DESCRIPTION	YOUR INVOICE NO./REF.	CITY ACCOUNT NO.	AMOUNT
water rights registration fees for the process			7650.00

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WATER RESOURCES DEPT.
SALEM, OREGON

CITY OF SPRINGFIELD 225 5th Street Springfield, Oregon 97477 (503) 726-3708

SPRINGFIELD

CITY OF SPRINGFIELD, OREGON

PUBLIC WORKS DEPARTMENT
ADMINISTRATION
ENGINEERING DIVISION
MAINTENANCE

225 FIFTH STREET
SPRINGFIELD, OR 97477

...VED

JAN - 2 1996

... DEPT.
..., OREGON

December 22, 1995

Reed Marbut
OR Water Resources Dept.
158 12th St., NE
Salem, Oregon 97310

Subject: SPRINGFIELD MILLRACE HYDROLOGIC STUDY AND ALTERNATIVE EVALUATION

Dear Mr. Marbut

The Springfield City Council has scheduled Otak, the project consultant, to present the subject report January 22, 1996. Otak will present their findings and recommendations on the hydrologic study of the Middle Fork of the Willamette River near the Springfield Millrace to the Springfield City Council at that time. You are invited to attend this Work Session beginning at 6:00 pm on January 22, 1995 at City Hall; 225 Fifth Street, Springfield, Oregon 97477.

Please call me at 541-726-3616 if you have questions regarding the forthcoming City Council Work Session.

Sincerely,

Edward Black

Ed Black
Maintenance Manager

STOEL RIVES BOLEY
JONES & GREY

ATTORNEYS AT LAW
SUITE 2300
STANDARD INSURANCE CENTER
900 SW FIFTH AVENUE
PORTLAND, OREGON 97204-1268
Telephone (503) 224-3380
Telecopier (503) 220-2480
Cable Lawport
Telex 703455
Writer's Direct Dial Number

(503) 294-9460

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December 14, 1992

Mr. Donald E. Knauer
Adjudication Specialist
Adjudication Section
Oregon Water Resources Department
Field Operations
3850 Portland Road, N.E.
Salem, Oregon 97310

Re: City of Springfield

Dear Don:

I enclose the following:

1. Surface Water Registration Statement signed and notarized by Michael A. Kelly, City Manager for the City of Springfield;

2. Original (mylar) and two copies of water map prepared by Tyler Parsons, Certified Water Right Examiner;

3. Exhibit A to the Registration Statement, which is an Affidavit by Barton McKee providing historical information regarding the Springfield Millrace;

4. Map showing ownership of the City's real property and adjacent real property in the vicinity of the millrace; and

5. Check in the amount of $7,650, constituting the applicable registration fees.

In accordance with our previous discussions, I would appreciate it if you would review these materials and then call me to confirm that they are complete and acceptable for filing.

STOEL RIVES BOLEY
JONES & GREY

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On behalf of the City and myself, I would like to thank you for the very helpful assistance you have provided in connection with this matter.

Happy holidays.

Very truly yours,

Jere M. Webb

JMW:dxe
Enclosures

cc: Mr. Edward Black
Mr. Joseph J. Leahy

EXHIBIT A

AFFIDAVIT OF BART McKEE

STATE OF OREGON)
) ss.
County of Lane)

I, BART McKEE, having been duly sworn, depose and say:

1. I am employed by the Springfield Utility Board, a division of the City of Springfield.

2. I have reviewed the City of Springfield's records regarding its pre-1909 vested water rights claim.

3. The history of the pre-1909 water use is found in a variety of sources including newspaper clippings, personal histories, and corporate filings. The Springfield Historical Commission received a grant to compile a history of the Springfield millrace, which resulted in a book published by the Commission in 1983 entitled The Springfield Millrace. It contains a detailed discussion of the history of the millrace and millpond and associated water use. Information regarding the millrace and the early mills also appears in A. G. Walling's Illustrated History of Lane County, Oregon, (1884).

4. A brief summary of the historical water use that forms the basis of the City's pre-1909 vested water rights claim is as follows: The millrace and millpond were constructed in 1852 by Elias and Isaac Briggs. Water was first appropriated for beneficial use in 1853. The water from the

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millrace and millpond has always been used for a variety of industrial and municipal beneficial uses. Although first used as a source of power for a flour and saw mill, the water from the millrace was also used for log processing, irrigation, fire suppression, as a municipal water source and for esthetic, recreation, and wildlife purposes. Water continues to be used for these purposes today.

5. In 1985, Georgia Pacific Corporation donated most of the millrace and a portion of the millpond to the City of Springfield. Accordingly, the City of Springfield became a successor in title to the water rights appurtenant to the donated property. A map showing the City's ownership of the millrace and millpond and surrounding lands is included with the City's registration statement.

6. A summary history of the development and use of the millrace, prepared by Slotta Engineering Associates, Inc., is attached to this affidavit.

Bart E McKee

SUBSCRIBED AND SWORN to before me this 18 day of November, 1992.

Thomas E. Davis
Notary Public for Oregon
My Commission Expires: 8-17-93

Surface Water Registration, City of Springfield, OR
Pre-1909 Vested Water Right Claim

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Exhibit A

The Springfield Millrace has historically been a multipurpose waterway. It has been a source of water for power for flour and saw mills, log processing, irrigation, fire control, municipal water, and recreation. The City desires to obtain a vested water right from the State of Oregon as successor in title to the Millrace and millpond in order to continue beneficial use of the water for the public in the Springfield area and to fulfill the donation agreement of 1985 with Georgia-Pacific Corporation.

The Millrace was constructed in 1852 and water first used for beneficial use in 1854. The millpond and dam was constructed in 1902.

Historical Summary of the Development and Use of the Springfield Millrace (from A Water Resource Assessment for the Springfield Millrace, Slotta Engineering Associates, Inc, 1989)

1849 - Elias Briggs settles in the Springfield area and acquires 640 acres.

1851 - A large flood destroys many recently constructed buildings in Springfield. This flood may have helped plan the course of the Millrace by low elevation indications from previous flooding. Isaac Briggs acquires land next to Elias Briggs.

1852 - Elias and Isaac Briggs, with help from T.J. Henderson, dig the Millrace channel using shovels and plows.

1853 & 1854 - Construction on the saw and flour mills is initiated and progresses. Construction was funded by Briggs, Briggs, and Company. The mills used the Millrace to run their waterwheels and the sawmill used the Millrace to float and hold logs. The flour mill was the largest in Lane County.

1853 - The saw mill commences operation.

1854 - (Fall) The flour mill goes into business. It is recorded that the drop of water across the mill was about 19 feet, but the dimensions of the mill are not known.

1861 - The worst flood ever recorded in the Willamette Valley occurs, altering the course of the Middle Fork of the Willamette River.

1865 - (April 1) Elias Briggs' property os bought by B.J. Pengra, Judge R.E. Stratton, and J.B. Underwood of the Springfield Manufacturing Co.

1866 - The old saw mill is demolished and replaced by a larger mill.

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1871 - The flour mill is expanded with increased power requirements. Since the elevation was established, increased power supply could have only been accomplished through increased flow.

1871 - Eugene received the main line of the Oregon and California Railroad, taking away business from the mills of Springfield.

1876 - The Kellys sell their property to the Springfield Milling Co.

1882 - The rebuilt sawmill is destroyed by fire. This mill is replaced by Pengra with a larger sawmill having a capacity of sawing 30,000 board feet of lumber per day. The flour mill also expands.

1885 - B.J. Pengra becomes owner (via W.B. and L.B. Pengra) of the mill property, along with the tail race. It is believed the remaining property of the Millrace was also transferred.

1885 - Springfield becomes a town with Albert Walker the mayor.

1890 - Another flood hits the City of Springfield. This flood is said to have exceeded 22.5 feet over the flood stage of the Willamette.

1890 - The train depot at the south enc of 7th Street was constructed. This greatly improved business in Springfield because of the new connection to a rail network.

1890 - (September 24) C.W. Washburn purchases William Pengra's property and renovates the flour mill.

1891 - Albert Walker purchases and operated the sawmill on the Millrace. However, the waste discharge into the Millrace impacted the river to the point where using the Millrace for high loading discharge was prohibited.

1892 - The flour mill in Eugene is destroyed by fire. As a result, the Springfield flour mill business increased.

1901 - Booth Kelly acquires the Millrace property.

1902 - Booth Kelly builds a new mill in Springfield and completed the dam to create the log pond at the present site.

1904 - (October 16) John W. Blodgett, Arthur Hill, Mike Kelly, and C.D. Danaher purchase the controlling stock interest of the saw mill.

1906 - Railroad connection between Eugene and Springfield is completed with a newly constructed steel bridge.

1907 - The Booth-Kelly Company initiates construction of a million gallon holding reservoir at the tip of the Springfield Butte for municipal water supply. Water for this reservoir was pumped from the Millrace.

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1907 - Railroad shipping rates skyrocketed, having a negative impact on the lumber business.

1911 - A steam plant is constructed of brick at the Booth-Kelly mill housing a steam turbine and generators.

1911 - (July 29) The Booth-Kelly Mill burns to the ground. The entire City of Springfield's water supply is lost.

1913 - (August) Alice and Bernice Noel purchase the flour mill from Washburne and Son. (The date Washburne and Son purchased the mill is not known)

1915 - (March) The new Booth-Kelly mill is completed.

1917 - (June 15) S.H. Barker sells the flour mill to Elmer D. Paine, C.S. Williams and Associates.

1919 - (August 21) George Bushman and Son purchase the flour mill, changing the name to the "Springfield Mill and Grain Company".

1924 - Harvey Scott writes in the "History of Oregon Country" that at times the entire flow of the Middle Fork may have been diverted through the Springfield Millrace.

1930 - (September 16) The flour Mill burns to the ground. (October 17) The land that the flour mill occupied was sold to the First Investment and Loan Company of Eugene.

1947 - The Springfield rock quarry begins mining basalt, and water is pumped from the Millrace to wash gravel.

1948 - Booth Kelly modernizes the sawmill. (July 26) Western Timber Products has a large lumber fire.

1949 - (July 28) Clear Fir Products main mill and lumber stores burn. A $250,000 loss is realized.

1959 - Georgia-Pacific out bids U.S. Plywood to buy out Booth-Kelly and plan for expansion of the mill to a chipping operation. Georgia Pacific announces that 30 percent of the former Booth-Kelly timber holdings will be sold to finance the debt for buying Booth-Kelly out.

1964 - The former Booth-Kelly mill is closed and the Millrace is no longer used to provide power. The mill buildings are then developed into the Big-M shopping center.

1967 - The Weiss brothers purchase the Springfield Rock Quarry.

1967 - (July 3) Roseboro Lumber reduces its plywood plant by 50 percent of its capacity.

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1985 - (December 15) Georgia-Pacific donates the Millrace properties and its operation to the City of Springfield.

The Millrace and millpond was donated to the City of Springfield on December 15, 1985 by Georgia-Pacific Corporation. The donation agreement contained the following conditions.

a. Provide sufficient inlet control so that the water level in the millrace does not exceed the bank elevation.

b. Maintain sufficient water level in the millrace so that existing pump intake pipes are submerged.

c. Maintain sufficient water level in the millpond so that the existing submersible pump owned by G-P is submerged.

d. Maintain the water level in the millpond so that moving water is provided to the existing fish ladder at all times.

e. Provide removal of debris along the millrace and annually remove debris at the existing log boom located upstream of Quarry Road Bridge.

Since 1985, flow through the Millrace has been regulated by the City of Springfield following the prior practices of Georgia-Pacific Corporation. In early Winter, two 48" corrugated metal pipes are placed in the channel of the Millrace at its inlet from the Middle Fork and gravel is used to close off the channel to prevent flow around the culverts. In the late Spring, the culverts and gravel are removed and a "wing dam" is constructed of gravel between the bank and a small island in the river to divert water into the Millrace. This practice is no longer considered satisfactory due to the coarse regulation of water flow, difficulties in installation and removal of the culverts and the wing dam, and sedimentation caused by dredging

The channel is kept clear at approximately 6 month intervals by City crews who remove trash and cut fallen trees and excessive debris and allow them to float downstream. A log boom East of the millpond pond catches the debris, which is removed by city crews.

Beneficial use of the Millrace and millpond water by the City of Springfield has continued since the donation by Georgia-Pacific in 1985. Prior to that date and continuing to the present, the Springfield Utility Board has been using water from the Millrace and the Gorrie Overflow to recharge wellfields providing municipal water to the City. Non-consumptive beneficial uses include fish and wildlife habitat, particularly along the portion of the Millrace between the diversion point and the millpond, and public recreation use for fishing, boating, swimming, and general enjoyment. The Millrace is also beneficial to the adjoining private landowners in the enjoyment of their homes and property. The Millrace empties into the Willamette River at the southerly end of Island Park, and adds to the public enjoyment of that park.

Oregon
Theodore R. Kulongoski, Governor

Water Resources Department
North Mall Office Building
725 Summer Street NE, Suite A
Salem, OR 97301-1271
503-986-0900
FAX 503-986-0904

January 23, 2004

Thorp Purdy Jewett Urness & Wilkinson
Atten: Mary Lewis
1011 Harlow Road, Suite 300
Springfield, OR 97477

Re: Surface Water Registrations 320 and 131 Maps

Dear Mary:

Enclosed please find copies of the maps included with Surface Water Registrations 131 and 320. Also enclosed is your receipt #65226 for the amount of $14.00.

Please do not hesitate to contact us if we may be of further assistance.

Sincerely,

Teri Hranac
Adjudications Specialist

Enclosures

c: Reed Marbut

LEE BEYER
STATE REPRESENTATIVE
District 42 Springfield

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JUN - 3 1997
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SALEM, OREGON

REPLY TO ADDRESS INDICATED:
☑ House of Representatives
Salem, OR 97310
503 986-1442

☐ 1439 Lawnridge Ave
Springfield, OR 97477
503 726-2533

HOUSE OF REPRESENTATIVES
SALEM, OREGON

Paul R. Cleary
Director, Division of State Lands
775 Summer Street
Salem, OR 97310-1337

June 2, 1997

Martha Pagel
Director, Water Resources Department
158 12th Street NE
Salem, OR 97310

Rod Ingram
Acting Director, Department of Fish and Wildlife
2501 SW First Avenue
Portland, OR 97207

Re: The Springfield Millrace

Ladies and Gentlemen:

This letter is written on behalf of the City of Springfield and also expresses my personal concern about the difficulty that the City of Springfield is experiencing in finding a solution to apparent issues surrounding the continued viability of the Springfield Millrace, practices of long standing use to maintain Millrace flows, and, the regulatory requirements and interpretations of your agencies, and the U.S. Army Corps of Engineers.

The Springfield Millrace dates from about 1852, when one of the earliest settlers of Springfield hand dug a channel to extend or channel a naturally occurring watercourse to run to the site of the first industrial development in the City, a sawmill constructed in 1853. It has continued to flow for over 140 years. While originally developed as a source of industrial power, it appears that early in this century, as the City of Springfield was organized and grew, it became an important source of public drinking water, a function that continues to this day. Fully one-third of the City's residents receive water from Springfield Utility Board wells located just south of the Millrace, wells which depend on the water flowing from the Millrace into Gorrie Creek to support the ground water table.

In addition, industries such as Springfield Forest Products, and other industrial and agricultural users, rely on Millrace flow to support their water needs. This perennial water course provides substantial support to wetlands and habitat in this portion of Springfield.

The City of Springfield assumed responsibility for the Millrace in 1985, when Georgia-Pacific Company donated most of the waterway and underlying land to the City with the understanding that the City would maintain flows to support several existing uses. Historically, Millrace flows have been managed by using a bulldozer in the river to move and/or remove gravel deposits adjacent to and upstream from the Millrace inlet. An annual fill and removal permit (issued by the Corps of Engineers and the Division of State Lands) is required to perform this activity. When the City's first permit application was submitted in 1987 the reviewing agencies expressed environmental concerns about the possibility of hydraulic fluid and grease and oil leaks and increased turbidity and sedimentation resulting from the use of heavy equipment in the river. These concerns resulted in the inclusion of several special conditions in the City's first and subsequent permits. The federal and State agencies which regulate the City's activities in the river have urged the City to find other, less intrusive alternatives to maintain flow. The citizens of Springfield, recognizing the importance of this waterway, approved a general obligation bond which included funding for improvements to maintain water flow in the Millrace.

In 1994, at the urging of the regulatory agencies, the City commissioned a hydrologic study of the Millrace system by Otak, a respected firm of consulting engineers. That study, completed in February 1996, concluded that the City's current practice was unsound and described several alternatives. Most of the alternatives Otak explored presented problems as to their long-term viability and, accordingly, Otak gave attention to one alternative which involved changing the point of diversion of the Millrace by moving the inlet about 1800 feet upstream, to a point just downstream of the existing boat ramp at Clearwater Park. The hydrologic study concluded that this point was the only place in this area of the River where one could reasonably anticipate long-term stability. Regulatory agency staff endorsed the report but declined to endorse any of the alternatives, saying, informally, it was a matter for the City to decide.

When these alternatives were reviewed by the Springfield City Council, the Council focused on a different alternative and directed staff to explore the alternative to its fullest before again considering moving the inlet. That alternative involved installation of a dragline at the current inlet opening. That dragline would periodically remove rock from the mouth of the current inlet on the north side of the river by means of a bucket conveyed on a cable extending across the Middle Fork of the Willamette River. Under this alternative, the removed rock would remain in the river, being deposited near the southern bank. At the Council's direction, staff applied to the Division of State Lands and the U.S. Army Corps of Engineers for a five-year permit for this "reverse dragline." It was hoped that the five year test of this approach might demonstrate it could be a permanent solution.

During the course of agency review of this application the regulatory agencies again did not formally respond to the City's application. Rather they continued to raise informally a number of questions for further study, including concerns about whether or not the movement of the rock as described would exacerbate instability of the main channel at the point were operations were anticipated to occur. Working closely with the regulatory agencies on design of a further study, the City retained consultants who took a much closer look at the potential instability in this area. Recently, those consultants reviewed their draft report with City and regulatory agency staff. Their conclusion is that the area proposed for operations of the "reverse dragline" is highly unstable, and that this method of maintaining flow in the Millrace might not be viable even as a short term solution and would certainly not offer a permanent solution. The City has been told, informally, that each of the regulatory agencies involved shared these concerns. Nonetheless the City's application for a permit for the "reverse dragline" remains in administrative limbo; the agencies will neither take formal action on the request nor provide the City with clear direction as to what course of action they will all support. Rather, the agencies continue to advise the City to study fully all of the alternatives and develop a solution - a process in which they are reluctant fully to participate. They have not even suggested any specific areas of further study for the approach now before them for review and have, in staff meetings, made it explicit that they believe the City has studied all of the reasonably possible alternatives. They originally indicated support for the City's suggestion to pursue a legislative clarification affecting one of the alternatives, only to withdraw their support and speak against the proposal or remain silent when the proposal went to public hearing on May 13th, 1997, before the Senate Water and Land Use Committee.

As a result, since 1994, the City has spent over $175,000 in taxpayer funds, and a considerable amount of City and agency staff time, to study, and restudy, the possible alternatives. Yet the City appears to be no closer to resolving finally whether the Millrace will survive and, if so, how that is to be accomplished. The City remains with eight alternatives, seven of which have engineering and environmental problems associated with them and one which, while it appears technically feasible, and the most cost effective approach, may require acquisition of private property through negotiation or eminent domain.

Although I know each of your agencies is sincerely working toward finding a solution, I fear, however, that agency staff may not recognize that interagency cooperation, and participation in, and support of, a commonly agreed upon solution are essential. To assure that staff direction is clear on the importance of developing a common solution which involves the City and all of the regulatory agencies, I request that you meet with elected officials and staff of the City at the Capitol, so that we may develop a common understanding of the issues and gain joint agreement on a strategy for resolving this problem. I have tentatively set up this meeting for Tuesday, June 10th at 2:00 PM in Room 257 of the Capitol Building . Please let me know if this date does not work for you. Please bring whatever staff support you feel is necessary to make it possible to resolve all outstanding issues.

Lee Beyer,
State Representative,
District 42 - Springfield

c: Gov. John Kitzhaber
Hon. Bill Morrisette, Mayor
Members of the Springfield City Council
Michael A. Kelly, City Manager

LEE BEYER
STATE REPRESENTATIVE
District 42 Springfield

c: Reed Marbut

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REPLY TO ADDRESS INDICATED:
☑ House of Representatives
Salem, OR 97310
503 986-1442

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HOUSE OF REPRESENTATIVES
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Paul R. Cleary
Director, Division of State Lands
775 Summer Street
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June 2, 1997

Martha Pagel
Director, Water Resources Department
158 12th Street NE
Salem, OR 97310

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Acting Director, Department of Fish and Wildlife
2501 SW First Avenue
Portland, OR 97207

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Lee Beyer,
State Representative,
District 42 - Springfield

c: Gov. John Kitzhaber
Hon. Bill Morrisette, Mayor
Members of the Springfield City Council
Michael A. Kelly, City Manager

Letter of Transmittal

Transmitted By...

- ☐ Mail
- ■ Courier
- ☐ Will Call
- ☐ Other

Date June 9, 1995 ***Project #*** L5326

Project Springfield Millrace Hydrologic Study

To Mr. Reed Marbut

Address Oregon Water Resources Department
158 - 12th NE
Salem, OR 97310

We Are Sending You...

- ☐ Drawings
- ☐ Specifications
- ☐ Copy of Letter
- ☐ Change Order
- ☐ Prints
- ☐ Plans
- ☐ Samples
- ■ Other

Transmitted...

- ☐ For Approval
- ☐ As Requested
- ■ For Your Use
- ☐ Comment

otak

17355 SW Boones Ferry Rd.
Lake Oswego, OR 97035
Phone *(503) 635-3618*
Fax *(503) 635-5395*

Copies	***Description***
1	Springfield Millrace Hydrologic Study

Items Are...

- ■ Attached
- ☐ Under Separate Cover *via*

Remarks

For your review.

From John Houle, PE, Project Manager

STOEL RIVES LLP
ATTORNEYS
STANDARD INSURANCE CENTER
900 SW FIFTH AVENUE, SUITE 2300
PORTLAND, OREGON 97204-1268
Phone (503) 224-3380 Fax (503) 220-2480
TDD (503) 221-1045
Internet: www.stoel.com

RECEIVED
MAR 14 1996
WATER RESOURCES DEPT.
SALEM, OREGON

March 11, 1996

GAIL L. ACHTERMAN
Direct Dial
(503) 294-9123
internet:glachterman@stoel.com

Mr. A. Reed Marbut
Adjudication Section
Oregon Water Resources Department
158 - 12th Street, NE
Salem, OR 97310

Re: City of Springfield Pre-1909 Water Rights

Dear Reed:

This firm represents the City of Springfield (the "City") for some matters related to its water rights. On December 14, 1992, the City filed a registration statement pursuant to ORS 539.240 for its pre-1909 surface water rights. The City claimed 150 cfs of water from the Middle Fork of the Willamette River for municipal purposes. The water is diverted from the Middle Fork into a millrace and is returned to the Middle Fork approximately 3.5 miles downstream.

This letter is to request written confirmation from the Director of the Oregon Water Resources Department ("WRD"), Ms. Martha Pagel, that the City's registration statement has been examined by the WRD pursuant to ORS 539.240(6). In addition to confirming the adequacy of the City's registration statement by written endorsement, please also include the WRD's position as to the effect of the valid registration statement on the City's ability to continue diverting water. We have advised the City that it may rely on ORS 539.240(7), which states that the registrant of a pre-1909 claim is "entitled to continue to appropriate the surface water and apply it to beneficial use to the extent and in the manner disclosed in the recorded registration statement," to continue exercising its claimed water right. Please discuss the WRD's position relative to this statutory provision.

PDX1A-22965.1 20257-0001

Thank you in advance for your attention and consideration of this matter. Please call me if you have any questions.

Very truly yours,

Gail L. Achterman

GLA:P-S:d-r
cc: Mr. Joseph J. Leahy
Mr. Edward Black

PDX1A-22965.1 20257-0001

SURFACE WATER REGISTRATION CHECKLIST

(received after July 18, 1990)

CHECK BASIN MAP ~~DAL~~ NAME Upper Willamette #2A UNADJUDICATED AREA ? YES

RECEIPT # 95063 S W R NUMBER 131

CHECK ENCLOSURES Deuc PRELIMINARY DATA BASE ENTRY DWP

ACKNOWLEDGEMENT LETTER Deuc ENTER ON STREAM INDEX ____

Eugene East 82 + Springfield
CHECK QUADRANGLE MAP CAR CHECK GLO PLATS ____

WATERMASTER CHECKLIST ____ PUBLIC NOTICE PUBLICATION Saw

FORM REVIEW

____ blanks filled in
____ signed
____ date received stamped

MAP REVIEW

✓ source and trib
✓ diversion point location
✓ conveyances (pipes, ditch, etc.)
✓ place of use
✓ scale
✓ township, range, section
✓ north arrow
✓ CWRE stamp
✓ disclaimer
____ date survey was performed
✓ P.O.B. of survey
✓ dimensions and capacity of diversion system
✓ "beneficial use" type title
✓ "permanent-quality" paper

WATER RIGHT RECORD CHECK ____ FIELD INSPECTION ____

FINAL FILE REVIEW ____ FINAL DATA BASE ENTRY ____

ENTER ON PLAT CARDS ____

C:\WP51\SWR\CHCKLIST.1

7-30-92

Oregon

WATER
RESOURCES
DEPARTMENT

January 15, 1993

CITY OF SPRINGFIELD,OREGON
CITY MANAGERS OFFICE
255 FIFTH STREET
SPRINGFIELD OR 97477

Dear MR KELLY,

This will acknowledge that your Surface Water Registration Statement in the name of CITY OF SPRINGFIELD,OREGON has been received by our office. The fees in the amount of $7650.00 have been received and our receipt #95063 is enclosed. Your registration statement has been numbered SWR-131.

Our office will review your form and map in the near future. If necessary we will schedule a meeting with you that will include a site inspection. If there are problems with your form we are usually able to take care of them during our visit. We will be able to answer any questions you might have about the adjudication process at that time.

Please feel free to contact this office if you have any questions.

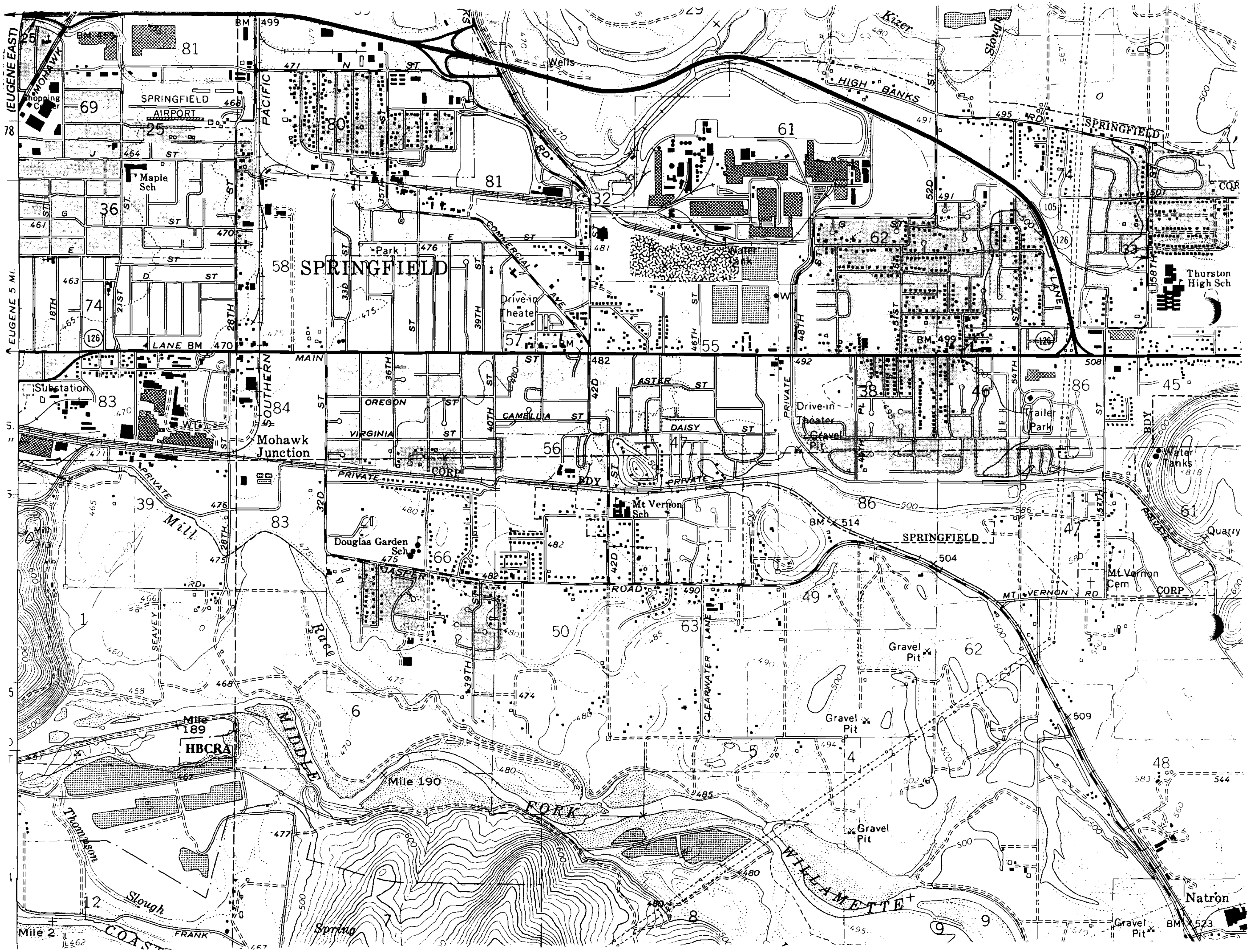
Sincerely,

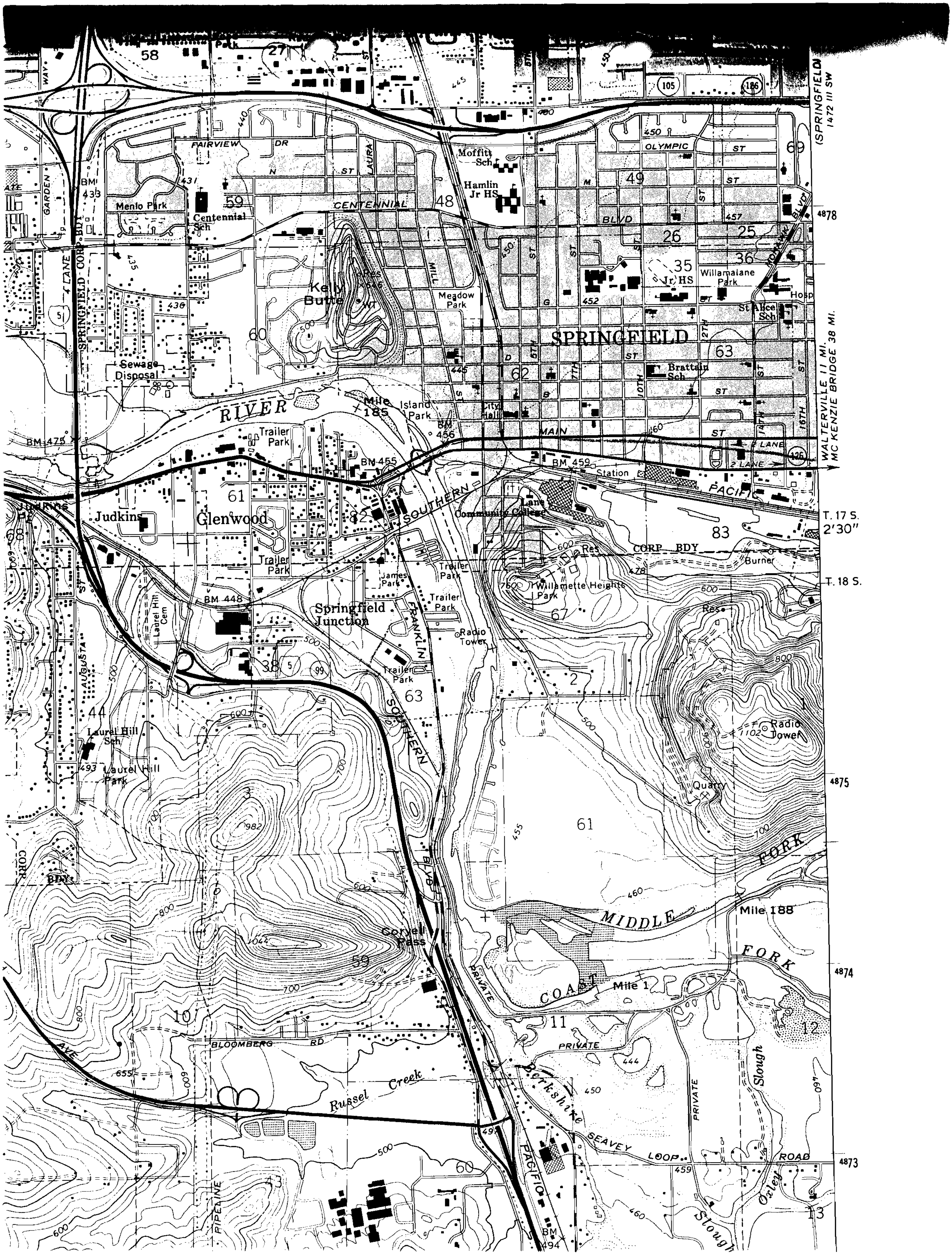
Don Knauer
Adjudication Specialist

Enclosure

C:\WP51\SWR\CLAIMANT\SWR-0131.001

3850 Portland Rd NE
Salem, OR 97310
(503) 378-3739
FAX (503) 378-8130


EUGENE EAST
MOHAWK
Shopping Center
SPRINGFIELD AIRPORT
Maple Sch
EUGENE 5 MI.
PACIFIC
SPRINGFIELD
Park
COMMERCIAL AVE
Drive-in Theater
MAIN
LANE
SOUTHERN
Substation
Mohawk Junction
OREGON
VIRGINIA
CAMELLIA
ASTER
DAISY
PRIVATE
CORP
BDY
Mt Vernon Sch
Douglas Garden Sch
JASPER
ROAD
CLEARWATER LANE
Mill
Race
SEAVEY
Wells
Kizer
Slough
HIGH BANKS
RD
Water Tank
Thurston High Sch
Trailer Park
Gravel Pit
Water Tanks
Quarry
MT VERNON RD
Mt Vernon Cem
SPRINGFIELD
Mile 189
HBCRA
Mile 190
MIDDLE
FORK
WILLAMETTE
Thompson
Slough
Mile 2
FRANK
COAST
Spring
Natron



(SPRINGFIELD)
1472 III SW
SPRINGFIELD
FAIRVIEW DR
OLYMPIC ST
CENTENNIAL BLVD
Moffitt Sch
Hamlin Jr HS
Menlo Park
Centennial Sch
Kelly Butte
Meadow Park
Jr HS
Willamalane Park
Hosp
St Alice Sch
Brattain Sch
City Hall
MAIN ST
Station
Sewage Disposal
RIVER
Mile 185
Island Park
Trailer Park
Judkins
Glenwood
SOUTHERN
PACIFIC
Lane Community College
CORP BDY
Burner
Willamette Heights Park
James Park
Springfield Junction
FRANKLIN
Radio Tower
Laurel Hill Cem
AUGUSTA
Laurel Hill Sch
Laurel Hill Park
Quarry
MIDDLE FORK
Mile 188
COAST
Mile 1
Coryell Pass
BLOOMBERG RD
Russel Creek
PRIVATE
Berkshire
SEAVEY LOOP ROAD
Slough
Oxley Slough
PIPELINE
WALTERVILLE 11 MI.
MC KENZIE BRIDGE 38 MI.
T. 17 S.
2'30"
T. 18 S.
4878
4875
4874
4873

STATE OF OREGON
WATER RESOURCES DEPARTMENT
3850 PORTLAND ROAD NE
SALEM, OR 97310
378-8455/378-8130 (FAX)

RECEIPT # 95063

RECEIVED FROM: City of Springfield
BY:

APPLICATION	
PERMIT	
TRANSFER	

CASH: [ ] CHECK: # [X] 24-201 OTHER: (IDENTIFY) [ ]

TOTAL REC'D $7650.00

01-00-0 WRD MISC CASH ACCT

842.010	ADJUDICATIONS		$ 7650.00
831.087	PUBLICATIONS/MAPS		$
830.650	PARKING FEES Name/month		$
	OTHER: (IDENTIFY)		$

02-00-0 FEDERAL FUNDS

	OTHER: (IDENTIFY)		$

03-00-0 WRD OPERATING ACCT

MISCELLANEOUS:

840.001	COPY FEES		$
850.200	RESEARCH FEES		$
880.109	MISC REVENUE: (IDENTIFY)		$
520.000	OTHER (P-6): (IDENTIFY)		$

	WATER RIGHTS:	EXAM FEE		RECORD FEE
842.001	SURFACE WATER	$	842.002	$
842.003	GROUND WATER	$	842.004	$
842.005	TRANSFER	$	842.006	$
	WELL CONSTRUCTION	EXAM FEE		LICENSE FEE
842.022	WELL DRILL CONSTRUCTOR	$	842.023	$
842.016	WELL DRILL OPERATOR	$	842.019	$
	LANDOWNER'S PERMIT		842.024	$

