF CHANNEL
Upper Delaware Intercepting Sewer 12'-3" Diam.
DWG. NO. RI36-5
DUMP AREA
NORTH EAST SEWAGE TREATMENT PLANT
STREET
JAMES STREET
TACONY AVE.
MARGARET STREET
BRIDGE ST.
PRATT ST.
KIRKBRIDE ST.
ASH ST.
BUCKIUS ST.
LEFEVRE ST.
BELGRADE ST.
ORTHODOX ST.
ALMOND
THOMPSON
EDGEMONT
SALMON
RICHMOND
BRISTOL ST.
ROXBOROUGH ST.
SEASHORE LINES
LEWIS ST.
RICHMOND ST.
BELT LINE R.R.
KENSINGTON & TACONY R.R.
U.S. BULKHEAD LINE
DELAWARE RIVER
CITY OF PHILADELPHIA
DEPARTMENT OF PUBLIC WORKS
BUREAU OF ENGINEERING SURVEYS AND ZONING
REPORT ON
FRANKFORD CREEK FLOOD CONTROL
RECOMMENDED PLAN
KNAPPEN ENGINEERING COMPANY
280 MADISON AVE, NEW YORK, N.Y.
DRAWN BY: B.F.J
CHECKED BY: P.K.
SCALE IN FEET
500 0 500 1000 1500
DATE: AUGUST 1947
DRAWING NO.
RI36-3



CHANNEL SECTIONS

TYPE A: EARTH CHANNEL, SEEDED SIDE-SLOPES.

TYPE B: EARTH BOTTOM, SHEET-PILE BULKHEADS AT SIDES.

TYPE C: EARTH BOTTOM, CONCRETE "T" WALLS AT SIDES.

TYPE D: EARTH BOTTOM, CONCRETE TOE-WALLS, RIPRAP SIDE-SLOPES.

TYPE E: CONCRETE BOTTOM & WALLS.

TYPE F: CONCRETE CONDUIT.

NOTE: PLANS "A" AND "B" ARE IDENTICAL ABOVE SILL NEAR TORRESDALE AVE.

LEGEND

Sewer Outfalls { R.B.= Right Bank, L.B.= Left Bank

Intercepting Sewer or Water Pipe Crossing.

CITY OF PHILADELPHIA
DEPARTMENT OF PUBLIC WORKS
BUREAU OF ENGINEERING, SURVEYS AND ZONING

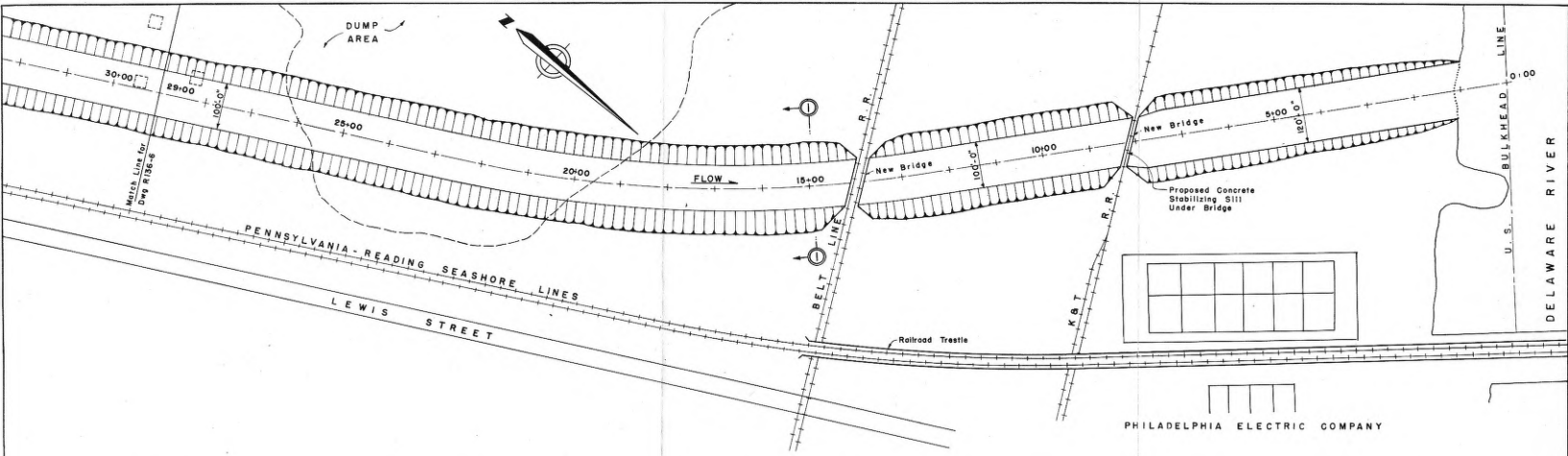
REPORT ON FRANKFORD CREEK FLOOD CONTROL

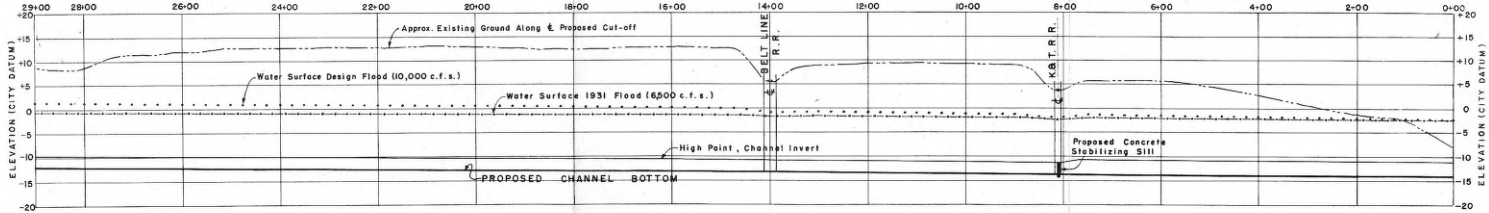
PROFILES
RECOMMENDED PLAN (PLAN "A") AND PLAN "B"

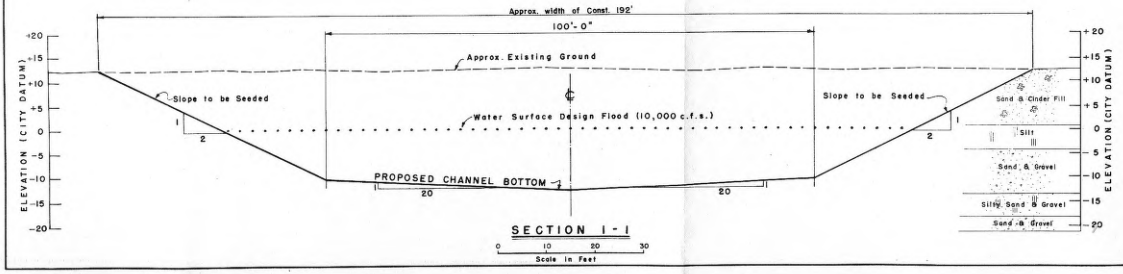
KNAPPEN ENGINEERING COMPANY
280 MADISON AVE. NEW YORK, N.Y.

SCALE IN FEET 500 0 500 HORIZ. 5 0 5 VERT.

DRAWN BY: S.F.
CHECKED BY: D.S.B.
DATE: AUGUST 1947
DRAWING NO. R136-4







CITY OF PHILADELPHIA
DEPARTMENT OF PUBLIC WORKS
BUREAU OF ENGINEERING SURVEYS AND ZONING

REPORT ON FRANKFORD CREEK FLOOD CONTROL

PLAN, PROFILE AND SECTIONS

DELAWARE RIVER TO PENNA. R.R. BRIDGE

RECOMMENDED PLAN

SHEET 1 OF 3

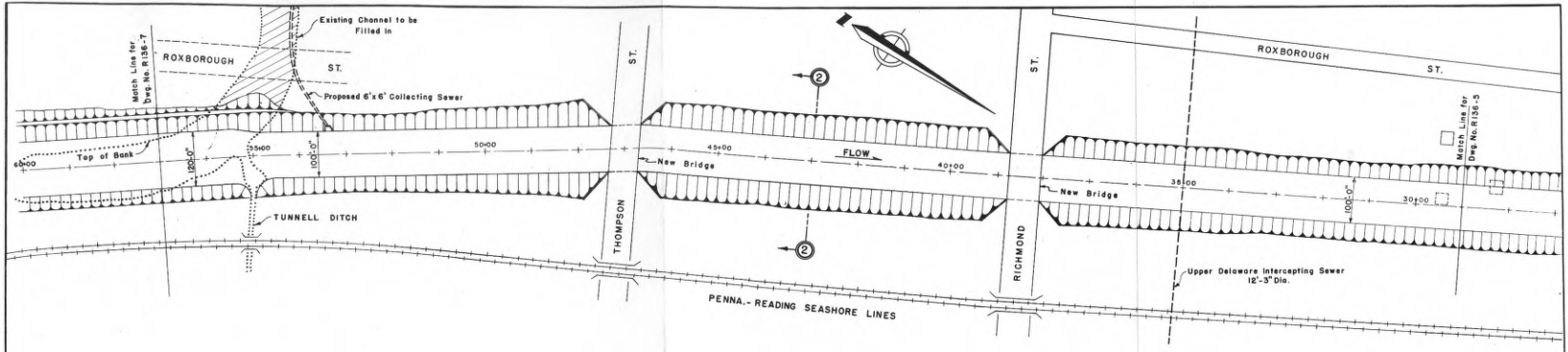
KNAPPEN ENGINEERING COMPANY
280 MADISON AVE. NEW YORK, N.Y.

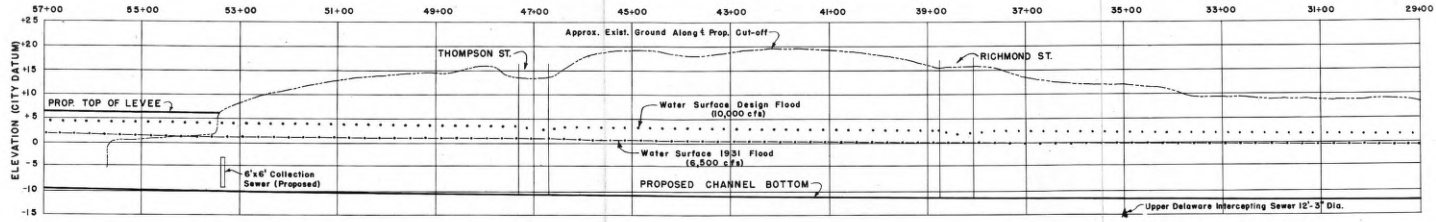
DRAWN BY: R.G.H.
CHECKED BY: P.K.

