

TEN MILE RIVER FEASIBILITY STUDY HYDROLOGIC ANALYSIS

1. AUTHORITY AND HISTORY OF STUDY

Authority for a "Rhode Island Ecosystem Restoration" Reconnaissance Study was specifically provided in the U.S. Congress' Energy and Water Development Appropriation Bill. A July 1999 Reconnaissance Report, prepared by the U.S. Army Corps of Engineers (USACE) identified a total of 25 restoration sites. One of the identified projects included restoration of the Ten Mile River Basin migratory corridor, with fish passage needed at three dams (Omega Pond, Hunts Mill and Turner Reservoir). An agreement was signed by the State of Rhode Island and the Army on 15 March 2001 to conduct a Feasibility Study for the Ten Mile River Basin.

2. TEN MILE RIVER BASIN DESCRIPTION

The Ten Mile River watershed, which drains to the Seekonk River, has a total drainage area of about approximately 56 square miles, 51 square miles of which is in the southeast corner of Massachusetts and 5 square miles of which is in northeast Rhode Island. The Ten Mile River watershed is flanked by the Blackstone River, Charles River, Taunton River, and Narragansett Bay watersheds. The watershed drains parts of Attleboro, North Attleborough, Plainville, Seekonk, Wrentham, Foxborough, Rehoboth (all in Massachusetts), and East Providence and Pawtucket in Rhode Island. Approximately 15 miles of the river's 21-mile length are in Massachusetts.

The Ten Mile River's headwaters begin at Cargill Pond in Plainville at an elevation of approximately 230 feet above mean sea level. From there, the river flows slowly south through urbanized areas of North Attleboro, Attleboro, and Seekonk before entering Rhode Island and its ultimate outlet, the Seekonk and Providence Rivers of Narragansett Bay. The Ten Mile picks up flow from its first major tributary, the Bungay River, in Attleboro. As the Ten Mile River continues its path south, it flows through numerous ponds. The Ten Mile receives flow from its other major tributary, the Sevenmile River, at an impoundment in Rhode Island's Ten Mile River Reservation. From there, the Ten Mile flows into James V. Turner Reservoir, then into the small pond behind Hunts Mill Dam, and then into Omega Pond. Omega Pond, located at the mouth of the Ten Mile River, discharges directly to the Seekonk River.

3. DAMS ON THE TEN MILE RIVER

Figure 1 shows the locations of the three dams on the Ten Mile River being studied: Omega Pond Dam, Hunts Mill Dam, and Turner Reservoir Dam:

Omega Pond Dam, owned by the city of East Providence, is located at the mouth of the Ten Mile River at tidewater, and discharges to the Seekonk River. The masonry and earth dam has a hydraulic height of 15 feet. The 106-foot-long spillway crest is at elevation 9.9 feet above the North American Vertical Datum of 1988 (NAVD88).

Drainage area at the dam is approximately 56 square miles. Omega Pond is 33 acres in size.

Hunts Mill Dam, owned by the city of East Providence, is located approximately 1.9 miles above Omega Pond Dam. The masonry and earth dam has a hydraulic height of about 8.5 feet. The 80-foot-long spillway crest of this dam is at elevation 33.6 feet above NAVD88. Drainage area at this dam is 53.6 square miles. There is no significant-size pond associated with this dam.

Turner Reservoir Dam, owned by the city of East Providence, is located approximately 2.3 miles above Omega Pond Dam. The concrete and earth dam has a hydraulic height of 22 feet. Turner Reservoir covers 297 acres. The 200-foot-long spillway crest of this dam is at elevation 47.6 feet above NAVD88. Drainage area at this dam is 48.3 square miles.