06-00-0 WELL CONST START FEE

842.013	WELL CONST START FEE	$	CARD #	
	MONITORING WELLS	$	CARD #	

45-00-0 LOTTERY PROCEEDS

864.000	LOTTERY PROCEEDS	$

07-00-0 HYDRO ACTIVITY

		LIC NUMBER	
842.011	POWER LICENSE FEE(FW/WRD)		$
842.115	HYDRO LICENSE FEE(FW/WRD)		$
	HYDRO APPLICATION		$

RECEIPT # 95063 DATED: 12/16/92 BY: C. Engel

Distribution—White Copy-Customer, Yellow Copy-Fiscal, Copy-Fiscal

CITY OF SPRINGFIELD, OREGON

SPRINGFIELD

PUBLIC WORKS DEPARTMENT
MAINTENANCE

EDWARD BLACK
MAINTENANCE MANAGER

JOHN SEADERS, PE
OWNER/CONSULTANT
ENGINEERING AND DESIGN BY:
MSS Inc

SUB

SPRINGFIELD UTILITY BOARD

BART McKEE
TECHNICIAN, WATER DEPARTMENT

(503) 746-8451
202 SOUTH 18TH STREET, SPRINGFIELD, OREGON 97477

1/2

SPRINGFIELD, CITY
NOV 3, 1992

DAN KRAMER

JERE WEBB
ED BLACK - CITY
JOHN SEADERS - ENG
BART McKEE - UTILITY BOARD

REVIEWED PRELIMINARY MAP & FORM
SUGGESTED ADDING INFO DESCRIBING CONTROL
STRUCTURE AT DIV PT & SIZE FOR CAPACITY

TY PARSONS = CURE

TALKED ABOUT JUNIOR WATER RIGHTS = ARE NOT
INCLUDED IN PRE 1909 CLAIM

MILLRACE MAX CAPACITY = 300 cfs ±

THEY WILL FILE ON 150 cfs = $7650 FEES

TALKED ABOUT MUNICIPAL USE AND PROJECTED NEEDS.
MUNICIPAL FUTURE USE - OK

TALKED ABOUT [illegible] FILING REQUIREMENTS
MAP - FORM - FEES

CITY OF SPRINGFIELD NOV 3, 1992 2/2

JUDGE MIGHT BE HESITANT TO GIVE EVIDENCE WHICH WOULD GIVE CONTESTORS ADVANTAGE

TALKED ABOUT INTENT & DUE DILIGENCE

WHILE REED MARBUT WAS AT MEETING TALKED ABOUT NEW FILING NATURAL FLOW & STORED WATER & USBR project WATER

Final Report

and

Ogden Beeman & Assoc. Inc

Springfield Millrace

Hydrologic Study and Alternatives Evaluation

prepared for

SPRINGFIELD

REGISTERED PROFESSIONAL ENGINEER
13266
OREGON
JULY 17, 1986
JOHN M. HOULE
12-31-96

submitted by

Otak, Inc.
17355 SW Boones Ferry Rd.
Lake Oswego, Oregon 97035

June 15, 1995

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Evaluation of Alternatives— Section III

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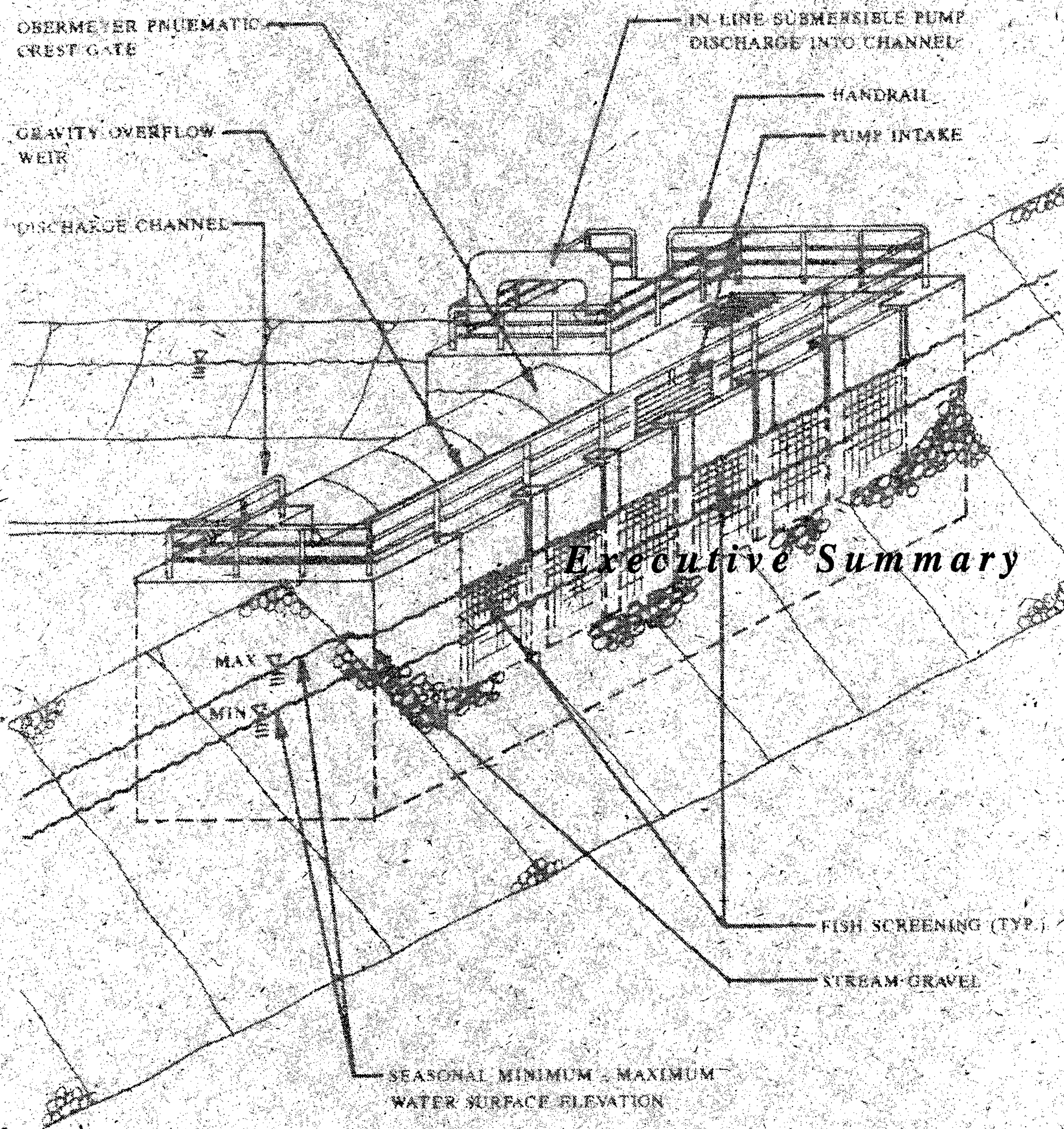
Appendix B

Appendix C



Executive Summary

Executive Summary

Introduction

The Springfield Millrace, a man-made waterway located near Springfield, Oregon, meanders through natural scenic and rural industrial areas. The Millrace consists of an inlet on the Middle Fork of the Willamette River, a 3.5 mile long canal, a 35-40 acre mill pond with a fish ladder, and an outlet about 0.5 miles long that re-enters the Middle Fork.

The Millrace was hand-dug in the mid 1800s and has served various purposes, including water supply for a grist mill, lumber production, irrigation, groundwater recharge, and other uses. Because of its natural setting, it has been studied by the National Park Service, and the City of Springfield has prepared a Millrace Concept Plan.

Current Uses of the Millrace

Currently, the Millrace is used for a variety of purposes. The City of Springfield's Millrace Concept Plan envisions multiple benefits to the community from improvements to the Millrace and surrounding area. Water from the Millrace is used for groundwater recharge, fire protection, irrigation and natural resources. The city has filed an application for a pre-1909 vested water right for 150cfs from the Middle Fork Willamette River for the Millrace flow.

The current operation of the Millrace inlet involves an awkward process of adjusting inflow by modifying the Millrace inlet channel and the north channel of the Middle Fork of the Willamette River. Annually, heavy equipment is used to construct a channel to divert water from the Middle Fork of the Willamette River into the Millrace because high water flows deposit gravel in the north channel, thus increasing the channel elevation. The increase in elevation results in reduced flows to the north channel and hence to the Millrace.

The use of heavy equipment to reconstruct the north channel and the inlet to the Millrace endangers fish habitat, including spawning areas downstream of the north channel. Current procedures include using heavy equipment and river gravel as needed to maintain flow into the Millrace for water supply and flood control purposes.

Objectives of the Present Study

The objectives of the present study are to identify and evaluate alternatives for a permanent inlet facility. The permanent facility would provide the necessary flows to the Millrace to achieve City of Springfield objectives for the Middle Fork and the Millrace Concept Plan while avoiding or minimizing impacts to natural resources, including water quality and fisheries and adjoining landowners.

Methods Utilized to Achieve the Objectives

The study process included consultation with the regulatory agencies (Corps of Engineers and Oregon Division of State Lands), resource agencies (U.S. Fish and Wildlife Service, National Marine Fisheries Service, and Oregon Department of Fish and Wildlife), adjoining landowners at the Millrace inlet, and public meetings to discuss the study. Field reviews were also made when the public meetings occurred and with the regulatory and resource agencies.

Field surveys and analyses were conducted to provide basic information about historic and existing conditions. These included evaluations of bedload size and historic changes in the channel based on historic aerial photographs; hydrographic survey data were collected to evaluate elevations of the river channel in the vicinity of the Millrace inlet; hydraulic modeling of various flow conditions in the existing and proposed channel systems was conducted; and fisheries information was reviewed to evaluate species present and screening criteria for intakes.

Alternatives Identified

The present study considered several alternatives, including:

Alternative 1 — Move the Millrace Intake Upstream to the Area of the Clearwater Boat Ramp

Alternative 2 — Provide a Ground Water Source for the Millrace

Alternative 3 — Continue Present Practices

Alternative 4 — Pump Water from Middle Fork of the Willamette River

Alternative 5 — Reduce Impacts by using a Sauerman Dragline to Remove Gravel from the Millrace and North Channel

Evaluation of Alternatives

Alternative 1
Move Intake Upstream to Vicinity of ClearwaterBoat Ramp

Description

The Millrace inlet would be relocated to a site near the existing boat ramp at Clearwater Park, near an old natural channel meander of the Middle Fork. Flood control gates, a pump and fish screening facilities would be constructed at a point just downstream from the boat ramp.

This alternative will accomplish the following:

1. Provide a stable inlet location.
2. Allow gravity flow of approximately 60 cfs or greater for approximately 81 percent of the time. Allow gravity flow of approximately 150 cfs or greater for approximately 45 percent of the time. It may be possible to increase this figure to approximately 95 percent by modifying the design, but further data is needed to assure that this modification is feasible.
3. Provide the means of pumping water, as needed, at the lowest ongoing cost.
4. Provide automatic flow control throughout the year.
5. Provide flood protection for up to approximately the 25-year event.
6. Include a fish protection screen to prevent fish from entering the Millrace.

Estimated Cost

The total annualized cost for Alternative No 1 was estimated, using a 50-year design life and a 50-year amortization period at five percent simple annual interest. Cost estimates were prepared for a 150 cfs capacity facility and a smaller 60 cfs facility. These hydraulic capacities represent the high and low limits of the water rights the City of Springfield anticipates eventually receiving from the Oregon Water Resources Department under the pre-1909 vested water rights criteria. Estimated costs for 150 and 60 cfs facilities are shown:

150 cfs Facility

All construction, materials and equipment	$1,200,000
Annual pumping costs	$9,880
Annual Maintenance	$10,000
Equivalent annualized cost	$85,800

60 cfs Facility

All construction, materials and equipment	$681,000
Annual pumping costs	$300
Annual Maintenance	$10,000
Equivalent annualized cost	$47,600

Alternative 1 is the recommended alternative for the following reasons:

1. This alternative is a long-term solution.
2. The boat ramp location is the most stable site on the channel in this general vicinity, and appears to be least vulnerable to being left "high and dry" should additional channel movement on the Middle Fork Willamette River occur.
3. Moving the inlet upstream maximizes use of the available hydraulic head to drive water into the Millrace.
4. The facility can be constructed in stages, allowing additional time to further evaluate future needs.

Alternative 2
Ground Water Source — Ranney Well

Provide supplemental flow into the Millrace by installing a Ranney well near the river. A Ranney well is designed to draw water downward through river bed gravels into a series of horizontal well shafts. This alternative would require the water to be pumped a distance of approximately 800 feet. This well would only be used when the natural flow of the river could not supply adequate flow into the Millrace by the existing channel.

Alternative 2 is more costly than Alternative 1 and fails to address the problem of the north channel gradually silting in over time. This alternative also provides less water during the driest times of year, since it is not feasible to construct a single Ranney well with a capacity greater than approximately 20 cfs. Additional wells would make the cost prohibitive.

Alternative 3
Continue Present Practices

This alternative was considered for comparison purposes only, as it is clear that a change in current operating practices will become mandatory in the near future.

Alternative 4
Pump Water from the Middle Fork

During times of low flow in the Middle Fork of the Willamette River, water would be pumped from the river through a temporary pipe a distance of approximately 1,200 feet to the Millrace inlet. A temporary berm near the location of the present berm would be needed to prevent pumped water from flowing back into the north channel.

Alternative 4 is not feasible because of costs associated with fish screening to prevent damage to fish during pumping operations.

Alternative 5
Reduce In-water Impacts by using a Sauerman Dragline

Leave the north channel of the Middle Fork of the Willamette River in its present condition and continue operating the inlet structure as it is presently being operated. When gravel deposits accumulate to the point where channel maintenance is required, install a Sauerman dragline across the river instead of operating heavy equipment directly in the north channel.

This alternative may be feasible as a temporary measure. However, serious permitting issues must be resolved before it can by executed.

Recommendations

1. This plan should be adopted as a guidance document supportive of the Millrace Concept Plan.

2. Alternative 1, movement of the Millrace inlet upstream to near Clearwater Park, is the recommended alternative. Development of detailed design documents for this alternative should proceed as soon as funding can be provided.

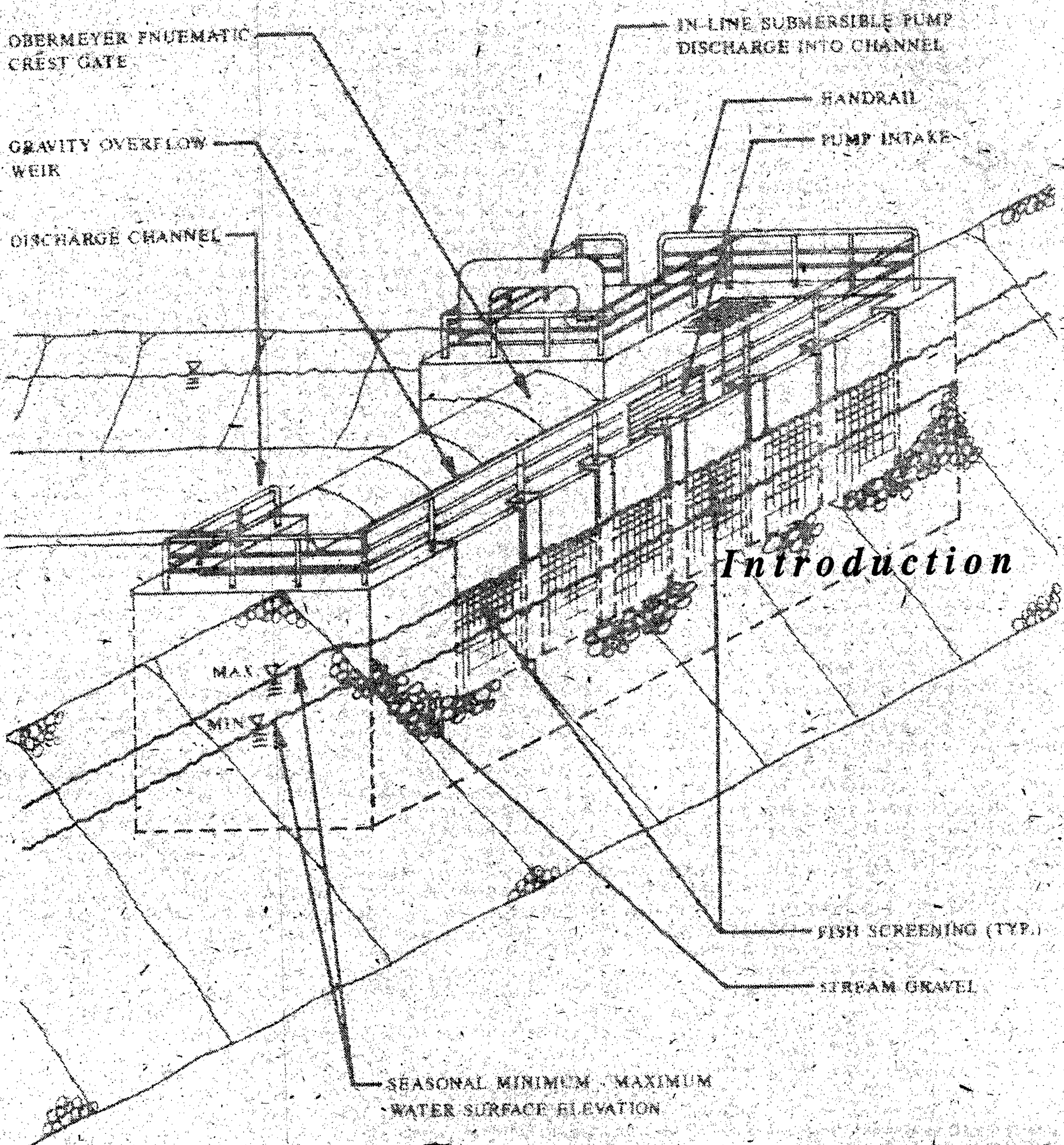
3. A through understanding of water availability and water use in the Millrace needs to be developed. It is recommended that a water balance for the Millrace be prepared as part of the design of the recommended alternative.

4. Conduct studies to define the habitat conditions in the Millrace that relate to the necessity for fish screening at the Millrace intake and fish barriers at the tailrace of the Millrace.

5. Explore with ODFW the possibility of an instream water right on the Millrace for fisheries and water quality purposes. This water right would be over and above the pre-1909 vested water right for which the city has already applied.

6. Implement a water quality monitoring program to evaluate changes in water quality as water passes through the Millrace as it relates to passage of fish and fish screening.

7. Continue dialogue with Oregon Water Resources Department regarding the adjudication of the city's application for a pre-1909 vested water right.



Introduction

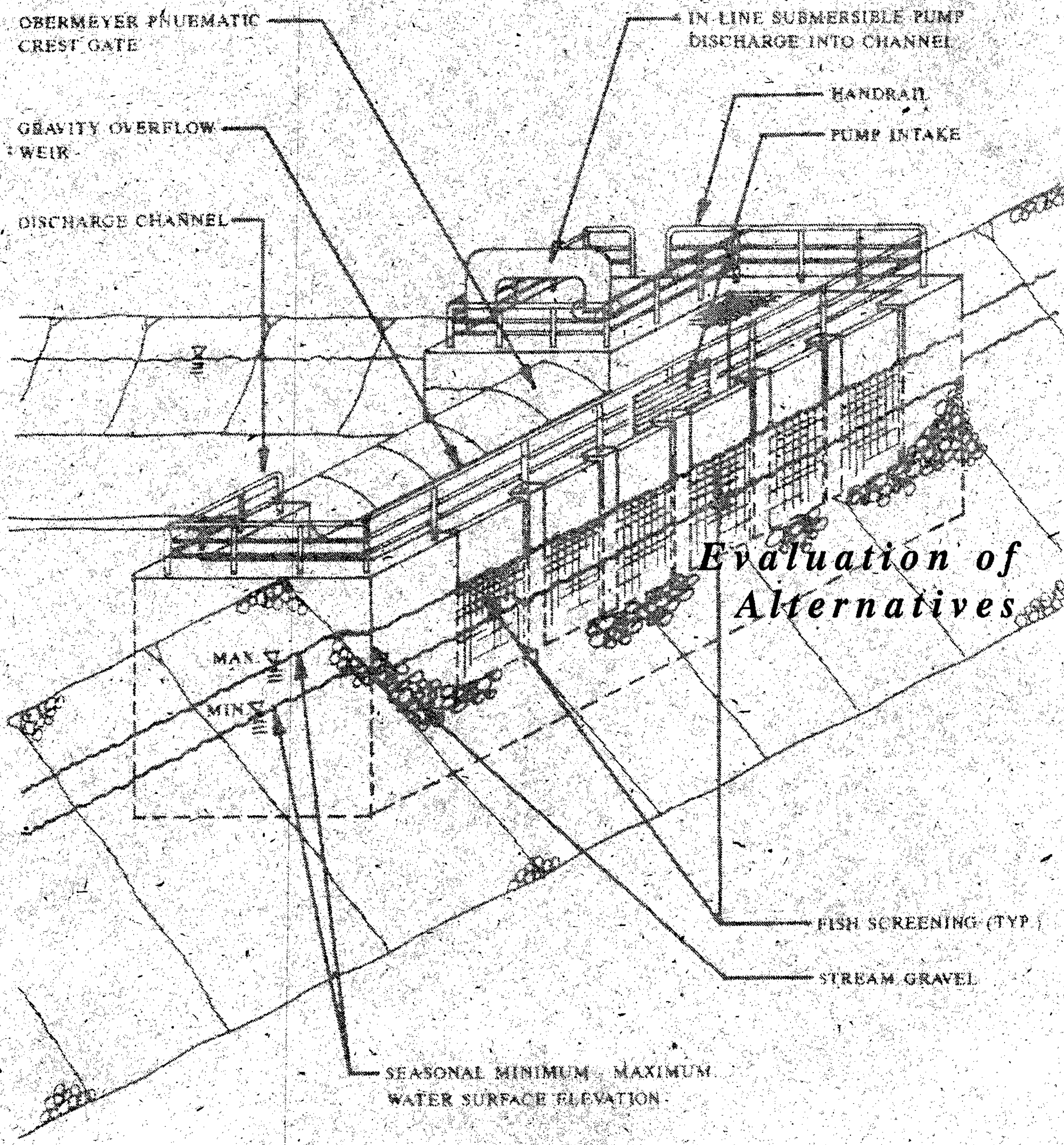
Introduction

The Springfield Millrace, a man-made waterway, was originally constructed in 1852 by Elias and Issac Briggs in order to divert water from the Middle Fork Willamette River for operation of a flour mill and sawmill. The Millrace was donated to the City of Springfield in 1985 by then owner, Georgia-Pacific Corporation. A major condition of the donation calls for the city to continue operation and maintenance of the Millrace for flood control purposes and to provide water supply to the Springfield Forest Products Company mill adjacent to the mill pond (fire protection and process water), the Springfield Utility Board wellfield (municipal water supply), and for various water right holders along the waterway.

The City of Springfield has carried out its water management responsibilities for the Millrace by continuing the same basic management techniques that were formerly used by Georgia Pacific Corporation. These techniques require the operation of heavy equipment in the north channel of the Middle Fork Willamette River and at the mouth of the Millrace channel. The city is required to apply for an annual removal-fill permit from the Oregon Division of State Lands and a Section 404 permit from the U.S. Army Corps of Engineers for this in-water work. The permit generally allows work in the river only during a six-week period beginning on or about July 16th. Each year, the permit contains a comment that the applicant (City of Springfield) needs to develop a more permanent method of flow control for the Millrace which will cause less streambed disturbance and associated water quality and fishery habitat impacts.

Otak was retained by the City of Springfield to conduct a study of the hydrologic, hydraulic, sediment transport and fisheries issues of the Middle Fork Willamette River at the Springfield Millrace diversion point. Otak's scope of work also included an evaluation of possible alternative solutions that respond to both the physical realities of the Millrace and the concerns of regulatory agencies.

This report presents the results of this study and also includes a recommended course of action for preserving the Springfield Millrace as an important municipal water and habitat resource.



Evaluation of Alternatives

Evaluation of Alternatives

Introduction

The Evaluation of Alternatives describes and compares the design options that were considered as possible means of addressing the need for an inlet control structure at the Millrace. The alternatives considered consist of two permanent alternatives, which include fish screens, and three temporary alternatives that assume fish screening will not be immediately required. For the sake of comparing full impacts, cost estimates for the two permanent alternatives without fish screens were also prepared.

As used in this cost analysis, "temporary" means five years or less duration. Alternative 1, relocating the inlet adjacent to the boat ramp, shows up clearly as the most realistic and also the least expensive[1] of the permanent alternatives. Several variations of Alternative 1 are also presented and evaluated.

Of the temporary alternatives, the least expensive is Alternative 5, the use of a Sauerman dragline to maintain the capacity of the north channel. This alternative has both the lowest capital cost and the lowest annualized cost of any of the alternatives. It is recommended for implementation only if funds necessary to begin construction of Alternative 1 are not available in time to meet the city's needs. The channel-construction portion of Alternative 1 could also be viewed as a temporary measure if planned as a first stage. This is the recommended temporary alternative because it feeds directly into a permanent solution.

Tables III-1 through III-6, at the end of this section, summarize the costs of each alternative. For most of the alternatives evaluated, cost estimates are given for two different conditions, the low end and the high end of the range of discharges that may be adjudicated in the ongoing water right application process. It is expected that the water right will be for at least 60 cubic feet per second (cfs) but it may be for as much as 150 cfs. Costs vary with discharge because pipe, pumps, fish screens, and gates can be sized smaller for a lower required flow

[1]Most of the high cost is related to fish screens and pumping requirements. It may be possible to eliminate both of these parts of Alternative 1 or to perform construction in stages to spread out the cost.

rate. Most of the cost difference between the two discharge rate assumptions are due to the cost of pumps and fish screens. In addition, differences in channel widths for the two discharge rates were also considered, but were not included on the cost summary tables because it would result in an "apples and oranges" comparison. For both discharge rates, costs for only one size for a channel (a 12-foot bottom and 3:1 side slopes) were included on the summary tables. A discussion of the costs and benefits of a wider or deeper channel is presented under Alternative 1, below.

Spreadsheets showing the annualized costs and how they were derived appear at the end of this section (Tables III-1 through III-6). Fish screens are clearly a major portion of the cost for either of the permanent alternatives. Since the elimination of the fish-screen requirement[2] is a real possibility, the cost picture was re-evaluated without the fish screens as well. Eliminating fish screens could reduce the capital cost of those alternatives requiring screening by $600,000 for the 150 cfs flow and by $250,000 for the 60 cfs flow.

Much of the technical basis for this evaluation was derived as described in Appendices B, C, and D, (Hydrology, Hydraulics, and Sediment Transport appendices of this report). Particularly valuable were Figures C-3 and C-5 from the Hydraulics appendix because they provide stage-discharge relationships for the Millrace and for the Main Channel of the river at the boat ramp. Both of these figures were developed by calibrating HEC-2 hydraulic models using field survey data which was obtained on August 11, 1994. These relationships, while expected to be reasonable, represent only one point in time and one set of flow conditions. They are subject to change as channel conditions change over time. The computer model was used to create the curve both above and below the known data point, but as with any modeling method, the limitations of the model must be kept in mind. The stage-discharge estimates for the Millrace itself were derived using a technically acceptable though approximate method. Since construction of a permanent gaging station in the Millrace is now planned, it will be important to check these curves against future data

[2]The fish screen requirement is tied to water quality problems in the Millrace. Improvement in water quality in the Millrace could therefore eliminate the need for fish screens.

that will be obtained from the gage. The gage data should be combined with field surveyed water surface data and evaluated to assure the accuracy of these stage-discharge relationships.

Alternative 1 — (Permanent)
Move Millrace Intake Upstream to Boat Ramp Area

Description

Relocate the inlet to a site near the existing boat ramp. A new channel, which will convey water into the 1950 channel meander, will be excavated. Flood control gates and fish screening facilities will be constructed. The general configuration of this Alternative is shown in Figure III-1. This is the recommended alternative.

Intake Construction

A gate structure would be constructed for this alternative as illustrated in Figure III-2. It will be located just downstream from the boat ramp. The purpose of the crest gate is to automatically regulate flow into the Millrace and prevent flood flows from entering. It would also prevent backflow when water is being pumped during low flow periods. It is recommended that small levees (about three feet high to an elevation of around 480 ft. msl) be constructed along the low areas of the river bank downstream of the boat ramp, as there are some locations where floods less than the 25-year event could pass over the island and into the Millrace. To provide flood protection for events larger than the 25-year flood would require extensive levees that are not part of this alternative and are not recommended at this time.

Just south of this gate structure, a fish screen will be constructed. The screen will be parallel to the flow of the river and will be set back away from the river enough to reduce the likelihood of damage from floating debris. The cost estimate for the fish screen (approximately $600,000) was based on the U.S. Bureau of Reclamation's (USBR) estimate for a recently designed 150 cfs screen. The USBR screen consists of six - 6 x 13.5 ft panels of 2 mm mesh screen and an automatic mechanical arm to periodically clean the screen. Although it may be possible to design lower cost screens, this does provide a rough estimate of the magnitude of the cost. Note that the flow analysis assumed that hydraulic head losses through the screen were negligible.

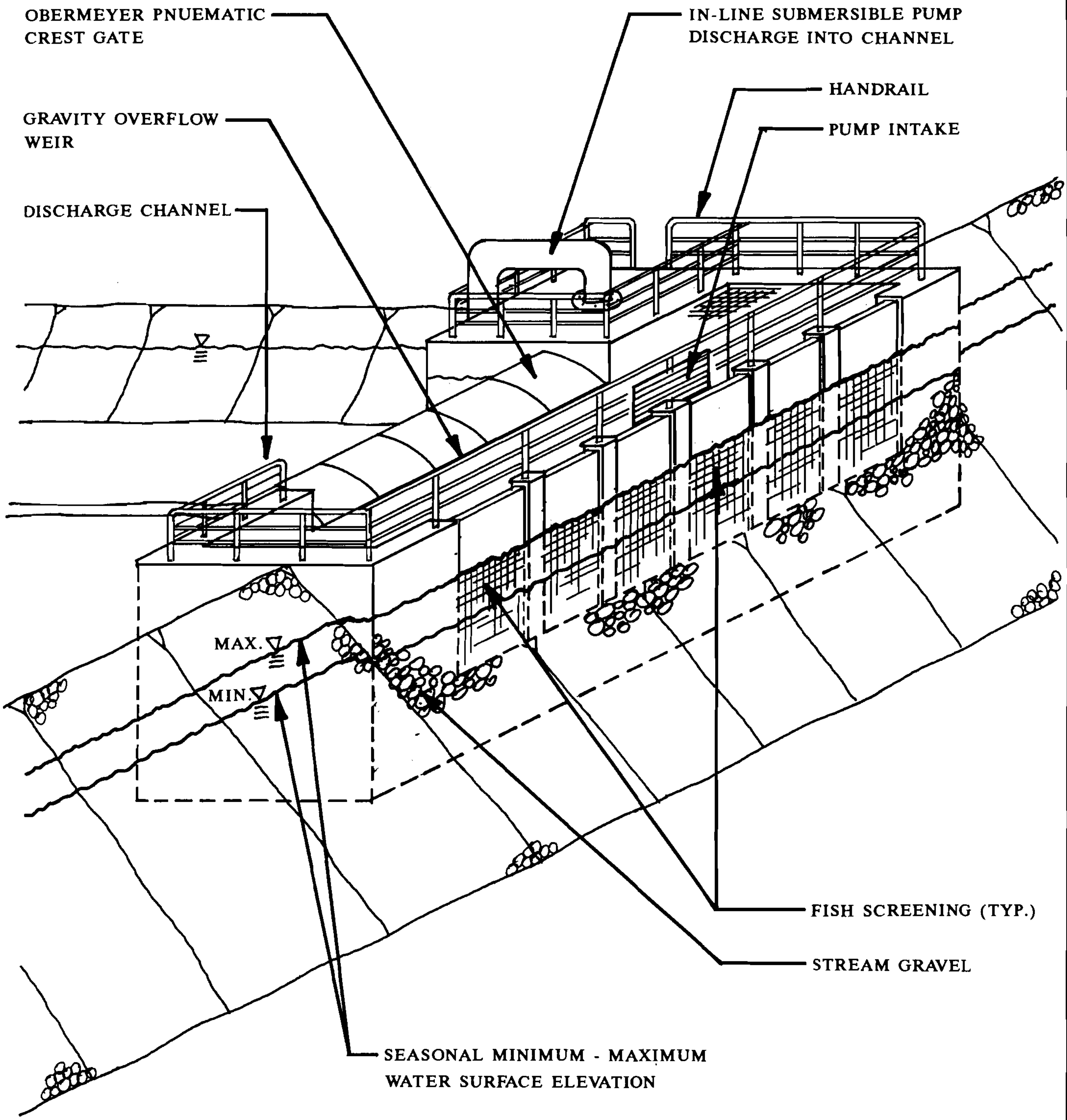


FIGURE III-2

SPRINGFIELD MILLRACE HYDROLOGIC STUDY AND ALTERNATIVES

ALTERNATIVE 1 - GATE AND INTAKE STRUCTURE (GRAVITY FLOW)

17355 SW Boones Ferry Rd.
Lake Oswego, OR 97035
Phone (503) 635-3618
Fax (503) 635-5395
otak
Architects Engineers Landscape Architects Planners Scientists Surveyors Urban Designers

A pump will be designed into the gate structure to provide supplemental water when low flow conditions on the main channel prevent full gravity flow into the Millrace. In the case of the 60 cfs flow rate, the pump may not be needed because a 60 cfs flow rate would be achieved 81 percent of all days without any pumping, and the lowest discharge that would be likely would be 18 cfs. If this occasional low flow can be tolerated, then a construction savings of over $60,000 would be made in addition to eliminating all power costs for pumping.

In the case of the 150 cfs diversion rate into the Millrace (should the city receive a 150 cfs pre-1909 vested water right), this flow rate could not be achieved more than about one-half of the time without supplemental pumping, unless dredging of the Millrace (not part of this proposal) makes it possible to lower the stage-discharge relationships as shown in Figure C-3. Supplemental pumping about one-half of the time at the 150 cfs inflow rate will be required because of the relationship of the water surface elevation in the Millrace flowing at 150 cfs and the river's water surface elevation at the boat ramp. According to the hydrologic investigation conducted as part of this study, approximately 55 percent of the time, the water surface elevation at the boat ramp will be less than 474.7 ft. msl as shown on the stage-discharge curve of Figure C-5. The stage-discharge curve of Figure C-3 shows that the 150 cfs flow rate in the Millrace corresponds to a water surface elevation in the Millrace of 473.7, for a drop of 1.0 ft from the river. This one-foot drop will provide a minimal hydraulic head for conveying water through the proposed 2,000-foot long inlet channel. Therefore, any elevation lower than 474.7 in the river will not allow gravity flow of 150 cfs into the Millrace, unless the Millrace stage-discharge curve can be lowered either by dredging the Millrace to a lower base elevation or removing flow obstructions in the channel. Lowering the proposed inlet channel would also help, but this would result in sedimentation problems unless the Millrace is also dredged to a lower base elevation.

Excavation and Earthmoving

A typical cross-section of the proposed channel is shown in Detail 'A' of Figure III-1. The upstream end of the channel would have an invert elevation of 471 ft. msl, while the lower end would be at 470 ft. Thus, the 2,000-foot long channel would have a slope of 0.05 percent. The channel above water line should be seeded and protected with a cocoamat fiber while vegetation is becoming established. Below waterline, a variety of channel stabilization methods are available, but for the purpose of estimating costs, a "Geoweb" cellular confinement system was assumed.

A total excavation volume of approximately 16,000 cubic yards of material is required for this alternative[3]. Approximately 9,200 yards of excavation will be needed to connect the river to the existing 1950 channel meander, while another 6,900 cubic yards of excavation is to create a channel through the peninsula between the meander and the Millrace [4]. Further dredging of a smaller, not yet accurately determined quantity will be required in the "slough" portion of the 1950 channel meander to create a uniform and adequately sized channel.

Some of the material from the peninsula excavation will be used to construct two dams, one to block off the old entrance to the Millrace and another to plug the entrance of the slough at the Millrace. These dams will also serve two additional project purposes: flood control and redirection of flow. Without the dams, water from the new channel would most likely flow into the north channel of the Middle Fork Willamette River. In addition, flood control needs dictate the need for small levees along the riverbank.

Possible Design Variations

Piping the water through the peninsula separating the slough and the Millrace instead of using an open cut:
An advantage of this variation would be that not as much vegetation would be disturbed as with the open cut channel. Disadvantages include: 1) increased excavation cost due to the need to remove and replace the soil; and 2) increased project cost due to the cost of pipe. To provide as much conveyance as with an open channel would be expensive because conveyance capacity must be provided when the

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[3]Based on topographic data furnished by the City of Springfield. Please note that this is not considered to be design level information, but is acceptable for order of magnitude cost estimates.

[4]For purposes of this report, it is assumed that all excavation will be in river gravels and cobbles. A geotechnical reconnaissance will be required to verify subsurface conditions during project final design.

water stage in the river is low. Doing this would require low and flat culverts. It would be necessary to provide approximately 35 square feet of flow area below the 2-foot flow depth. This option will also reduce the amount of available material for constructing the two dams to block off the slough and the Millrace, thus possibly costing more for earthmoving. This variation should be considered only if it is absolutely necessary to limit the impact on vegetation on the peninsula.

Piping water the entire distance from the inlet to the Millrace:
This variation on Alternative 1 would greatly increase both construction costs and annual pumping costs. The least expensive pipe that might be able to accomplish the job with minimal pumping cost would be 4-foot diameter high density polyethelene culvert pipe. To achieve a hydraulic capacity of 150 cfs, three of these pipes would be required in parallel. At approximately $68/ft this would cost $408,000 just for pipe. An additional $360,000 would be needed to install this pipe for a total cost of $760,000 just for the conveyance system. This would have to be compared to the $270,000 estimated for open channel construction. For the 60 cfs option, the cost for continuous pipe is comparable to the cost for the open channel. A single four-foot-diameter pipe would cost approximately $150,000 for the pipe plus an estimated $120,000 for excavation and installation. Thus, the total for the conveyance system is $270,000 for either open channel or the 60 cfs piped construction. The piped option would, however, be more expensive to operate because of additional pumping costs associated with the higher hydraulic losses in the pipe.

Eliminate the pump at the inlet:
This alternative should be considered seriously, at least as a temporary condition, if flows of less than 60 cfs can be tolerated for approximately 19 percent of the time during an average year. The minimum flow would be approximately 18 cfs during the lowest flow day likely each year on the Middle Fork Willamette River. If this variation is used, then it is recommended that the intake structure be designed to accommodate a pump, in case it is determined to be necessary in the future. If it proves necessary to convey the full 150 cfs, then this variation should not be considered as a temporary condition.

Increase the channel bottom width by 8 feet to a 20-foot width:
This possibility was evaluated to give some perspective on the benefits of widening the channel to reduce pumping costs - if 150 cfs is necessary in the Millrace. It is recommended that further efforts be made to optimize the channel width during the final design process, but this estimate provides some concept of the trade-offs. An 8-foot increase in channel width would cost approximately $148,000 more for excavation and would reduce pumping costs at 150 cfs by approximately $4,600 per year. The wider channel could also provide benefits under the 60 cfs flow condition. In this case, the benefit was viewed in terms of how frequently pumping would be required. Although a dramatic reduction in pumping frequency to only three percent of the time on average was projected, this estimate should be used with caution due to the sensitivity of the calculation to small changes in site conditions and assumptions.