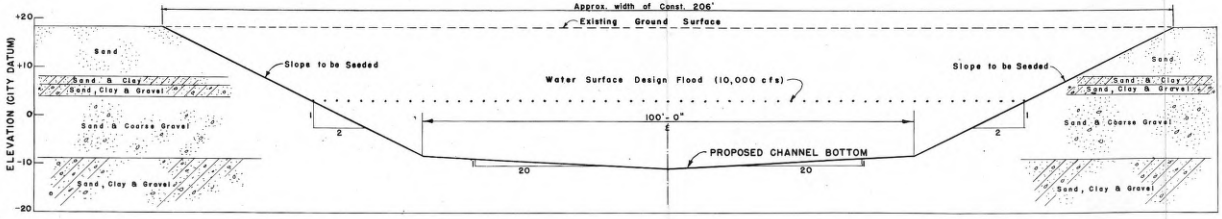
SCALE IN FEET
100 0 100 200

DRAWING NO. R136-5

DATE: AUGUST 1947







SECTION 2-2

0 10 20 30
Scale in Feet

LEGEND

Sewer outfalls { R.B= Right Bank / L.B= Left Bank

Intercepting sewer or water pipe crossing

CITY OF PHILADELPHIA
DEPARTMENT OF PUBLIC WORKS
BUREAU OF ENGINEERING SURVEYS AND ZONING

REPORT ON FRANKFORD CREEK FLOOD CONTROL

PLAN, PROFILE AND SECTIONS

DELAWARE RIVER TO PENNA R.R. BRIDGE

RECOMMENDED PLAN

SHEET 2 OF 3

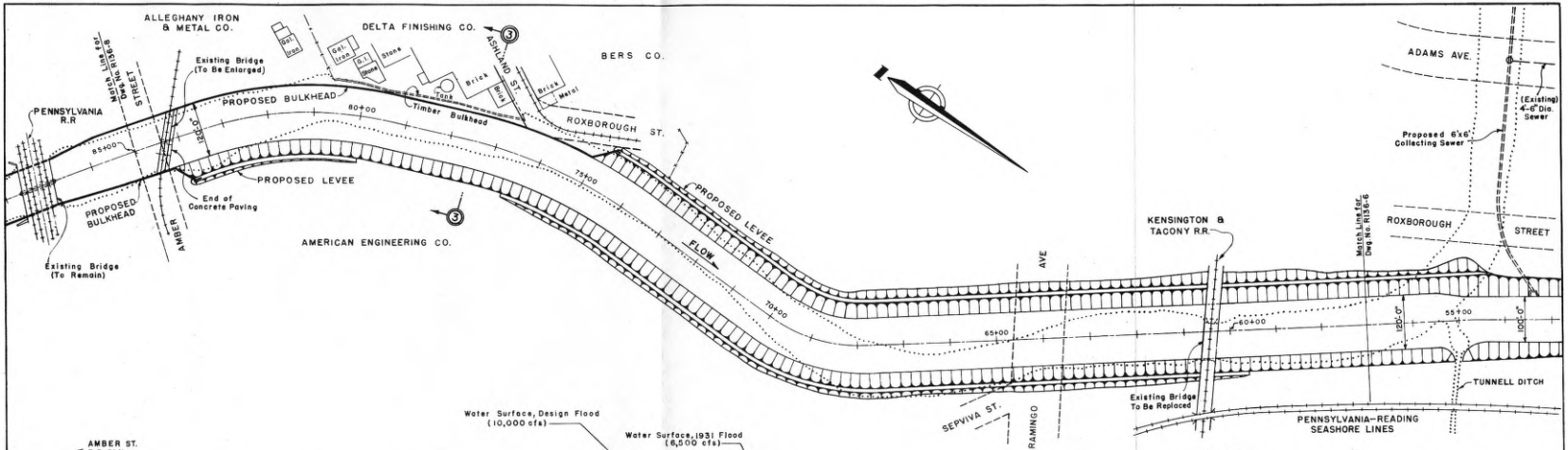
KNAPPEN ENGINEERING COMPANY
280 MADISON AVE NEW YORK, N.Y.

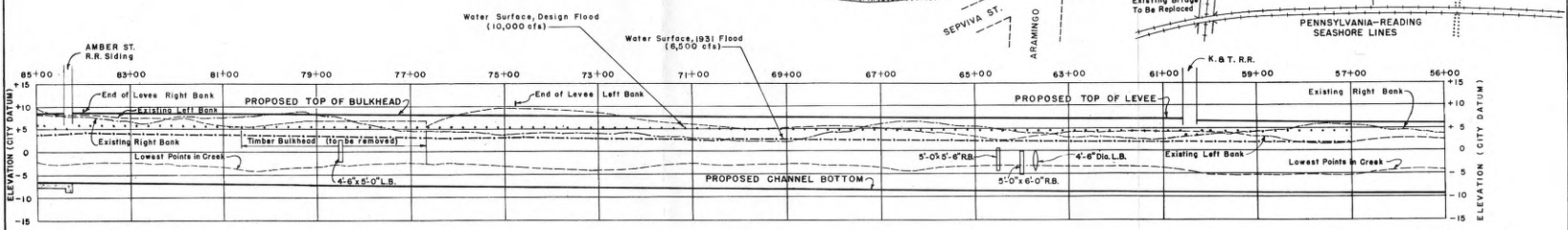
DRAWN BY: G.B.
CHECKED BY: P.K.

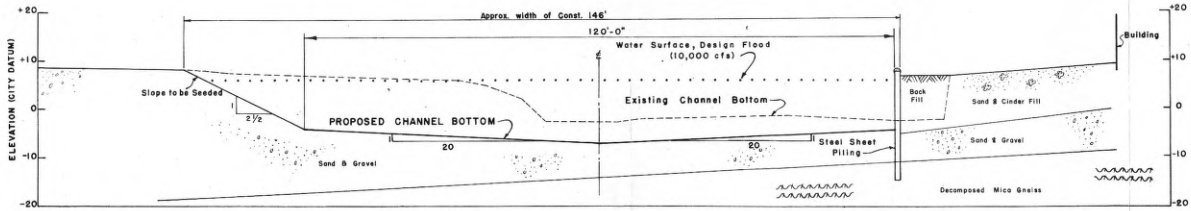
SCALE IN FEET
100 0 100 200

DATE: AUGUST 1947

DRAWING NO. R 136-6







SECTION 3-3

0 10 20 30
Scale in Feet

LEGEND

Sewer outfalls { R.B. = Right Bank, L.B. = Left Bank

Intercepting sewer or water pipe crossing.

CITY OF PHILADELPHIA
DEPARTMENT OF PUBLIC WORKS
BUREAU OF ENGINEERING SURVEYS AND ZONING

REPORT ON FRANKFORD CREEK FLOOD CONTROL

PLAN, PROFILE AND SECTIONS

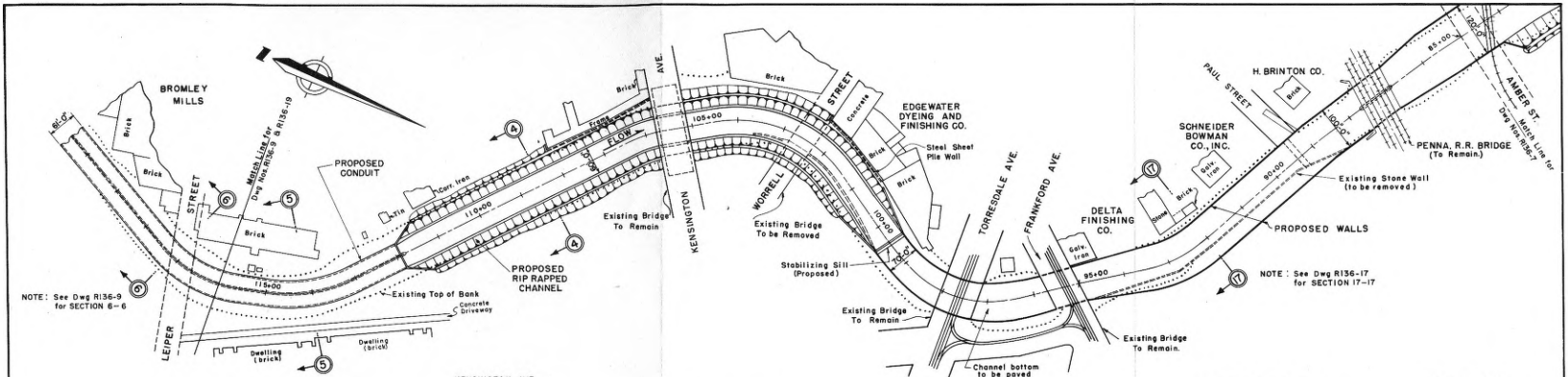
DELAWARE RIVER TO PENNA R. R. BRIDGE

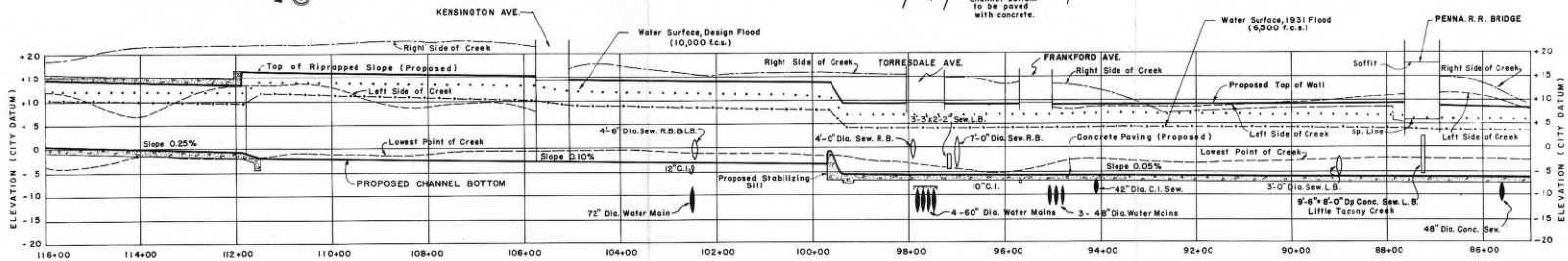
RECOMMENDED PLAN

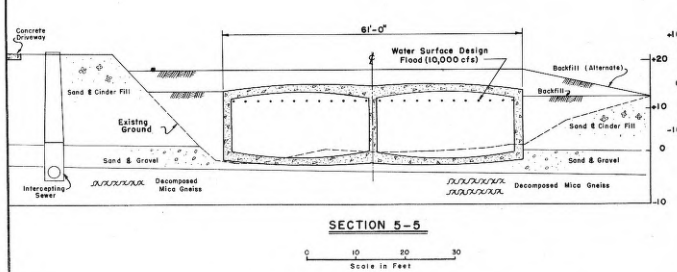
SHEET 3 OF 3

KNAPPEN ENGINEERING COMPANY
280 MADISON AVE. NEW YORK, N.Y.