4. DENIL FISH LADDERS

Design requirements of Denil fishways were provided entirely by U.S. Fish and Wildlife Service (USFWS). Denil fishways have been widely tested and have been found to be successful with enabling the passage of several types of anadromous fish species over dams. Denil fish ladders are used for upstream passage only, and are operated only during the fish migration season. Downstream fish passage, which occurs in late summer when flows are usually at their lowest, is achieved simply by construction of a notch (in the spillway) discharging to a plunge pool that reduces injury to the fish as they pass over the dam. Denil fish ladders occupy relatively small footprints and use only a small portion of the river's total streamflow. USFWS, in particular, has a large body of experience with their construction in New England.

Denil fish ladders are designed with a sloped baffle section with closely-spaced upstream-sloping V-shaped baffles (designed to dissipate energy enough to enable fish movement), an entrance channel at the foot of the dam with a level floor section and walls, a level resting or turning pool for every 6 to 9 feet of vertical rise, and an exit channel at the headpond. The main function of a turning pool is to switch the direction of the ladder so that the entrance may be placed near the foot of the dam, where fish swimming at the base of the dam can find it.

Denil fish ladder designs are based upon the species having the most difficulty when ascending fishways. Target species for the Ten Mile River include American shad, alewife, and blueback herring, with shad being the limiting species. At each of the three dams, a four-foot-wide, 1-foot vertical on 8-foot horizontal sloped Denil fishway would be required for American shad to ascend into the headponds.

5. DESIGN OPERATING DISCHARGES AND WATER SURFACE ELEVATIONS

USFWS design criteria were adopted for Denil fishway design at the three subject dams, with USFWS preparing the conceptual design plans at the three subject dams under contract to USACE. Denil fish ladder entrance and exit floor elevations are based upon “normal” and minimum operating flows and associated water surface elevations occurring during the April through June anadromous fish migration period. Attainment of the minimum water depth required by fish at the fishway entrance (at the base of the dam) often requires some excavation in the channel downstream of the dam, while attainment of the minimum required depth at the fishway exit (at the crest of the spillway of run-of-river dams) typically requires the cutting of a notch into the spillway crest. Maximum operating flows are used primarily to establish the elevation of the top of the entrance channel sidewalls, while the 10-year flood flow elevation is used to set the top of the exit channel sidewalls. Extreme flows occurring during the migration period are not considered, since fish usually await more seasonal flows before they resume their upstream migration.

Migration-season streamflows were determined using United States Geological Survey (USGS) gage 01109403, “Ten Mile River at Pawtucket Avenue at East Providence, Rhode Island”. This gage has operated from October 1986 to the present. According to the USGS, drainage area of this gage is 53.1 square miles (there is a small discrepancy between the drainage area cited by USGS and those of the three dams as cited in East Providence’s 1982 Flood Insurance Study). Because the drainage area of the gage and the dams are in the same general range, flows at all of these locations may be considered to be one and the same. Average discharge is 104 cfs, with average monthly flows shown in Table 1:

Table 1: Average Monthly Flows (cfs) at the Ten Mile River in East Providence, R.I.

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Flow	60	89	126	131	139	182	181	113	80	47	47	47

USFWS determines the minimum operating range flow by examining the mean daily flows for the last 15 years, and selecting the lowest flow that occurs 2 or 3 times for at least a three-day period. Examination of the gage records indicates this flow to be approximately 30 cfs.

USFWS calculates the “normal” operating range flow by averaging the April mean flow and the April median flow. The normal operating flow is calculated to be approximately 160 cfs for the three dams.

The maximum operating range flow is established by selecting a “reasonable” maximum flow value when fish are likely to still be migrating. Early-season coldwater high flow “pulses” are not considered “reasonable” since anadromous fish are not

migrating under that condition. In the case of the Ten Mile River dams, this maximum flow value has been determined to be 400 cfs.

Staff gages were installed by USACE at both the headpond and tailwaters of each of the three dams, and the gages were surveyed to a common vertical datum (NAVD88). Several readings of the staff gages were then taken over a several day period in order to ascertain “typical” headwater and tailwater elevations at each dam. The gage reading are mainly used only to confirm the reasonableness of the range of water surface elevations calculated for headponds (using the weir equation) and to establish the approximate range of expected tailwater elevations. Table 2 provides spillway crest elevation data for each of the three dams, and the headpond and tailwater elevations for the design operating range flows (elevations are feet above NAVD88).