Dredge the Millrace channel for a significant distance downstream of the point where the proposed channel joins the Millrace:
The invert of the Millrace channel at this point is now at an elevation of 470 feet msl. Any dredging that could be done in the Millrace to lower this elevation consistently downstream would enable the entire proposed channel to be lowered by an equivalent amount. This would increase the flow capacity of the proposed inlet channel. In addition, it may be possible to lower the stage-discharge curve of the Millrace by such dredging, which would further increase its capacity.[5] However, even neglecting this effect, a one-foot reduction in the channel bottom elevation, would increase the probable minimum gravity flow into the Millrace from 18 cfs to 48 cfs. One possible further variation would be to lower the inlet channel without doing the downstream dredging. This would have nearly as much beneficial effect on channel capacity, although if this were done, then sediment would accumulate at the confluence of the proposed inlet channel with the Millrace. Provisions for periodic removal of this sediment would then be necessary. This

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[5]As an additional beneficial effect, it is possible that if the stage-discharge curve were lowered enough by dredging the Millrace, that gravity flow for the 150 cfs discharge rate would become practical at the lower discharge rates. It should be noted here that there is significant variation in the depth and cross-section size of the Millrace, and that there may be a downstream constriction or obstruction that could be removed to lower this stage-discharge curve. Further survey data must be collected and evaluated to determine if this is possible.

variation, without considering any dredging or periodic sediment removal, would cost approximately $33,000 in additional excavation to lower the proposed channel by 1 foot. At the 150 cfs flow rate, some savings in pumping costs would thus be incurred, but the amount of the savings has not yet been determined. At the 60 cfs flow rate, similar to the channel widening option, there would also be a dramatic reduction in required pumping time to approximately three percent of the time on an average annual basis. Note, however that the same disclaimer as above applies.[6]

Advantages of Alternative 1

Alternative 1 is the preferred alternative for the following reasons:

1. It provides the greatest amount of hydraulic head for water to enter the Millrace, and therefore the highest possible discharge with the least amount of pumping.

2. It provides the best maintenance access to the inlet structure without constructing any new roadways.

3. It can be constructed in stages; initially providing the benefit of improved water supply, then later being expanded to include fish screens, pumping capability and flood control.

4. While Alternative 1 is the most costly alternative, it is the only one that is likely to meet all of the Millrace operational objectives over the long-term. While other inlet locations are possible, the boat ramp location for the inlet is the location where the channel is most likely to be stable for the long-term. With increasing distance downstream, the channel becomes wider and shallower and therefore, more likely to shift. The original inlet site is almost certain to either become filled with gravel or to become deprived of water as the main channel of

[6] All projections of pumping frequencies and flow rates, are only as good as the available data. They are also subject to considerable change as bed material moves and changes the stage-discharge relationships in the channel. Before committing major funding to a project, it is therefore essential to collect more water surface elevation data at Clearwater Park that can be correlated with data from the Jasper gage and similar data taken in the Millrace itself using the proposed flow gage there.

the river continues to cut down at the head of the island. Locating the intake near the boat ramp also provides easy access for maintenance vehicles, and electric power for pumping is available there.

Disadvantages of Alternative 1

1. High cost.

2. Purchase of property or easements would be required.

3. Relatively high impact to vegetation where excavations are made for the inlet channel.

4. The north channel would be likely to fill in with river gravel over time due to a discontinuation of dredging operations.

Alternative 2 — (Permanent) Supplemental Ranney Wells Watersource

Description

Conventional wells were considered as a possible means of supplementing the flow in the Millrace. This concept was rejected because the experience of the Springfield Utility Board (SUB) in the area indicates that it is impractical. The nearby sub-well field of 13 wells produces only 6,000 gallons per minute (gpm). This is 13 cubic feet per second (cfs) compared to the minimum desired flow of 50 to 60 cfs. However, the use of one Ranney well, if the site proves to be feasible, could potentially produce as much as 9,000 gpm or 20 cfs.

Ranney wells are generally used for municipal water supply, but may also be applicable to supplementing the needs of the Springfield Millrace. They are constructed by sinking a cassion (a large diameter well casing) to a depth usually 30 to 40 feet below the bottom of an adjacent river channel. A series of horizontal radial borings are then made into the river gravel. Well screens are installed in these borings, and they draw water from the river by gravity as it filters through the gravel. This is generally considered a surface water source for the purpose of water rights, although some groundwater regulations may still apply, depending on the specifics of the installation.

Although two different possibilities were initially considered for the use of Ranney wells, only one of these was analyzed in detail; the use of a single Ranney well to supplement flow in the Millrace during the lowest flow portion of the year. The other rejected alternative was to provide all of the required flow using a series of Ranney wells. This was rejected because it is impractical to provide that much capacity, and even if it were done, year-round pumping costs would be prohibitive. For this reason, a detailed cost estimate for this later alternative was not prepared. As a supplemental source of water during dry times of year, Ranney wells would also be expensive, and would not be cost-competitive with Alternative 1. A rough sketch of the proposed configuration is shown in Figure III-3. This would still require a fish screen and a gate structure at the present Millrace inlet. Pumping costs would be higher than in Alternative 1 because of the added need to pump against the draw down in the well.

Advantages of Alternative 2

1. The Millrace inlet would not need to be relocated.

2. Less excavation for channel construction and therefore lower impact on the environment compared to Alternative 1.

3. No fish screens would be required for the supplemental pumped flow, although fish screening may still be required at the main millrace inlet.

4. This alternative could be implemented as a phased construction, by constructing only the well and pipe facilities first, then later adding in a control gate structure for flood control and the fish screen.

Disadvantages of Alternative 2

1. This alternative does not address the problem of the north channel eventually filling in over time unless it is combined with Alternative 5 (Sauerman dragline) to keep the channel clear.

2. Pumping costs and construction costs are both very high compared to Alternative 1.

3. As analyzed, this alternative would only provide approximately 20 cfs of water during the driest time of year. Thus, it is not even equivalent to the 60 cfs option for Alternative 1. Yet it is considerably more costly.

4. Purchase of property or easements would be required,

5. More than one Ranney well installation may be required even if only for supplemental water.

6. Access to the site for the control gate structure and fish screens would not be as convenient as with Alternative 1.

Alternative 3 — (Temporary) Continue Present Practice

Description

Continue the present practice of operating heavy equipment in the north channel during a six week summer permitted maintenance "window" to enhance the flow of water into the Millrace. The annual costs for continuing these practices is estimated to be $6,000. No detailed cost summary was prepared for this alternative.

Advantages of Alternative 3

1. No additional construction is required.

2. Relatively low cost.

Disadvantages of Alternative 3

1. Flood control is not as reliable as it would be with a gate structure in place.

2. This alternative does not address the problem of the north channel filling in over time.

3. This alternative provides no means of preventing fish from entering the Millrace.

4. This alternative does not satisfy the requirement of the current DSL permit that a permanent solution be constructed, and it may not be possible to continue to obtain annual permits in the future.

Alternative 4 — (Temporary)
Temporary Pumping from the Middle Fork Willamette River into the Millrace

Description

At a point approximately 900 ft. upstream from the present Millrace inlet, a small swale provides a relatively easy path to connect a temporary piping system from the north bank of the river to the Millrace inlet. This is the same location as that shown on Figure C-1 for the north end of cross-section 120.61. This alternative would involve the temporary installation of a pump at this location and approximately 1,100 feet of temporary pipe line that would discharge into the Millrace, as shown in the conceptual sketch, Figure III-4.

One possible variation of this alternative would be to only pump water across about 100 feet of the river bank into the 1950 river meander. From this point, it would gravity flow to the slough. This variation runs into problems because it would require two gravel dams in the north channel in order to prevent the water from flowing back into the river before getting into the Millrace.

One major problem with this alternative is that the pump intake could have to be equipped with a fish screen, which would be expensive to install and difficult to maintain. One possible solution would be to build an infiltration gallery using porous riverbed material as described below under "Other Alternatives Considered". This concept would most likely require extensive prototype testing before it could be approved by the Oregon Department of Fish and Wildlife and the National Marine Fisheries Service.

Advantages of Alternative 4

1. Relatively low construction cost compared to other alternatives.

2. Only a minimal amount of excavation would be required for pump and pipeline installation, although it may be necessary to place portions of the culvert pipes underground.

Disadvantages of Alternative 4

1. As conceived, this alternative would still require heavy equipment operation in the Millrace channel similar to current practices. The possibility of constructing a permanent inlet structure and gate at the present Millrace inlet was not considered as part of this alternative because such a structure would have only temporary value since continued channel movement and sedimentation processes with no corrective dredging will ultimately isolate the existing inlet. Since flow control gates are impractical for this alternative, flow control would have to be accomplished by moving gravel around within the channel to plug and unplug the millrace similarly to the present method. A gravel plug near the downstream end of the temporary pipe would have to be constructed whenever pumping would be required. The plug would be essential to prevent the pumped water from flowing back into the north channel of the river.

2. There may not be a practical way to effectively provide temporary fish screens. Since fish screens are very expensive to build and install, it may be impractical to build and install temporary fish screens that meet regulatory agency criteria at this site or to temporarily install the permanent screens here, only to remove them later and re-install them at their permanent location.

3. The river channel at this site is not stable, and channel depths are only a couple of feet deep. Upstream at the boat ramp, the river bank is considerably more stable and the river bottom is approximately five feet deeper.

Alternative 5 — (Temporary) Sauerman Dragline

Description

Leave the north channel of the Middle Fork Willamette River mostly as it now exists and continue annual dredging operations. However, instead of operating heavy equipment directly in the river channel, install a Sauerman dragline across the river as illustrated in Figure III-5.

The cost estimate for this alternative was obtained from Larry Ramsey of Centralia, Washington, who installs Sauerman draglines throughout Oregon and Washington. He estimates $15,000 for installation and operation including a deadman anchor at the opposite shore of the Middle Fork Willamette River for anchoring the dragline. In addition, it may be necessary to provide a spar-pole on the south bank as well to prevent the line from being carried downstream by the river. Since the rigging would have to be removed after every use, the entire cost, except for the installation of the deadman, would be incurred every time the Sauerman dragline is mobilized and used. It is anticipated that the equipment would be used twice per year. The total estimated annualized cost for a five-year life would then be $33,600 as shown in Table III-6.

The length of this dragline installation would be approximately 1,100 ft. It would not require any support in the center, but it may require an elevated anchor on the south side of the river.

Advantages of Alternative 5

1. Reduced likelihood of pollution from operating heavy equipment in the river channel.

2. Low capital cost for construction.

3. More localized disturbance of river gravel because of the relatively narrow swath of the dragline bucket.

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Disadvantages of Alternative 5

1. The gravel dam and culverts would still have to be installed annually at the Millrace entrance as is currently being done to prevent excessive flood discharge from entering the Millrace. Although it would be possible to construct a control gate structure for flood control at the inlet to the Millrace, this provides little long-term advantage, as this is assumed to be a temporary solution for approximately five years. Constructing a control gate structure at the Millrace inlet that was not part of a comprehensive permanent solution would be a poor expenditure of public funds.

2. Flood control with this alternative is not as reliable as it would be with a control gate structure in place.

3. This alternative includes no provisions for preventing fish from entering the Millrace.

4. Some disturbance of river gravels and associated water toxicity would continue to be experienced with this alternative.

5. There is no certainty that regulatory agency approval for this alternative could be obtained.

Other Alternatives Considered

In addition to the alternatives discussed previously, the following additional alternatives were also considered, but were rejected for the reasons discussed. These additional alternatives are described here to show that all potentially feasible possibilities were considered. It is possible that variations of these ideas may become feasible in the future as technology and economics evolve, or that some of their elements might be combined to form a more feasible alternative.

Infiltration Pipes

<u>Description</u>
In its most developed form, this alternative would eliminate the need for a fish screen by installing a series of perforated pipes in the gravel bed of the north channel of the Middle Fork Willamette River. A full-time pumping plant would move collected water into the Millrace.

<u>Reasons for Rejection</u>
Excessive pumping costs. Also, in the future the north channel may be left high and dry during the summertime as headcutting and channel shifting continues in the main channel. Without a reasonable flow of surface water to the north channel, it would not be possible to provide even the 60 cfs flow rate by pumping from the infiltration pipes.

Ranney Wells as Primary Water Source

<u>Description</u>
A Ranney well is similar to an infiltration pipe system except that the infiltration pipes or well screens are installed radially from the bottom of a cassion that is sunk into a water bearing layer adjacent to a river. In part, the purpose of the well would be to eliminate the need for fish screens. A series of Ranney type wells would have to be constructed along the north bank of the Middle Fork Willamette River downstream from the existing county boat ramp in order to provide needed flow into the Millrace.

<u>Reasons for Rejection</u>
While Ranney wells, due to their greater depth, would probably provide water more dependably than the shallow infiltration pipes as discussed previously, a single Ranney well is not capable of providing the high rates of flow that are required here. Based on an assumed yield of between 2,000 gpm and 5,000 gpm that is common for such wells, between 5 and 11 wells would be needed to supply only 60 cfs to the Millrace. Also, even if enough Ranney wells could be constructed to provide the required flow, they would have to be pumped continuously at great expense to maintain the needed flow into the Millrace.

Infiltration Gallery

<u>Description</u>
This concept was developed as an alternative to fish screens. It would work best as a temporary measure, and may still have some merit if temporary pumping, Alternative 4, is selected. With this alternative, a porous berm made of coarse river bed material would be constructed in the north channel of the Middle Fork Willamette River for the water to pass through before going into the Millrace. The berm would be constructed by excavating material from a length of the river bank (perhaps 200 to 300 feet) to an elevation of several feet below the

lowest expected water surface elevation in the river. It would be designed with enough area for flow through the porous media to assure that velocities through the gravel were low enough to avoid drawing fish into the porous berm.

Reason for Rejection
This concept may have some merit as a temporary intake system if permitting agencies would accept it. In the long-term, however, it runs into the problems of eventual plugging of the berm and increased pumping costs due to head losses as water passes through the berm at reduced rates.

Move Millrace Intake Downstream

Reason for Rejection
This alternative would incur excessive pumping costs because there is no place downstream that could provide gravity flow from the river to the Millrace. Also, there is no potential Millrace intake location downstream of the existing intake that has a reasonably stable channel history, free from excessive meandering. The relocation of the intake downstream could negatively impact public and private water use on the Millrace.

Low Dam on the Middle Fork Willamette River

Description
Build a low concrete diversion dam across the main channel of the Middle Fork of the Willamette about 200 feet downstream from the east end of the existing island that separates the north channel from the main channel. This dam would be made just high enough to raise the water in the river 2 to 3 feet; enough to allow flow into the Millrace during the lowest flow conditions in the river. In conjunction with this, another small diversion dam would have to be built on the north channel to prevent the diverted water from continuing down the north channel past the Millrace intake.

Reasons for Rejection
Although a small dam would, in theory, be able to direct water to the Millrace without any pumping, it would be nearly impossible to design a dam that could meet all regulatory agency conditions that would be placed on it. A small dam at this location would be subject to future river channel changes and meanderings. A single major flood event

could cause a new river meander to completely bypass the dam unless it was built very massively. It would also be subject to constant infilling with gravel from upstream bed material. Fish passage issues would most likely render this alternative unfeasible.

Recommendations

1. It is recommended that the City of Springfield proceed with design and construction of Alternative 1. This is the only feasible alternative that can be designed and constructed in a manner that will fully comply with regulatory agency requirements and enable the Springfield Millrace to continue to supply water users along the waterway.

2. Additional hydrographic survey data for the Millrace will need to be collected for final design purposes. This data will determine if the water surface elevation of the Millrace near its existing inlet can be lowered by downstream dredging. If this can be done, then the entire proposed new channel can be designed to a lower culvert elevation, which would provide significantly more flow with less frequent pumping. It is important that the new channel be designed at as low an invert elevation as reasonable without inviting excessive sedimentation by creating a channel bottom that is too flat. The lower the channel invert elevation, the more likely it will to be able to convey the desired flow rate without supplemental pumping.

   It would also be extremely helpful in the final design process to have access to stage discharge data from the proposed new gaging station. It is recommended that data be collected for a variety of different flow conditions. This would provide a more precise stage-discharge relationship for the Millrace.

3. Construct a new 2,000-foot-long water supply channel and inlet structure, including a flow-control gate, at the county boat ramp site. Include provisions in the inlet structure for a pump without initially installing it. Allow the channel to operate naturally for at least one irrigation season to determine how much supplemental pumping may be necessary. During this time period, collect data from the flow gauge and correlate it

with survey data of water surface elevations at both ends of the new channel taken at approximately the same time. Collect this data under a variety of different flow conditions, and use it to determine the type and size of pump needed, and to more accurately determine the operational needs of the system. Proceed with eventual pump installation if the actual operational studies confirm that it is cost effective to do so.

Table III-1 Cost Estimate: Alternative 1 - With Fish Screens Move Intake Upstream to Boat Ramp					
150 CFS			**60 CFS**		
Obermeir Gate (16' wide X 10' high)		$39,000	Obermeir Gate (10' wide X 10' high)		$24,000
Air Compressor		$2,000	Air Compressor		$2,000
Control System		$5,000	Control System		$5,000
Slab and Installation		$6,000	Slab and Installation		$3,700
	Subtotal	**$52,000**		**Subtotal**	**$34,700**
Pump - Flygt PL-7121-510		$139,000	Pump - Flygt PL-7081-705		$60,000
Bring in Power		$2,000	Bring in Power		$2,000
Structure, piping and installation		$4,000	Structure, piping and installation		$3,000
	Subtotal	**$145,000**		**Subtotal**	**$65,000**
Channel Construction (12 foot wide bottom; 3:1 ss)			Channel Construction (12 foot wide bottom; 3:1 ss)		
Land Acquisition			Land Acquisition		
	5 acres @ $2,500/ac	$12,500		5 acres @ $2,500/ac	$12,500
Excavation at inlet - 9,264 cu.yd.			Excavation at inlet - 9,264 cu.yd.		
	@ $15/yd	$138,960		@ $15/yd	$138,960
Excavation at peninsula - 6,875 cu. yd.			Excavation at peninsula - 6,875 cu. yd.		
	@ $15/yd	$103,125		@ $15/yd	$103,125
Dredging in slough			dredging in slough		
		$15,000			$15,000
	Subtotal	**$269,585**		**Subtotal**	**$269,585**
Fish Screen for 150 cfs		**$600,000**	Fish Screen for 60 cfs		**$250,000**
Construction Subtotal		$1,066,585	Construction Subtotal		$619,285
Engineering 10%		$106,659	Engineering 10%		$61,929
Grand Total - Construction		**$1,173,244**	**Grand Total - Construction**		**$681,214**
Annualized Construction costs			Annualized Construction costs		
50 years @ 5% interest		$64,294	50 years @ 5% interest		$37,330
Annual Pumping Costs		$9,880	Annual Pumping Costs		$300
Annual Maintenance		$10,000	Annual Maintenance		$10,000
Total Annualized Cost		**$84,174**	**Total Annualized Cost**		**$47,630**

Table III-2
Cost Estimate Alternative 1 - WITHOUT Fish Screens
Move Intake Upstream to Boat Ramp

150 CFS		60 CFS	
Obermeir Gate (16' wide X 10' high)	$39,000	Obermeir Gate (10' wide X 10' high)	$24,000
Air Compressor	$2,000	Air Compressor	$2,000
Control System	$5,000	Control System	$5,000
Slab and Installation	$6,000	Slab and Installation	$3,700
Subtotal	**$52,000**	**Subtotal**	**$34,700**
Pump - Flygt PL-7121-510	$139,000	Pump - Flygt PL-7081-705	$60,000
Bring in Power	$2,000	Bring in Power	$2,000
Structure, piping and installation	$4,000	Structure, piping and installation	$3,000
Subtotal	**$145,000**	**Subtotal**	**$65,000**
Channel Construction (12 foot wide bottom; 3:1 ss)		Channel Construction (12 foot wide bottom; 3:1 ss)	
Land Acquisition		Land Acquisition	
5 acres @ $2,500/ac	$12,500	5 acres @ $2,500/ac	$12,500
Excavation at inlet - 9,264 cu.yd.		Excavation at inlet - 9,264 cu.yd.	
@ $15/yd	$138,960	@ $15/yd	$138,960
Excavation at peninsula - 6,875 cu. yd.		Excavation at peninsula - 6,875 cu. yd.	
@ $15/yd	$103,125	@ $15/yd	$103,125
Dredging in slough		dredging in slough	
	$15,000		$15,000
Subtotal	**$269,585**	**Subtotal**	**$269,585**
Construction Subtotal	$466,585	Construction Subtotal	$369,285
Engineering 10%	$46,659	Engineering 10%	$36,929
Grand Total - Construction	**$513,244**	**Grand Total - Construction**	**$406,214**
Annualized Construction costs		Annualized Construction costs	
50 years @ 5% interest	$28,126	50 years @ 5% interest	$22,260
Annual Pumping Costs	$9,880	Annual Pumping Costs	$300
Annual Maintenance	$2,000	Annual Maintenance	$2,000
Total Annualized Cost	**$40,006**	**Total Annualized Cost**	**$24,560**

Table III-3

Cost Estimate: Alternative 1A - Piped - With Fish Screens

Move Intake Upstream to Boat Ramp & Pipe to Millrace

150 CFS		60 CFS	
Obermeir Gate (16' wide X 10' high)	$39,000	Obermeir Gate (10' wide X 10' high)	$24,000
Air Compressor	$2,000	Air Compressor	$2,000
Control System	$5,000	Control System	$5,000
Additional Valve & Concrete	$5,000	Additional Valve & Concrete	$3,000
Slab and Installation	$6,000	Slab and Installation	$3,700
Subtotal	**$57,000**	**Subtotal**	**$37,700**
Pump - Flygt PL-7121-510	$139,000	Pump - Flygt PL-7081-705	$60,000
Bring in Power	$2,000	Bring in Power	$2,000
Structure, piping and installation	$4,000	Structure, piping and installation	$3,000
Subtotal	**$145,000**	**Subtotal**	**$65,000**
Pipe Installation		Pipe Installation	
Easements		Easements	
2 acres @ $1,000/ac	$2,000	1.5 acres @ $1,000/ac	$1,500
Back-hoe Excavation: 8,900 cu-yd		Back-hoe Excavation: 4,800 cu-yd	
@ $40/yd	$358,000	@ $40/yd	$193,000
Pipe Cost:: 3 barrels 4' diameter "Spiral-Light"		Pipe Cost:: 1 barrel 4' diameter "Spiral-Light"	
6,000LF @ $68/ft	$408,000	2,000LF @ $68/ft	$136,000
Subtotal	**$768,000**	**Subtotal**	**$330,500**
Fish Screen for 150 cfs	$600,000	Fish Screen for 60 cfs	$250,000
Construction Subtotal	$1,570,000	Construction Subtotal	$683,200
Engineering 10%	$157,000	Engineering 10%	$68,320
Grand Total - Construction	**$1,727,000**	**Grand Total - Construction**	**$751,520**
Annualized Construction costs		Annualized Construction costs	
50 years @ 5% interest	$94,640	50 years @ 5% interest	$41,183
Annual Pumping Costs*	$8,815	Annual Pumping Costs *	$5,034
Annual Maintenance	$8,000	Annual Maintenance	$8,000
Total Annualized Cost	**$111,455**	**Total Annualized Cost**	**$54,217**

*Based on constant pumping against 1.4 ft head
May be lower if siphoning is possible

*Based on constant pumping against 2 ft head
May be lower if siphoning is possible

Table III-4
Cost Estimate: Alternative 2
Supplemental Flow with Ranney Well

150 CFS gravity flow 20 CFS minimum pumped flow			**60 CFS gravity flow 20 CFS minimum pumped flow**		
Obermeir Gate (10' wide X 10' high)		$39,000	Obermeir Gate (10' wide X 10' high)		$24,000
Air Compressor		$2,000	Air Compressor		$2,000
Control System		$5,000	Control System		$5,000
Slab and Installation		$6,000	Slab and Installation		$3,700
	Subtotal	**$52,000**		**Subtotal**	**$34,700**
Ranney Well - Install		$800,000	Ranney Well - Install		$800,000
	Subtotal	**$800,000**		**Subtotal**	**$800,000**
Construct 800 ft of pipeline for 20 cfs			Construct 800 ft of pipeline for 20 cfs		
800 ft @ $70/ft		$56,000	800 ft @ $70/ft		$56,000
	Subtotal	**$56,000**		**Subtotal**	**$56,000**
Fish Screen for 150 cfs		$600,000	Fish Screen for 60 cfs		$250,000
	Subtotal	**$600,000**		**Subtotal**	**$250,000**
Construction Subtotal		$1,508,000	Construction Subtotal		$1,140,700
Engineering 10%		$150,800	Engineering 10%		$114,070
Grand Total - Construction		**$1,658,800**	**Grand Total - Construction**		**$1,254,770**
Annualized Construction costs			Annualized Construction costs		
50 years @ 5% interest		$90,902	50 years @ 5% interest		$68,761
Annual Pumping Costs *		$3,000	Annual Pumping Costs *		$2,000
Annual Maintenance		$1,000	Annual Maintenance		$1,000
Total Annualized Cost		**$94,902**	**Total Annualized Cost**		**$71,761**

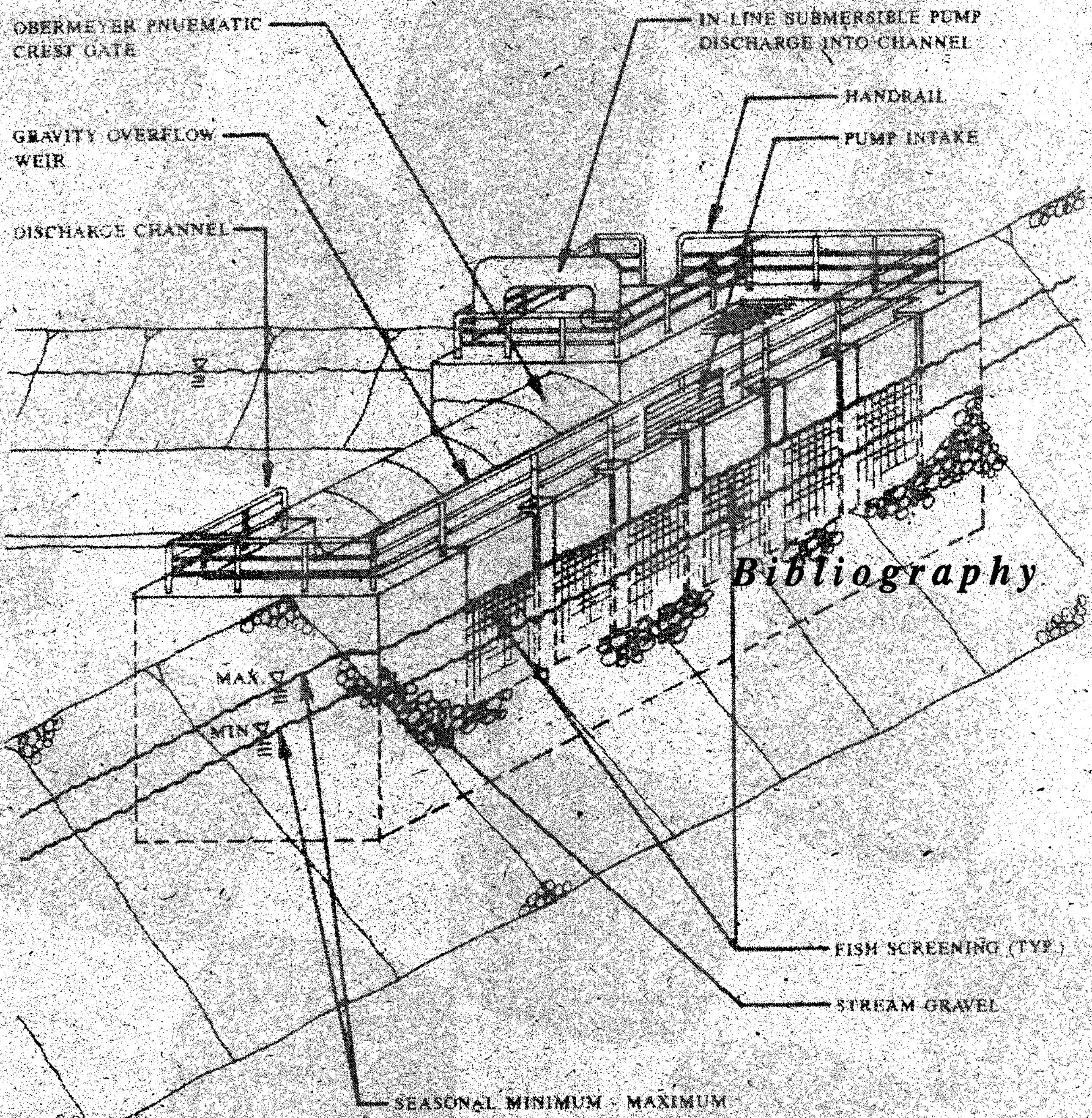
* These costs are a very rough estimate. Note, however, that regardless of pumping costs, this alternative cannot compete on cost with Alternative 1.

Table III-5
Cost Estimate: Alternative 4
Temporary Pumping

150 cfs		60 cfs	
Pump - Flygt PL-7121-510	$139,000	Pump - Flygt PL-7081-705	$60,000
Bring in Power	$2,000	Bring in Power	$2,000
Structure, piping and installation	$4,000	Structure, piping and installation	$3,000
Subtotal	**$145,000**	**Subtotal**	**$65,000**
Land Acquisition		Land Acquisition	
2 acres @ $2,500/ac	**$5,000**	2 acres @ $2,500/ac	**$5,000**
Temporary Fish Screening		Temporary Fish Screening	
Assume none		Assume none	
Spiral-Ribbed pipe		Spiral-Ribbed pipe	
1,200 lf @ $75.00/ft.	$90,000	1,200 lf @ $25.00/ft.	$30,000
pipe installation & removal	$5,000	pipe installation & removal	$3,000
Subtotal	**$95,000**	**Subtotal**	**$33,000**
Construction Subtotal	**$245,000**	Construction Subtotal	**$103,000**
Engineering + 10%	$24,500	Engineering + 10%	$10,300
Total Construction Costs	**$269,500**	**Total Construction Costs**	**$113,300**
Annualized Construction Costs		Annualized Construction Costs	
5-years @ 5%	$62,255	5-years @ 5%	$26,172
Annual Maintenance	$2,000	Annual Maintenance	$2,000
Annual pumping costs	$15,000	Annual pumping costs	$800
Total Annualized Cost	**$79,255**	**Total Annualized Cost**	**$28,972**

Table III-6
Cost Estimate - Alternative 5
Sauerman Dragline
Discharge Rate - Questionable

Install Dragline	$12,000
Install Spar Pole	$7,500
Install Deadman	$3,000
Total Construction Costs	$22,500
Annualized construction (5 years)	$5,198
Annual Maintenance (Install & Remove 2 times/year)	$26,000
Operator Salary (2 weeks @ $30/hr)	$2,400
Total Annualized Cost	**$33,598**



Bibliography

Bibliography

Brice, J.C., "Planform Properties of Meandering Rivers," River Meandering, Proceedings of the Conference of Rivers '83, New Orleans, Louisiana, 1983.

Graf, W.H., Hydraulics of Sediment Transport, Water Resources Publications, Littleton, Colorado, 1984.

Hydrologic Engineering Center, U.S. Army Corps of Engineers, HEC-2 Water Surface Profiles - User's Manual, HEC Center, Davis, California, 1990.

Klingeman, P.C., Indications of Streambed Degradation in the Willamette Valley, Water Resources Research Institute, Oregon State University, Corvallis, Oregon, 1973.

Klingeman, P.C., Willamette River Sediment Transport Investigation, Appendices on Bed Material Characteristics, Water Resources Research Institute, Oregon State University, Corvallis, Oregon, 1981.

Leopold, L.B., Wolman, M.G. and Miller, J.P., Fluvial Processes in Geomorphology, W.H. Freeman Co., San Francisco, California, 1964.

Lindeburg, Michael R., Civil Engineering Reference Manual, Professional Publications Inc., 1986

ODFW. 1992. Middle Fork Willamette River Subbasin Fish Management Plan. Oregon Department of Fish and Wildlife, Portland, Oregon.

ODFW. 1989a. Fish Screening Policies and Standards. Oregon Department of Fish and Wildlife, Habitat Conservation Division, Portland, Oregon.

ODFW. 1989b. Waterway Habitat Alteration Policies. Oregon Department of Fish and Wildlife, Habitat Conservation Division, Portland, Oregon.

NMFS. 1994. Juvenile Fish Screening Criteria. National Marine Fisheries Service, Environmental and Technical Services Division, Portland, Oregon.

Roberson, John, and Crowe, Clayton, Engineering Fluid Mechanics, Houghton Muffin Company, 1975

Simons, D.B., Senturk, F., Sediment Transport Technology, Water Resources Publications, Fort Collins, Colorado, 1977.

Slotta Engineering Associates, Inc., A Water Resource Assessment for the Springfield Millrace, 1990.

Steel, E. W. and McGhee, Terence J, Water Supply and Sewerage, McGraw-Hill Book Company, 1979

Thorne, C.R., Bathurst, J.C., Hey, R.D., Sediment Transport in Gravel-Bed Rivers, John Wiley & Sons, New York, 1987.

Todd, David Keith, Groundwater Hydrology, John Wiley and Sons, Inc., 1959.

U.S. Army Corps of Engineers, Portland District, Aerial Photography Archive.

U.S. Army Corps of Engineers, Draft Reconnaissance Report on Potential Flood Control for Springfield Mill Race, Portland District, 1991.

U.S. Army Corps of Engineers, HEC-2, Water Surface Profiles Computer Program, Hydrologic Engineering Center, Davis, California, 1991.

U.S. Army Corps of Engineers, Draft Flood Control Reconnaissance Report, February 1992. Proposing 3 alternatives: 1. Diversion Canal, 2. Permanent Closure, and 3. Full Protection (Levees).

U.S. Army Corps of Engineers, Reconnaissance Report - H & H Appendix, July 1991.

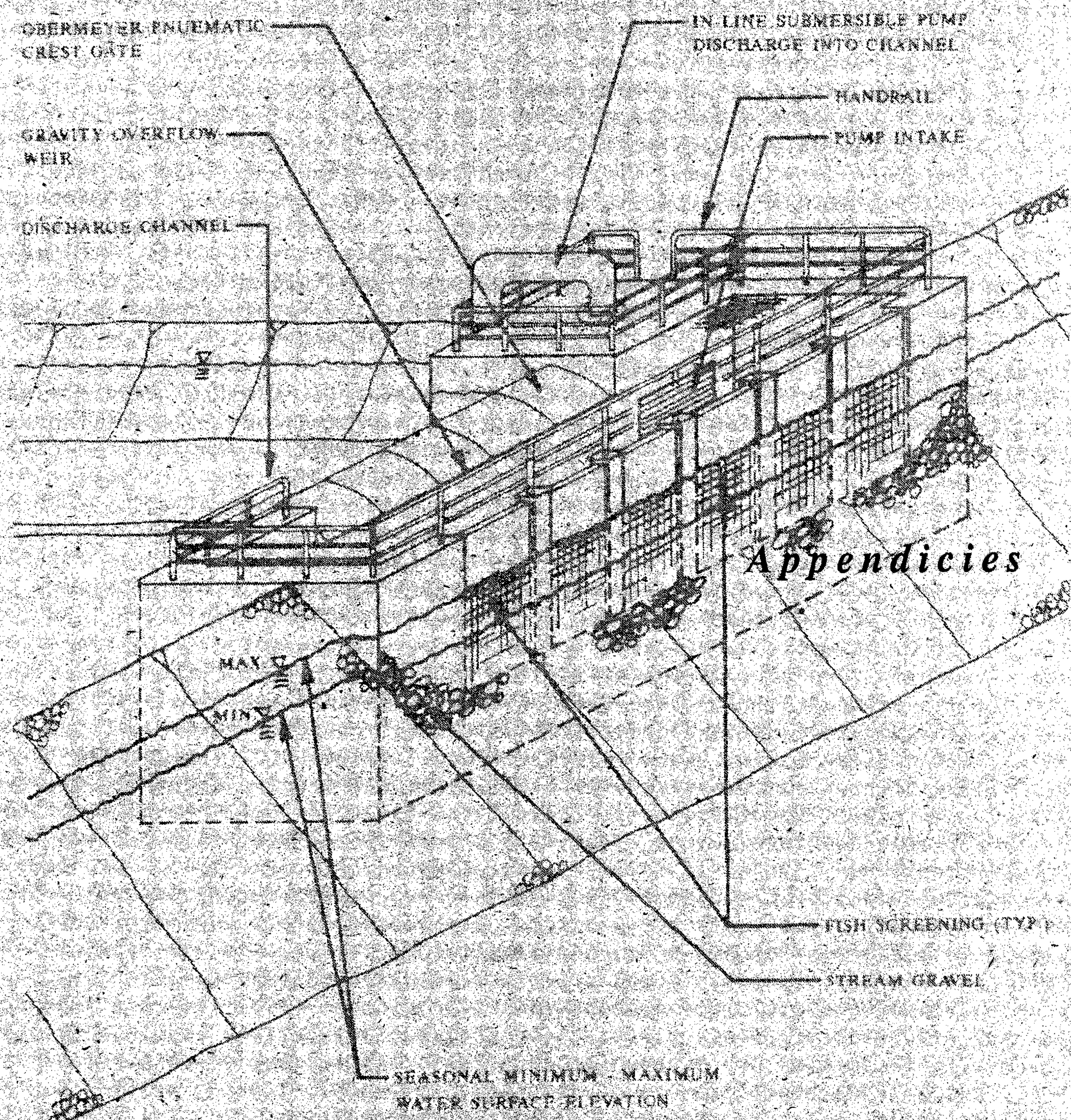
U.S. Army Corps of Engineers, Initial Appraisal Report, AugU.S.t 1990.

U.S. Army Corps of Engineers, Initial Appraisal and Economic Analysis, June 19, 1990.

U.S. Army Corps of Engineers, Memo from Ken Soderlund, June 1, 1990.
Proposing 3 alternatives: 1. Gate, 2. Diversion Canal, 3. Extensive Levees.

U.S. Department of Transportation - Federal Highway Administration, Hydraulic Design of Highway Culverts, September 1985.