DRAWN BY: S. F.
CHECKED BY: P. K.
SCALE IN FEET 100 0 100 200
DATE: AUGUST 1947
DRAWING NO. R136-7

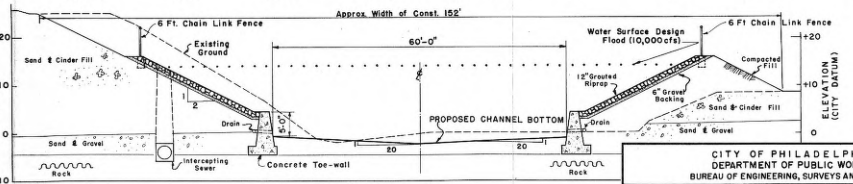






SECTION 5-5

0 10 20 30
Scale in Feet



SECTION 4-4

0 10 20 30
Scale in Feet

LEGEND

Sewer outfalls (R.B.= Right Bank, L.B.= Left Bank)

Intercepting sewer or water pipe crossing

CITY OF PHILADELPHIA
DEPARTMENT OF PUBLIC WORKS
BUREAU OF ENGINEERING, SURVEYS AND ZONING

REPORT ON FRANKFORD CREEK FLOOD CONTROL

PLAN, PROFILE AND SECTIONS

PENNA. RAILROAD BRIDGE TO LEIPER STREET

RECOMMENDED PLAN

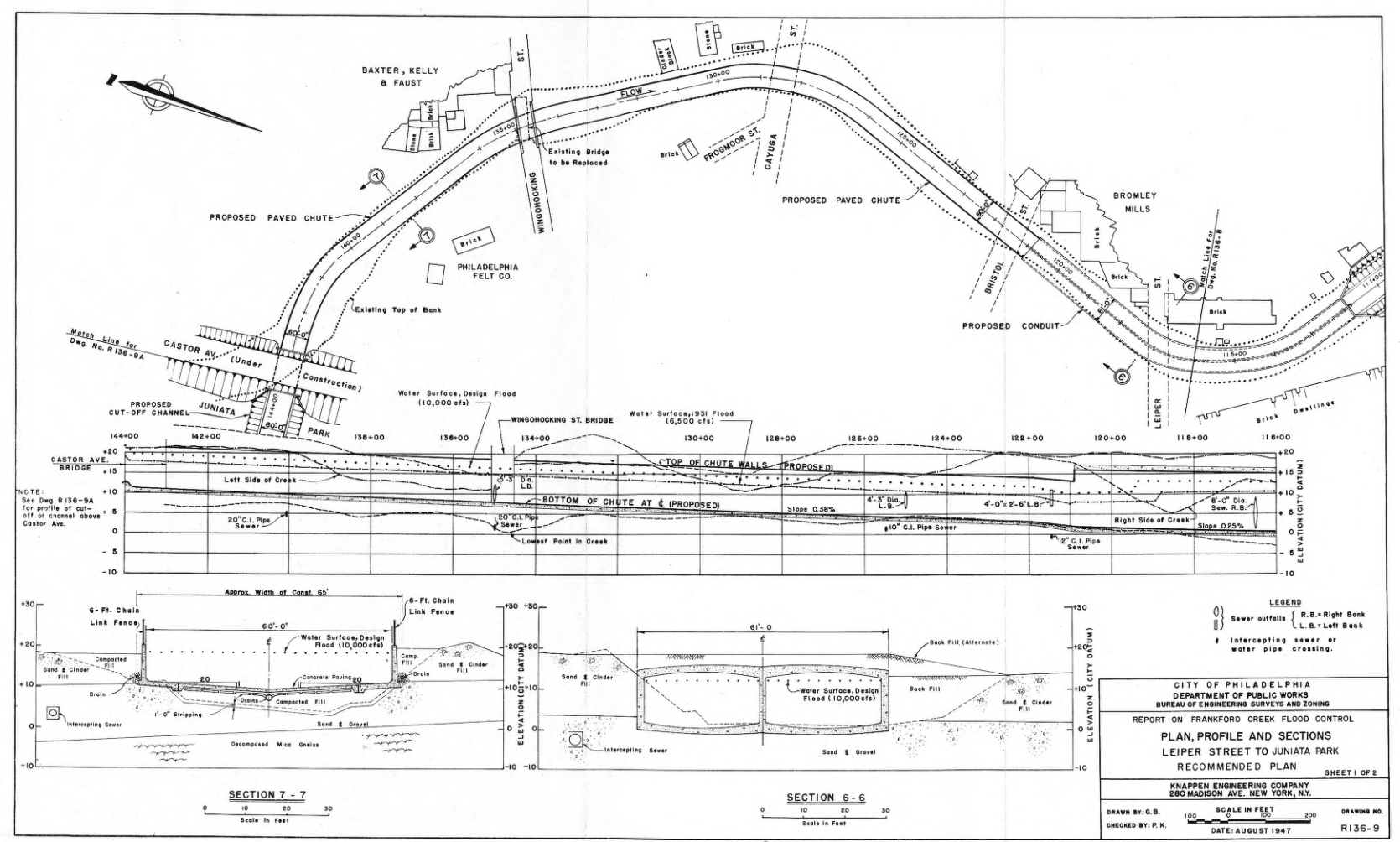
KNAPPEN ENGINEERING COMPANY
280 MADISON AVE. NEW YORK, N.Y.

DRAWN BY: S.F.
CHECKED BY: P.K.

SCALE IN FEET
100 0 100 200

DRAWING NO. R136-8

DATE: AUGUST 1947



CITY OF PHILADELPHIA
DEPARTMENT OF PUBLIC WORKS
BUREAU OF ENGINEERING SURVEYS AND ZONING

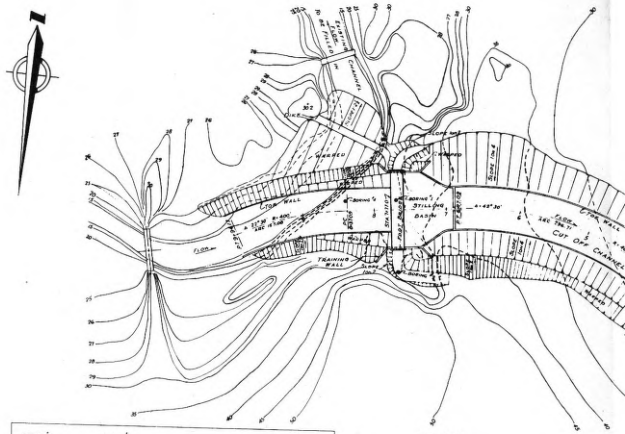
REPORT ON FRANKFORD CREEK FLOOD CONTROL

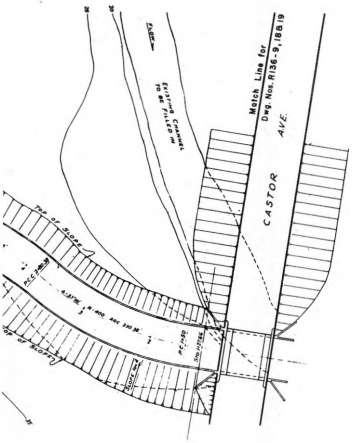
PLAN, PROFILE AND SECTIONS
LEIPER STREET TO JUNIATA PARK
RECOMMENDED PLAN

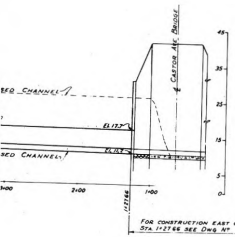
SHEET 1 OF 2

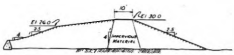
KNAPPEN ENGINEERING COMPANY
280 MADISON AVE. NEW YORK, N.Y.

DRAWN BY: G.B.
CHECKED BY: P.K.
SCALE IN FEET
DATE: AUGUST 1947
DRAWING NO. R136-9


PLAN
SCALE IN FEET
50 0 50 100 150
BORING 1
BORING 2
BORING 4
BORINGS
STILLING BASIN
FOOT BRIDGE
EXISTING GROUND SURFACE ALONG ℄ OF PROPO
DEBRIS WEIR
EL 20.0
EL 13.5
EL 13.7
EL 13.0
EL 13.0
0.3% GRADE
0.3% GRADE
TOP OF TOE WALL
℄ PROPO
10+00
9+00
8+00
7+00
6+00
5+00
4+00
PROFILE OF CUTOFF CHANNEL
SCALE IN FEET
VERT. 10 5 0 10 20 30
HORIZ. 50 0 50 100 150
WYOMING AVE.
CREEK
SAN FRANCISCO
LOCATION PLAN
DIKE NEAR WYOMING AVE.
SCALE IN FEET
50 0 50 100 150
EL 22
EL 6
IMPERVIOUS MATERIAL
SECTION OF DIKE NEAR WYOMING AVE.
AREA BELOW DIKES T
SC

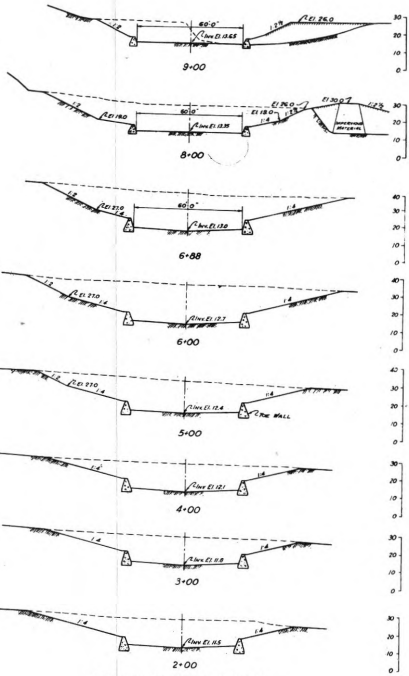






SECTION OF DIKE AT CHANNEL

BE STRIPPED AS SPECIFIED
ALE IN FEET
30 40 60



SECTIONS OF CUTOFF CHANNEL
SCALE IN FEET
0 20 40 60

ALL SIDE SLOPES TO BE COVERED WITH 6" TOPSOIL AND SEEDED AS SPECIFIED.