Table 2: Pertinent Information Used In the Design of Denil Fishways

Dam	Spillway crest elev.	Flow (cfs)	Headpond elevation	Tailwater elevation
Omega Pond	9.9	30	10.15	MLW = -2.3* MTL = 0.71 MHW = 2.12
		160	10.65	
		400	11.29	
Hunts Mill	33.55	30	33.83	Ranged from 25.5 to 26.2
		160	34.33	
		400	34.93	
Turner Res.	47.55	30	47.68	Ranged from 33.6 to 34.45
		160	47.95	
		400	48.29	

* Omega Pond Dam’s tidal tailwater data from the nearby Providence River tide gage

Using the information provided in Table 2 and the design criteria provided above, the elevation of the floors of the entrance and exit channels for Omega Pond Dam will be set at -4.35 feet NAVD88 and 8.15 feet NAVD88, respectively. For Hunts Mill Dam, the elevation of the floors of the entrance and exit channels will be set at 23.5 feet NAVD88 and 31.8 feet NAVD88, respectively. For Turner Reservoir Dam, the elevation of the floors of the entrance and exit channels will be set at 32.0 feet NAVD88 and 45.45 feet NAVD88, respectively.

The rating curve for a 4-foot wide, 1 vertical on 8 horizontal Denil fishway has been determined by others through laboratory tests, therefore, there is no need for its calculation. The normal operating flow in a 4-foot-wide Denil fish ladder is approximately 10-11 cfs, however, operating flows range from approximately 4 to 30 cfs.

6. FLOOD FLOWS

Denil fishways are not operated during flood conditions, and the fishways have little impact on flood stages with the only exception being the two 1-foot-thick walls of the

fishway exit and the two 1-foot-thick walls of the downstream migrant flume that block the free flow of the spillway. The non-overflow “flashboard” section, used to still the waters in the vicinity of the fishway entrance channel, is designed to fail during significant floods, and therefore does not impact peak flood water surface elevations. The notch cut into the spillway for downstream fish passage increases flow passage capabilities. The net impact of Denil fishways and associated appurtenant features on the passage of flood flows may be considered to be “a wash”, i.e. no impact to flood elevations upstream or downstream of the dam.

Flood flows are presented in Table 3 primarily for informational purposes. Recent statistical analysis of streamflow gage 01109403 indicates expected peak streamflows for the 10-, 50-, 100-, and 500-year recurrence intervals that are within about 15-20 percent of the values published in the December 1982 Flood Insurance Study (FIS) for the City of East Providence, Rhode Island. Revision of the peak flows provided in the FIS, calculated using the Natural Resources Conservation Service TR-20 computer program, are probably not warranted based upon the magnitude of the newly calculated flows.

Table 3 - Peak Flood Flows (cfs) at Ten Mile River in East Providence, R.I.

Recurrence interval	COE analysis (1987-2001)	Flood Insurance Study
10-year	1260	1460
50-year	1960	2280
100-year	2360	2710
500-year	3680	4460

Although they are based upon somewhat higher 10-year flood flows, the 10-year peak water surface elevations shown in the FIS (see attached Ten Mile River Flood Profiles, Figures B-2 through B-5) are used to set exit headwall elevations. The elevations for Omega Pond, Hunts Mill, and Turner Reservoir dams are 13.9 feet, 36.2 feet, and 50.0 feet above NGVD, respectively (or 13.1 feet, 35.4 feet, or 49.2 feet above NAVD88, respectively).