Appendicies



Appendix A

Appendix A

Background and History of the Springfield Millrace

The city has carried out this flow management process thus far by using the same techniques that were previously used by Georgia Pacific Corporation. These techniques require the operation of heavy equipment in the main channel of the Middle Fork Willamette River and the north channel near the inlet to the Millrace. The permit to do this, which is issued by the Division of State Lands jointly with the U.S. Army Corps of Engineers, must be applied for each year. It generally allows work in the stream only during a six-week period beginning on July 16. Each year the permit also contains a comment requiring that a more permanent method of flow control be developed which will create less streambed alteration and associated turbidity.

The use of heavy equipment in the Middle Fork Willamette River channel started many years ago because major floods caused drastic movements of the river channel and blockage of the Millrace. The ongoing annual maintenance work does not generally involve reopening of an altered channel, but does require periodic adjustments to accommodate incremental changes in the channel. Maintenance practices at the inlet are divided into two categories: low-flow practices intended to maintain flow in the Millrace when river stages are low-flow and high-flow practices intended to prevent excessive water flow from entering the Millrace during storm events or times of unusually high water in the river.

While low-flow practices may be needed during any time of year, high flow practices are most likely to be needed between November and March. In general, the gravel dam is left in place all year and provides both a degree of flood protection and adequate flow into the Millrace. Only during extremely low or high flows is it necessary to modify the dam.

High-Flow Operation

To prevent excessive water from entering the Millrace during the winter, heavy equipment is operated directly within the channel of the Millrace for short periods of time to shape the river gravel into a dam embankment.

Two (or recently three) four-foot diameter corrugated metal culverts are emplaced through this dam to allow water to enter the Millrace. These culverts generally constrict the flow sufficiently to prevent flows of more than 300 cfs from flowing in the Millrace. During high water periods, the dam is sometimes modified to restrict flow and prevent flooding. Work in the channel is relatively localized around the inlet to the Millrace. The U.S. Army Corps of Engineers has determined that inflows in excess of 300 cfs can cause flooding problems at low-lying areas adjacent to the Millrace and Mill pond.

Low-Flow Operation

Low-flow operation is somewhat more complex than high-flow operation, but it also involves the use of heavy equipment in the river channel. Typically, in-channel work performed during low-flow periods can be more extensive than high-flow work, and can disturb gravel in the Millrace and along the north channel over a length of approximately 900 feet from the gravel dam at the inlet to a point above the upstream and the island. Low-flow work can take various forms. Current as well as previous practices are summarized below:

1. During extreme low-flow in the river, the gravel dam used in the winter is occasionally removed. (This activity is still permitted by regulatory agencies.)

2. Creation of a second small dam across the north channel of the Middle Fork Willamette River to force the diversion of more water into the Millrace. (No longer allowed by regulatory agencies.)

3. Excavation of the north channel bed to provide greater flow depth all the way from the Millrace inlet to a point 100 to 200 feet upstream from the upper end of the island. In the past, the spoils from this operation were moved onto the banks of the channel. Channel work will become more expensive in the future because the dredged material will have to be removed from the site. (Channel work is still allowed under these conditions, but Oregon Department of Fish and Wildlife considers it undesirable.)

4. Construction of a spur dike (or wing dam) projecting out into the north channel starting at the upstream end of the island

and proceeding upstream approximately 200 feet. (No longer allowed by regulatory agencies.)

During high flows in the Middle Fork Willamette River, much of the work accomplished in items 2, 3, and 4 above is undone by the natural action of the river.

Figure A-1 summarizes the general location of these activities during the time frame of 1940 - 1990. As previously noted, most of these activities are no longer allowed by the regulating agencies.

Appendix B

Appendix B

Hydrology of the Middle Fork Willamette River & Springfield Millrace

Introduction

The word "hydrology" as used in this report, refers to the analysis of flow rates and changes in stream flow rates. Stream flow changes with the season of the year and from year to year. These changes are caused by a wide variety of factors including weather, the operation of upstream dams, development, logging practices, ground cover, snow pack and combinations of these factors. For the purpose of this report, however, the parameters affecting stream discharge rates are only important as far as they allow us to understand long-term trends that will impact either flooding or minimum flows. Hydrology in this study has three purposes:

1. To provide input for the Hydraulic Analysis portion of this study (Appendix C) to determine the potential impacts from major flood events such as the 100-year flood (1 percent annual occurance event) and how to protect against more frequently occurring events such as the 25-year-flood.

2. To provide input for the Sedimentation Analysis portion of this study (Appendix D).

3. To evaluate hydrologic and hydraulic relationships such as the relationship between flow rates in the Middle Fork Willamette River and in the Springfield Millrace to provide input into the Alternatives Evaluation portion of this study (Section III).

For the first purpose, the peak discharge for the 100-year-flood event on the Middle Fork Willamette River at the Springfield Millrace is 35,500 cfs. Peak discharges for other flood frequencies are discussed below under "Peak Flow Hydrology." The peak flow values were obtained directly from the hydraulic model prepared for the FEMA Flood Insurance Study for Lane County[1], which takes into consideration the current reservoir storage upstream from the site. For the second purpose (evaluation of the impact of various flow rates

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[1] Lane County Flood Insurance Study, Federal Emergency Management Agency, 1982.

on the movement of bed material) streamflow data was obtained on Earth-Info CD-ROM disk for the US Geological Survey Gauge No. 14152000, Middle Fork Willamette River at Jasper[2]. This gauge, which has a tributary drainage area of 1,340 square miles, is located five miles upstream from the Millrace inlet, and represents hydrologic conditions that are essentially the same as the site itself. Figure B-1 depicts the general location of the Millrace inlet within the Middle Fork Willamette River watershed. Data from the gauge is presented in Figures B-2 through B-7.

Reservoir Operation

Four major flood control storage reservoirs upstream from the Millrace are operated in a carefully coordinated manner by the U.S. Army Corps of Engineers to effectively regulate flow in the Middle Fork Willamette River. The locations of these reservoirs are shown on Figure B-1. Three of these reservoirs are within 15 miles upstream (Dexter, Lookout Point, and Fall Creek), and one (Hills Creek Reservoir) is over 30 miles upstream of the study location. No additional reservoirs are planned for this area. The reservoirs are multi-purpose facilities that serve flood control, hydropower generation, recreation and irrigation needs. The operational target for flood control is to limit the discharge at the Jasper gauge to 20,000 cfs.

Figure B-2 is a bar graph of the maximum annual discharge at this gauge for each year of record. Note that the maximum annual discharges have gradually decreased over the years, and that there is a particularly obvious reduction in maximum discharges beginning in 1966. This is apparently related to the completion of the U.S. Army Corps of Engineers flood control reservoir system upstream from the gauge in that year.

For the sedimentation analysis, which appears as Appendix D in this report, it was necessary to evaluate the occurrence and expected duration of the highest discharge rates that occur every few years. Any discharge above a threshold of approximately 8,000 cfs in the Middle Fork Willamette River has been determined to be capable of producing movement of bed material. Above this flow rate, flow

[2] This daily flow data is included on computer disk in a Lotus 123 spreadsheet file.

Middle Fork Willamette R. - Jasper Gage

Maximum Annual Discharge

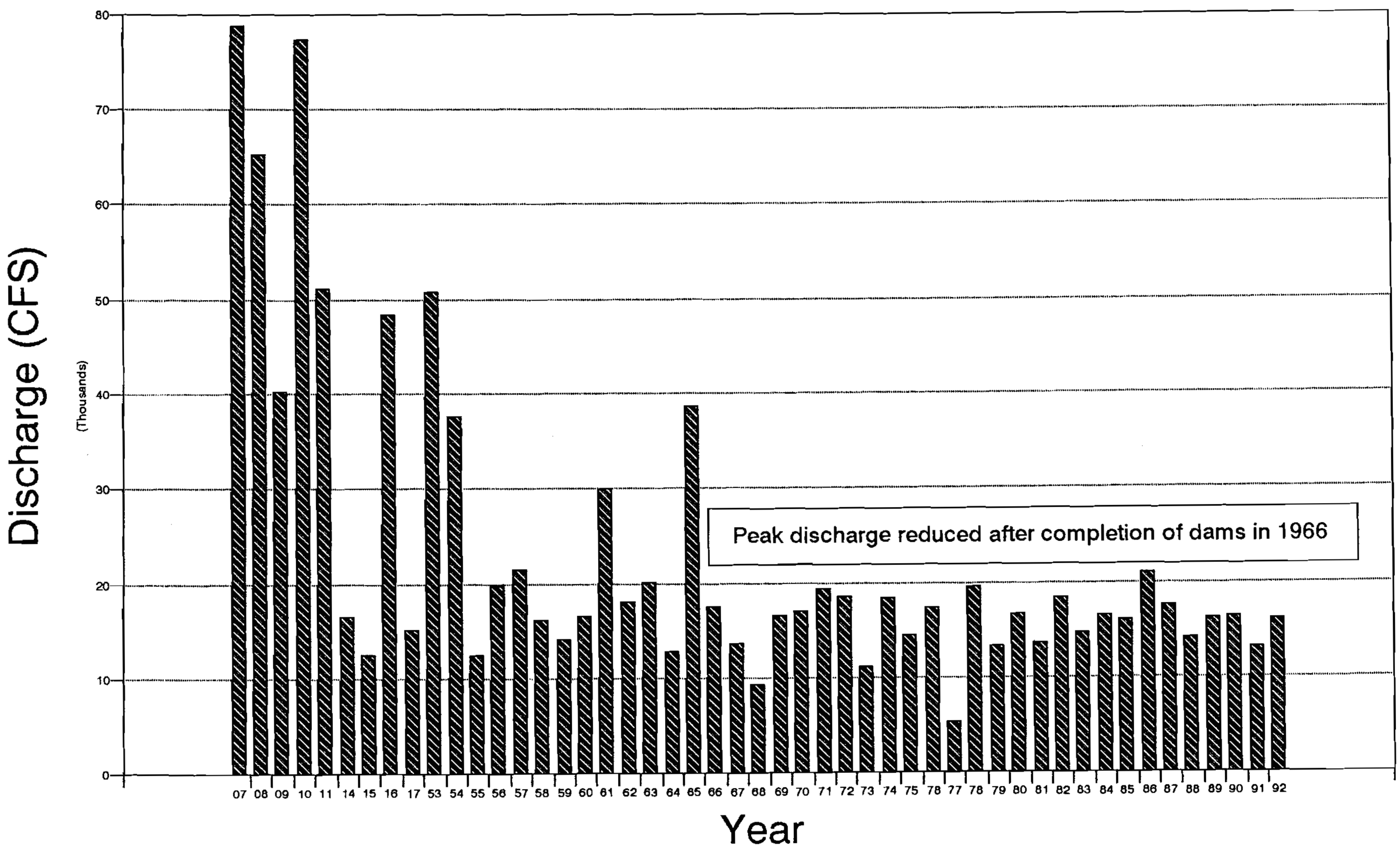

Figure B-2

Middle Fork Willamette R. - Jasper Gage

Percent of Days Discharge Exceeded

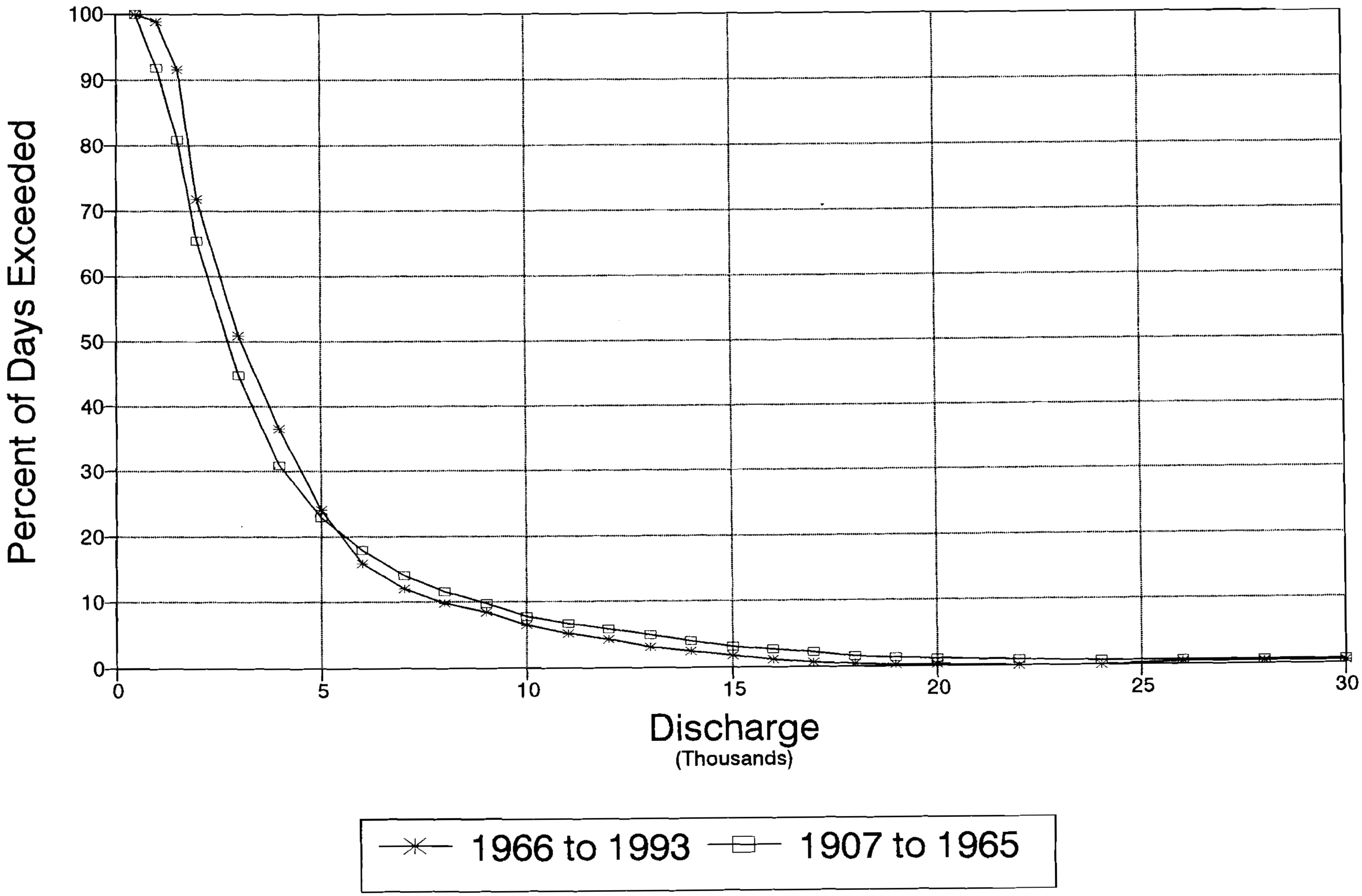

Figure B-3

velocities are sufficient to reshape gravel bars, and side-channels can be altered as the high velocity water moves riverbed materials and cuts into banks and channels. Both historic and expected future channel movements are discussed in detail in Appendix D.

Aerial photographs, included in Appendix E, Historic River Meanders of the Middle Fork Willamette River, show clearly that the stream channel has undergone significant changes during several flood events which occurred prior to 1966. The channel movements and changes that have occurred since that time are much less dramatic but are still significant. Prior to 1966 and the completion of the Middle Fork reservoir system, the recurrent impact of flood events played a major role in shaping the river channel. Although a considerable degree of flood protection has been provided in the Middle Fork Willamette River basin by the reservoir system, extreme events can and still will occur in the future. For these larger events, significant reshaping of the river channel will still take place, but the overall frequency to these events will be reduced from what has happened historically.

Hydrologic Data and its Use

Another way to view the change in peak discharge rates is to look at the percentage of time that mean daily discharges were above or below a certain level. Table B-1, below, shows exceedence relationships as derived from the data for the Jasper gauge.

Table B-1
High Flow Discharge - Exceedence Relationships

Discharge (cfs)	% Exceedence 1907 - 1965	% Exceedence 1966 - 1993
8,000	11.7	10.0
12,000	5.7	4.2
18,000	1.5	0.3
20,000	0.8	0.6

This table presents discharge exceedence values for two time periods; 1907 to 1965 (before reservoir completion) and 1966 to 1993 (after reservoir completion). The discharge exceedance percentage for each discharge represents the percentage of time on an annual basis during which time they are expected on average to occur.

The first discharge, 8,000 cfs, was selected for evaluation because it represents close to the mean discharge during the wettest time of year and is the threshold for bedload movement. The highest discharge (20,000 cfs) was selected because it represents the maximum discharge that is likely to occur in the next few years and is higher than any recorded discharge rate since the dams were completed.

It is clear from this table that the reservoirs have caused a reduction in the frequency of higher peak discharges.

Figure B-3 shows the same relationships and extends them through the entire range of expected discharge rates. For the more frequently occurring lower discharge rates, (below 5,000 cfs), the frequency of occurrence has actually been increased by the upstream reservoirs. This shows the effect of reservoir regulation on daily discharge at the Jasper gauge.

A second set of discharge-exceedence relationships was derived from the Jasper gauge data for use in the Evaluation of Alternatives (Section III). These data are presented below in Table B-2.

Table B-2
Low Flow Discharge - Exceedence Relationships

Discharge	% Exceedence 1966 - 1993	% Non-Exceedence 1966 - 1993
700 cfs	99.8 %	0.2 %
1,500 cfs	97.9 %	2.1 %
2,000 cfs	72.0 %	28.0 %
2,800 cfs	54.0 %	46.0 %
3,400 cfs	45.0 %	55.0 %

In this case, it was important to look at the data in terms of *non-exceedence* because of the need to evaluate the percent of the time that river discharge would be below a certain level. In order to clarify the meaning of the term non-exceedence, the data are presented in this table both in terms of percent exceedence and percent non-exceedence.

The same information is also included with Figure C-5 in Appendix C, Hydraulic Analysis, of this report.

Discharge values used in the hydraulic modeling portion of this study were selected from commonly occurring annual maximum discharges. A progressively increasing series of discharges above the 8,000 cfs threshold where bedload movement is initiated in the Middle Fork were selected for sediment analysis.

Calibration Discharges

A mean discharge of 2,800 cfs was recorded by the Jasper Gauge for August 11, 1994, the day of the field hydrographic survey performed by Otak. This discharge was used in the hydraulic modeling effort as a calibration discharge. On that same day, the flow rate into the Millrace itself was estimated approximately 60 cfs, based on hydraulic modeling using the HEC-2 program. This information became very useful in the alternatives evaluation process as discussed in Section III of this report, and was also used to derive the flow relationships between the river and the Millrace.

Mean and Minimum Annual Discharges

Figures B-4 and B-5 present the mean and the minimum annual discharges for the entire period of record at the Jasper gauge. The tendency for generally higher mean daily discharges for more recent years, as shown on Figure B-4, reflects the way in which the dams are operated to produce higher flow rates in late summer and fall as reservoir storage is drawn down to create storage capacity for winter storm events. The very lowest discharges recorded since the dams were completed (772 cfs in 1973, and 536 cfs in 1977) are considerably lower than most other years, which average around 1400 cfs. This apparently reflects the lack of available reservoir storage during extremely dry years.

Minimum flows are of interest because very low flows in the Middle Fork Willamette River reduce the availability of water to enter the Millrace. Based on field survey data for the existing river channel, even the lowest observed discharges still allow some water to enter the Millrace. This is only the case, however, because past work in the

Middle Fork Willamette R. - Jasper Gage

Mean Annual Discharge

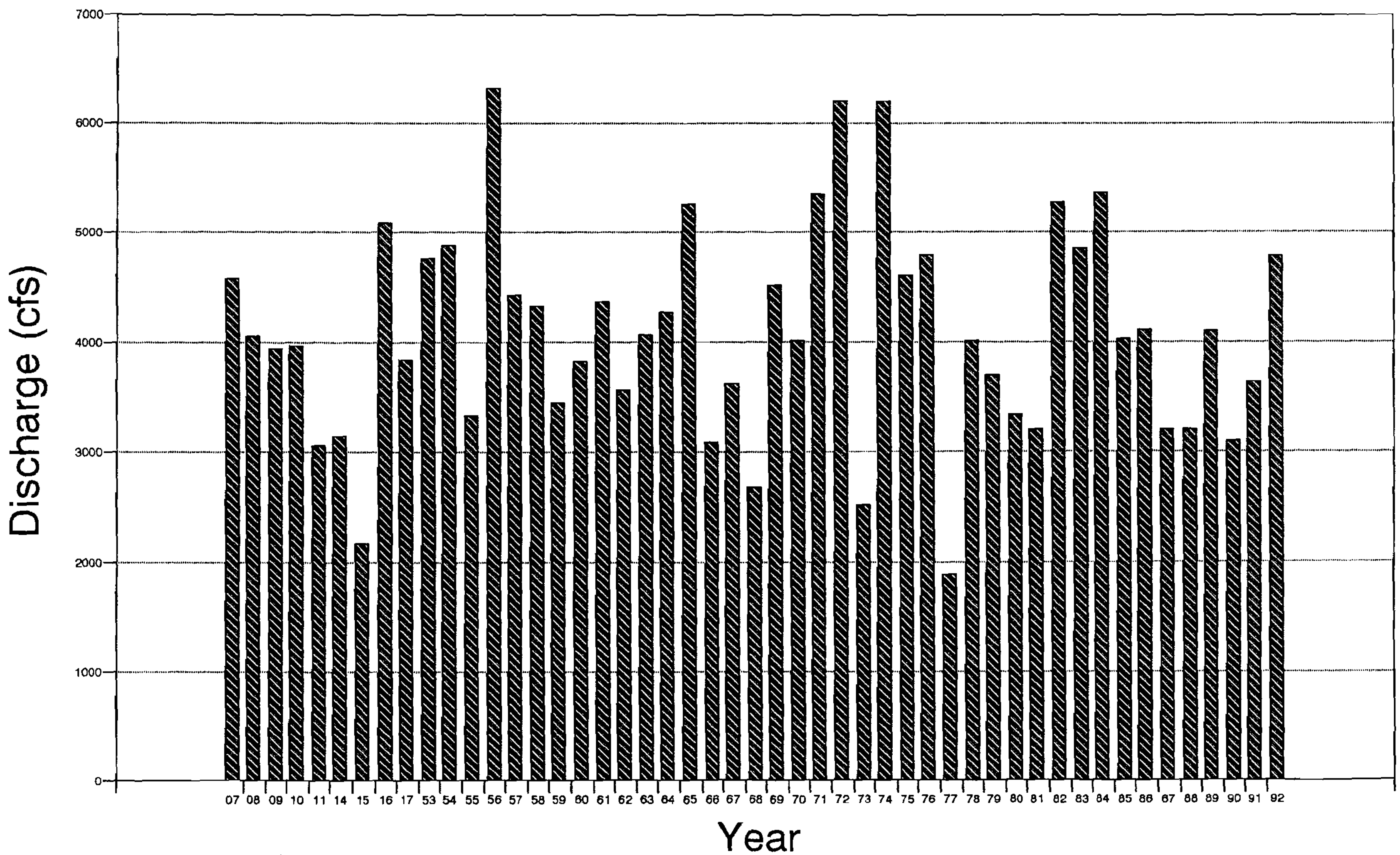

Figure B-4

Middle Fork Willamette R. - Jasper Gage

Minimum Annual Discharge

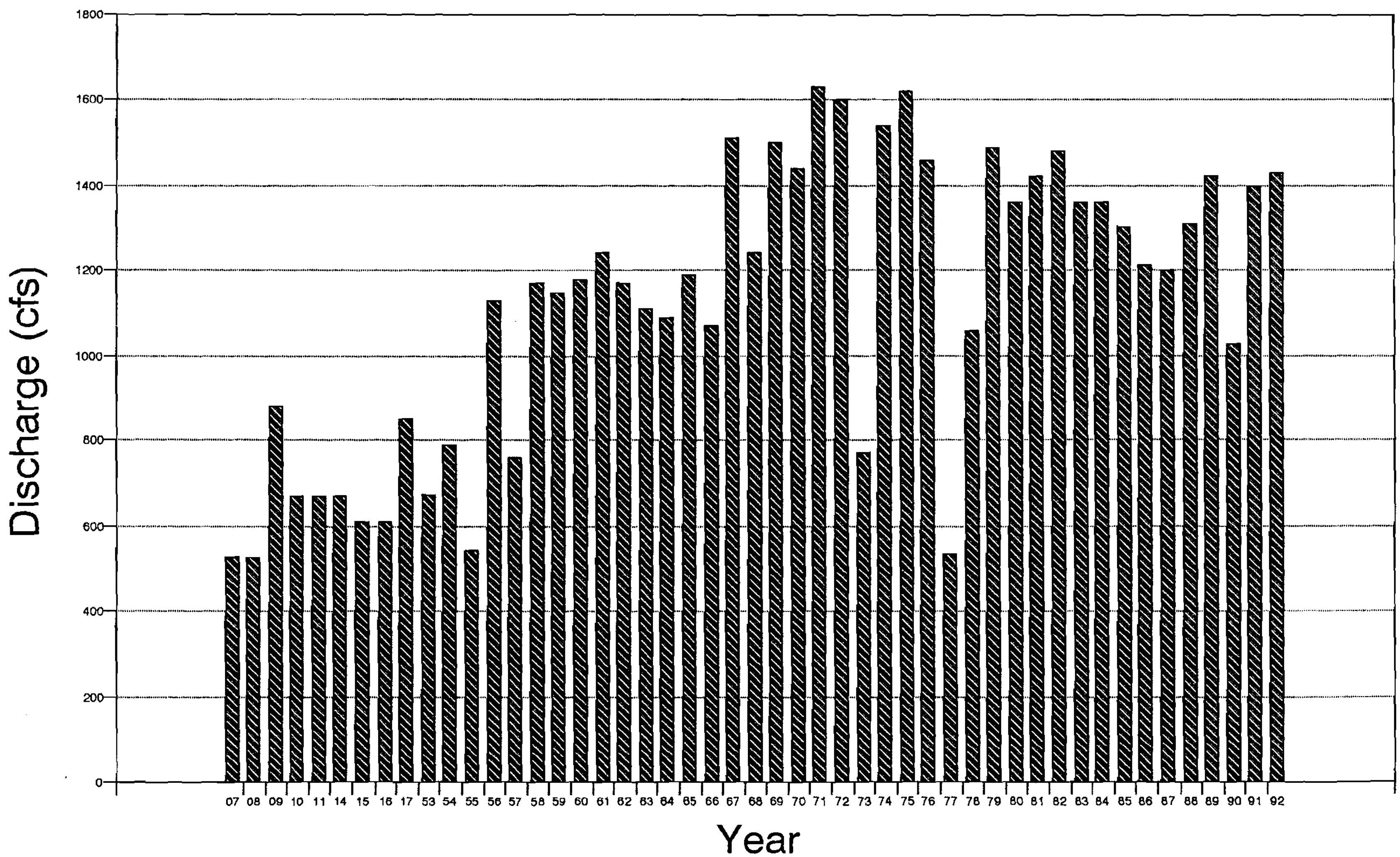

Figure B-5

channel has maintained the bottom of the north channel entrance at an elevation lower than the main channel. Without annual removal of gravel that is deposited in winter, the north channel would most likely fill in to a point where water could be prevented from entering the Millrace during seasonal low flow periods. In addition, future changes in channel shape may also affect the availability of water. This is discussed in more detail under Appendix D, Sedimentation Analysis. It is probable that the north channel of the Middle Fork Willamette River will eventually fill in if annual maintenance work in the channel is eliminated by future permit restrictions.

Annual Peak Flow Discharges

The peak flow hydrology for the Middle Fork Willamette River was taken directly from the Lane County Flood Insurance Study. Only the discharges for the 10-year, 50-year, 100-year, and 500-year-flood events were provided. This data is shown in graphic form in Figure B-6. The recurrence frequency of a flood is expressed in terms of an annual probability of occurance. The 100-year-flood would be expected on average to occur once every 100-years. This can also be expressed in terms of its expected probability in any one year. The 100-year-flood, for example, has a 0.01 (or 1 percent or 1 in 100) probability of occurrence in any one year.

Note that Figure B-6 is a semi-log plot. Usually a semi-log plot of a discharge curve such as this, will produce a relatively straight line. In this case, the plot is not straight. This is apparently because flood events greater than approximately the 50-year event begin to exceed the attenuation capability of the upstream reservoirs.

Conclusions

Peak discharge rates during flood events have decreased since completion of upstream dams in the Middle Fork Willamette basin.

During the seasonal low flow periods, flow rates have increased as a result of the reservoir releases.

Channel movements and streambed degradation over time has affected the ability of water to enter the Millrace, and this trend will

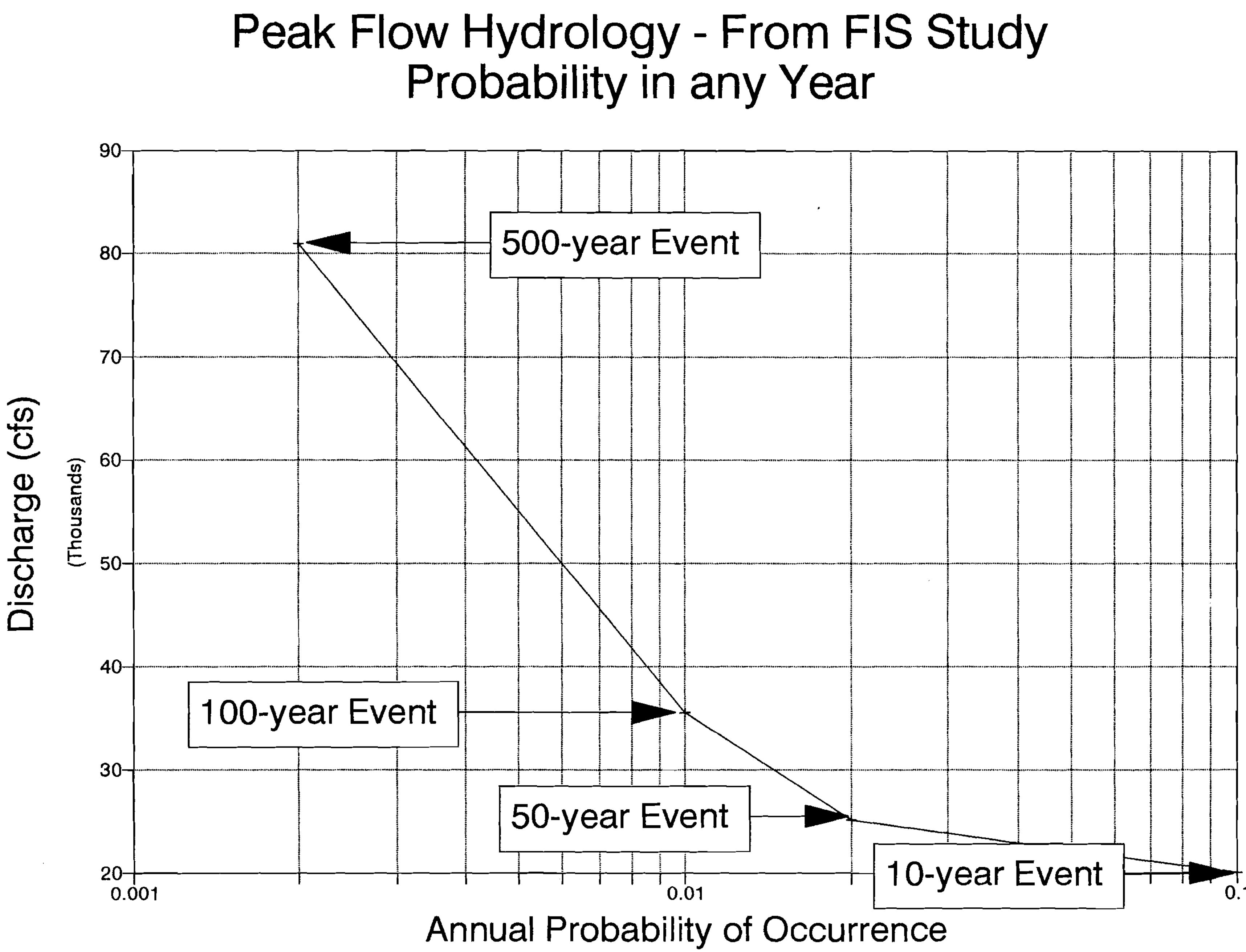
Peak Flow Hydrology - From FIS Study
Probability in any Year
Discharge (cfs)
(Thousands)
90
80
70
60
50
40
30
20
0.001
0.01
0.1
Annual Probability of Occurrence
500-year Event
100-year Event
50-year Event
10-year Event

Figure B-6

continue. Since the completion of dam construction, however, channel movements have been less severe. Although major flood events and channel movements are less likely to occur now, major flood events are still possible on the Middle Fork Willamette River and these events would have a significant impact on channel configuration.

Other than unforeseen changes in weather patterns, there are no long-term trends or plans for additional reservoir construction that would significantly affect the discharge rates reported here. Although increased development in the watershed will locally increase flows, the basin is so large this will not have any significant effect on the basin as a whole.

Appendix C

Appendix C

Hydraulics of the Middle Fork Willamette River and Springfield Millrace

Introduction

Within the context of this report,"hydraulics" refers to that portion of the civil engineering field that deals with estimating water surface elevations and water velocities from the flow rates determined in the hydrology portion of this study. In this study there is also an unusual overlap between hydrology and hydraulics because the flow rate into the Millrace (hydrology) depends on the hydraulic capacity of the Millrace entrance. Thus, the hydraulics portion of this study actually determines some of the hydrology data. In general, the hydraulic performance of a stream depends on a number of factors such as a channel slope, roughness characteristics of the stream channel, cross-sectional area available for flow, and any downstream conditions that may backup water onto the reach being studied. As with the hydrology portion of the study, the hydraulic analysis has three purposes:

1. To assess the vulnerability of the study area to damage from major floods such as the 100-year flood event and determine how to protect against more frequently occurring lower magnitude flood events.

2. To provide input for the Sedimentation Analysis portion of this study (Appendix D).

3. To analyze hydraulic relationships such as the relationship between flow rates in the river and flow rates in the Millrace to provide input into the Alternatives Evaluation portion of this study (Section III).

A hydraulic analysis was performed using the computer program HEC-2 developed by the U.S. Army Corps of Engineers. Version 4.6.2, compiled in May 1991, was used throughout this project. A copy of the HEC-2 input file, as used for the 1982 Lane County Flood Insurance Study (FIS), was obtained and used to analyze the potential impact of the 100-year-flood. For the more detailed analysis required to evaluate the transport of bed load material at the Millrace inlet, new site-specific input data files were generated.

Survey Data and its Use

Stream cross-section data was obtained by field survey at the locations indicated on Figure C-1. All survey data were tied into the three-dimensional coordinate and base mapping system of the City of Springfield. Hydraulic cross-sections, as presented in Appendix G, were derived from an ASCII file containing the survey data. To derive these sections from survey data, the ASCII file was loaded into a Quattro Pro spreadsheet and all of the data points were sorted by cross-section. Quattro Pro was then used to determine the distance between points and obtain the horizontal distances for each cross-section.

In order to cover the entire floodplain, some data points outside the surveyed cross-sections were obtained from the topographic map of the area by measuring horizontal distances between the contours or spot elevations shown on the map. According to the convention used in most HEC-2 input, the cross-sections are viewed as looking downstream. Numbering proceeds in the upstream direction starting from downstream. The cross-section numbers as used are simply assigned numbers, and do not relate to river miles[1] or any unit of measurement.

The first section in this model is Section 120 which corresponds to Section 120 in the computer model for the Lane County Flood Insurance Study (FIS model). Sections were then numbered sequentially using decimals of 120 (i.e., 120.1, 120.2, 120.3 ...). All section numbers ending in decimals are those added to the model in this study. Note that Section 120.4 corresponds to Section 130 in the FIS model, and that Otak Section 120.7 is approximately 400 feet downstream from FIS section 140.

Survey data were obtained on two different dates. The first survey took place on August 11, 1994. On that date the Middle Fork Willamette River had a mean flow rate of 2,800 cfs at the USGS Jasper

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[1]The location of each section in river miles upstream from the Middle Fork/Coast Fork confluence is shown on Figure C-1. To convert to river miles from the mouth of the Willamette, as shown on the FIS map, add 187.2 to these numbers.

gage. The second field survey was conducted on October 21, 1994. No flow data is available for the second survey. Note that the cross-section plots in Appendix G show marks labeled EW. These points are "edge of water" as surveyed in the field on August 11, 1994.

A total of nine cross-sections were taken in the field; six on the main channel of the Middle Fork Willamette River, and three on the Millrace. Two cross-sections on the main channel were taken continuously across the river and its north channel. In some cases, such as at the Millrace culverts, the survey data for one section was used to represent more than one cross-section in the HEC-2 model. In other cases, data points that were not lined up directly in a single cross-section line were combined to form a single cross section. This was done for section 120.5 in order to make the best use of available data.

Modeling Procedure and Parameter Estimation (Detailed Model)

This study required development of detailed hydraulic data for a wide range of flow conditions. The Sedimentation Analysis (Appendix D) required determination of flow velocities during higher flow conditions, while the Alternatives Analysis (Section III) required water surface elevations and stage-discharge relationships for both high-flow and low-flow conditions. Since the modeling effort required a greater level of detail than was provided in the Flood Insurance Study (FIS) model, the new model was based mostly on supplemental field surveyed cross-sections.

The original model contained only three cross-sections within the general vicinity of the Millrace inlet: section 120, which is 2,700 ft downstream from the Millrace inlet; section 130, which is at the Millrace inlet; and section 140 which is approximately 400 ft upstream from the Clearwater Park boat ramp. The main portion of the new model contains a total of nine cross-sections between FIS section 120 and 140, inclusive. In addition, the tributary portion of the model contains four cross-sections[2] that represent the North Channel of the Middle Fork Willamette River.

Figure C-1 also shows an overall plan view of the island between the main channel and north channel of the Middle Fork Willamette River and the area around the Millrace inlet. Flow first splits from the main channel of the river at the upstream end of the island where it splits off to form the north channel. Approximately 500 feet downstream of the head of the island, more flow splits off at the Millrace entrance.

Figure C-2 is a schematic depiction of the same area, which shows how the flows in the various channels relate to each other. Due to the complexity of this channel system, and the need to employ trial and error procedures in the analysis, a spreadsheet was used to create the HEC-2 input file and assure that these relationships remained fixed while different flow splits on the north channel and in the Millrace were tested in the model. The procedure used in the modeling process took the following steps:

Performed once during the modeling procedure:

1. Model the Millrace itself separately from the rest of the channel system to develop relationships between stage and discharge at the Millrace entrance for the expected range of flows. This model was calibrated with known water surface elevations observed during the field survey of August 11, 1994. On that date, the flow into the Millrace was determined to be approximately 60 cfs. Please refer to Figure C-3.