CITY OF PHILADELPHIA
DEPARTMENT OF PUBLIC WORKS
BUREAU OF ENGINEERING SURVEYS AND ZONING

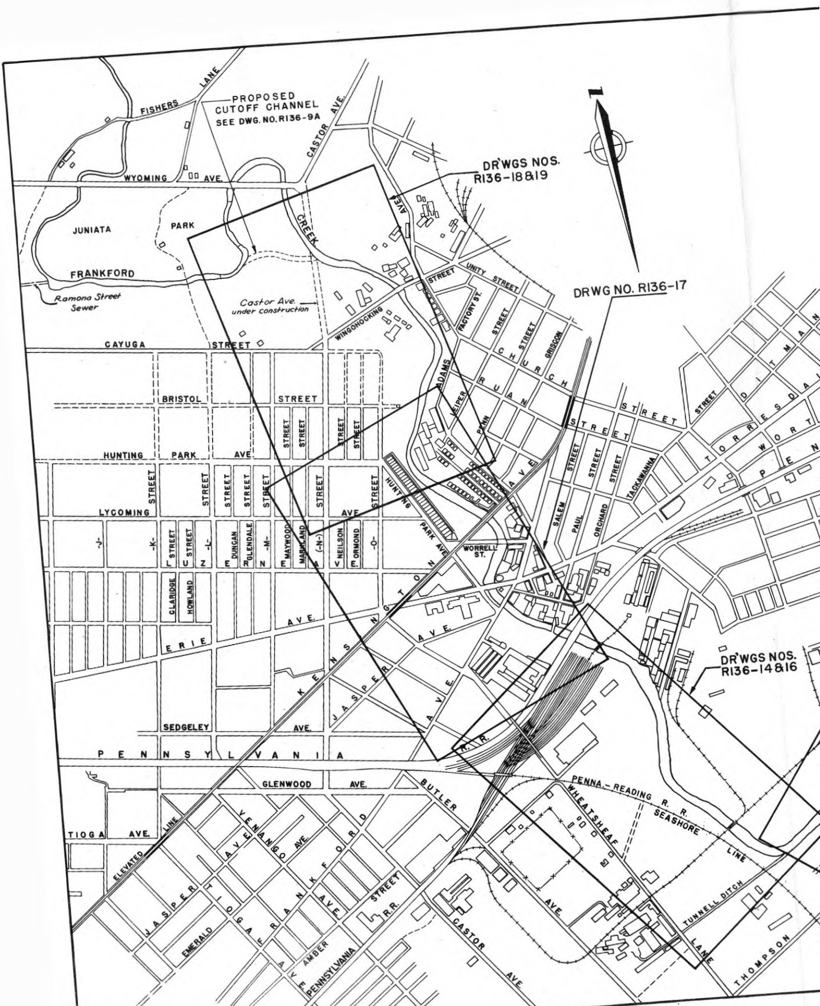
REPORT ON FRANKFORD CREEK FLOOD CONTROL

PLAN, PROFILE AND SECTIONS
LEIPER STREET TO JUNIATA PARK
RECOMMENDED PLAN

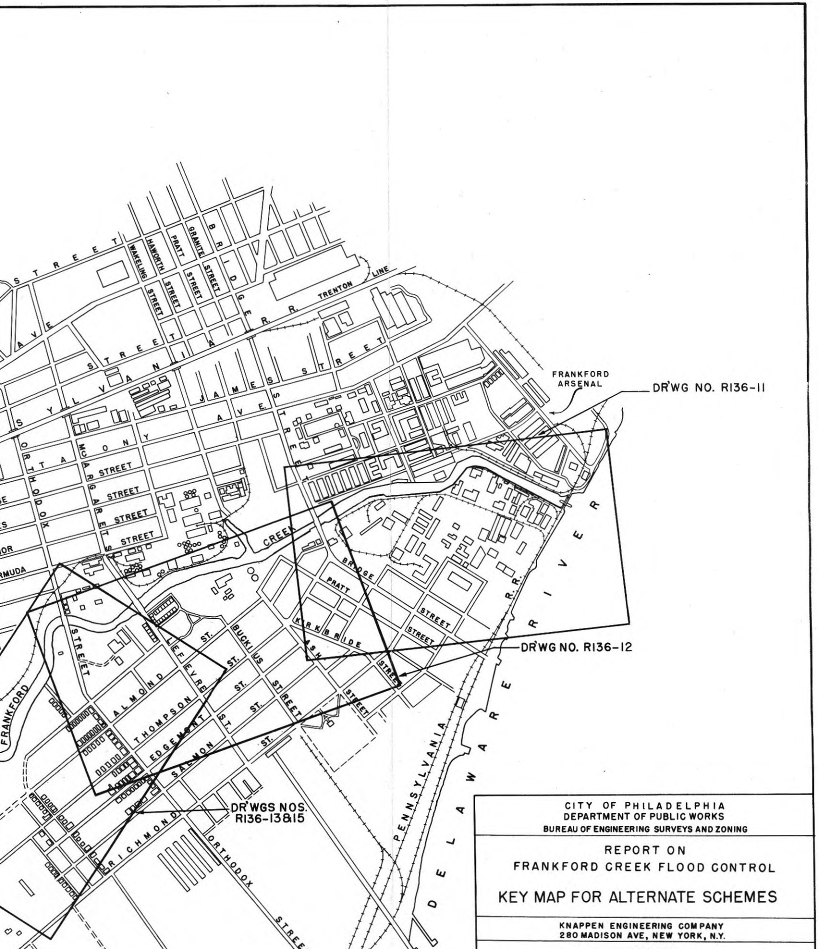
SHEET 2 OF 2

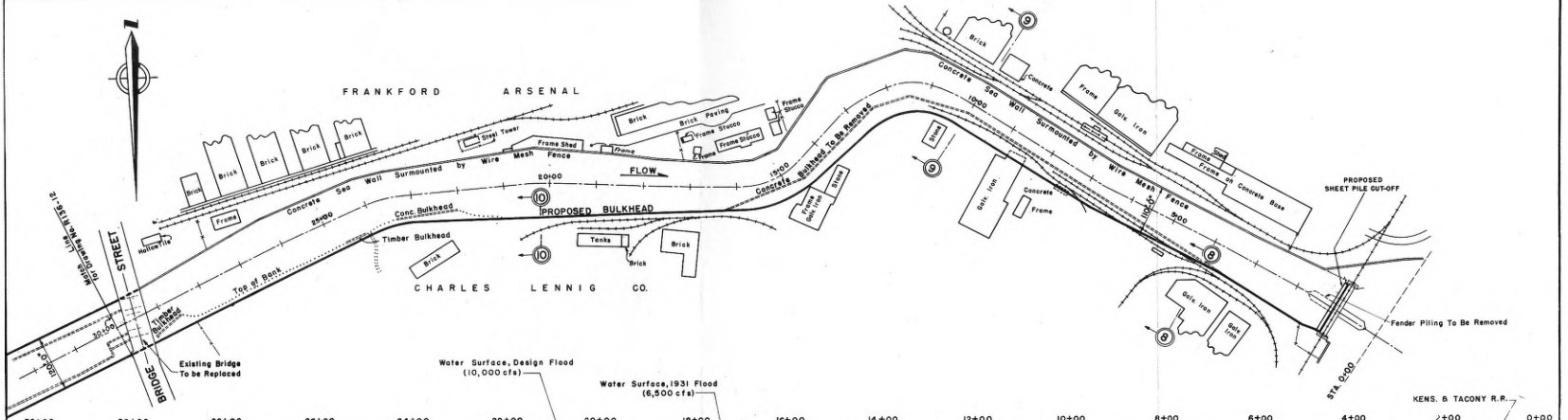
KNAPPEN ENGINEERING COMPANY
280 MADISON AVE. NEW YORK, N.Y.

DRAWN BY: I.J.S.
CHECKED BY: E.K.B.
SCALE AS SHOWN
DATE: AUGUST 1947
DRAWING NO. R136-9A



PROPOSED CUTOFF CHANNEL SEE DWG. NO. R136-9A
DR'WGS NOS. R136-18&19
DRWG NO. R136-17
DR'WGS NOS. R136-14&16
FISHERS LANE
CASTOR AVE.
WYOMING AVE.
JUNIATA PARK
FRANKFORD CREEK
Ramona Street Sewer
Castor Ave. under construction
WINGOHOCKING STREET
UNITY STREET
FACTORY ST.
CHURCH STREET
GRISCOM STREET
CAYUGA STREET
BRISTOL STREET
ADAMS AVE.
KEIPER
PENN
RUAN STREET
HUNTING PARK AVE.
LYCOMING STREET
SALEM STREET
PAUL STREET
ORCHARD STREET
TACKAWANNA
DITMAN
TORRESDALE
WORTH
PENN
-J- -K- -L- -M- (-N-) -O-
L STREET
U STREET
ZERNER
DUNGAN
GLENDALE
MAYWOOD
MARKLAND
NEILSON
ORMOND
CLARIDGE
HOWLAND
WORRELL ST.
ERIE AVE.
KENSINGTON AVE.
JASPER AVE.
SEDGELEY AVE.
PENNSYLVANIA R.R.
GLENWOOD AVE.
BUTLER
PENNA.-READING R.R. SEASHORE LINE
WHEATSHEAF LANE
TIOGA AVE.
ELEVATED LINE
VENANGO AVE.
FRANKFORD AVE.
STREET R.R.
CASTOR AVE.
EMERALD
AMBER
PENNSYLVANIA
TUNNELL DITCH
THOMPSON


FRANKFORD ARSENAL
DR'WG NO. R136-11
DR'WG NO. R136-12
DR'WGS NOS. R136-13&15
DELAWARE RIVER
PENNSYLVANIA R.R.
TRENTON LINE
BRIDGE STREET
PRATT STREET
GRANITE STREET
HAWORTH STREET
WAKELING STREET
JAMES STREET
JAMES ST.
TACONY STREET
MARGARET STREET
ORTHODOX
KIRKBRIDE STREET
ASH STREET
BUCKIUS STREET
LEFEVRE ST.
ALMOND ST.
THOMPSON ST.
EDGEMONT ST.
SALMON ST.
RICHMOND ST.
ORTHODOX STREET
FRANKFORD
CREEK
BERMUDA
CITY OF PHILADELPHIA
DEPARTMENT OF PUBLIC WORKS
BUREAU OF ENGINEERING SURVEYS AND ZONING
REPORT ON
FRANKFORD CREEK FLOOD CONTROL
KEY MAP FOR ALTERNATE SCHEMES
KNAPPEN ENGINEERING COMPANY
280 MADISON AVE, NEW YORK, N.Y.
DRAWN BY: B.F.J.
CHECKED BY: P.K.
SCALE IN FEET
500 0 500 1000 1500
DATE: AUGUST 1947
DRAWING NO.
R136-10



CITY OF PHILADELPHIA
DEPARTMENT OF PUBLIC WORKS
BUREAU OF ENGINEERING, SURVEYS AND ZONING

REPORT ON FRANKFORD CREEK FLOOD CONTROL

PLAN, PROFILE AND SECTIONS

DELAWARE RIVER TO PENNA. R.R. BRIDGE
ALTERNATE NOS. 1 & 2

SHEET 1 OF 4

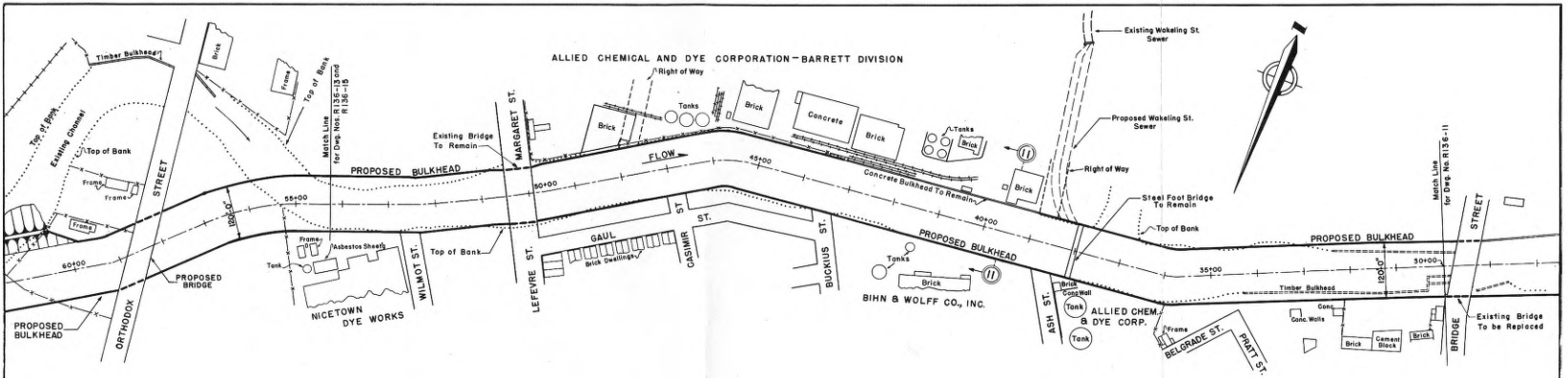
KNAPPEN ENGINEERING COMPANY
280 MADISON AVE. NEW YORK, N.Y.