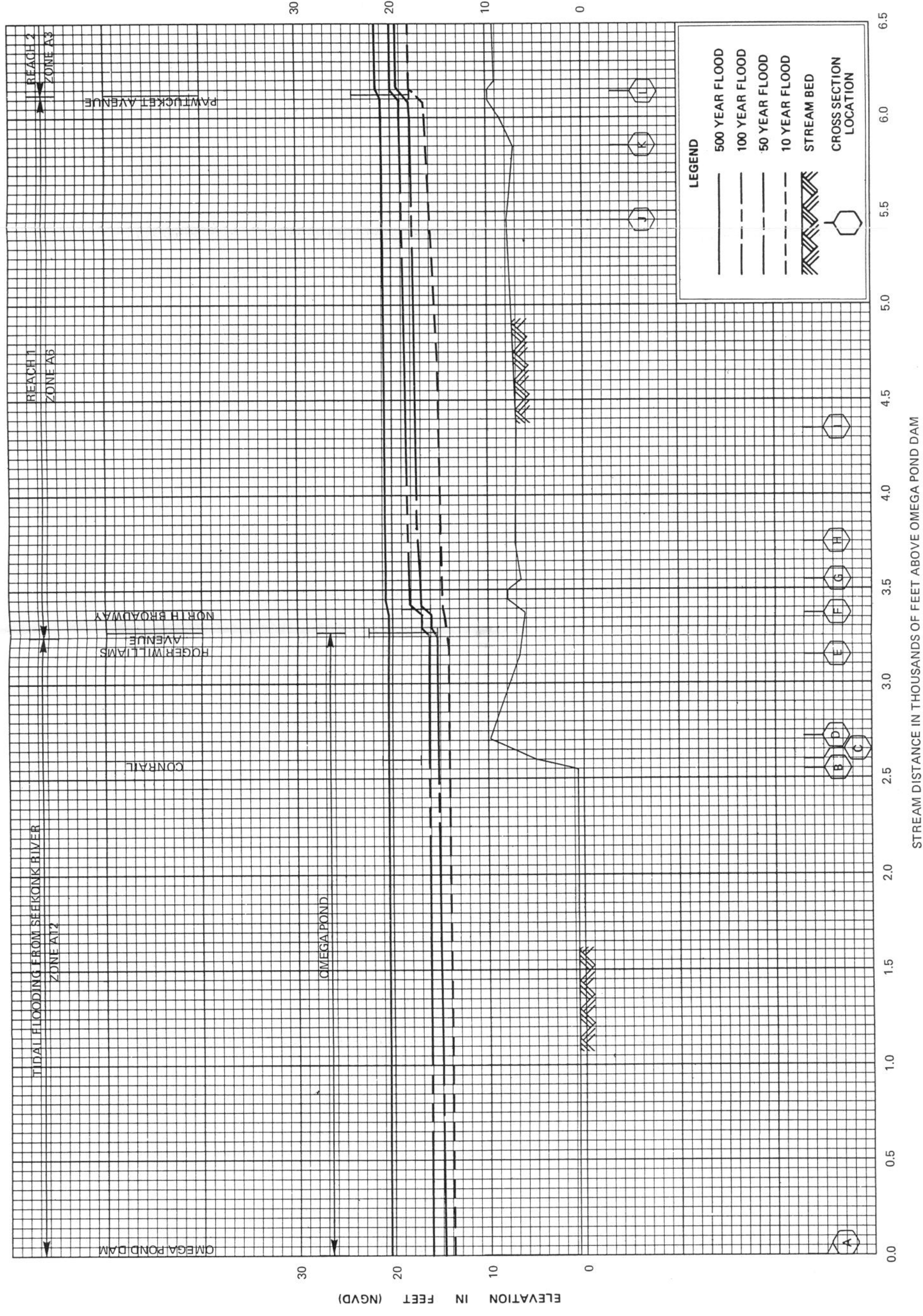


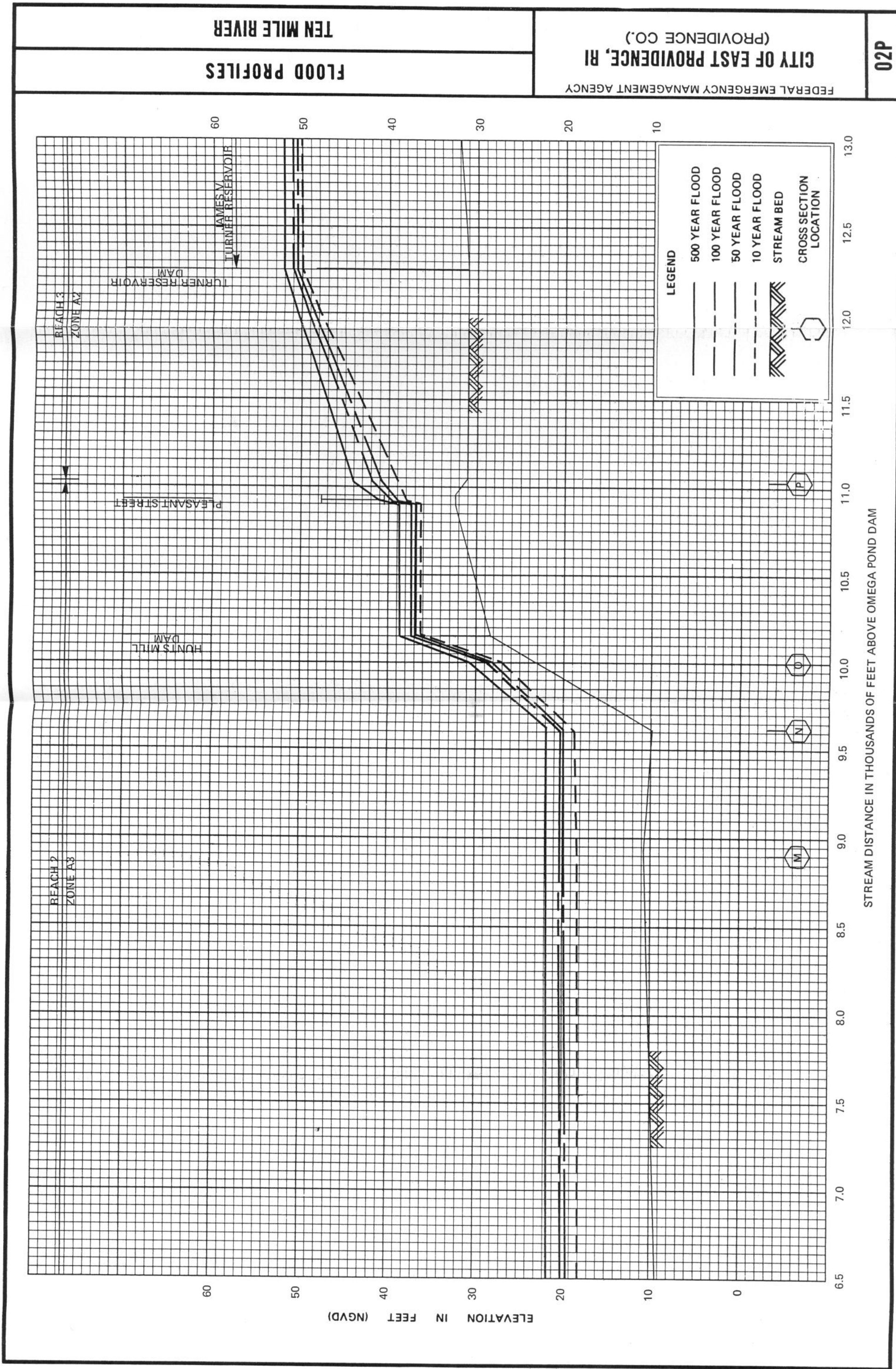
Ten Mile River Feasibility Study, East Providence, Rhode Island
Anadromous Fish Passage Restoration Sites