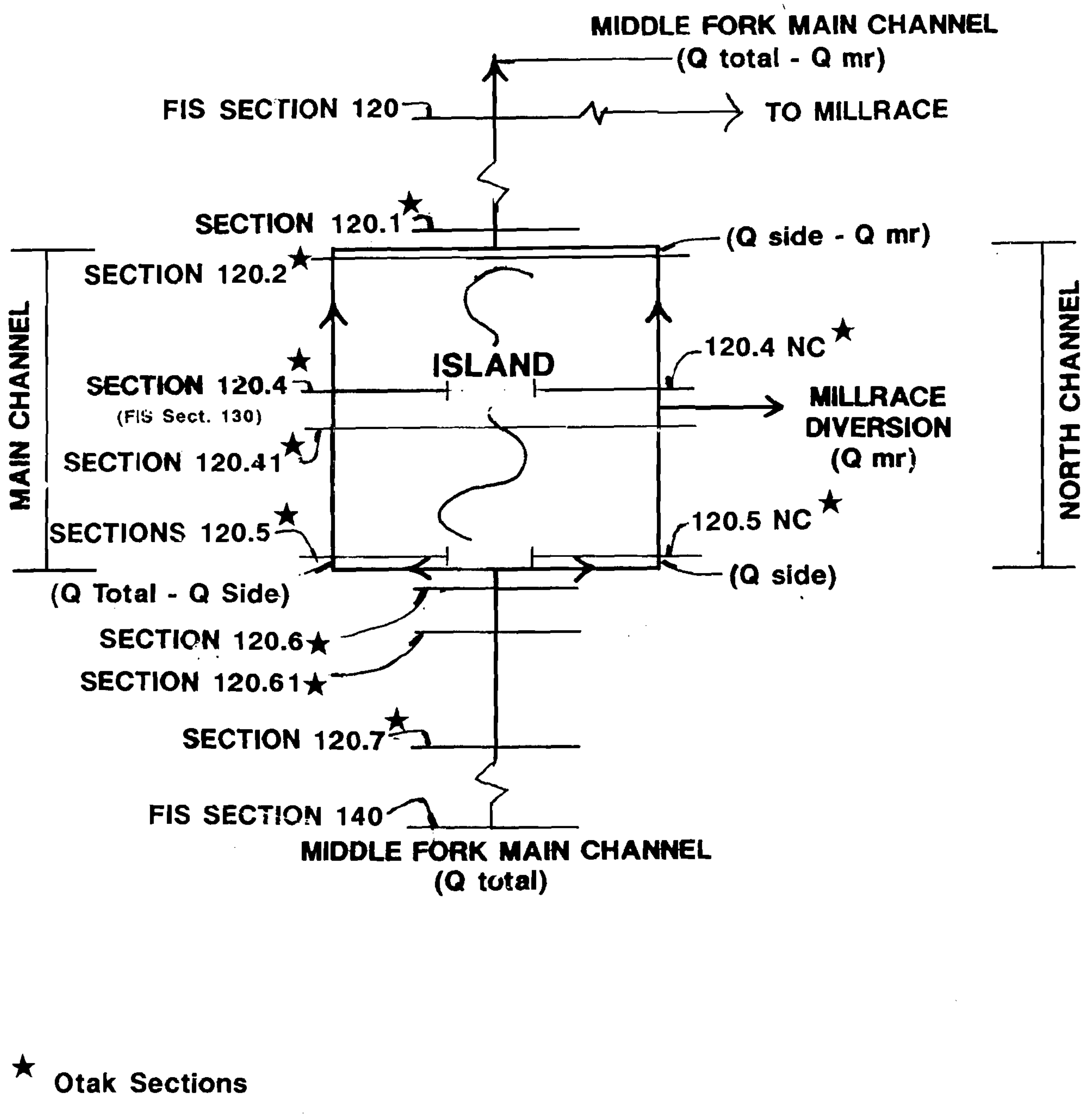
Performed once for each discharge scenario evaluated in the model:

2. For the first cut, assume a discharge into the Millrace.

3. Assume a discharge into the north channel that is greater than that assumed for the Millrace discharge in step 2.

---

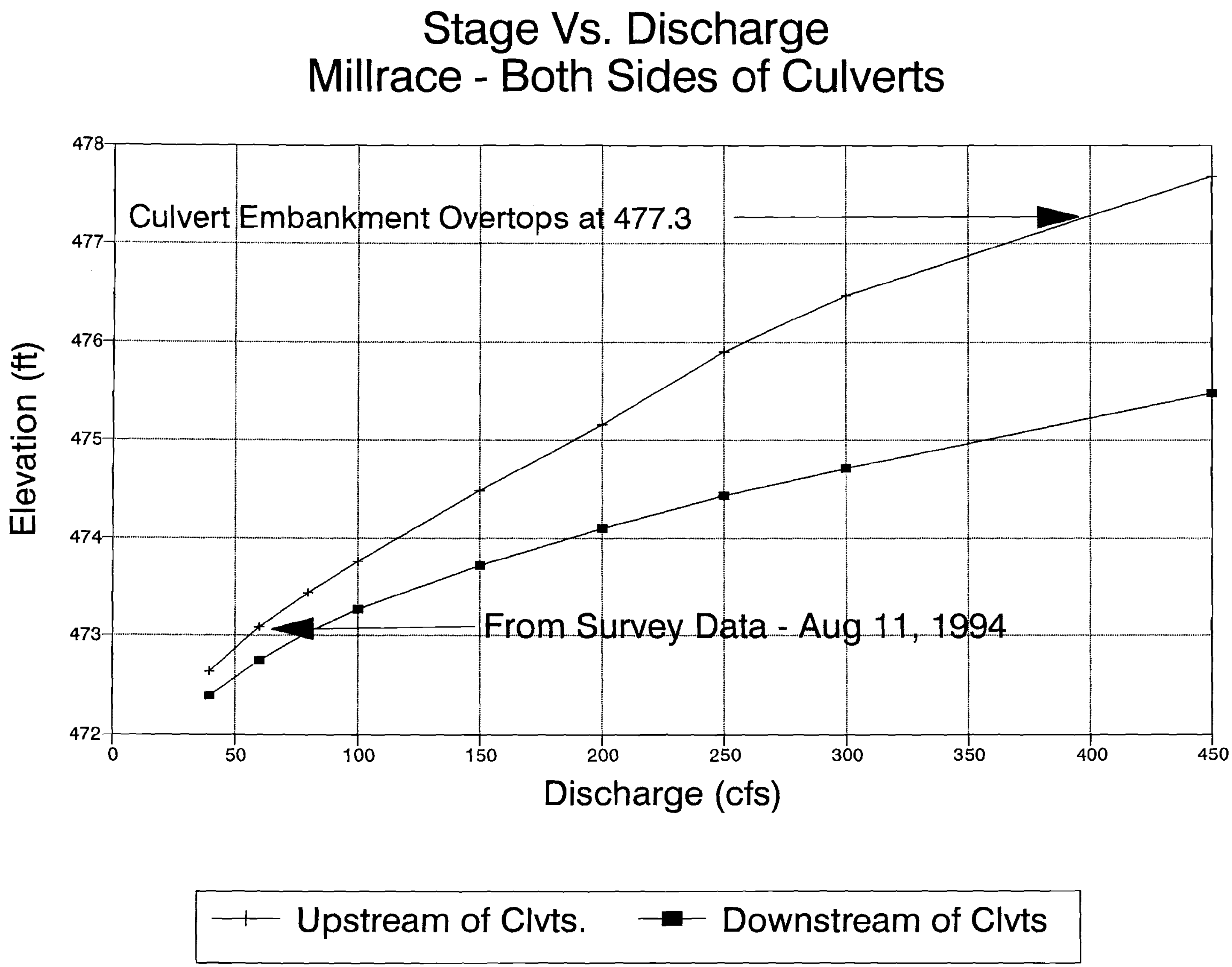
[2]These sections were not all independently surveyed. All sections crossing both the main and north channels, as shown on Figure C-1, were represented as separate sections with the north channel portion of each represented as a separate section in the HEC-2 tributary option. Section 140.1 was derived from survey data from section 120.4.



CITY OF SPRINGFIELD
SPRINGFIELD MILLRACE HYDROLOGIC STUDY AND ALTERNATIVES ANALYSIS
ISLAND SPLIT FLOW SCHEMATIC

Figure C-2

otak incorporated
17355 S.W. Boones Ferry Rd, Lake Oswego, OR 97035 (503) 635-3618
101 E. 8th Street, Vancouver, WA 98660 (206) 695-6357
25 Central Way, #305, Kirkland, WA 98033 (206) 822-4446



Stage Vs. Discharge
Millrace - Both Sides of Culverts
Culvert Embankment Overtops at 477.3
From Survey Data - Aug 11, 1994
Elevation (ft)
Discharge (cfs)
478
477
476
475
474
473
472
0
50
100
150
200
250
300
350
400
450
Upstream of Clvts.
Downstream of Clvts

Figure C-3

4. Check the water surface elevations at section 120.6 for both the main channel and north channel. If there is more than a 0.1 foot difference, then adjust the balance of flows in the north and main channels to bring the elevations closer together. (Note that this was set up in a spreadsheet to simplify the process and to assure that a balanced flow split was obtained each time.)

5. Rerun the model with the new flow split for the main and north channels.

6. Repeat steps 4 and 5 until a close water surface elevation match is obtained in step 4.

7. Check the elevation at Section 120.4 to assure that it matches reasonably closely with the stage for the Millrace discharge assumed in step 2.

8. Adjust the flow split to the Millrace if determined necessary in step 7. The discharges modeled in the Millrace were limited to 300 cfs, which is a flood stage.

9. Rerun the model with the new flow split for the Millrace and north channel.

10. Return to step 4 to assure that the main and north channel water surface elevations still match within 0.1 foot. This is usually the case, as the flow leaving the channel at the Millrace is relatively small compared to the total flow and the change is generally not large enough to significantly affect flood elevations.

A calibration of the HEC-2 model was then checked for all points where survey data was available. In general, the model initially gave higher elevations than what was actually measured at those points. A calibration was adjusted by making changes in hydraulic roughness coefficients (Manning's n-values) to bring the model closer to the survey data. The adjustments brought the modeled elevations to within 0.7 ft of those surveyed. For the purposes for which the data is being used in this study, the calibration obtained here is completely adequate. Keep in mind that this model represents hydraulic conditions that exist in the channel at the present time. Since the channel is in a constant state of change as the bed material moves downstream, the results presented here may not accurately simulate what the channel will be like in the future.

Modeling Procedure (100-year flood)

This part of the study was performed to make an estimate of how channel conditions have changed since 1982 when the HEC-2 model used in the Flood Insurance Study (FIS) was developed. The procedures used in this part of the study are listed below.

1. Obtain the FIS input data files for the HEC-2 model.

2. Run the FIS HEC-2 model.

3. Compare output with published data in the Flood Insurance Study to assure that the correct input file was used. When this was done, the data matched perfectly.

4. Where new channel cross-section data is available, replace the older cross-sectional data with the new cross-section data. One section (120.4 in the new model) was used to replace FIS section 130.

5. Run this new model.

6. Compare the results with the previous model.

The above procedure was followed, and the results obtained suggest that 100-year-flood elevations go down as a result of changes (manmade and natural) that have taken place in the channel since the FIS HEC-2 model was prepared in 1982. Note, however, that the FIS model is approximate, as it contains channel cross-sections at intervals of between 1,900 and 2,600 feet. The newer model, described in this section, contains cross-sections every 200 to 800 feet.

Since we do not have more detailed data for conditions prior to 1994, the FIS model provides the only basis for comparison with the present conditions. Although this form of analysis provides a reasonable estimate, any major impacts caused by changing channel conditions would show up if they existed. There is no evidence that changing channel conditions have produced higher flood elevations. The opposite situation appears to have occurred, and flood elevations are now actually lower than they were at the time the FIS was completed. The model results give the following flood elevations upstream from Section 120.4 (FIS Section 130):

Table C-1
Flood Elevation Comparison

Section #	Elevations (ft/msl) (FIS Model)	Elevations (ft/msl) (Model with New Section 120.4)
Section 120	473.86	473.86
Section 120.4	477.57	477.54
Section 140.0	487.59	486.86

Modeling Assumptions

As with all artificial simulations of natural systems, this modeling study cannot reproduce all of the details and dynamic conditions that affect the hydraulic performance of a stream channel. Simplifying assumptions are necessary for the model to work. This modeling effort is leased on the following assumptions:

1. Flow is steady-state. In other words, the model does not represent the dynamics of changing flow rates during the rising and falling limbs of the hydrograph.

2. Within the HEC-2 hydraulic computer model, the channel bed material is presumed to be fixed and not movable. However, the hydraulic model does facilitate an understanding of the distribution of flow velocities that aids in determining how bed material might move.

3. It is assumed that the cross sectional data taken in the field is representative of channel characteristics between the cross-sections.

4. It is assumed that the Manning's channel roughness n-values used in the model represent the true hydraulic friction in the channel.

Channel Discharge Relationships

In addition to the Stage-Discharge relationship shown in Figure C-3, another useful piece of information obtained through the modeling process is an evaluation of the relationship between discharge in the Millrace and discharge in the main channel. This relationship has two defining conditions, one for the condition with the culverts at the Millrace intake in place as developed in this study; and another flow split relationship for the condition with the culverts removed. Both of these relationships were developed by combining data from the HEC-2 models for the Millrace and for the main channel.[3]

Figure C-4 shows that relatively little benefit would be derived from removing the dam at the Millrace intake to increase flow to the Millrace. However, the sensitivity of the modeling procedures at the lower end of the curve casts doubt on this conclusion. Also, a closer look at the data shows that, with 1,000 cfs in the main channel, the Millrace inflow increases from 20 to 35 cfs on removal of the dam. While small in terms of total discharge, this can be seen as a significant increase in terms of percentage. Any operational decisions drawn from Figure C-4 should be carefully tempered with judgment and knowledge of actual conditions, as changing site conditions can affect these already sensitive relationships significantly.

Both discharge relationships (Figure C-3 and Figure C-4) rely on the same assumptions and modeling techniques. Figure C-3 is based on a calibrated HEC-2 model using the program's special culvert routines to determine the amount of head loss that takes place in the culverts. The three 4-foot diameter culverts were modeled using a Manning's n-value of 0.025 to represent the corrugated metal material. The

[3]The Corps of Engineers report of July 1991 showed a similar discharge relationship with the dam removed. The Corps data showed Millrace discharges that were significantly higher than those shown on Figure C-4. The Corps data was not included here because it is believed that the new data is more representative of current conditions.

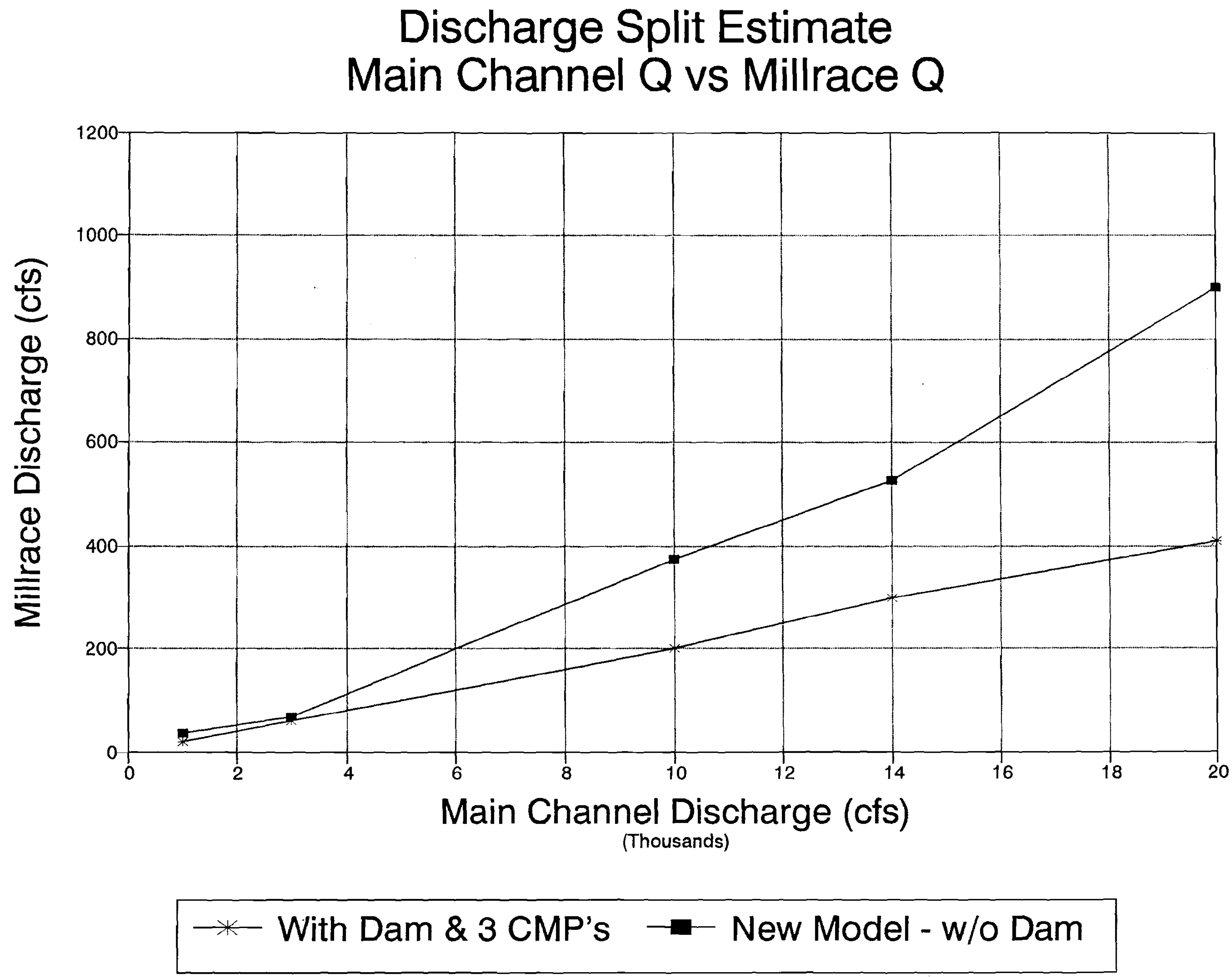

Discharge Split Estimate
Main Channel Q vs Millrace Q
Millrace Discharge (cfs)
1200
1000
800
600
400
200
0
0
2
4
6
8
10
12
14
16
18
20
Main Channel Discharge (cfs)
(Thousands)
With Dam & 3 CMP's
New Model - w/o Dam

Figure C-4

surveyed invert elevations for each of the three culverts were averaged to obtain the invert elevations used in the model. A calibration of the model used to derive Figure C-3 was particularly critical because the discharge rate is very sensitive to slight changes in elevation difference. The 60 cfs flow observed in the Millrace during the August 11, 1994, field topographic survey, for example, was based on a head difference of only 0.35 feet between the upstream and downstream sides of the culvert. For this reason, the Millrace portion of the model was calibrated very carefully to determine the actual discharge as accurately as possible. However, the sensitivity of the model, particularly at the lowest discharges, makes it difficult to verify its accuracy.

Figure C-5 represents the stage vs. discharge relationship for the Middle Fork Willamette River at the Clearwater Park boat ramp during relatively low flow conditions. This relationship is valuable in the alternatives analysis portion of this study for determining the hydraulic head is available to allow water to flow into the Millrace. It was derived from an HEC-2 model of the main channel of the Middle Fork of the Willamette. This model was calibrated to the observed discharge of 2,800 cfs of August 11, 1994, at the USGS Jasper gauge. Also presented on the graph are percentages representing the portion of the time that the discharge will be equal to or less than the discharge shown. The percentages were derived using a spreadsheet containing data from the Jasper gauge since 1966, and represent the condition after construction of the reservoirs.

Conclusions

1. The hydraûlic modeling effort in this study has demonstrated that 100-year flood event elevations have decreased or stayed nearly the same as they were in the 1982 FEMA flood insurance study.

Relationships were developed that allow closer evaluation of alternatives as discussed in Section III for changing or relocating the Millrace inlet. These include Stage vs. Discharge Relationships for the Millrace itself (Figure C-3) as well as Stage vs. Discharge relationships for the Middle Fork of the Willamette at the Clearwater Park boat ramp (Figure C-5). A third type of relationship between flow rates in

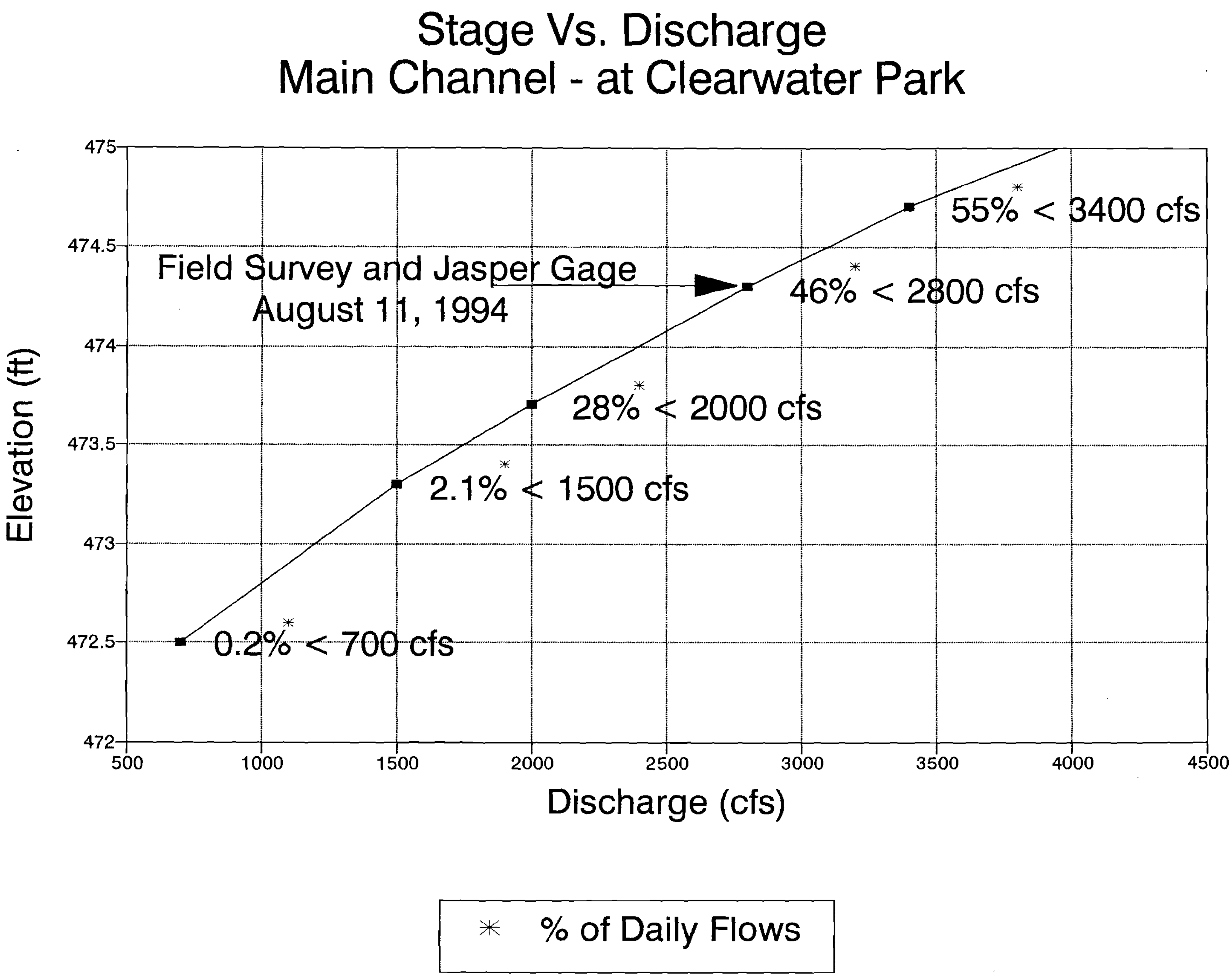

Stage Vs. Discharge
Main Channel - at Clearwater Park
Elevation (ft)
475
474.5
474
473.5
473
472.5
472
Discharge (cfs)
500
1000
1500
2000
2500
3000
3500
4000
4500
Field Survey and Jasper Gage
August 11, 1994
55% < 3400 cfs
46% < 2800 cfs
28% < 2000 cfs
2.1% < 1500 cfs
0.2% < 700 cfs
% of Daily Flows

Figure C-5

the river and flow rates in the Millrace (Figure C-4) may be valuable in making operational decisions, but should be used with caution.

Appendix D

Appendix D

Sedimentation Analysis of the Middle Fork Willamette River

Introduction

A sedimentation analysis was conducted to identify potential short- and long-term migration trends of the Middle Fork Willamette River to develop viable alternatives for the Springfield Millrace. The analysis consisted of examining historic meander patterns, identifying sediment characteristics, and estimating sediment bedload transport.

Historic Patterns

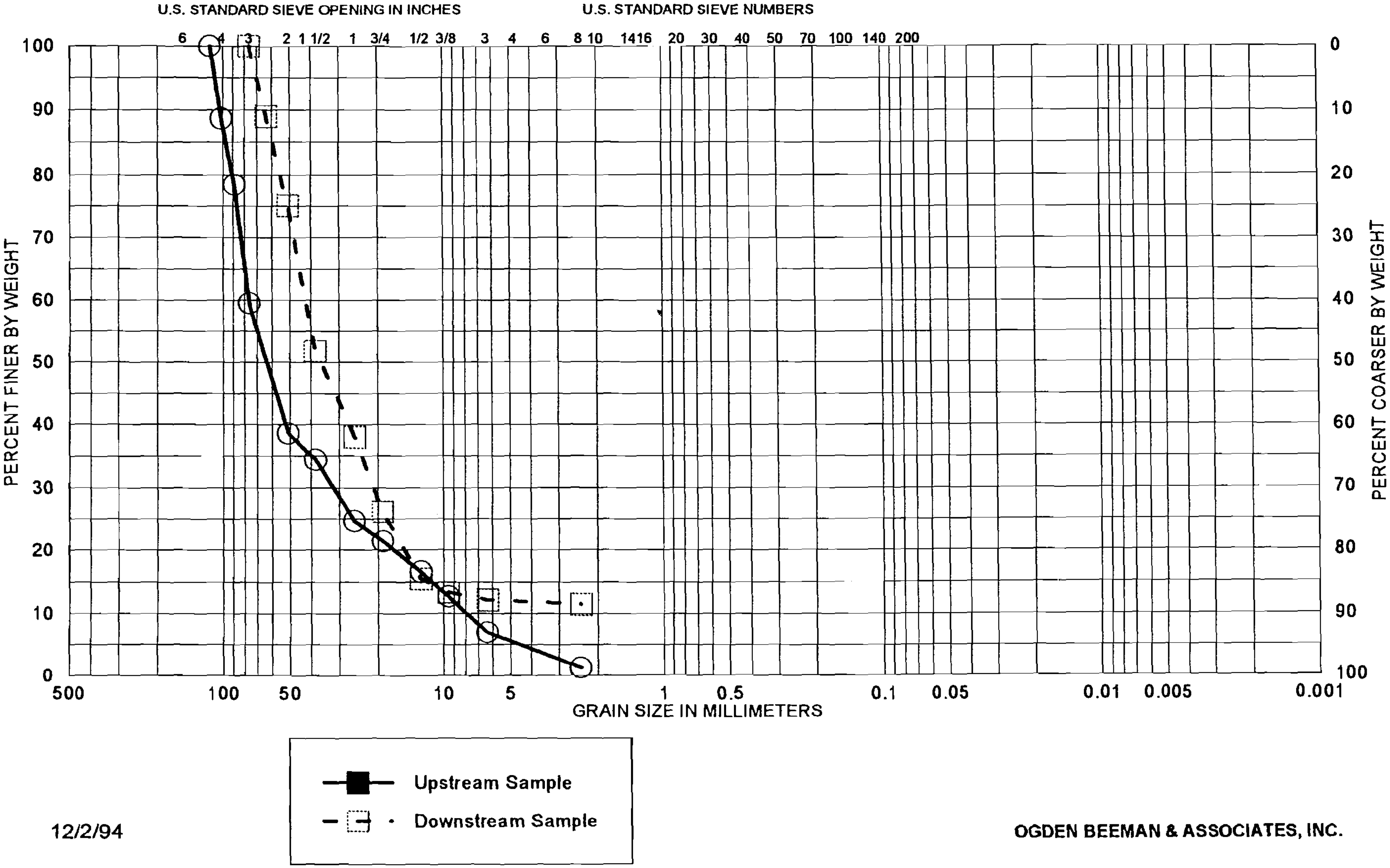
The historic meander patterns of the Middle Fork Willamette River were determined through the examination of aerial photographs of the Millrace site, obtained from the Portland District Office, U.S. Army Corps of Engineers. The photographs represent the progression of the Millrace over the following years: 1936, 1939, 1944, 1947, 1950, 1956, 1964, 1965, 1967, 1972, 1976, 1979, 1980, 1983 and 1990. Appendix E, Historic River Meanders, includes copies of some of these photographs, as well as comparison overlays and a discussion of the river meanders.

Sediment Characteristics

Two sediment samples were collected to typify bedload characteristics in the vicinity of the Millrace confluence with the Middle Fork Willamette River. The samples were run through a sieve analysis and the results are graphed in Figure D-1. As shown in the graph, the material is composed of coarse gravel and cobbles with a median diameter of approximately 35 to 60 millimeters (mm).

Additional sediment information was obtained from the Oregon State University Water Resources Research Institute investigation of Willamette River sediment transport. In this investigation, sediment samples were obtained from the Middle Fork Willamette River near Jasper. The median diameter of 38.7 mm of the OSU data corresponds well with the data collected at the Millrace.

FIGURE D-1
GRADATION CURVE
SPRINGFIELD MILLRACE



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Bedload

Bedload sediment transport varies as a function of the river energy gradient (slope) and depth, velocity, and sediment characteristics. Given the cobble and coarse nature of the sediments and rather steep energy gradient of the Middle Fork Willamette River, the Meyer-Peter and Mullers bedload transport equation was determined to be most applicable (Graf). Additionally, a history of the maintenance dredging by the City of Springfield since 1985 was utilized in calibrating the bedload equation. The hydraulic parameters obtained from the Corps of Engineers "Water Surface Profiles" HEC-2 computer model program (Appendix C, Hydraulic Analysis) were used with the Meyer-Peter and Mullers transport equation to calculate the potential for bedload transport through the site.

Discharges of 8000, 16000, 18000 and 20000 cubic feet second (cfs) were run with the HEC-2 model and the Meyer-Peter, Muller bedload equation and then applied to the hydrologic frequency distribution for the period 1966 through 1993 (Appendix C, Hydrologic Analysis) to produce an average annual bedload sediment transport capacity. The results indicate a potential bedload transport capability of approximately 40,000 to 60,000 cubic yards per year (cy/yr) for the river. The model also predicts that bedload transport is initiated at river discharges exceeding 8,000 cfs.

Due to the large variability in predicting sediment transport, an order of magnitude error tolerance is implicit in this analysis. The results of these analyses, are rather consistent on a cross section by cross section basis, however, in the vicinity of the Millrace entrance the predictions are erratic due to the artificially dredged channel and the placement of dredged material as wing dams. The calculations appear to be consistent compared to the history of maintenance dredging for the Millrace entrance.

It should be recognized that this model represents a "snapshot" in time and is based on existing topographic information. Over time, sedimentation will accumulate in some areas and other areas could erode, thus producing variable channel hydraulic conditions. The model, however, is still a valid tool for determining the relative potential bedload transport tendency of various discharges.

The bedload equation represents the potential for sediment transport and assumes an infinite supply of material. In addition, it represents the potential transport capacity, or the ability of the river to move material past a fixed cross-section. If the cross section is in equilibrium, the material will pass through; if the section is too narrow, scour will occur. If the section is too big, material will be deposited.

Summary

The tendency of the Middle Fork Willamette River to meander can be attributed to discharge, sediment load, longitudinal slope, bank and bed resistance to flow, vegetation, geologic type of sediment, and disturbances caused by the works of man. Flow has been regulated in the Middle Fork Willamette River since 1953 by Lookout Point and Dexter Lakes, since 1961 by the addition of Hills Creek Lake and since 1966, by the addition of Fall Creek Lake. As a result of this flow regulation, annual peak discharges have been reduced and consequently, the magnitude of river meandering appears to have decreased since 1966. Occasional peak events have triggered significant changes in the river meanders, however. Since 1966, the main stem of the river has meandered over 250 feet laterally in the vicinity of the Millrace, south of the island (Figures E-15 and E-16 in Appendix E).

The slope of the river bed in the vicinity of the Millrace confluence at River Mile 3.48 (river miles from the confluence of the Middle Fork Willamette River with the main stem Willamette River) is relatively flat (from River Mile 3.4 to River Mile 3.9) based on data contained in the Lane County Flood Insurance Study. This compares to a downriver gradient of 3.8 feet per 1000 feet from River Mile 2.5 to 3.4 and an upriver gradient of 4.5 feet per 1000 feet from River Mile 3.9 to 4.3. The relatively flat river gradient in the vicinity of the Millrace confluence has a significant positive effect on the river's tendency to meander at this location.

The ratio of a channel's length to down valley distance is referred to as its sinuosity. Streams with a sinuosity greater than 1.25 are generally classified as meandering. For the Middle Fork Willamette River in the vicinity of the Millrace the sinuosity was measured to be 1.27 for the time period 1936 through 1990. This classifies the river as a meandering stream, but close to the transition of a braided stream, which is divided into several channels.

The existing vegetation and sediment are susceptible to erosion during high discharge events. Historically and presently the river appears to be capable of both bank and streambed erosion.

The rate of streambed degradation for the main stem Willamette River has been measured to be approximately 1 foot every 10 years, and it could be presumed that the Middle Fork is experiencing similar rates. As the river continues to degrade, the Millrace confluence will have less available hydraulic head, which will require future extensions of the entrance in an upstream direction in order to continue operation as presently configured.

Works of man have been evident at the Millrace site since its construction. Annually, dikes are constructed or modified in attempts to divert and regulate flow into the Millrace. The impact of modifying hydraulic characteristics at a specific location on the river has both upstream and downstream effects on meandering.

Conclusion

A review of historic aerial photographs for the study area indicates that since about 1950 the Middle Fork Willamette River has been relatively more stable at the present county boat launch ramp location, approximately 2,000 feet upstream of the existing Millrace entrance. The boat launch ramp area appears to be a more stable and more maintainable point of diversion than the present Millrace entrance. Sediment transport would still occur at the boat launch ramp, but the site would have better access for maintenance.

In the future, it can be expected that the river will continue to meander in the vicinity of the Millrace entrance. The last few years have experienced relatively low discharges and therefore less change in channel alignment has occurred. But the river is not by any means in equilibrium at the present time. Over the long term, flattening of the river's slope by natural sedimentation processes may increase the tendency to meander. Significant discharge events have and will continue to change the alignment of the river channel.

Appendix E

Appendix E

Historic River Meanders of the Middle Fork Willamette River

An evaluation of the historic meander patterns of the Middle Fork Willamette River, at the Springfield Millrace, was conducted as part of the assessment of the stability of the Millrace entrance. The evaluation was based on a review of historic and current aerial photographs of the site. Photographs were obtained from the Portland District Office of the U.S. Army Corps of Engineers. Photographs were examined from 1936, 1939, 1944, 1947, 1950, 1956, 1964, 1965, 1967, 1972, 1976, 1979, 1980, 1983 and 1990. Included as Figures E-1 through E-7 are copies of photos for 1944, 1972, 1976, 1979, 1980, 1983 and 1990, respectively. These figures are all scaled to approximately 1"=1000'.

In order to compensate for the photographic distortion and slight variation in scale from one photograph to the next, key landmarks such as roads and structures on the river bank were digitized from the photos into a CAD (AutoCAD) drawing and a projective fit of the digitized landmarks was conducted (rubber sheeting).

Comparisons in photographs for the years 1936, 1939, 1944, 1947, 1950, 1956, 1964, 1965, 1967, 1972, 1979 and 1983 were plotted against the 1990 photograph and are presented in Figures E-8 through E-19, respectively. Significant shifts to the location of the present Millrace entrance in the main channel of the Middle Fork Willamette River are evident from this analysis.

Also worth noting in these figures is the land feature on the north channel where the county boat ramp is now located. This area can be recognized as the area along the north channel that bulges south into the main channel. Although not identified with text callout, this feature is recognizable in each figure and has remained relatively fixed during the time frame referenced in these figures. The following is a summary of the salient features of this photographic review:

Figure E-1 & Figure E-10 (1944)

The 1944 photograph Figure E-1 and Figure E-10, 1990 vs 1944, indicate that the Millrace entrance had shifted approximately 250 feet downstream.

Figure E-2 (1972)
The 1972 aerial photo and Figure E-17, 1990 vs 1972, shows channel conditions similar to 1967, but during a higher discharge. The man-made dike downstream of the Millrace still blocks flow around the north side of the island.

Figure E-3 (1976)
The 1976 aerial photo shows that the upstream man-made dike was extended approximately 100 feet further upstream. The main stem channel of the Middle Fork has moved approximately 250 feet more, south of the island and adjacent to the Millrace entrance.

Figure E-4 & Figure E-18 (1979)
The 1979 aerial photo and Figure E-18, 1990 vs 1979, indicate that the main stem channel of the Middle Fork has remained relatively stable. The man-made dike upstream of the island was re-oriented southward, thus intercepting more of the main stem channel flow.

Figure E-5 (1980)
The 1980 aerial photo shows a high water event indicating the main stem channel of the river shifted 150 feet further south. The upstream dike is washed out as well as the dike in the north channel downstream of the Millrace entrance.

Figure E-6 & Figure 19 (1983)
The 1983 aerial photo and Figure E-19, 1990 vs. 1983, indicate that the main stem of the river has moved northward approximately 100 feet since 1980.

Figure E-7 (1990)
The 1990 aerial photo. The channel has remained relatively stable between 1983 and 1990, although it appears that the bar is headcutting in an upstream direction in addition to eroding the south bank of the main stem channel of the river. This was also evident from field inspection performed in 1994. The upstream portion of the island, adjacent to the main stem channel of the river, has accreted due to the practice of rebuilding the upstream dike each year.