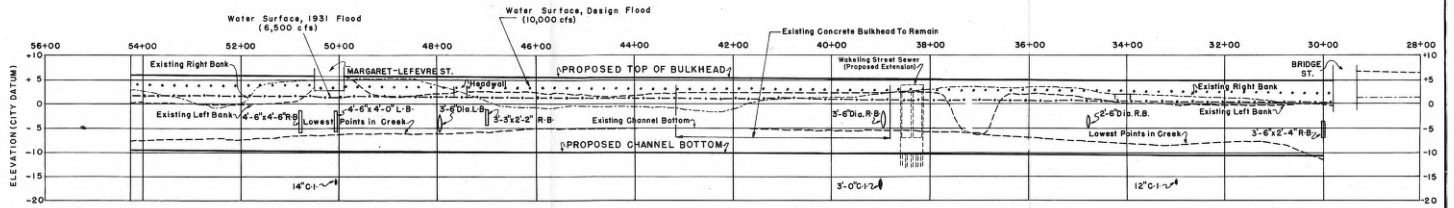
DRAWN BY: B. J.
CHECKED BY: P. K.

SCALE IN FEET 100 0 100 200

DRAWING NO. R136-11

DATE: AUGUST 1947

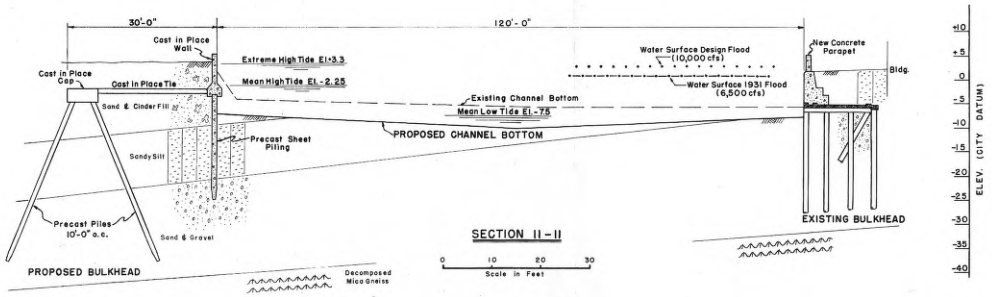




LEGEND

Sewer outfalls { R.B. = Right Bank, L.B. = Left Bank

Intercepting sewer or water pipe crossing.



SECTION II-II

0 10 20 30

Scale in Feet

CITY OF PHILADELPHIA
DEPARTMENT OF PUBLIC WORKS
BUREAU OF ENGINEERING, SURVEYS AND ZONING

REPORT ON FRANKFORD CREEK FLOOD CONTROL

PLAN, PROFILE AND SECTIONS

DELAWARE RIVER TO PENNA. R. R. BRIDGE
ALTERNATE NOS. 1 & 2

SHEET 2 OF 4

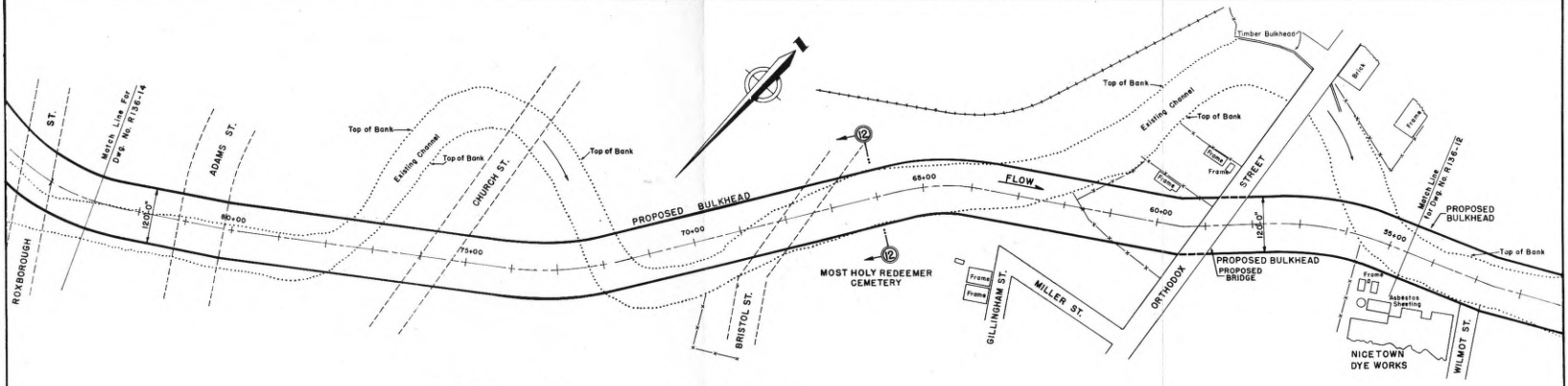
KNAPPEN ENGINEERING COMPANY
280 MADISON AVE. NEW YORK, N.Y.

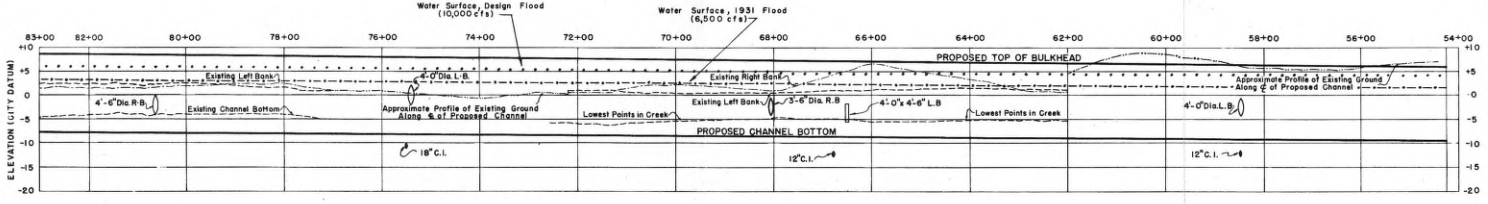
DRAWN BY: B. J.
CHECKED BY: P. K.

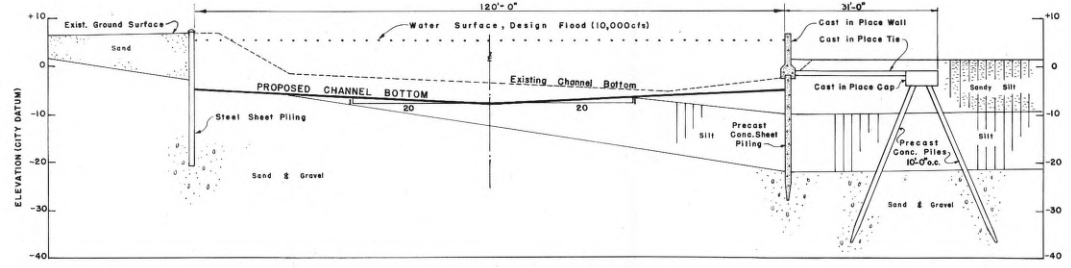
SCALE IN FEET
100 0 100 200

DATE: AUGUST 1947

DRAWING NO. R136-12







SECTION 12-12

0 10 20 30
Scale in Feet

LEGEND

Sewer outfalls { R.B. = Right Bank, L.B. = Left Bank }

Intercepting sewer or water pipe crossing.

CITY OF PHILADELPHIA
DEPARTMENT OF PUBLIC WORKS
BUREAU OF ENGINEERING SURVEYS AND ZONING

REPORT ON FRANKFORD CREEK FLOOD CONTROL

PLAN, PROFILE AND SECTIONS

DELAWARE RIVER TO PENNA. R.R. BRIDGE
ALTERNATE NO. 1

SHEET 3 OF 4

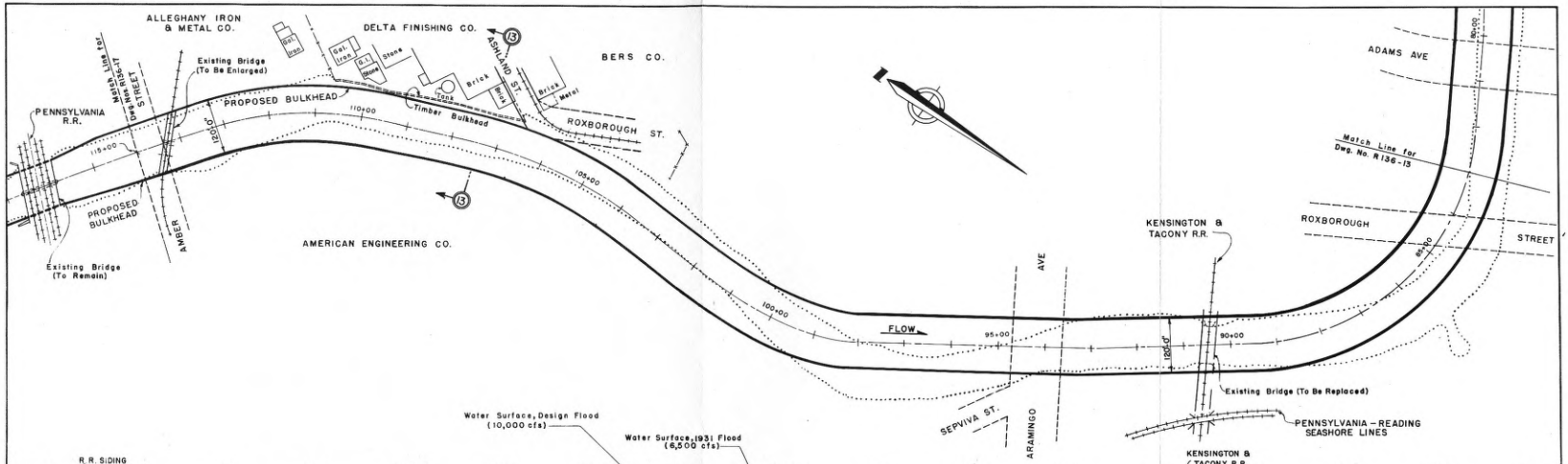
KNAPPEN ENGINEERING COMPANY
280 MADISON AVE, NEW YORK, N.Y.

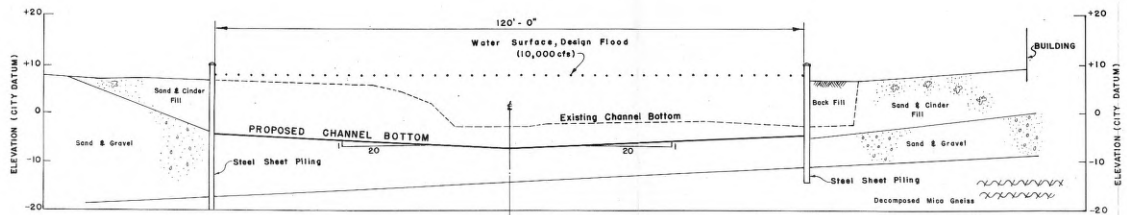
DRAWN BY: B. J.
CHECKED BY: P. K.