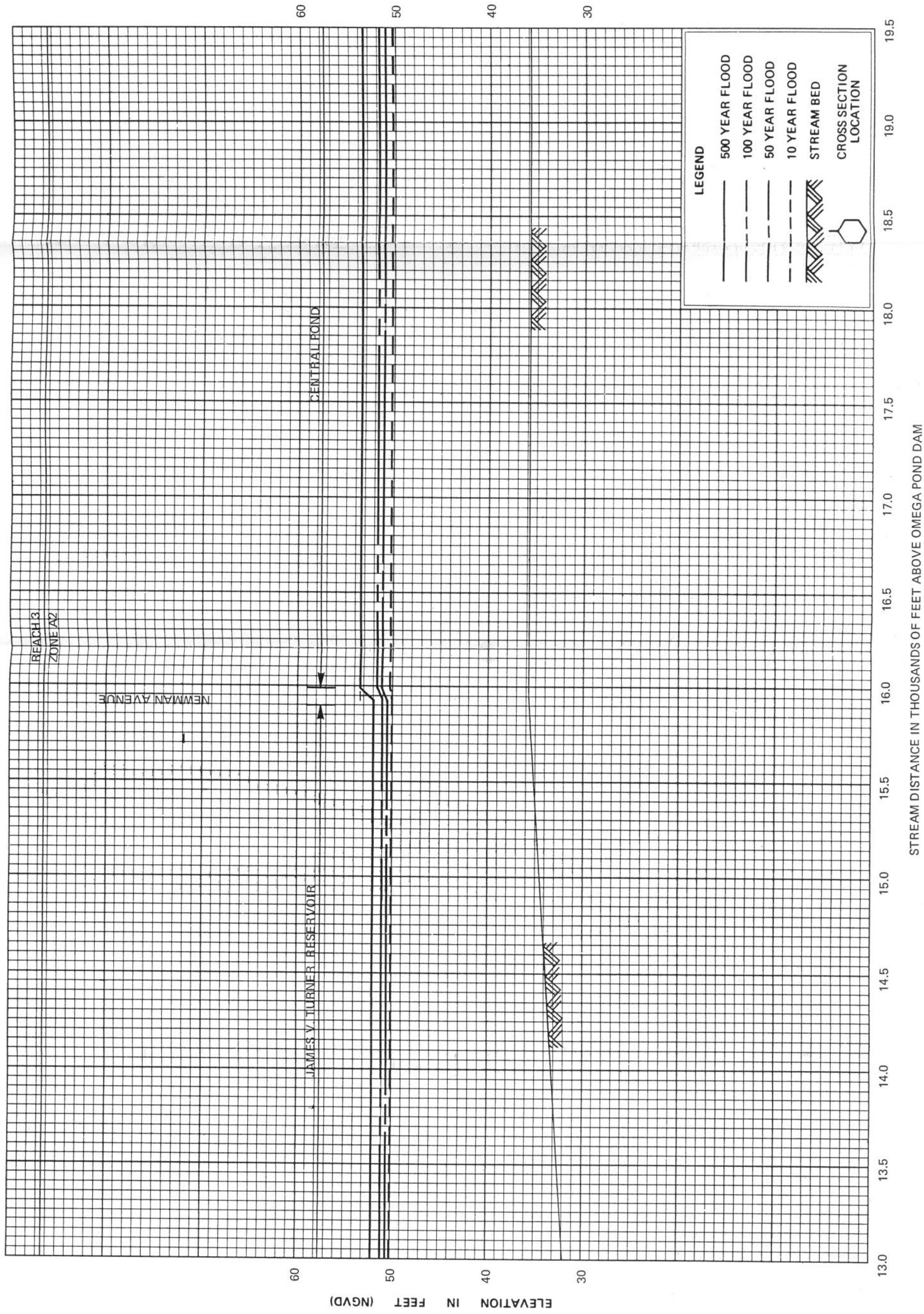
Figure B-1

FEDERAL EMERGENCY MANAGEMENT AGENCY
CITY OF EAST PROVIDENCE, RI
(PROVIDENCE CO.)