Figure E-8 (1936)
A comparison of the 1936 channel with the 1990 channel is shown on Figure E-8, 1990 vs 1936. It appears that in 1936 a channel was dredged through the a gravel bar in the vicinity of the middle of the present day island.

Figure E-9 (1939)
The dredged channel evident in the 1936 photograph is still in place with the river breaching the Millrace at the two locations indicated in Figure E-9, 1990 vs 1939.

Figure E-11 (1947)
Between 1944 and 1947, a new channel approximately 900 to 1000 feet in length was dredged in an upstream direction as shown on Figure E-11, 1990 vs 1947.

Figure E-12 (1950)
Significant high discharges on the Middle Fork Willamette River from 1947 through 1950 precipitated the foundation of a northerly meander just upstream of the present inlet, as shown on Figure E-12, 1990 vs 1950. For comparison, the 1990 channel is located approximately 500 feet south of the 1950 channel meander. Also indicated on Figure E-12, the main stem of the river passes close to the 1990 diversion point. The island immediately south of the millrace entrance is starting to emerge.

Figure E-13 (1956)
By 1956, the main stem of the Middle Fork Willamette River had moved south from the 1950 meander approximately 900 feet as shown on Figure E-13, 1990 vs 1956. In addition, the island became more clearly defined and had evenly split the flow of the river.

Figure E-14 (1964)
Over the next eight years, the main stem channel of the Middle Fork Willamette River moved north to the 1990 location as indicated on Figure E-14, 1990 vs 1964, approximately 1,000 to 1,500 feet upstream from the Millrace entrance. The main stem flow around the island became established on the south side of the island. A man-made dike was placed in the north channel just downstream of the Millrace entrance.

Figure E-15 (1965)
The Christmas flood of 1964 split the island, with the flow around the two remnant islands creating three distinct channels as shown in Figure E-15, 1990 vs 1965.

Figure E-16 (1967)
The main stem of the river is confined in a single channel with a man-made dike on the upstream point of the island diverting flow into the Millrace. Another man-made dike blocks the flow downstream of the Millrace on the north channel. See Figure E-16, 1990 vs. 1967.

Figure E-1
Springfield Millrace
1944 Aerial Photo
Approximate Scale 1"=1000'

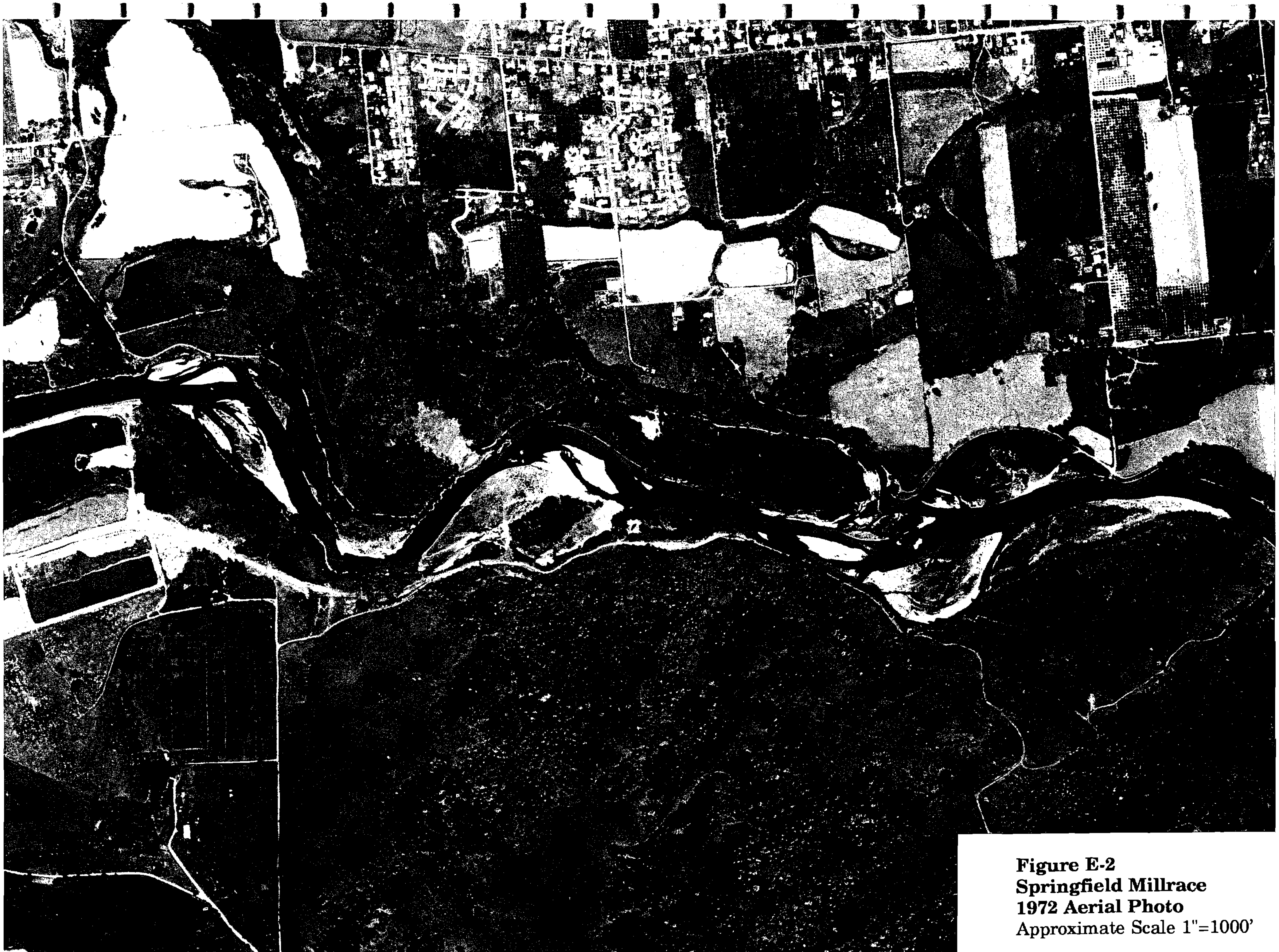

Figure E-2
Springfield Millrace
1972 Aerial Photo
Approximate Scale 1"=1000'

Figure E-3
Springfield Millrace
1976 Aerial Photo
Approximate Scale 1"=1000'

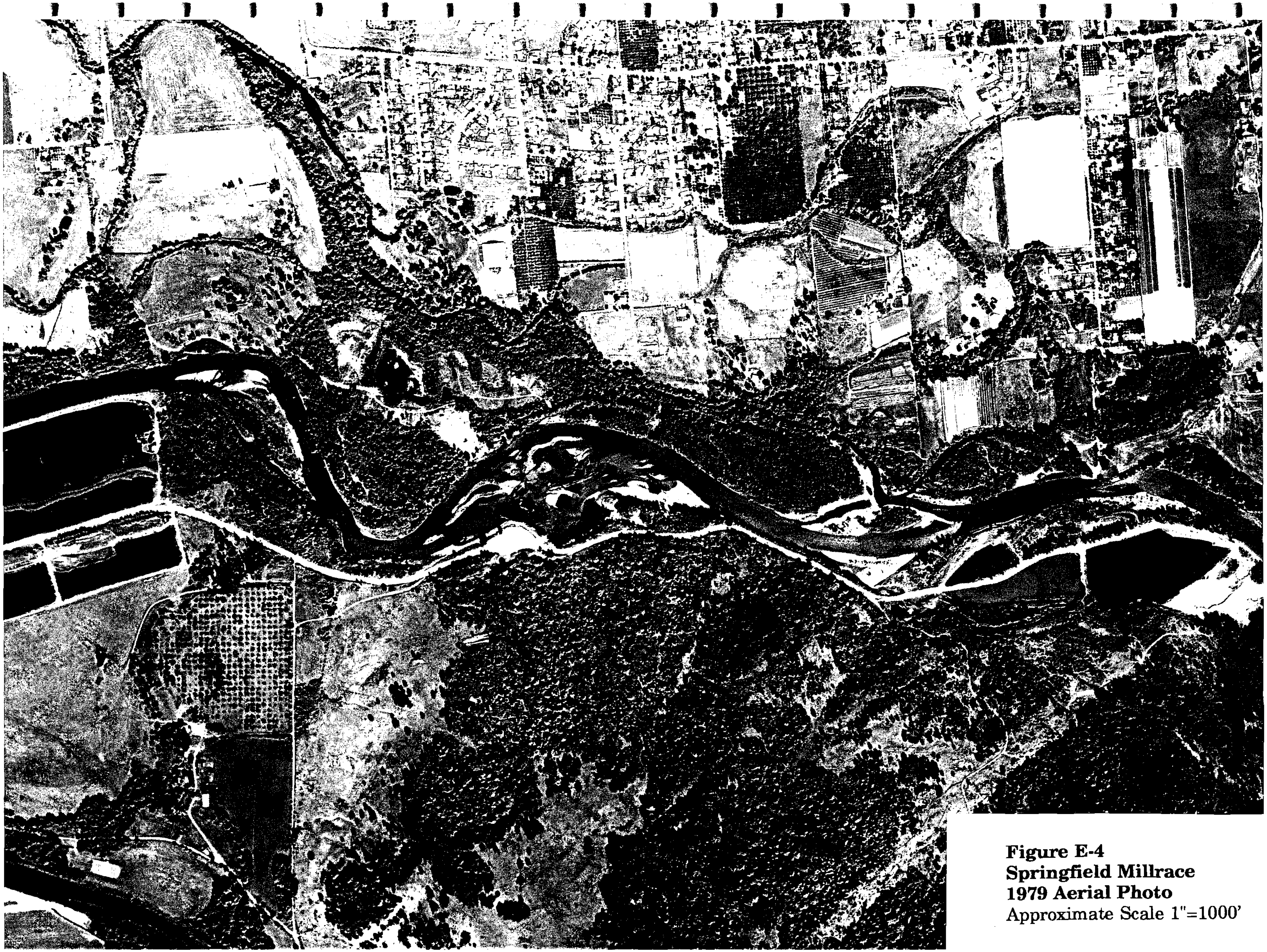

Figure E-4
Springfield Millrace
1979 Aerial Photo
Approximate Scale 1"=1000'

Figure E-5
Springfield Millrace
1980 Aerial Photo
Approximate Scale 1"=1000'

Figure E-6
Springfield Millrace
1983 Aerial Photo
Approximate Scale 1"=1000'

Figure E-7
Springfield Millrace
1990 Aerial Photo
Approximate Scale 1"=1000'

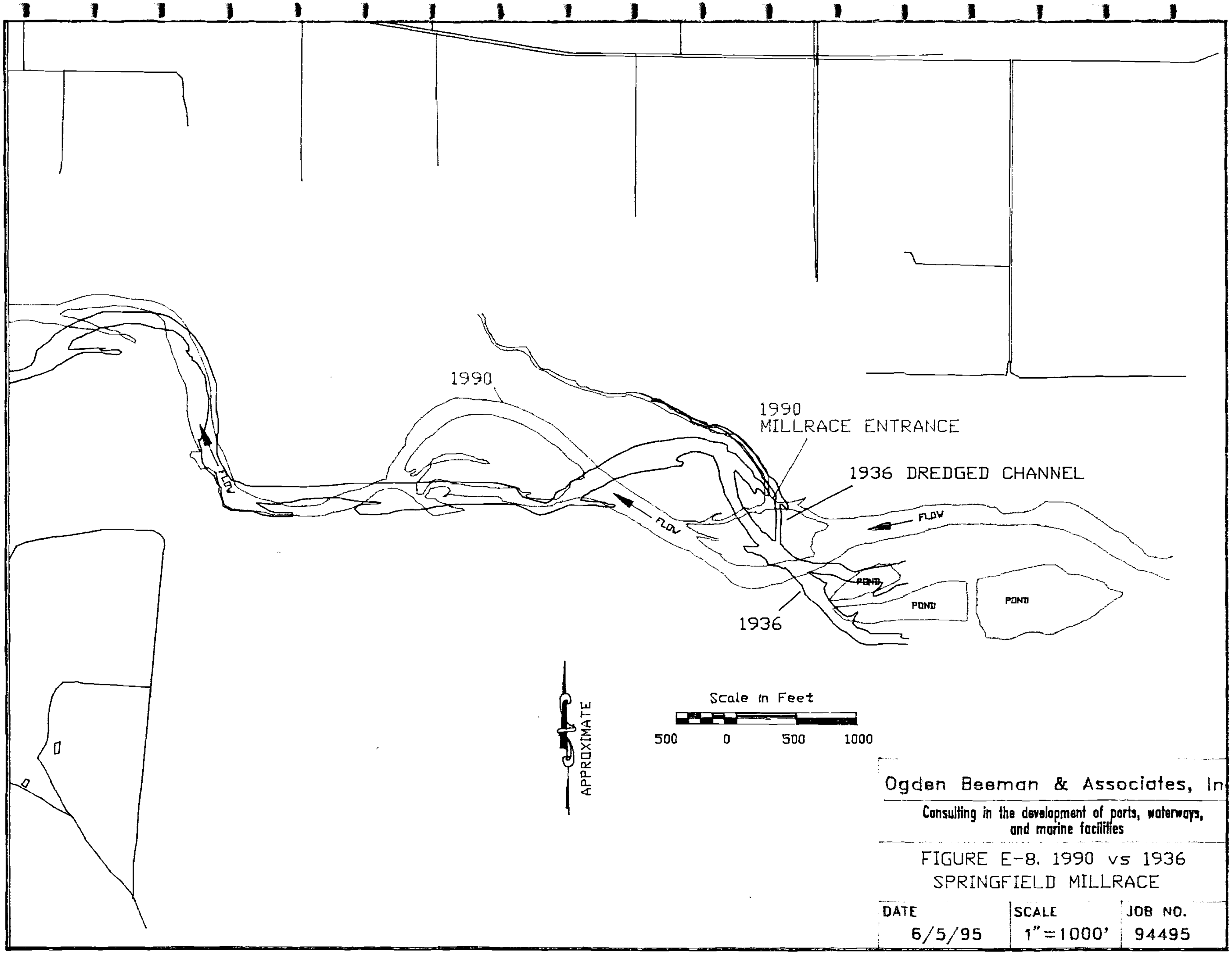

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FIGURE E-8. 1990 vs 1936
SPRINGFIELD MILLRACE

DATE	SCALE	JOB NO.
6/5/95	1"=1000'	94495

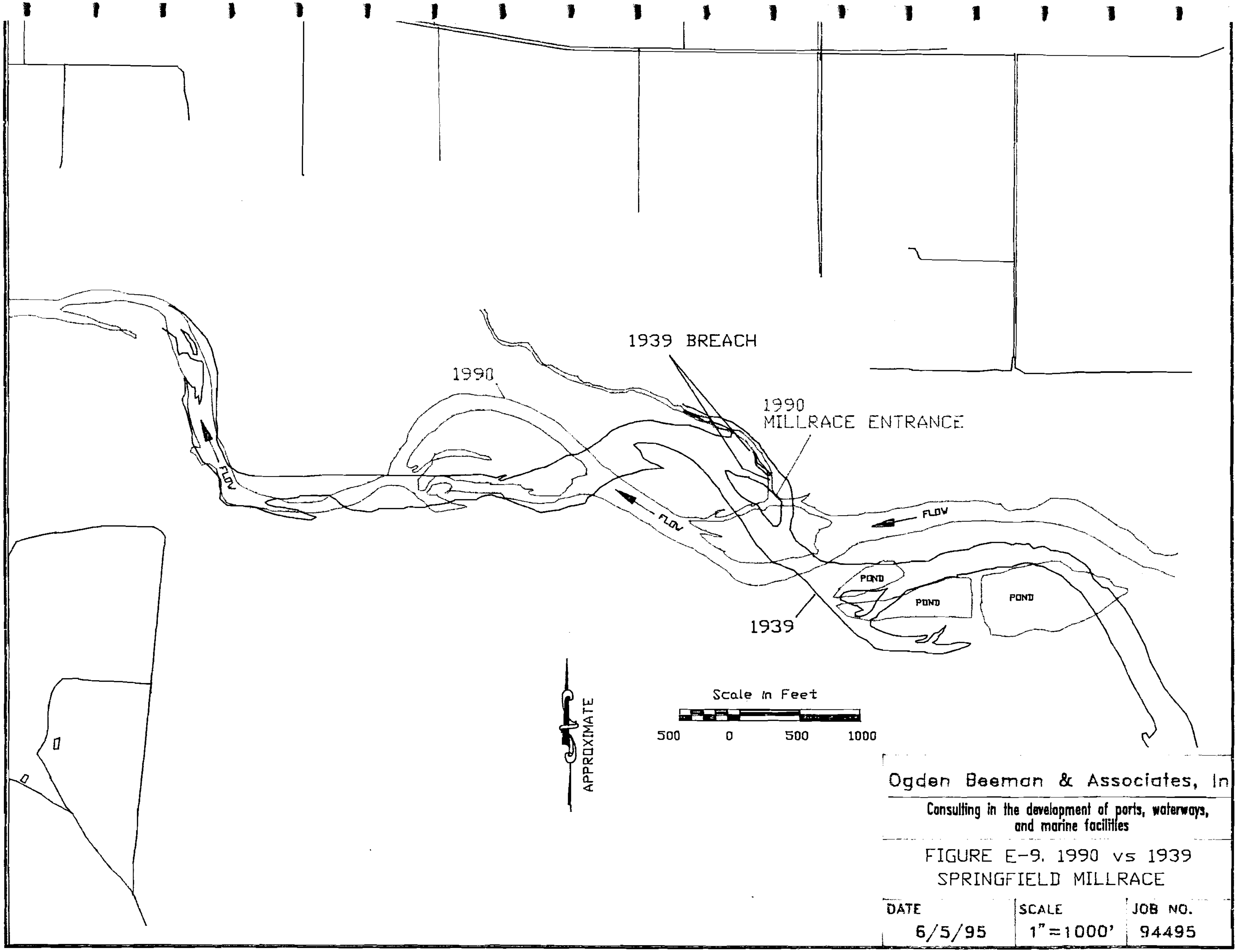

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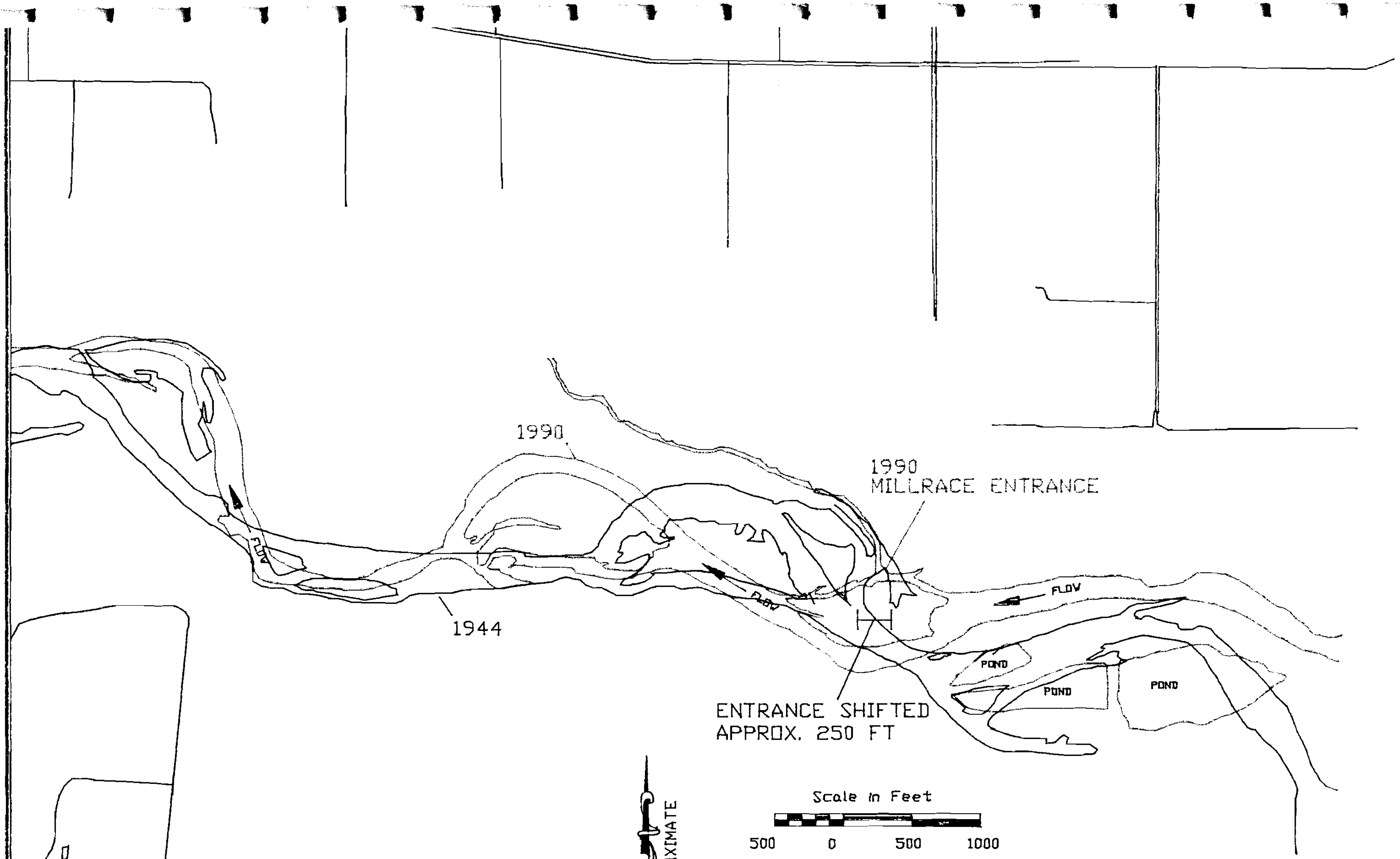
FIGURE E-9. 1990 vs 1939
SPRINGFIELD MILLRACE

DATE	SCALE	JOB NO.
6/5/95	1" = 1000'	94495



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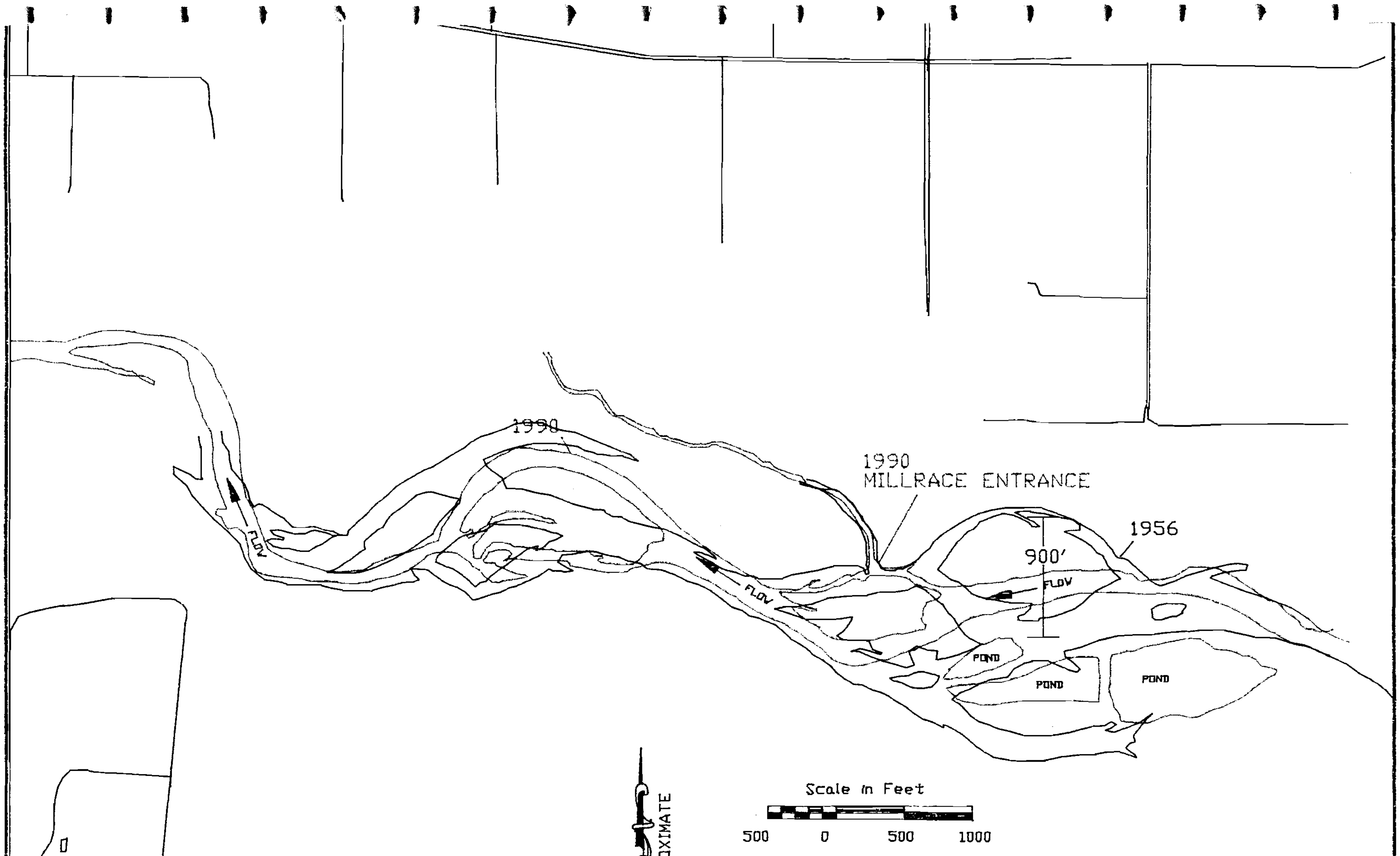
Consulting in the development of ports, waterways, and marine facilities

FIGURE E-10. 1990 vs 1944
SPRINGFIELD MILLRACE

DATE	SCALE	JOB NO.
6/5/95	1" = 1000'	94495



Ogden Beeman & Associates, In

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FIGURE E-13. 1990 vs 1956
SPRINGFIELD MILLRACE

DATE	SCALE	JOB NO.
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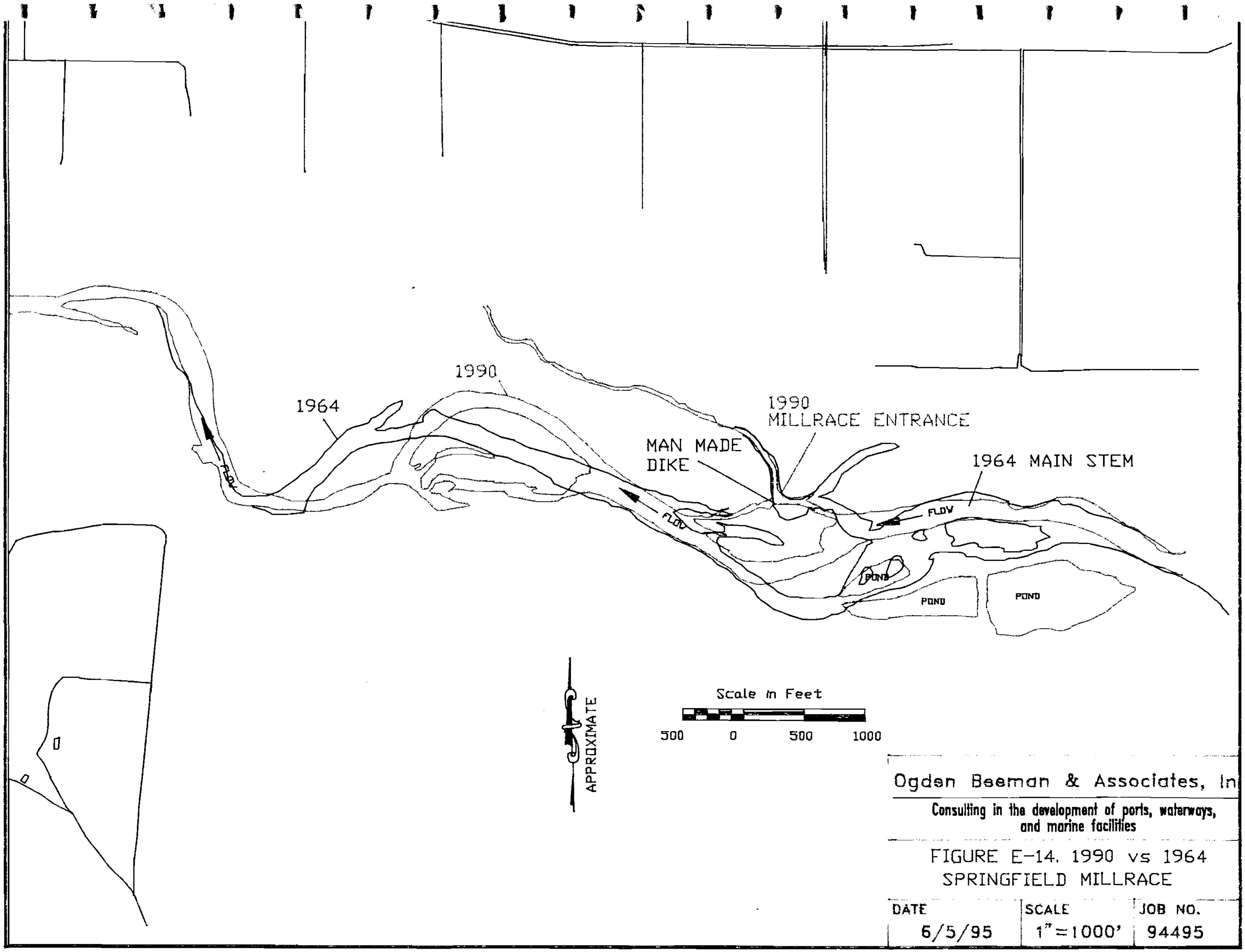
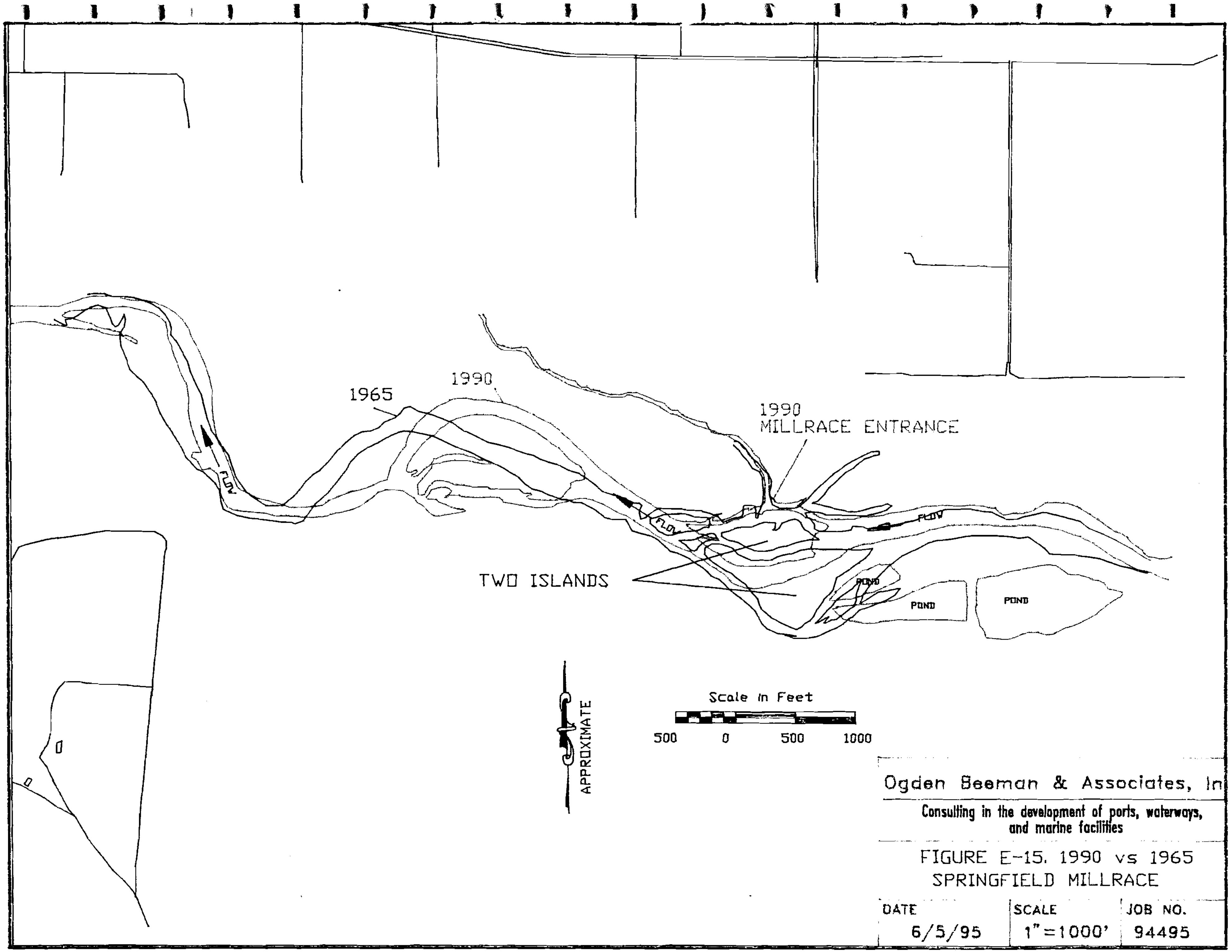


FIGURE E-14. 1990 vs 1964
SPRINGFIELD MILLRACE



Ogden Beeman & Associates, In

Consulting in the development of ports, waterways, and marine facilities

FIGURE E-15. 1990 vs 1965
SPRINGFIELD MILLRACE

DATE	SCALE	JOB NO.
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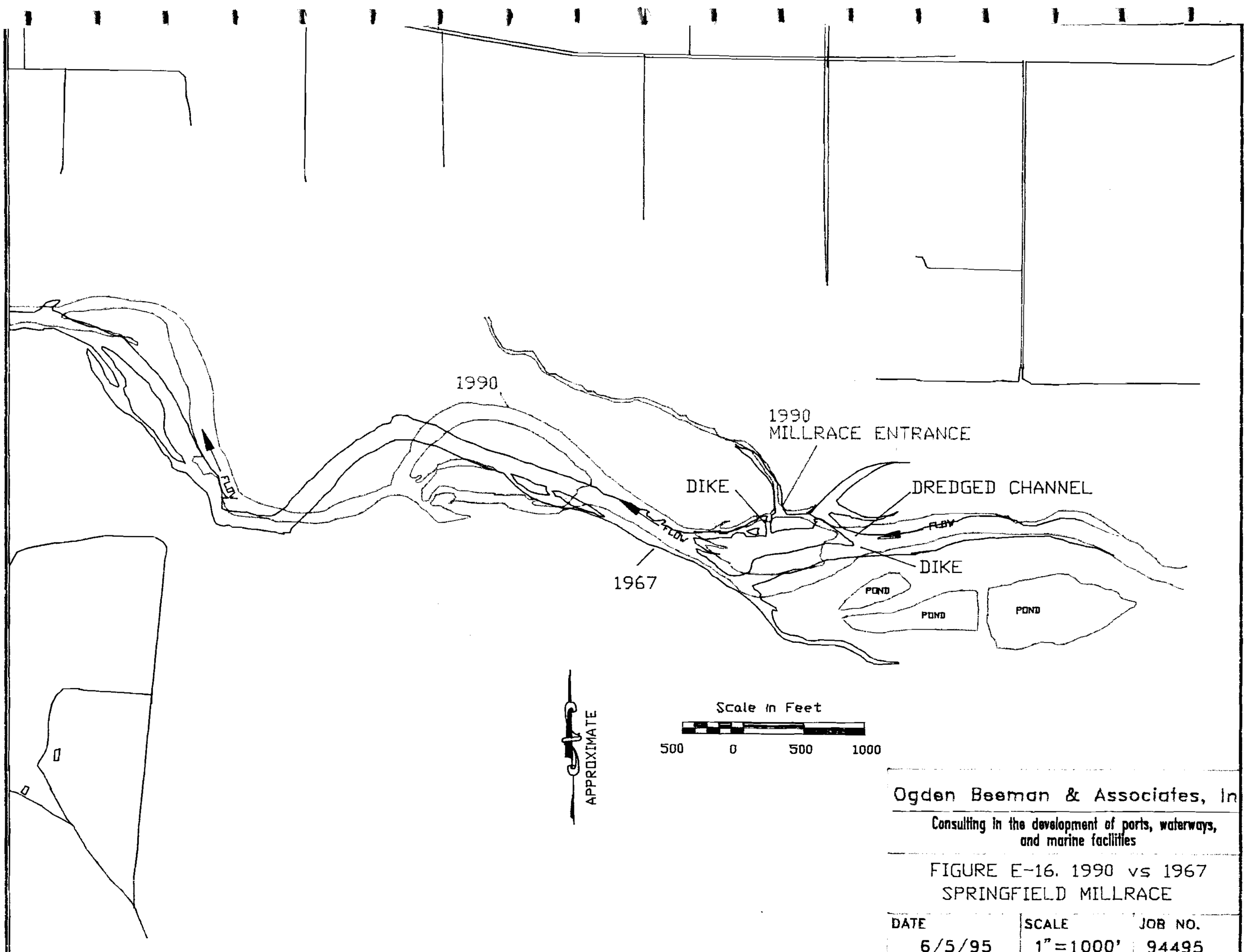