SCALE IN FEET
100 0 100 200

DRAWING NO. R136-13

DATE: AUGUST 1947





SECTION 13-13

Scale in Feet

LEGEND

Sewer outfalls { R.B. = Right Bank, L.B. = Left Bank

Intercepting sewer or water pipe crossing.

CITY OF PHILADELPHIA
DEPARTMENT OF PUBLIC WORKS
BUREAU OF ENGINEERING SURVEYS AND ZONING

REPORT ON FRANKFORD CREEK FLOOD CONTROL

PLAN, PROFILE AND SECTIONS

DELAWARE RIVER TO PENNA. R.R. BRIDGE
ALTERNATE NO. 1

SHEET 4 OF 4

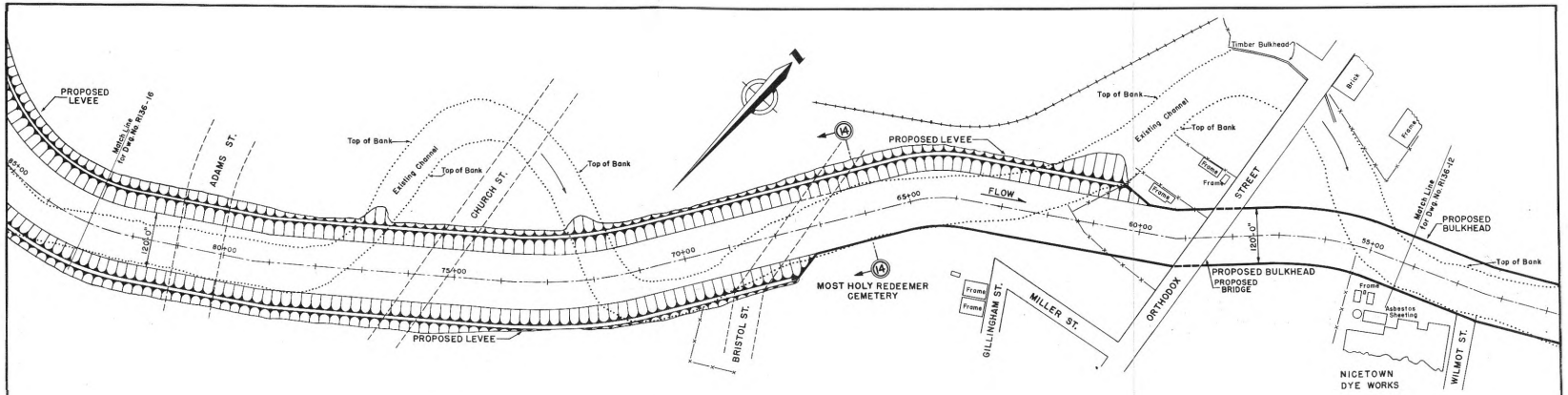
KNAPPEN ENGINEERING COMPANY
280 MADISON AVE. NEW YORK, N.Y.

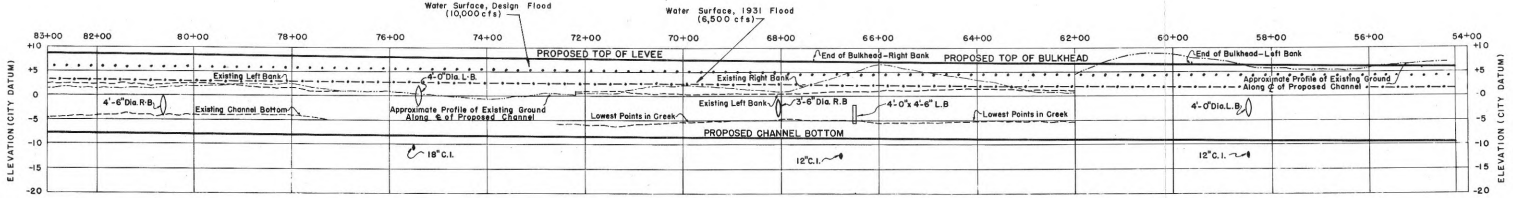
DRAWN BY: G. B.
CHECKED BY: P. K.

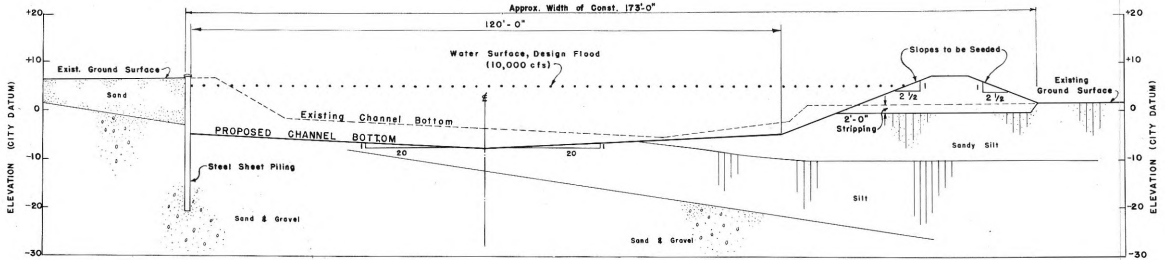
SCALE IN FEET

DRAWING NO. R136-14

DATE: AUGUST 1947







SECTION 14-14

0 10 20 30
Scale in Feet

LEGEND

Sewer outfalls { R.B.= Right Bank; L.B.= Left Bank

Intercepting sewer or water pipe crossing.

NOTE: For Alternate No.2, Sheets 1 and 2, See Drawing Nos. R136-11 and R136-12.

CITY OF PHILADELPHIA
DEPARTMENT OF PUBLIC WORKS
BUREAU OF ENGINEERING SURVEYS AND ZONING

REPORT ON FRANKFORD CREEK FLOOD CONTROL

PLAN, PROFILE AND SECTIONS

DELAWARE RIVER TO PENNA. R. R. BRIDGE
ALTERNATE NO. 2

SHEET 3 OF 4

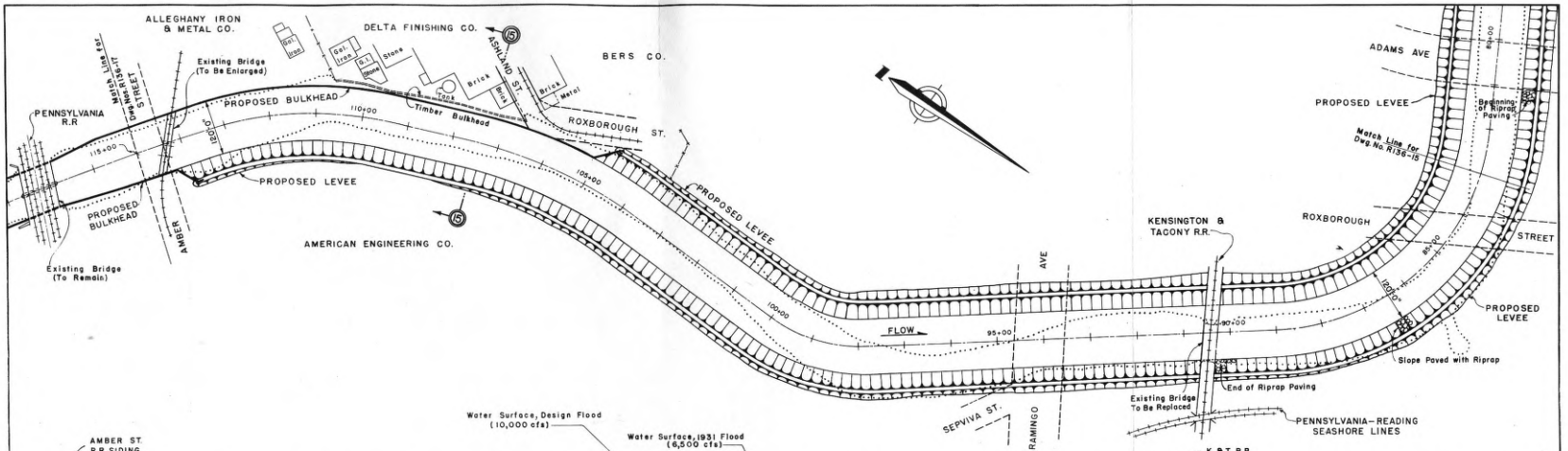
KNAPPEN ENGINEERING COMPANY
280 MADISON AVE, NEW YORK, N.Y.

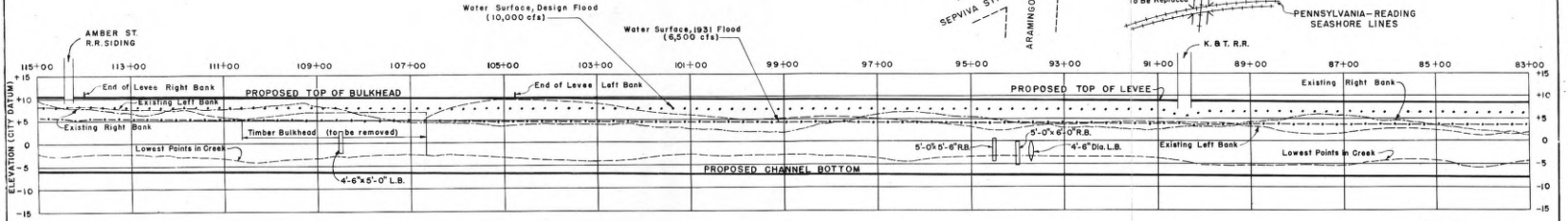
DRAWN BY: B.J.
CHECKED BY: P.K.

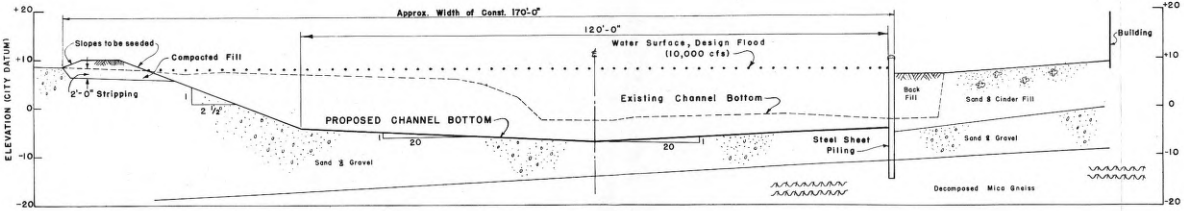
SCALE IN FEET
100 0 100 200

DATE: AUGUST 1947

DRAWING NO. R136-15







SECTION 15-15

0 10 20 30
Scale in Feet

LEGEND

Sewer outfalls { R.B.= Right Bank, L.B.= Left Bank

Intercepting sewer or water pipe crossing.