FLOOD PROFILES







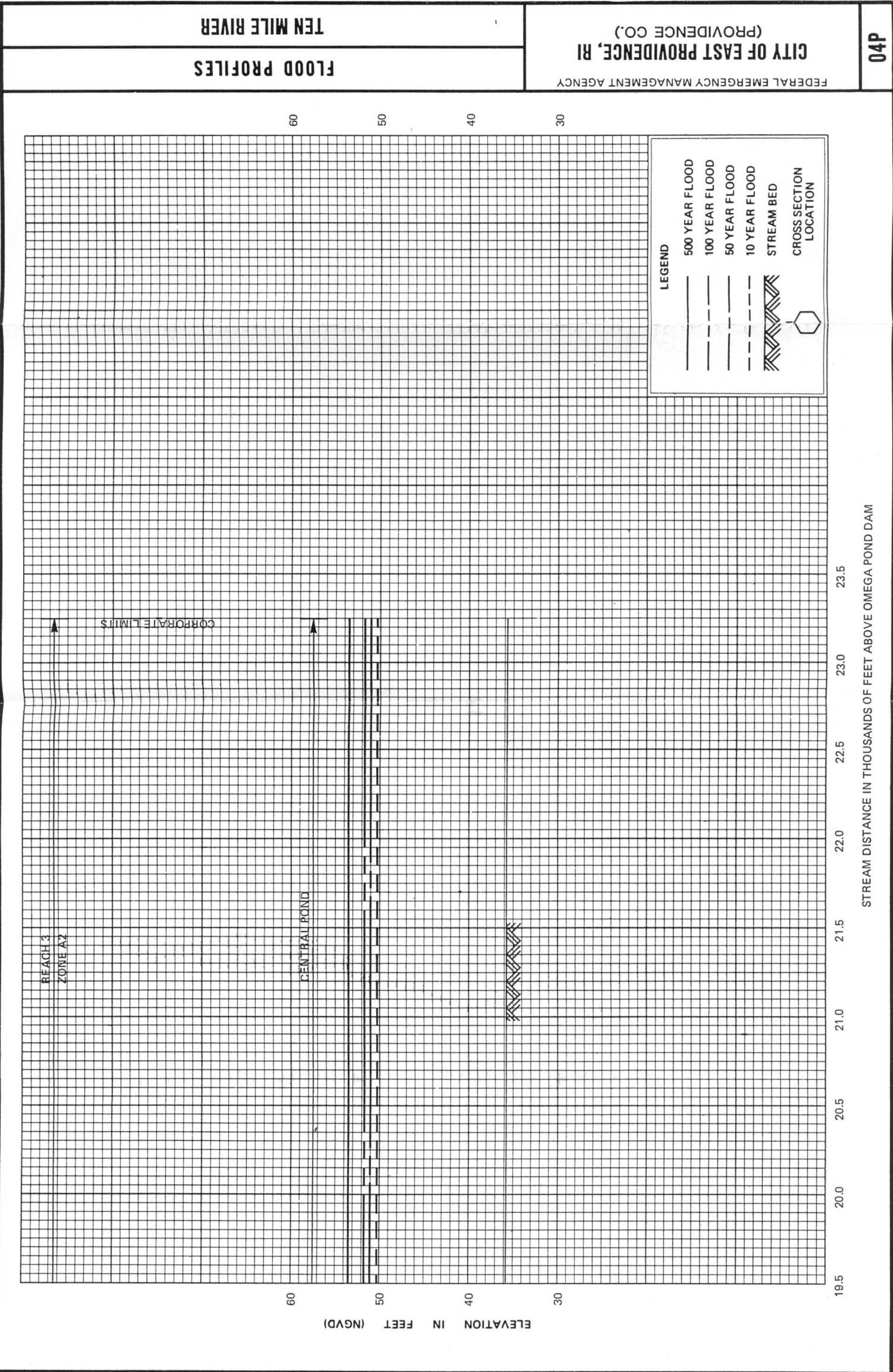


Figure B-5