Ogden Beeman & Associates, In

Consulting in the development of ports, waterways, and marine facilities

FIGURE E-16. 1990 vs 1967
SPRINGFIELD MILLRACE

DATE	SCALE	JOB NO.
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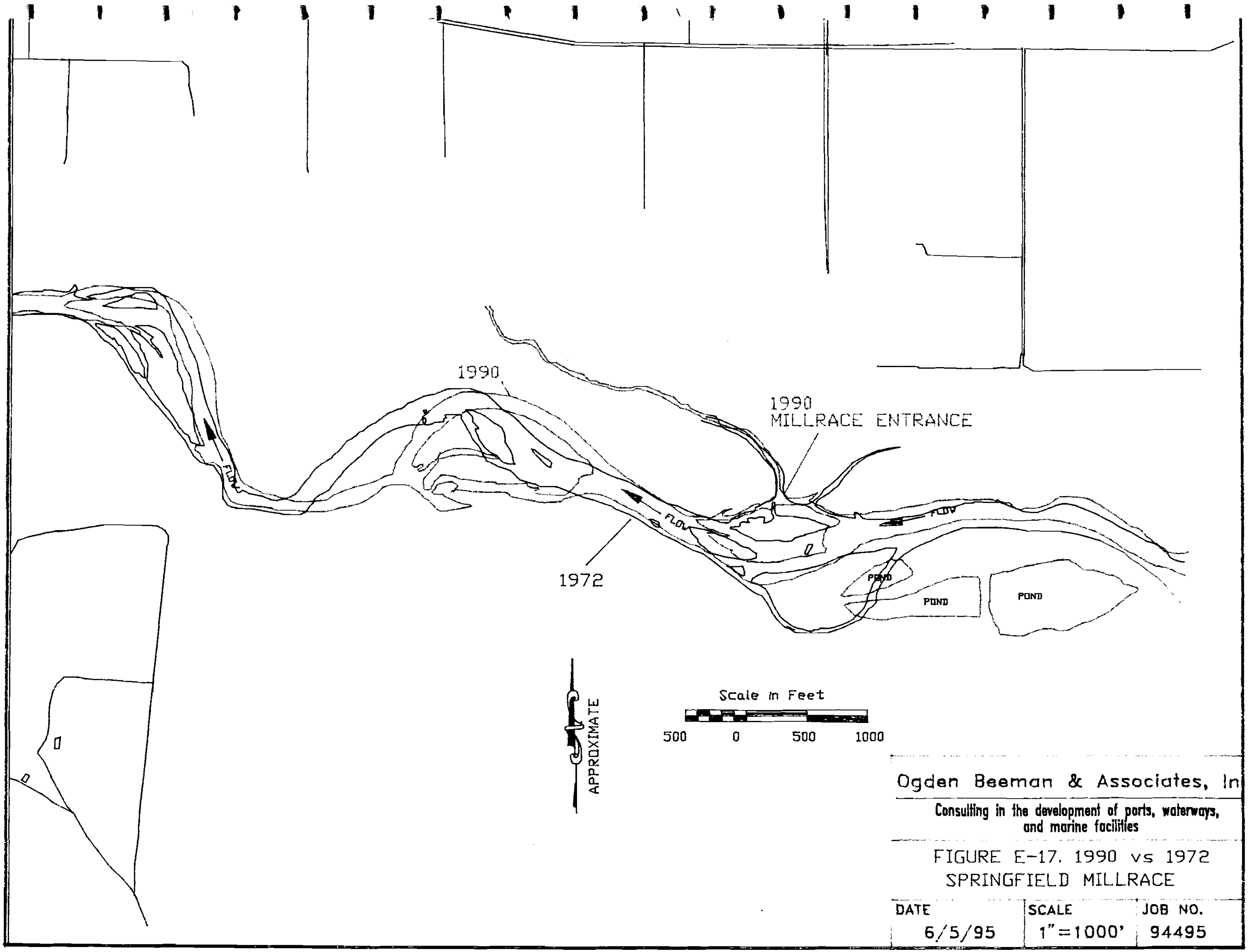

Ogden Beeman & Associates, In

Consulting in the development of ports, waterways, and marine facilities

FIGURE E-17. 1990 vs 1972
SPRINGFIELD MILLRACE

DATE	SCALE	JOB NO.
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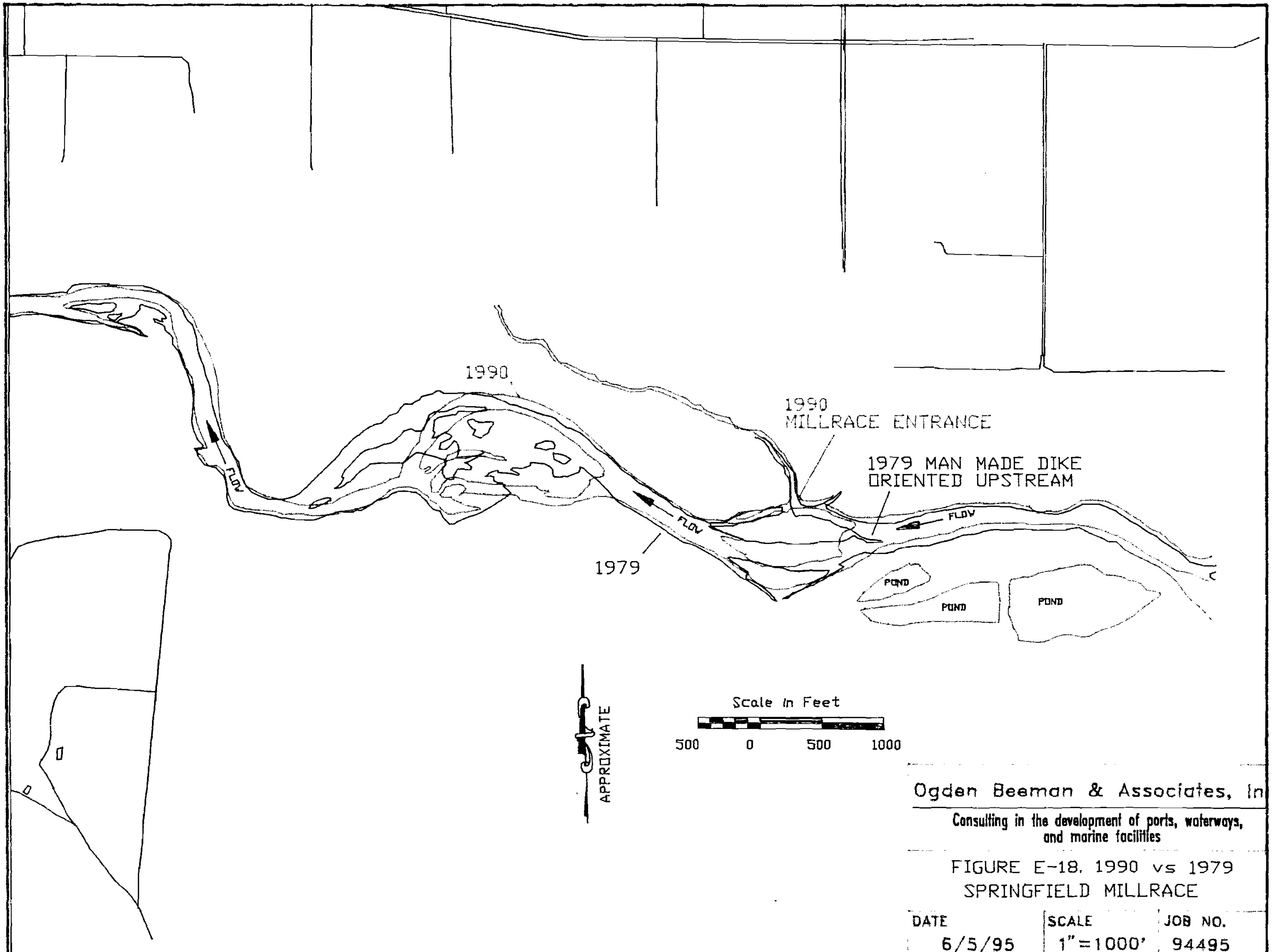

Ogden Beeman & Associates, In

Consulting in the development of ports, waterways, and marine facilities

FIGURE E-18. 1990 vs 1979
SPRINGFIELD MILLRACE

DATE	SCALE	JOB NO.
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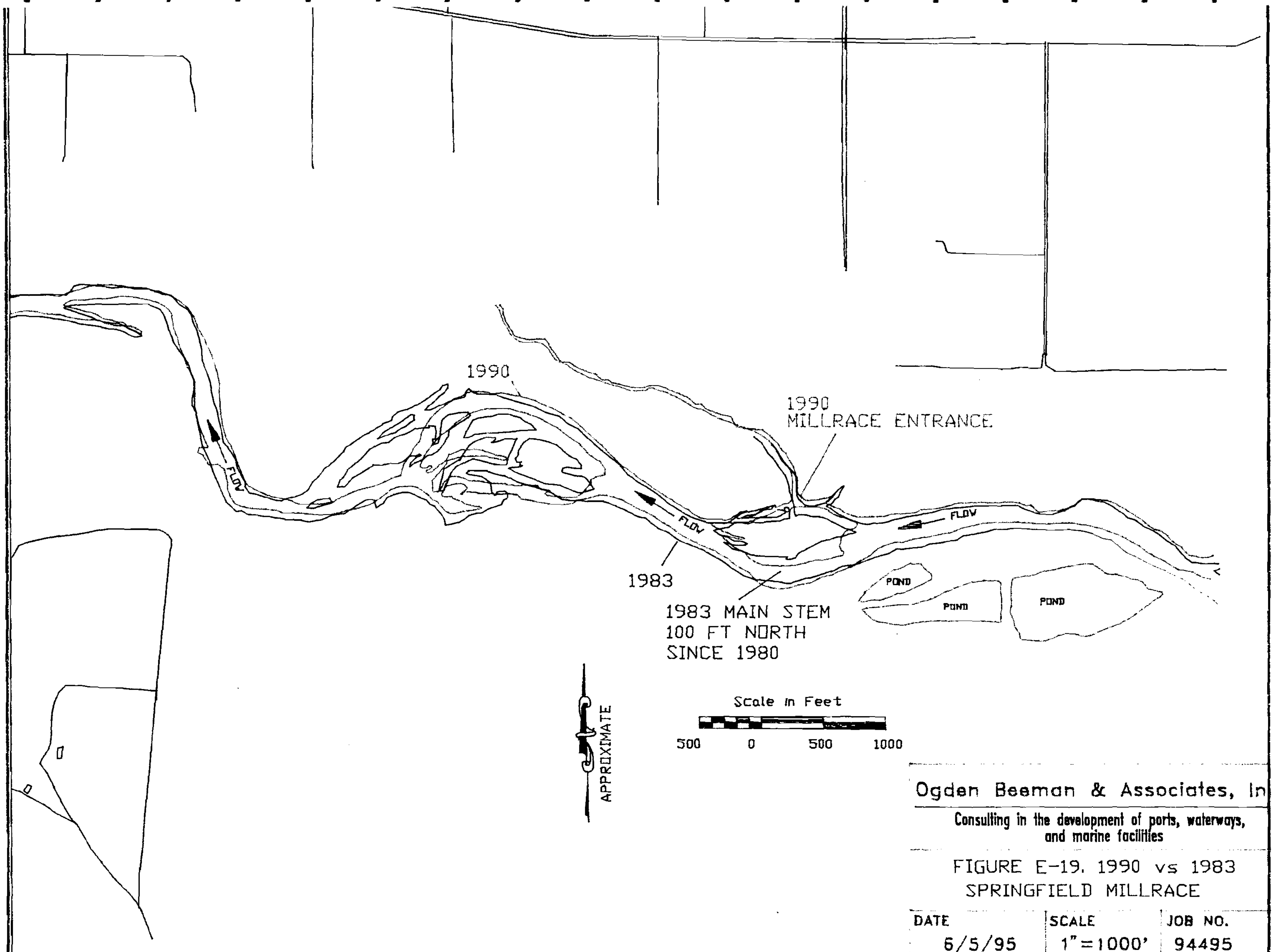

Ogden Beeman & Associates, In

Consulting in the development of ports, waterways, and marine facilities

FIGURE E-19. 1990 vs 1983
SPRINGFIELD MILLRACE

DATE	SCALE	JOB NO.
6/5/95	1"=1000'	94495

Appendix F

Appendix F

Fishery Issues

Background

The Springfield Millrace is an historic man-made canal dating from the mid-1850's diverting water from the Middle Fork Willamette River. The Millrace historically has been used to supply water for a grist mill, lumber production, irrigation, groundwater recharge and other uses.

The Millrace consists of a canal (3.5 miles long) from the Middle Fork, a 35-40 acre mill pond (approximately 0.7 miles long and 500 feet wide), and a narrow outlet area, approximately 0.5 miles long, that enters the Middle Fork. There are several side canals upstream of the mill pond that divert water for various purposes. There is a fish ladder at the lower end of the mill pond, however the ladder is in need of repair.

The Middle Fork is split by an island into a north channel and a south main channel upstream of the Millrace entrance. The entrance to the Millrace is on the north channel. Water flow into the Millrace is dependent upon annual maintenance of the north channel because of substantial bedload movement during seasonal high flows in the Middle Fork.

Annual maintenance has been performed under annual permits issued by the U.S. Army Corps of Engineers and Oregon Division of State Lands. Additional permit review has been performed by Oregon Department of Fish and Wildlife, National Marine Fisheries Service, and U. S. Fish and Wildlife Service. Maintenance activities include removal of substantial quantities of large gravel that has increased the bed elevation of the north channel to the point where water movement is impeded and diverted to the south channel.

Agency concerns have focused on the presence of heavy maintenance equipment in the north channel of the Middle Fork, construction of berms in the north channel to divert water into the Millrace, and potential pollution from the use of maintenance equipment in the Middle Fork. Other issues identified by the agencies include preventing juvenile fish from entering the upstream end of the Millrace, providing improved fish passage at the fish ladder located at the mill pond (since adult fish can enter the Millrace at the downstream end), minimizing disturbance of spawning areas in the north channel, and maintenance of water quality in the Middle Fork Willamette River and the Millrace.

The following sections of this appendix will discuss fish species of concern, fish screening criteria, adult fish barriers at the outfall of the Millrace, improvement of the fish ladder, permit requirements, alternatives to screening, and recommendations.

Fish Species of Concern

The following species have been identified by the Oregon Department of Fish and Wildlife and U.S. Fish and Wildlife Service as species of concern for this project. Efforts should be taken to protect all life stages and habitat conditions of these species. Juvenile winter steelhead and spring chinook, and rainbow trout adults are the primary life stages to consider.

Winter Steelhead

Winter steelhead were not found in the basin prior to 1956. Willamette hatchery stock was introduced in 1953. The estimated run size of winter steelhead is now 200 to 400 fish. The extent of winter steelhead spawning and rearing is not well known. Adults enter the river from January to early June (ODFW, 1992). Spawning occurs in the North Channel around the island as early as mid-March with the peak from mid-April to mid-May with incubation of eggs usually completed in June (Pers. Comm. Jeff Ziller ODFW Upper Willamette District Fish Biologist, 8/18/94). Winter steelhead adults migrate upstream through the Millrace which has a fish ladder.

Spring Chinook

Spring chinook are native to the Middle Fork Willamette River basin. Historically, the spring chinook run in the basin may have been the largest of any basin above Willamette Falls. Adult spring chinook begin to enter the Middle Fork Willamette River in early May and continue to arrive through late August with peak migration in the last half of June (ODFW, 1992). Spring chinook adults migrate upstream through the Millrace by using the fish ladder.

Rainbow Trout

Rainbow trout are native to the basin. They occur in the larger streams including the Middle Fork Willamette River from Staley Creek to the mouth of the Middle Fork. ODFW considers Willamette River rainbow trout as a stock of concern because of a lack of specific information over much of their range (ODFW, 1992). Rainbow trout adults reside in the Millrace.

Oregon Chub

Oregon chub are endemic to the Middle Fork Willamette River and were designated as a federally listed endangered species on November 17, 1993 (Volume 58 Federal Register 53800 (1993)). The chub prefers mainstem meanders and oxbows, stable backwater sloughs, marshes and beaver ponds. They prefer shallow water with little or no velocity, summer water temperatures exceeding 64°F, and depositional substrates with abundant aquatic vegetation. Presently, none of these habitat conditions exist in the Springfield Millrace or the Middle Fork Willamette River near the diversion.

Fish Screening Criteria

The construction of an intake structure for the Millrace to reduce maintenance activities in the Middle Fork and to provide a more dependable supply of water may require a screening system to prevent juvenile and/or adult fish from entering the Millrace. An alternative to fish screening on the entrance to the Millrace could be improvement and maintenance of water quality in the Millrace and Mill Pond as well as providing adequate flows through the system to provide guidance for fish. In addition, any side canals should be screened to prevent loss of fish.

The type of fish screen selected for this project will depend on the size of the intake and the applicable fish screening criteria. The following are juvenile fish screening criteria developed by the Oregon Department of Fish and Wildlife (ODFW) and the National Marine Fisheries Service (NMFS). The U.S. Fish and Wildlife Service (USFWS) does not have any criteria established for juvenile fish screens. The USFWS typically relies on criteria established by the ODFW and NMFS.

Screen Type

ODFW

All new screening systems will be of the physical barrier type. A physical barrier type screen is defined as any screen, bar, or rack in various shapes and orientations either stationary or moving with openings small enough to prevent fish movement into a diversion (ODFW, 1989a). The specific system selected will be approved by the ODFW after a site evaluation.

NMFS

All juvenile passage facilities shall be designed to function properly through the full range of hydraulic conditions in the lake, tidal area, or stream and in the diversion, and shall account for debris and sedimentation conditions which may occur (NMFS, 1994).

Screen Placement

ODFW

At the diversion entrance, and where physically practical, the screen face shall be parallel to the waterflow and aligned with the adjacent bankline. The bankline shall be shaped to smoothly match the face of the screen structure to prevent hydraulic disturbances upstream, downstream, or in front of the screen face (ODFW, 1989a).

All screens installed in a diversion canal downstream of the entrance shall be provided with an effective bypass system or trap or combination, to collect and safely transport fish back to the river or stream. Fish screens placed in diversion canals shall, where practical, be constructed at an angle to the approaching flow with the downstream end of the screen terminating at the bypass system or trap entrance (ODFW, 1989a).

NMFS

Where physically practical and biologically desirable, the screen shall be constructed at the diversion entrance with the screen face generally parallel to river flow. For screens constructed at the bankline, the screen face shall be aligned with the adjacent bankline, and the bankline shall be shaped to smoothly match the face of the screen structure to prevent eddies in front, upstream and downstream of the screen (NMFS, 1994).

Where installation of fish screens at the diversion entrance is not desirable or is impractical, the screens may be installed in the canal downstream of the entrance at a suitable location. All screens installed downstream from the diversion entrance shall be provided with an effective bypass system (NMFS, 1994).

Screen Material

ODFW

The screen material shall provide a minimum of 40 percent open area. Screen openings may be round, rectangular, square, or continuous slot provided screen cleaning operations and structural integrity of the screen are not impaired. Screens shall be constructed of any rigid corrosion resistant material, perforated or woven, that maintains a smooth uniform surface that is durable and strong enough for long-term continuous use (ODFW, 1989a).

NMFS

The screen material shall be corrosion resistant and sufficiently durable to maintain a smooth uniform surface with long term use. Types of material include perforate plate, profile bar screen, and woven wire screen (NMFS, 1994).

Screen Size

ODFW

For salmonid fry up to 59mm in length, screen openings shall not exceed 1/8 inch (3.2mm) in the narrowest direction. For salmonid fingerlings larger than 60mm, screen openings shall not exceed 1/4 inch (6.4mm) in the narrowest direction. For other species and life stages individual evaluation of the project will be required to determine screen opening size (ODFW, 1989a).

NMFS

Perforated plate openings for fry (less than 2.36 inches or 60mm) shall not exceed 3/32 or 0.0938 inches (2.38mm). For fingerlings (greater than 2.36 inches or 60mm) screen openings shall not exceed 1/4 or 0.25 inches (6.35mm). For profile bar screen for fry, the narrowest dimension in the screen openings shall not exceed 0.0689 inches (1.75mm) in the narrow direction. For fingerlings, the narrowest dimension in the screen opening shall not exceed 1/4 or 0.25 inches (6.35mm) in the narrow direction. Woven wire screen openings for fry shall not exceed 3/32 or 0.0938 inches (2.38mm) in the narrow direction. For fingerlings, screen openings shall not exceed 1/4 or 0.25 inches (6.35mm) in the narrow direction (NMFS, 1994).

Water Velocity

There are two types of velocity to consider in the design of fish screens: approach velocity and sweeping velocity. Approach velocity is defined as the water velocity component perpendicular to and approximately three inches in front of the screen face. Sweeping velocity is defined as the velocity of water flowing parallel and adjacent to the face of the screen in the direction of the bypass device. Screening facilities shall be designed hydraulically to ensure uniform flow distribution throughout the entire screen surface.

ODFW

The approach velocity component for salmonid fry, up to 59mm in length, shall not exceed 0.4 feet per second (fps). Two and one-half feet of effective screen area must be provided for each cubic foot per second of diverted water. The approach velocity component for salmonid fingerlings, 60mm and longer, shall not exceed 0.8 feet per second. One and one-quarter feet of effective screen area must be provided for each cubic foot per second of water diverted. For salmonids, the sweeping velocity component shall be equal to or greater than the approach velocity (ODFW, 1989a).

NMFS

The approach velocity for salmonid fry shall not exceed 0.4 feet per second (fps) and 0.8 fps for salmonid fingerlings. Sweeping velocity shall be greater than the approach velocity. This is accomplished by angling the screen face at less than 45° relative to flow (NMFS, 1994).

Fish Bypass

ODFW

Bypass configuration, hydraulic capacity, entrance and transport velocities, and other details will be dependent upon the design of the screening facility, such that the bypass acts in harmony with the screens to readily attract fish and provide safe passage. A fish bypass device is any pipe, flume, open channel or other means to collect and convey fish back to the body of water from which the fish was diverted (ODFW, 1989a).

NMFS

The screen and bypass shall work in tandem to move out-migrating salmonids (including adults) to the bypass outfall with a minimum of injury or delay. The bypass entrance shall be located so that it can easily be located by out-migrants. The bypass entrance must extend from the floor to the canal water surface. Bypass pipes shall have smooth surfaces and be designed to provide conditions that minimize turbulence. Bypass outfalls shall be located such that ambient river velocities are greater than 4.0 fps. Outfalls shall be located to minimize avian and aquatic predation in areas free of eddies, reverse flow or known predator habitat (NMFS, 1994).

Intake and Outfall Structure Criteria

The ODFW has established the following policy for intake and outfall structures: Installation and operation of intake and outfall structures shall result in no net loss of fish and wildlife resources, their habitat or public use of these resources (ODFW, 1989b).

The following standards should be considered when construction of an intake or outfall structure is proposed (ODFW, 1989b):

- ODFW fish passage and protection policies and standards shall be met whenever intake or outfall structures are constructed.

- Waterway banks and beds at the point of discharge for outfalls shall be protected to prevent erosion.
- Riparian vegetation shall be protected from erosion and disturbed banks shall be revegetated with compatible species to protect fish and wildlife or other aquatic life.
- Water quality shall conform to DEQ standards.
- Timing of construction shall be restricted to protect fish and wildlife or other aquatic life.
- Intake and outfall structures containing concrete or wood preservatives shall be isolated from the water, cured or dried prior to placement in waterways.
- Upland pumps are preferred to submersible pumps.

Adult Fish Barrier at the Outfall of the Millrace

A barrier to prevent adult fish from entering the Millrace at the downstream end may be necessary if water quality conditions are not improved in the waterway and if side channels and pumps on the canal are not screened, and the existing fish ladder is not maintained. In addition, the Mill Pond is shallow and may not provide adequate depths, water temperatures, and dissolved oxygen for migrating fish. If a barrier is not installed, then adequate means for adult fish to move past the intake area at the inlet of the Millrace need evaluation.

Fish Ladder

The fish ladder at the outlet of the Mill Pond is in disrepair and needs to be rehabilitated. The ladder should be evaluated relative to current standards for passage of fish. In addition, if the Mill Pond is considered as an area where juvenile fish will enter at the inlet of the Millrace and pass through the Millrace, then a bypass system should be considered for the area of the fish ladder. The bypass would likely be designed to pass fish from various depths once they reach the vicinity of the fish ladder.

Permits

Permits required for this project include U.S. Army Corps of Engineers Section 404, DSL Removal/Fill, and DEQ Section 401 Water Quality Certification. The DEQ 401 Certification is part of the Corps review. In Oregon, a joint permitting process exists for the application for the Corps 404 and the DSL Removal/Fill permits. An additional permit is required for the water right from the Oregon Water Resources Department (OWRD). The OWRD will require compliance to fish screening criteria that the ODFW recommends or will require evidence of an agreement that screening is not needed.

Alternatives to Fish Screening

Alternatives to provide water to the Millrace include both gravity flow and pumped flow or a combination of gravity and pumped flow. Pumped flow would likely require fish screening for the pumps. Preliminary evaluation of the Millrace during this study has identified a possible alternative to providing fish screening at the entrance to the Millrace if gravity flow is used. For gravity flow, the Millrace intake area would not contain mechanical devices that would injure fish during passage into the Millrace. There are no other mechanical devices that would injure or kill fish in the canal, except possibly for intake pumps that may exist within the Millrace. If intake pumps exist, the location, size of intake, and time of use should be determined, and the pump retrofitted with a fish screen. Retrofitting is usually convenient and inexpensive for irrigation or fire pumps.

The primary impediments to allowing fish to freely pass into the canal, if pumps are not necessary at the intake (and other pumps or canals on the Millrace are screened) would be: losses of juvenile or adult fish due to poor water quality in the Mill Pond, residualization in the Millrace and/or Mill Pond or side canals, and increased predation in the Millrace and/or Mill Pond.

Recommendations

1. *Water Intake Screening*
   The proposed intake structure at the Millrace should be adequately screened to the standards of the ODFW and NMFS

to prevent fish from entering the Millrace if water quality conditions are not conducive to survival or if pumps will be used to supply water to the system. If a gravity flow system is proposed, then screens may not be necessary, depending on the habitat and water quality of the Millrace, including presence of predators.

2. *Improvement of Habitat Quality in the Millrace*
The use of the Millrace to allow free passage of fish should be investigated. The Millrace potentially could be improved to provide acceptable habitat for fish. Studies necessary to evaluate habitat suitability include:

Water quality — Dissolved oxygen and water temperature are the primary parameters that will need evaluation. The apparent shallow nature of the mill pond produces considerable heating of the water in the pond. This may make the pond unsuitable for anadromous fish. Dissolved oxygen levels would also likely be lower due to higher temperatures and increased oxygen demand. Also, the high water temperatures could cause legal blooms that further deplete oxygen, especially at night. Increased flow of water through the Millrace may alleviate these problems.

Dissolved oxygen and water temperature may be dependent on the amount of flow that can pass through the Millrace. If flows are too low, then stagnant conditions will occur and low dissolved oxygen and high water temperatures may be the result. Adequate dissolved oxygen and water temperatures, especially during summer months, should be evaluated by modeling these parameters with a range of flows into the Millrace to determine the sensitivity of the water body to a range of flow conditions. Once the impact of flow on water temperature and dissolved oxygen are known, strategies to improve habitat conditions in the Millrace and mill pond can be developed.

Nutrient loading — Nutrient loading into the Millrace or Mill Pond from surrounding activities can impact the amount of dissolved oxygen in the water, especially during summer months. An evaluation of nitrates and phosphates can identify conditions that are conducive to oxygen sags that would be detrimental to fisheries resources.

Morphology of the Mill Pond — Survey and mapping of the Millrace, including the Millrace, mill pond and the outlet of the mill pond to the Willamette River will provide information on habitat available for juvenile and adult rearing and passage conditions for migratory fish. This information would be helpful in determining if feasible alternatives are available to provide improvements to the aquatic habitat.

Other Water Quality Concerns — An evaluation of historic activities in the Millrace should be undertaken to determine if other conditions exist that would impact the use of the Millrace and mill pond for fisheries habitat. This would include the presence of toxic substances in the vicinity of the Millrace complex and/or in the mill pond.

3. *Identification of Water Diversions in Millrace and Water Retention*

   Water Diversions from Millrace — There are a number of side channels or pump installations that should be located and mapped. The size of the pump and the volume of water that can be pumped as well as the size of the channels without pumps should be determined. This information will aid in evaluating water needs in the Millrace as well as help determine the size and number of barriers or screens to prevent fish injury and mortality.

   The ability of the mill pond to retain water has been questioned by resource agencies. A study to determine the water balance of the Millrace and mill pond should be conducted.

4. *Improvement of Fish Ladder*

   The ability of the fish ladder to pass both downstream migrating juvenile fish and upstream migrating adults should be evaluated. The present ladder is in disrepair and needs some upgrading and maintenance to meet current standards.

5. *Necessity of Tailrace Barrier*
The need for a barrier at the exit of the Millrace to prevent upstream passage of adult salmonids should be considered. If adult salmonids are to be excluded from the Millrace, a downstream barrier will be necessary. The nature of the barrier has not been determined, but it could be a physical screening with sufficient opening spacing to exclude adult salmonids. Other barriers might include a velocity barrier, or other designs consistent with use of the facility for recreational purposes.