CITY OF PHILADELPHIA
DEPARTMENT OF PUBLIC WORKS
BUREAU OF ENGINEERING SURVEYS AND ZONING

REPORT ON FRANKFORD CREEK FLOOD CONTROL

PLAN, PROFILE AND SECTIONS

DELAWARE RIVER TO PENNA R.R. BRIDGE
ALTERNATE NO. 2

SHEET 4 OF 4

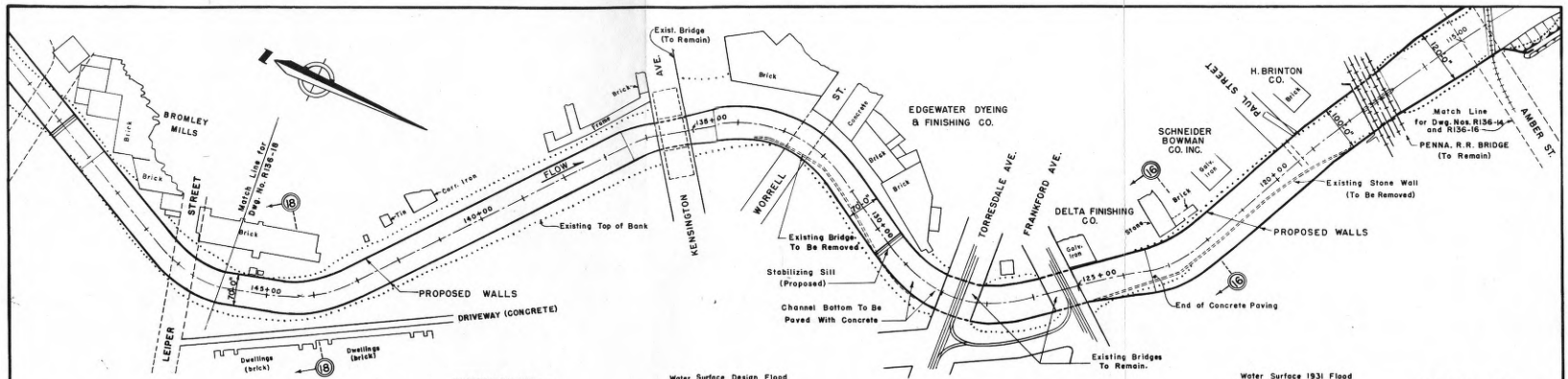
KNAPPEN ENGINEERING COMPANY
280 MADISON AVE. NEW YORK, N.Y.

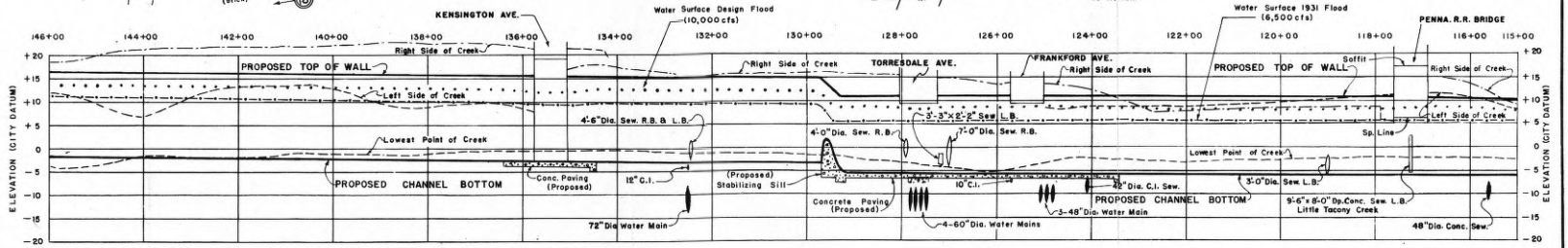
DRAWN BY: S. F.
CHECKED BY: P. K.

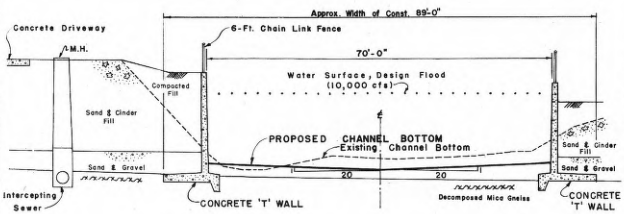
SCALE IN FEET 0 100 200

DATE: AUGUST 1947

DRAWING NO. R136-16

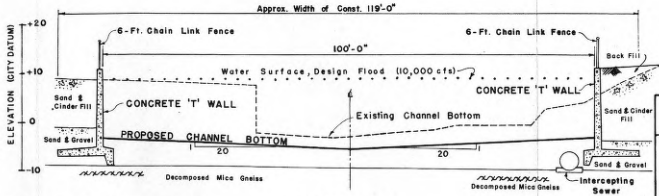






SECTION 18-18

0 10 20 30
Scale in Feet



SECTION 16-16

0 10 20 30
Scale in Feet

NOTE:
SECTION 17-17 (See Dwg. No. R136-8 for location) is the same as SECTION 16-16 except that the water surface and top of walls are 1'-6" lower, and the channel bottom would be paved with concrete

LEGEND
Sewer outfalls { R.B. = Right Bank / L.B. = Left Bank
Intercepting sewer or water pipe crossing

CITY OF PHILADELPHIA
DEPARTMENT OF PUBLIC WORKS
BUREAU OF ENGINEERING, SURVEYS AND ZONING

REPORT ON FRANKFORD CREEK FLOOD CONTROL

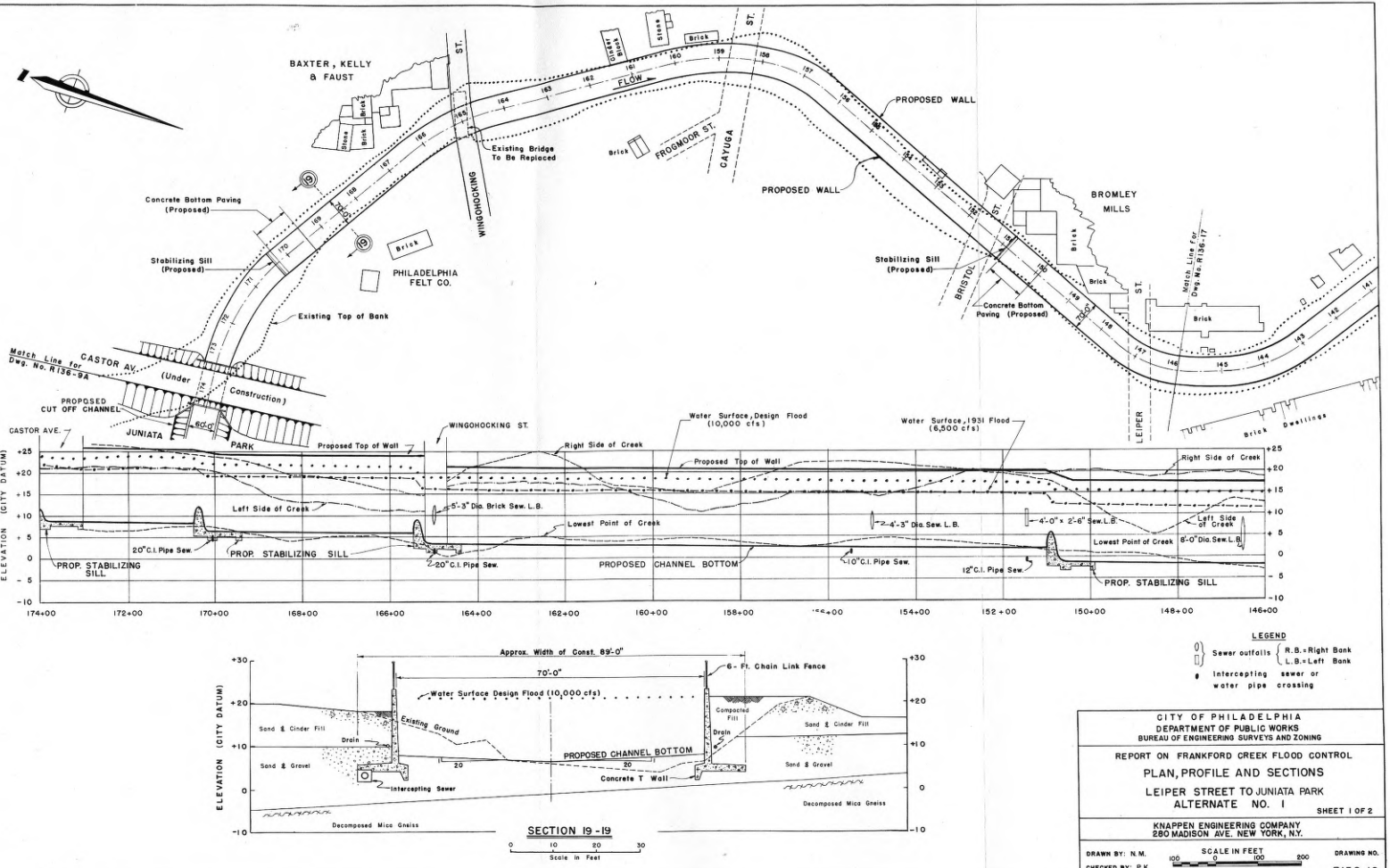
PLAN, PROFILE AND SECTIONS

PENNA. RAILROAD BRIDGE TO LEIPER STREET

ALTERNATE NO. 1

KNAPPEN ENGINEERING COMPANY
280 MADISON AVE. NEW YORK, N.Y.