Appendix G

120.2 - Main Channel

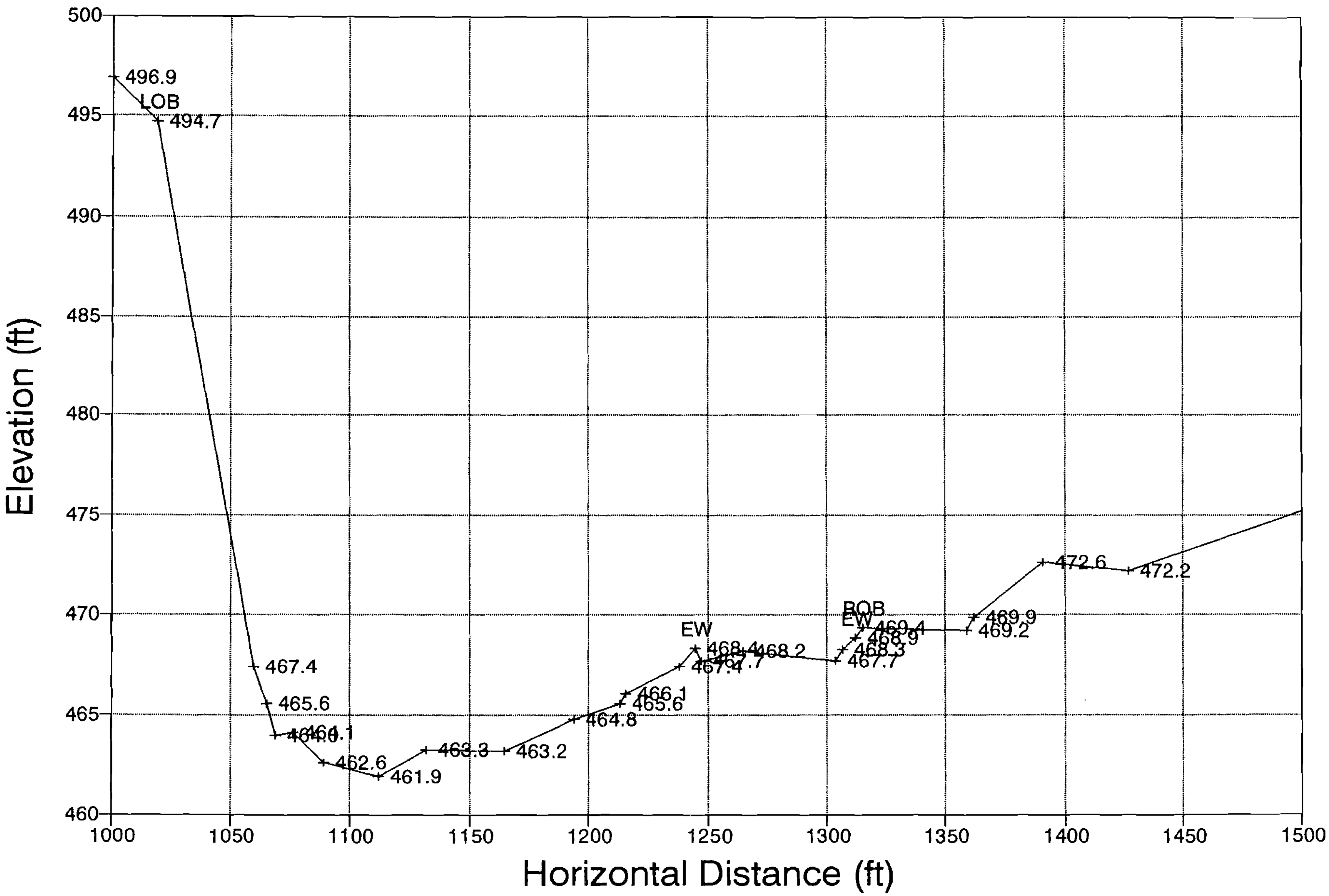

Figure G-1

120.4 - Main Channel

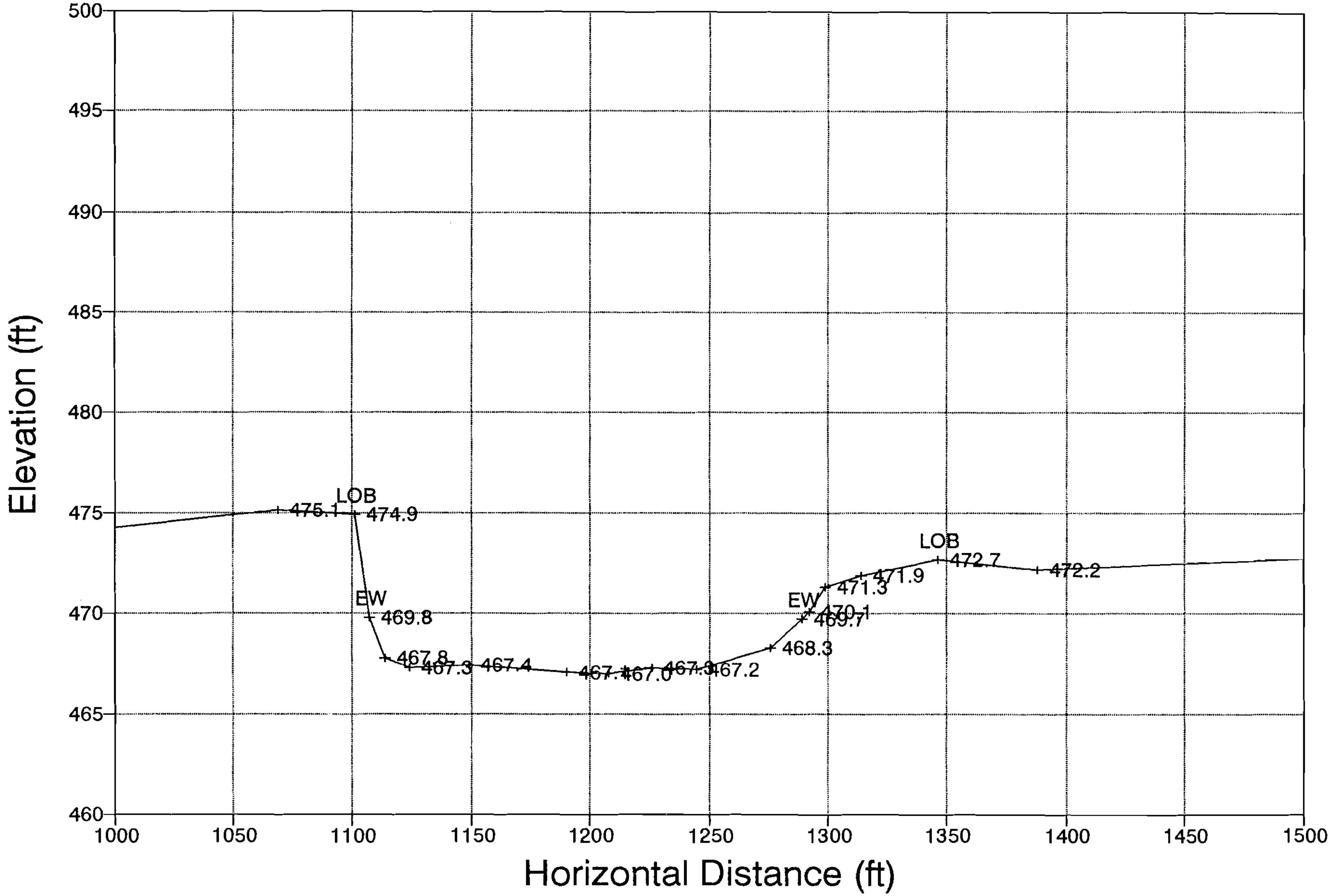

Figure G-2

120.5 - Main Channel

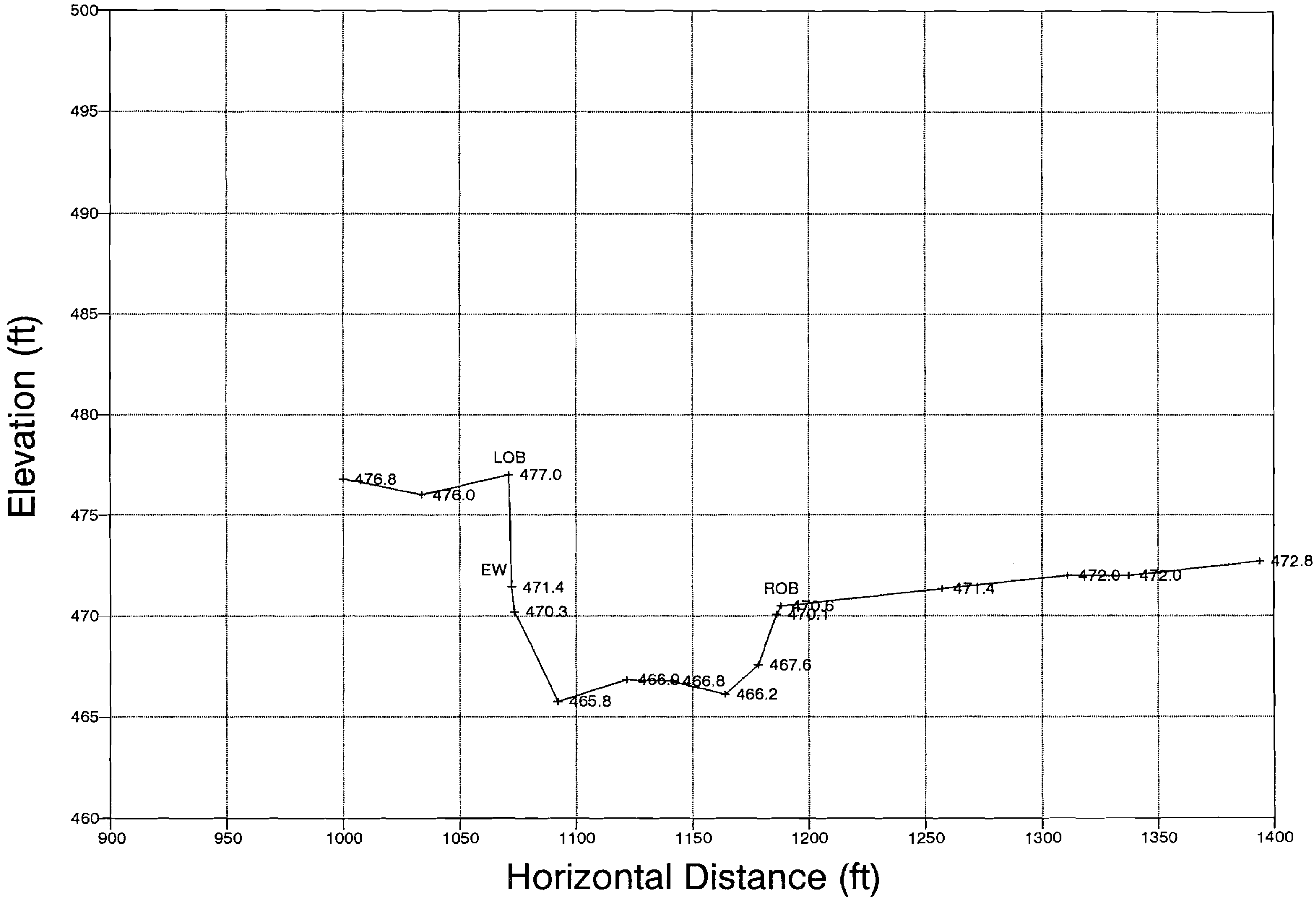

Figure G-3

120.6 - Main Channel

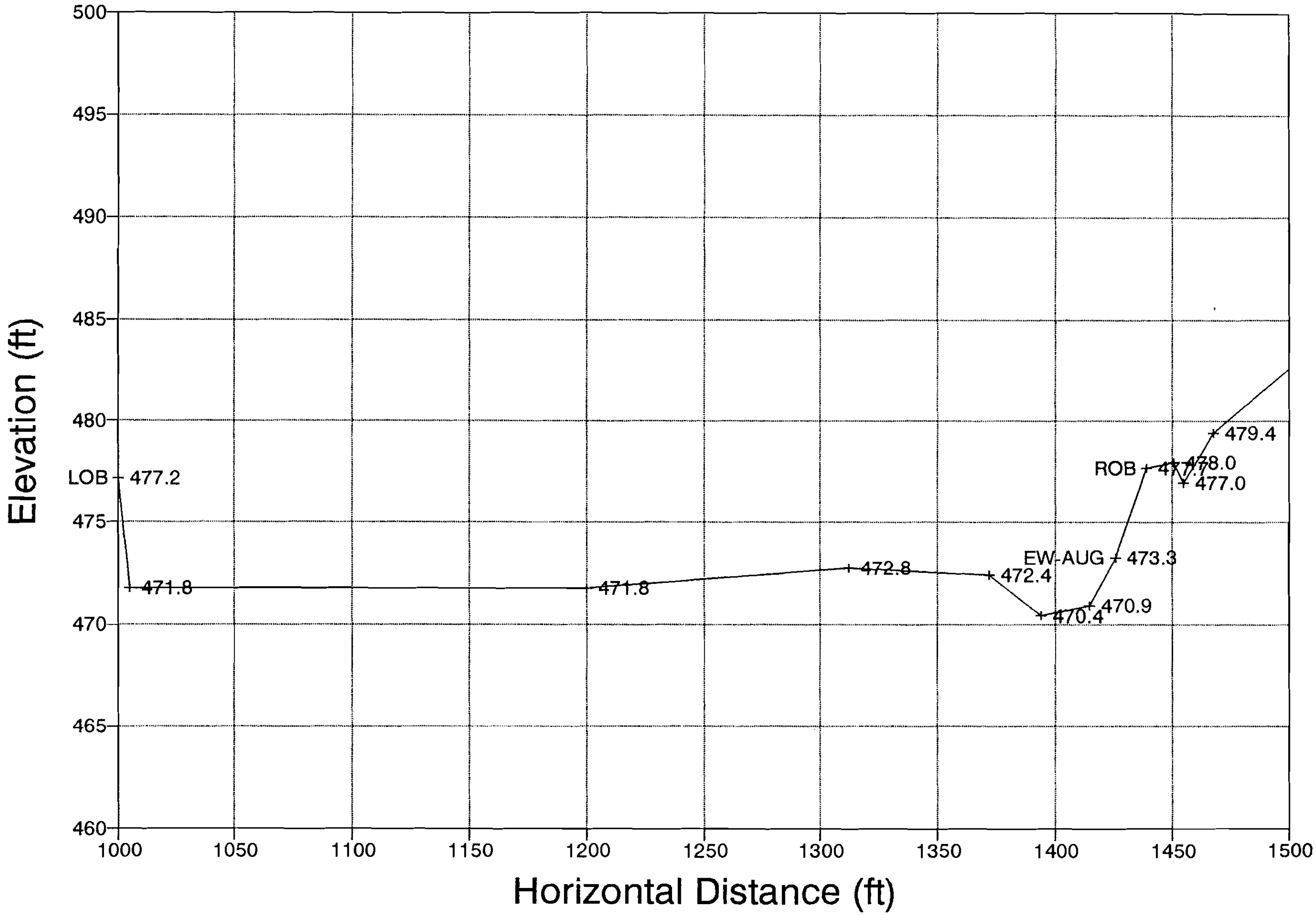

Figure G-4

120.61 - Main Channel

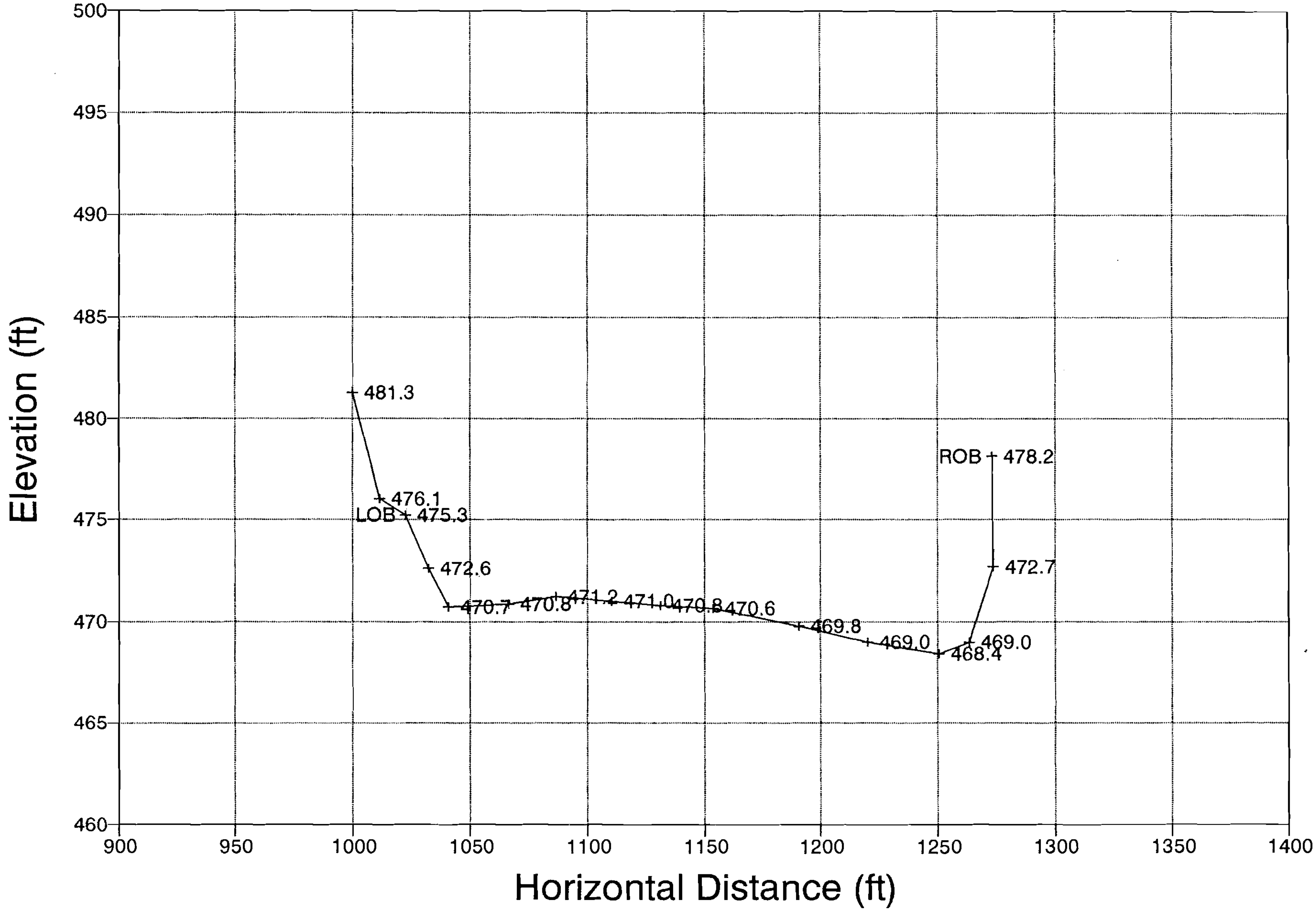

Figure G-5

120.7 - Main Channel

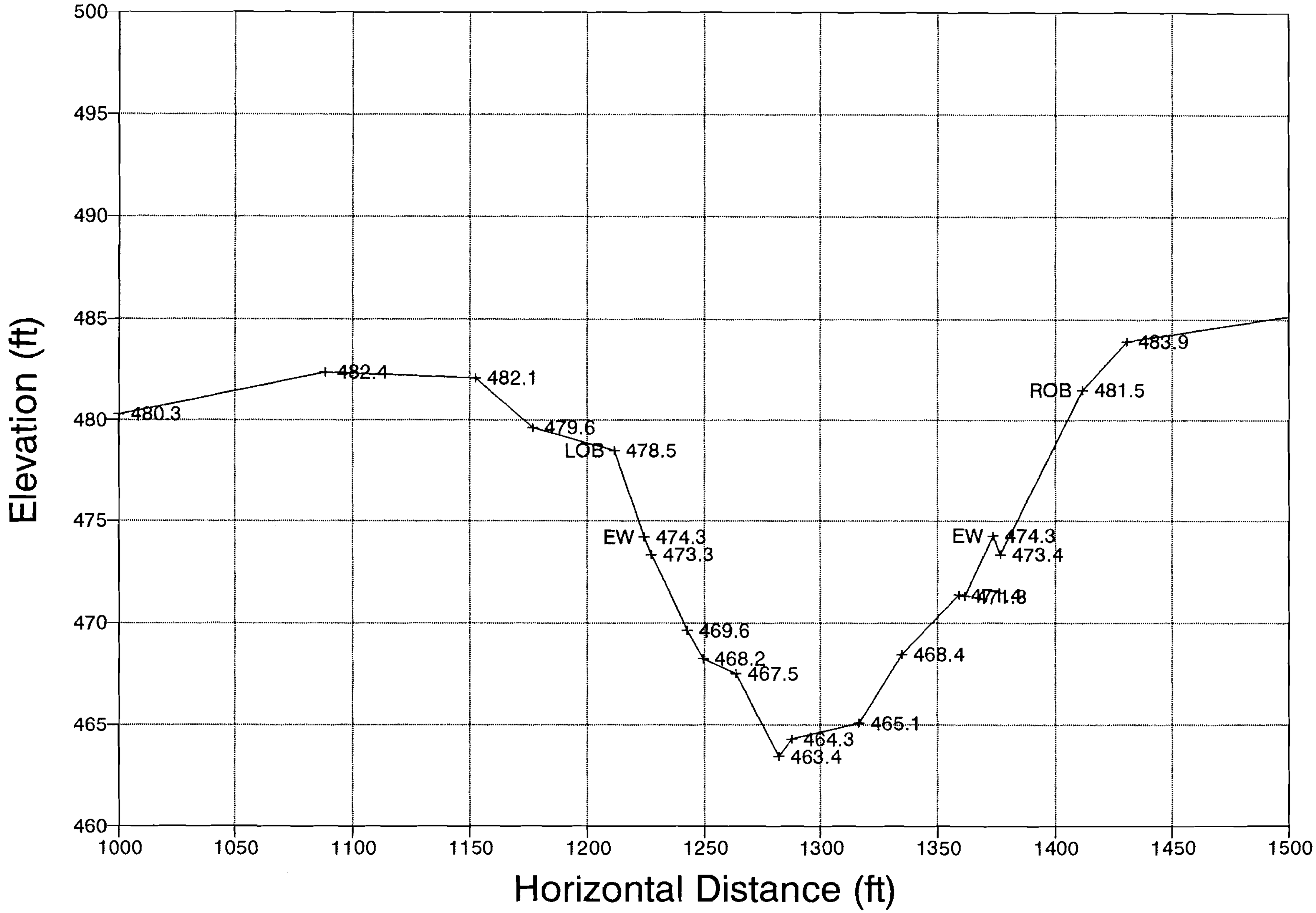

Figure G-6

120.2 - North Channel

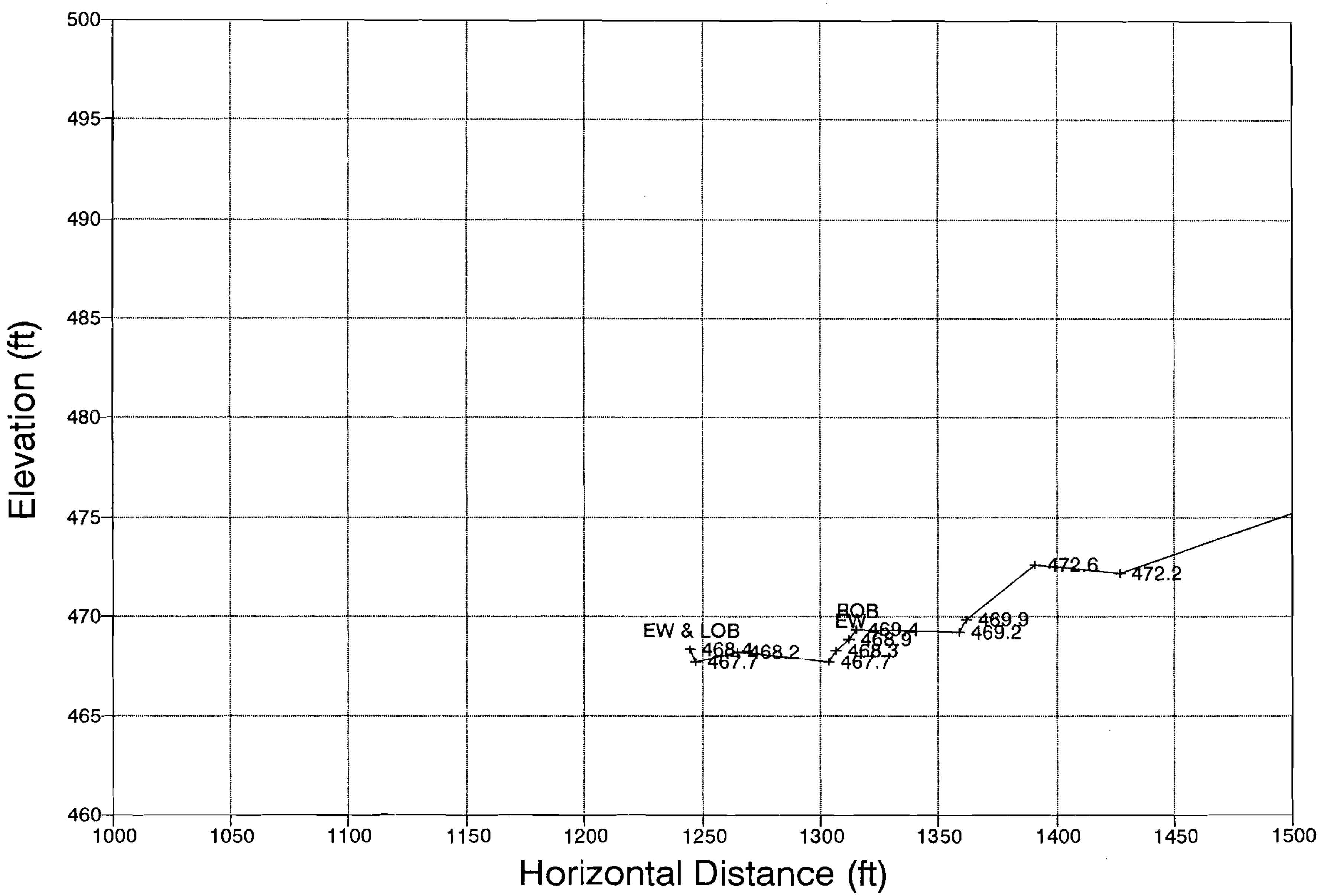

Figure G-7

120.4 - North Channel

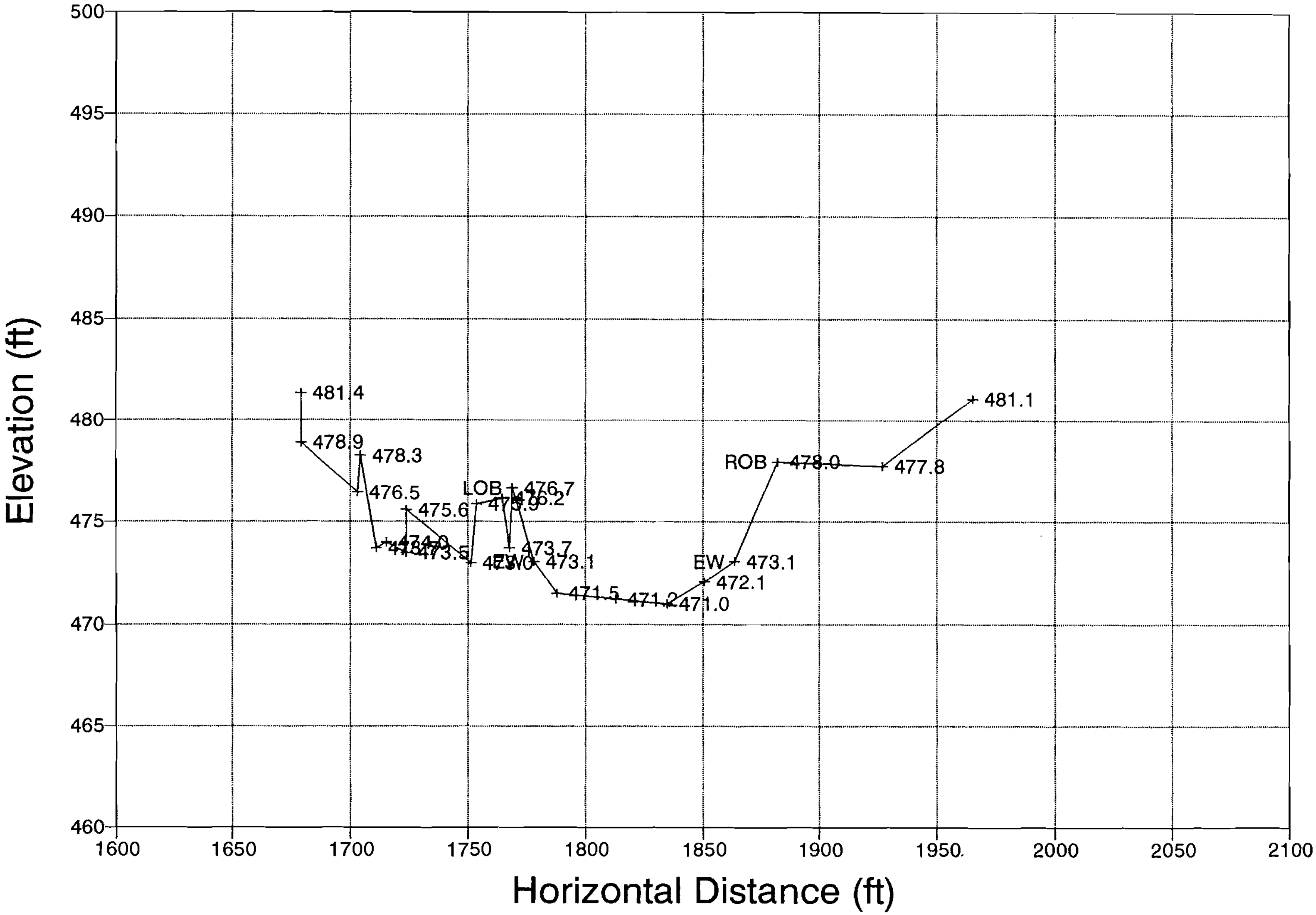

Figure G-8

120.5 - North Channel

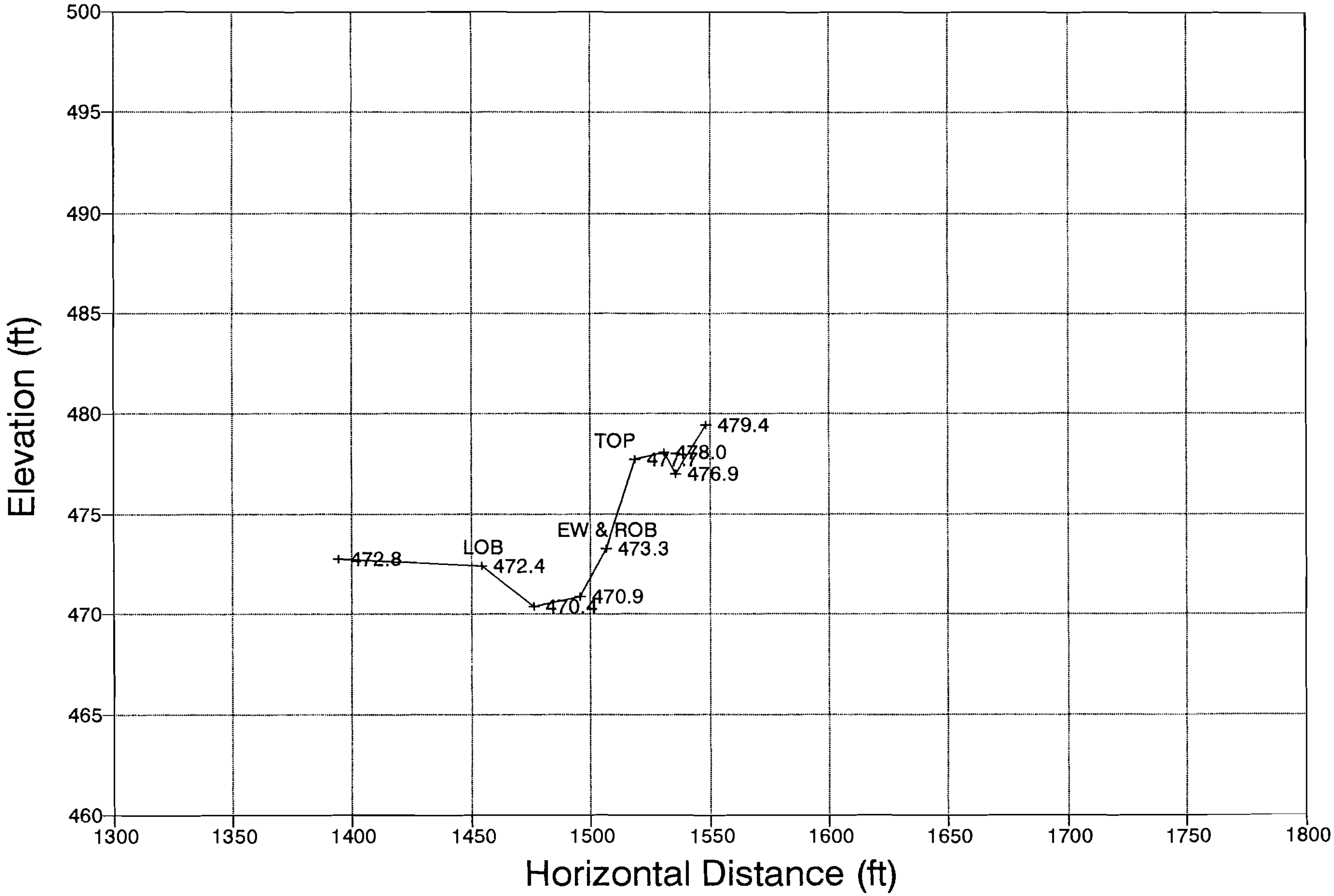

Figure G-9

Millrace - Section 100

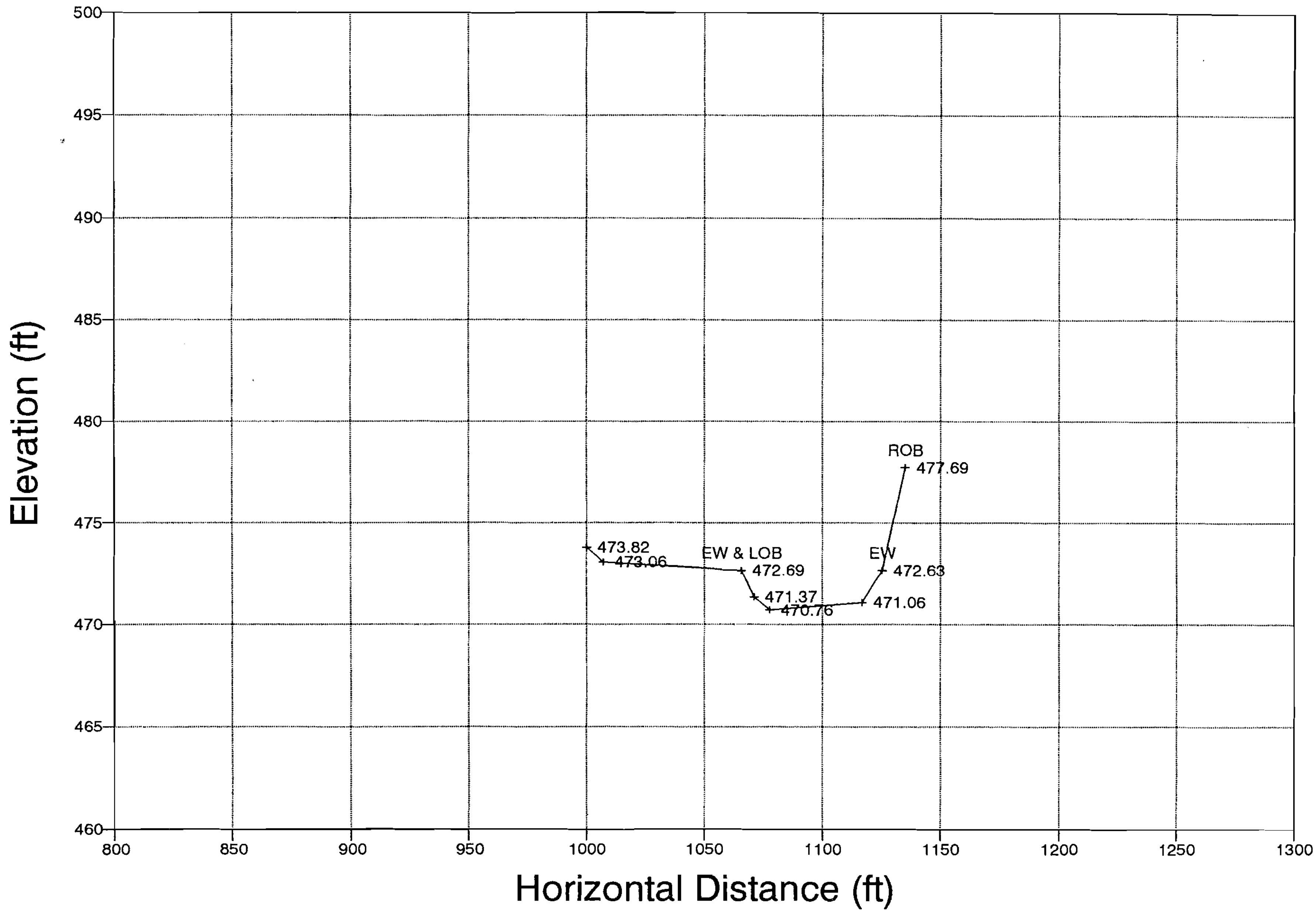

Figure G-10

Millrace - Section 110 - at Culverts

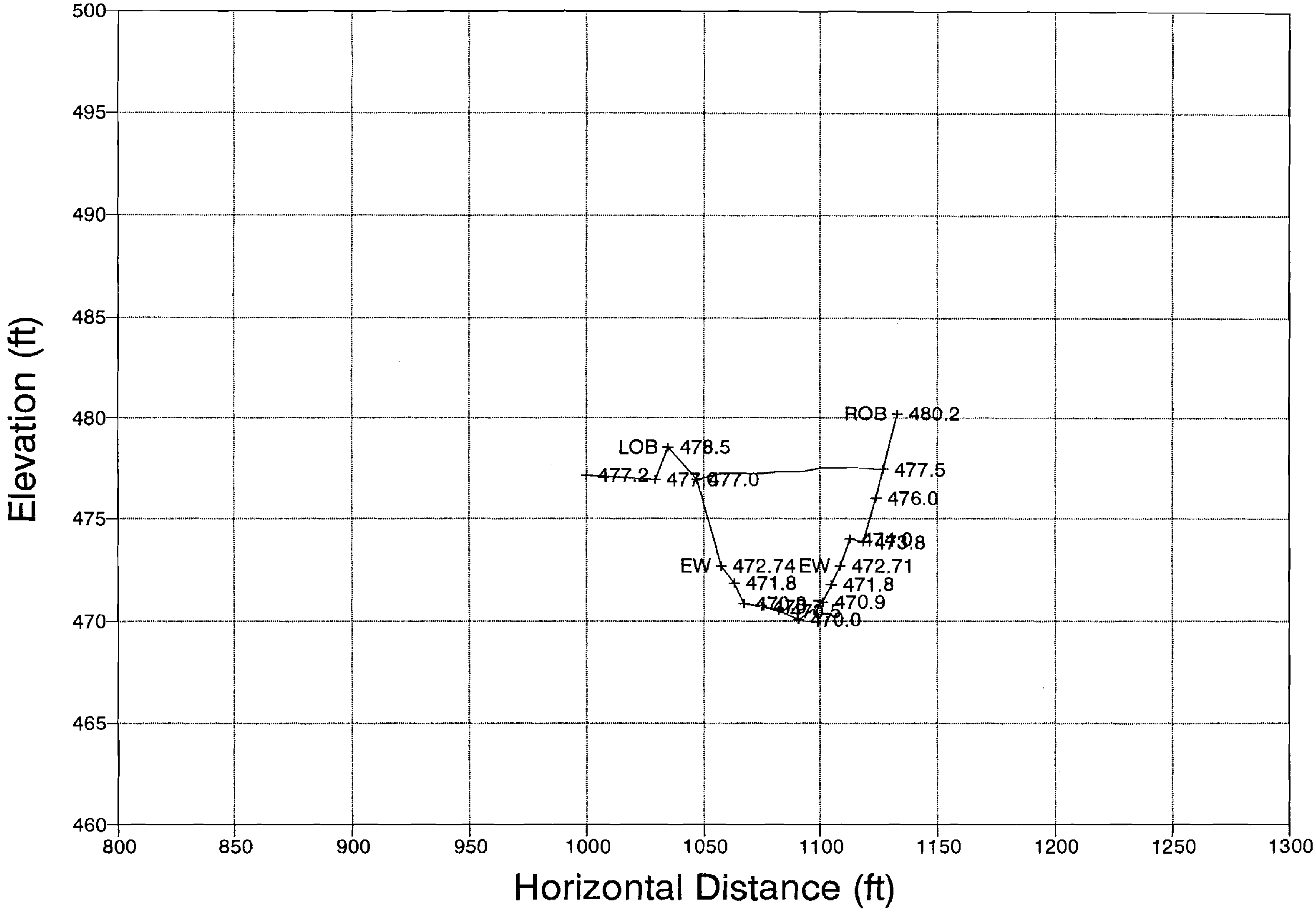

Figure G-11

Millrace - Section 120

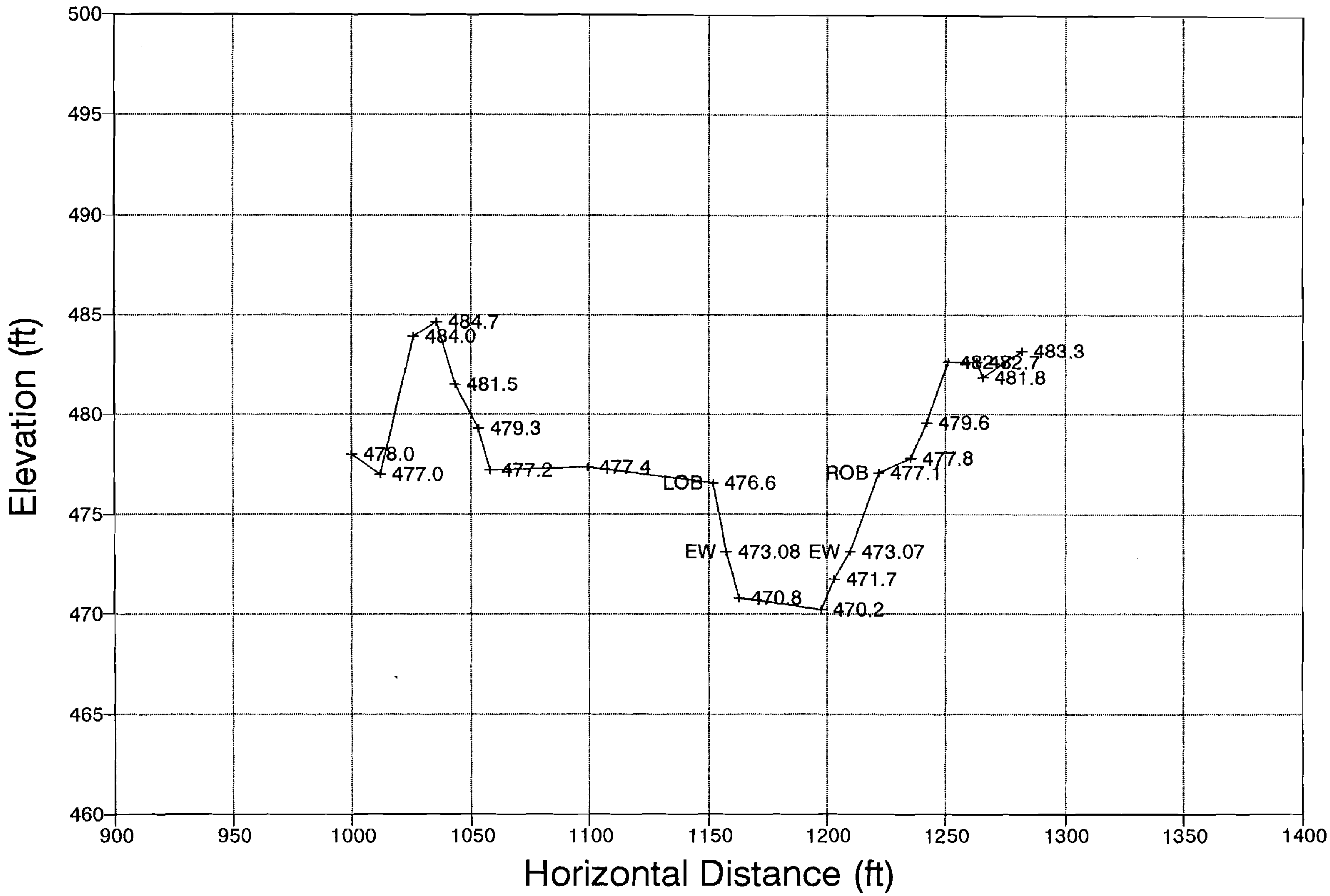

Figure G-12

Appendix H

The Corps report of August 1990 initially recommended a gatewell structure and dam on the Millrace intake and estimated a construction cost of $280,000 and annual maintenance costs of $600 for an annualized cost of $25,809. It was not clear what assumptions were made with regard to the size of the dam or the level of flood protection provided. It is possible that these estimates were made in the absence of the two-foot contour interval topography now available, but it is clear from a careful inspection of the current topography that flood protection for flood events in the order of the 25- to 50-year event can be obtained for very little excavation or construction cost. The Corps final report of February 1992 provided a construction cost estimate of $178,300 for a somewhat modified facility. With an annual maintenance cost of $600, this design concept had an annualized cost of $16,000.

The most useful information in the Corps report, with respect to the current study, is their evaluation that flooding problems start to occur when flows in the Millrace exceed 300 cfs. The Corps reports also define a relationship between discharge in the Middle Fork Willamette River and the Millrace inflow. This same information is reproduced in the upper curve on Figure C-4, and represents the Millrace inflow that would occur if the culverts and the gravel plug were completely removed. Under this condition, flooding would start to occur along the Millrace whenever the Middle Fork discharge is 5,000 cfs or greater.

Millrace Concept Report

The Millrace Concept Report[3] was published in December of 1992. This report was the end product of a public involvement process. It documents and summarizes the public vision of the future of the Millrace with respect to water quality, public access, agricultural use, wildlife habitat and recreation. It was also intended to be used as a promotional aid to obtain federal funding for a final solution to the Millrace problem. Water supply and flood control problems were dealt only in a cursory fashion in the Millrace Concept Report, although part

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[3] City Maintenance. Dept., US National Park Service, and other agencies, Millrace Concept Report, Dec. 1992

of its stated purpose was to obtain funding for a flow control and intake structure.

CH2M Hill — Booth Kelly Dam Report

In December of 1992, CH2M Hill produced an extensive report[4] that documented the structure and condition of the Booth - Kelly Dam which lies at the downstream end of the Millrace. The study also included a dambreak analysis. While this report is significant to the overall needs of the city with respect to management of the Millrace, it has little or no relevance to the current study.

U.S. Department of Agriculture (USDA) — SCS Report

In December of 1993, the USDA Soil Conservation Service provided a report consisting of a series of preliminary calculations and a cost estimate for a flow control system consisting of 12-foot-wide by 10-foot-high Hydro-Roller gate as produced by ARMCO Corporation. The cost estimate, inflated by 15 percent for contingencies, and including $40,000 for engineering, fees, and permits came to a total of $114,395. The gate hardware itself was estimated at $30,000 and the fish screen at $15,000. Note that this estimate for fish screen cost is extremely low compared to estimates provided by other engineers more experienced with fish screen design.

Gauging Station Design Report

In March of 1994, a report was produced which was the work of SEA Inc. and MSS Inc. This report outlines the design and operation procedures for a stream flow gauge that would be installed in the Millrace near the end of a private driveway that is the extension of 36th Avenue. When installed, the data collected by this gauging station could be used in conjunction with periodic upstream water surface data to provide valuable information for refining the final design of the facilities recommended in the current study.

[4] CH2M HILL, Assessment of Booth Kelly Dam, December 1992