DRAWN BY: N. M.
CHECKED BY: P. K.
SCALE IN FEET 100 0 100 200
DATE: AUGUST 1947
DRAWING NO. R136-17



CITY OF PHILADELPHIA
DEPARTMENT OF PUBLIC WORKS
BUREAU OF ENGINEERING SURVEYS AND ZONING

REPORT ON FRANKFORD CREEK FLOOD CONTROL

PLAN, PROFILE AND SECTIONS

LEIPER STREET TO JUNIATA PARK
ALTERNATE NO. 1

SHEET 1 OF 2

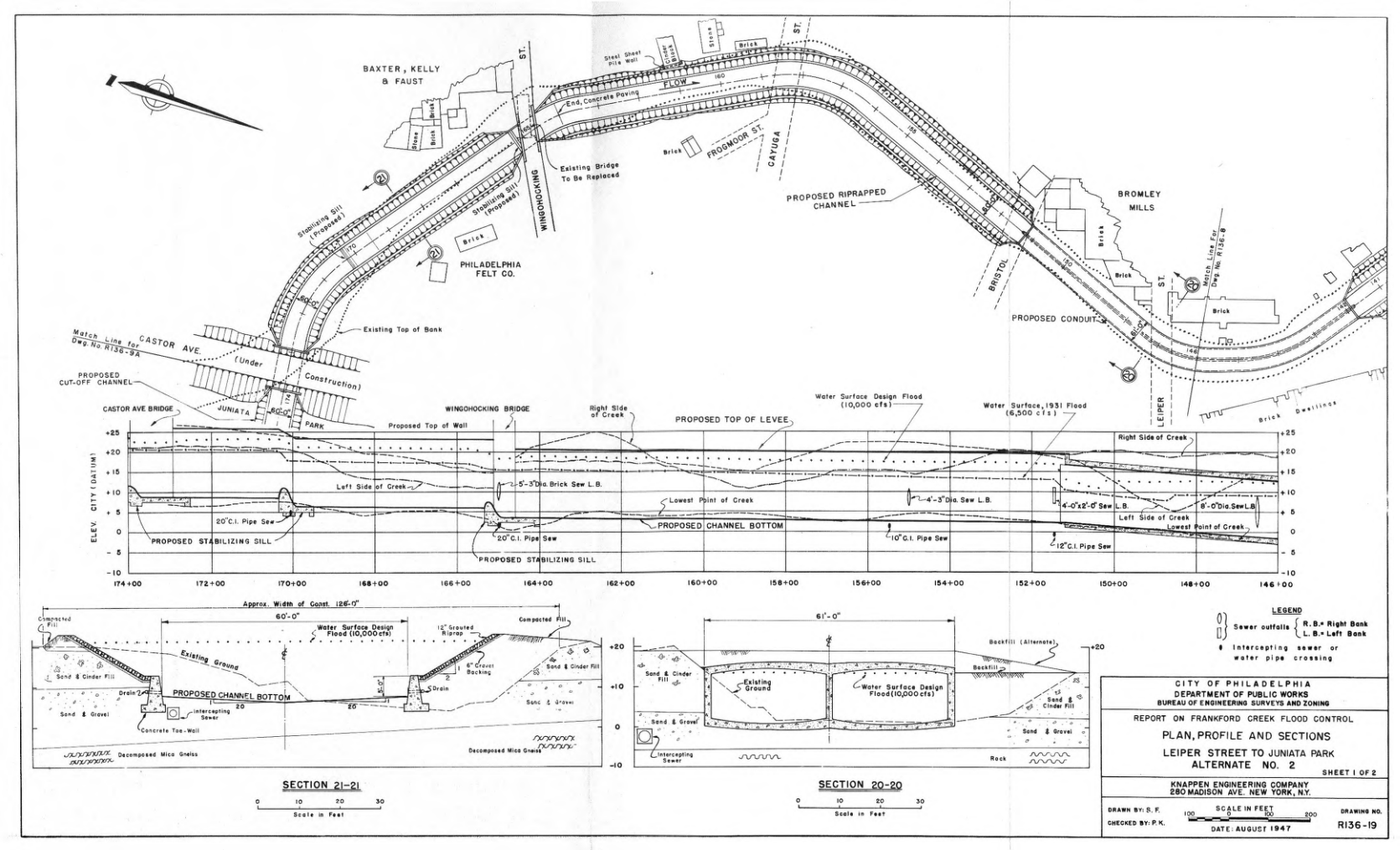
KNAPPEN ENGINEERING COMPANY
280 MADISON AVE. NEW YORK, N.Y.

DRAWN BY: N.M.
CHECKED BY: P.K.

SCALE IN FEET
100 0 100 200

DATE: AUGUST 1947

DRAWING NO.
R136-18



CITY OF PHILADELPHIA
DEPARTMENT OF PUBLIC WORKS
BUREAU OF ENGINEERING SURVEYS AND ZONING

REPORT ON FRANKFORD CREEK FLOOD CONTROL

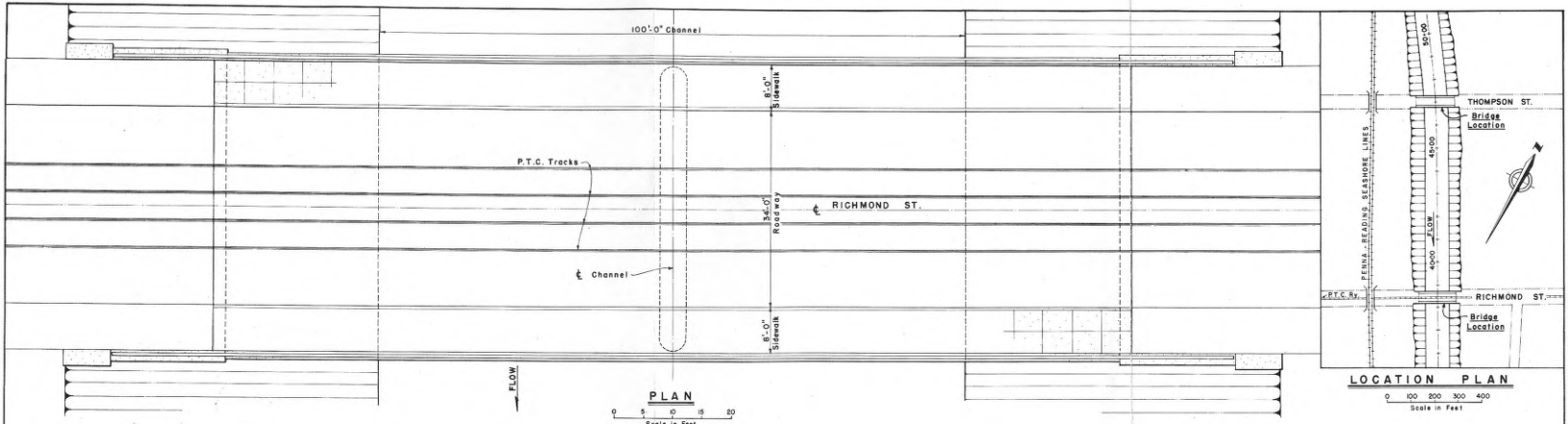
PLAN, PROFILE AND SECTIONS

LEIPER STREET TO JUNIATA PARK
ALTERNATE NO. 2

SHEET 1 OF 2

KNAPPEN ENGINEERING COMPANY
280 MADISON AVE. NEW YORK, N.Y.

DRAWN BY: S. F.
CHECKED BY: P. K.
SCALE IN FEET 100 0 100 200
DATE: AUGUST 1947
DRAWING NO. R136-19

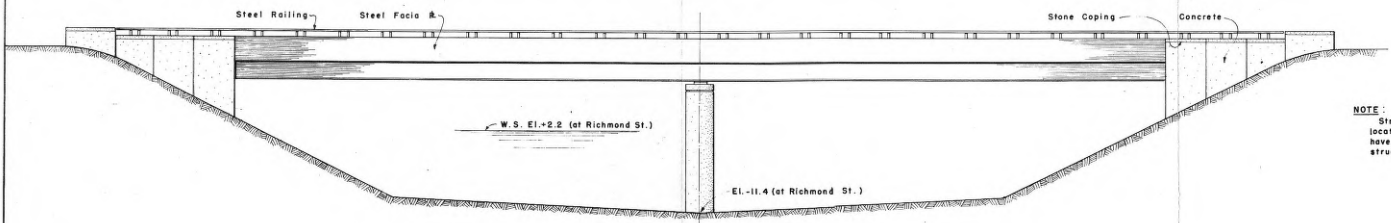


PLAN

0 5 10 15 20
Scale in Feet

LOCATION PLAN

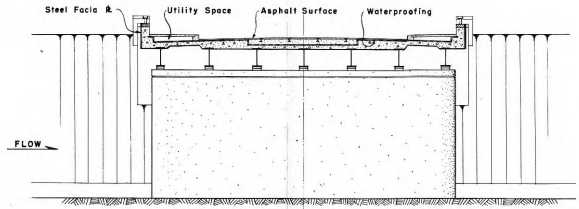
0 100 200 300 400
Scale in Feet



DOWNSTREAM ELEVATION

0 5 10 15 20
Scale in Feet

NOTE:
Structure shown is for Richmond Street location. Thompson Street Bridge will not have P.T.C. tracks but will be of similar construction and architecture.



TYPICAL TRANSVERSE SECTION

0 5 10 15 20
Scale in Feet

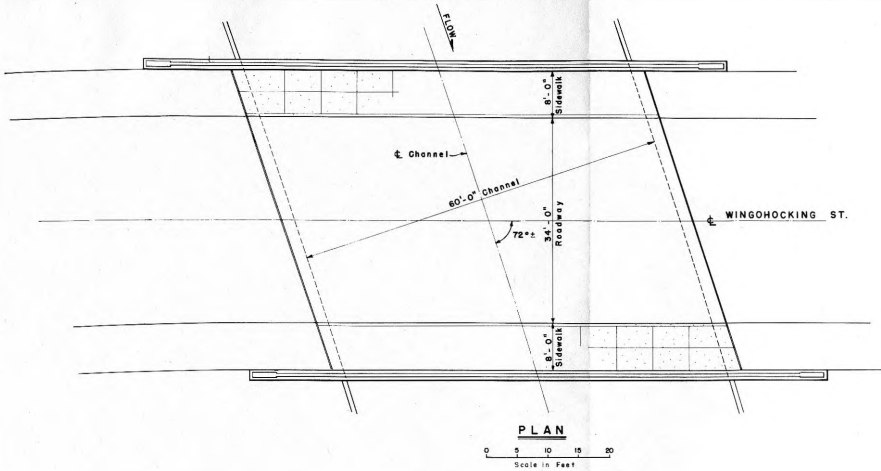
CITY OF PHILADELPHIA
DEPARTMENT OF PUBLIC WORKS
BUREAU OF ENGINEERING, SURVEYS AND ZONING

REPORT ON FRANKFORD CREEK FLOOD CONTROL

PLAN, ELEVATION AND SECTION
PROPOSED BRIDGES AT RICHMOND AND THOMPSON STREETS

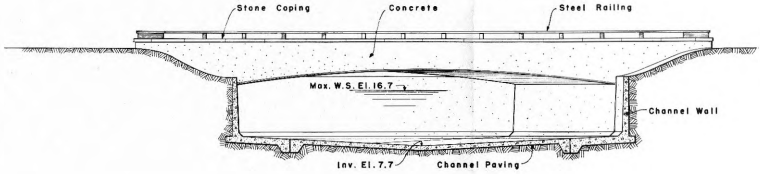
KNAPPEN ENGINEERING COMPANY
280 MADISON AVE. NEW YORK, N.Y.

DRAWN BY: R.G.H.
CHECKED BY: Z.L.
SCALE AS SHOWN
DATE: AUGUST 1947
DRAWING NO. R136-20



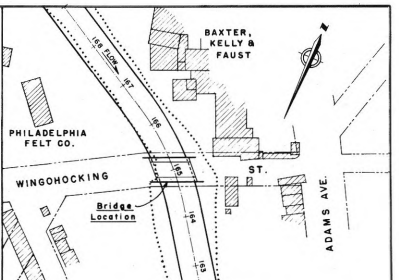
PLAN

0 5 10 15 20
Scale in Feet



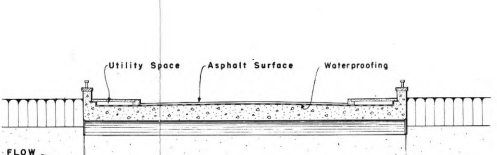
DOWNSTREAM ELEVATION

0 5 10 15 20
Scale in Feet



LOCATION PLAN

0 50 100 150 200
Scale in Feet



TYPICAL TRANSVERSE SECTION

0 5 10 15 20
Scale in Feet

CITY OF PHILADELPHIA
DEPARTMENT OF PUBLIC WORKS
BUREAU OF ENGINEERING, SURVEYS AND ZONING

REPORT ON FRANKFORD CREEK FLOOD CONTROL

PLAN, ELEVATION AND SECTION
PROPOSED BRIDGE AT
WINGOHOCKING STREET

KNAPPEN ENGINEERING COMPANY
280 MADISON AVE., NEW YORK, N.Y.

DRAWN BY : R.G.H.
CHECKED BY : Z.L.
SCALE AS SHOWN
DATE : AUGUST 1947
DRAWING NO. R136-21

Composite of Plans R-136-5, -6, -7, -8, -9, -9A from 1947 Knappen Report on Frankford Creek