ESTRELLA CORRIDOR STUDY

MC 85 to Interstate 17

Drainage Technical Memorandum

August 1998

Maricopa County
Department of Transportation
CONTRACT NO. CY 1997-14
WORK ORDER NO. 80505

Prepared by:

DeLeuw Cather & Company
3875 N. 44th Street * Suite 250 * Phoenix, Arizona 85018

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Registered Professional Engineer
CERTIFICATE NO.
19427
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1. INTRODUCTION

The Estrella Corridor is a regional transportation facility planned to serve the traffic needs of the northwest part of Maricopa County (MC) and the Phoenix Urban Area. It connects MC 85 and Interstate 10 (I-10) with US 60 (Grand Avenue) and Interstate 17 (I-17) and originally was a part of the Arizona Department of Transportation's (ADOT) 372 km (231 mile) Maricopa Association of Governments (MAG) Regional Freeway System. In May 1995, ADOT gave four year notice of intent to abandon the corridor, including 24 km (15 miles) of interim two lane roadway constructed between Thomas Road to Grand Avenue, to Maricopa County and those cities that have jurisdiction. Although it now appears ADOT will retain the section of the Estrella Corridor between Interstate 10 and Grand Avenue, MCDOT will assume the lead role of "caretaker" for the corridor; constructing, operating, and maintaining it in partnership with the jurisdictions through which it passes. This Drainage Technical Memorandum will provide the Maricopa County Department of Transportation (MCDOT) and the other affected agencies with the conceptual information necessary for planning future Estrella Corridor improvements.

1.1 Study Area

The Estrella Corridor study area is 59.4 kilometer (37 mile) long and it passes through the cities of Goodyear, Glendale, Surprise, Peoria and Phoenix as well as unincorporated Maricopa County (see Figure 1). The study area begins on the south west at MC 85 and follows the adopted ADOT alignment northward along or east of Cotton Lane north to Grand Avenue. From Grand Avenue to Lake Pleasant Road, the corridor turns eastward to follow Happy Valley Road to Interstate 17.

1.2 Purpose

The purpose of this Drainage Technical Memorandum is to summarize and supplement existing drainage studies for future Maricopa County Department of Transportation (MCDOT) improvements. The information provided is based on existing hydrologic and hydraulic studies from various municipal, county and federal agencies. Qualitative hydrology and hydraulic calculations were conducted to identify or refine concepts discussed.

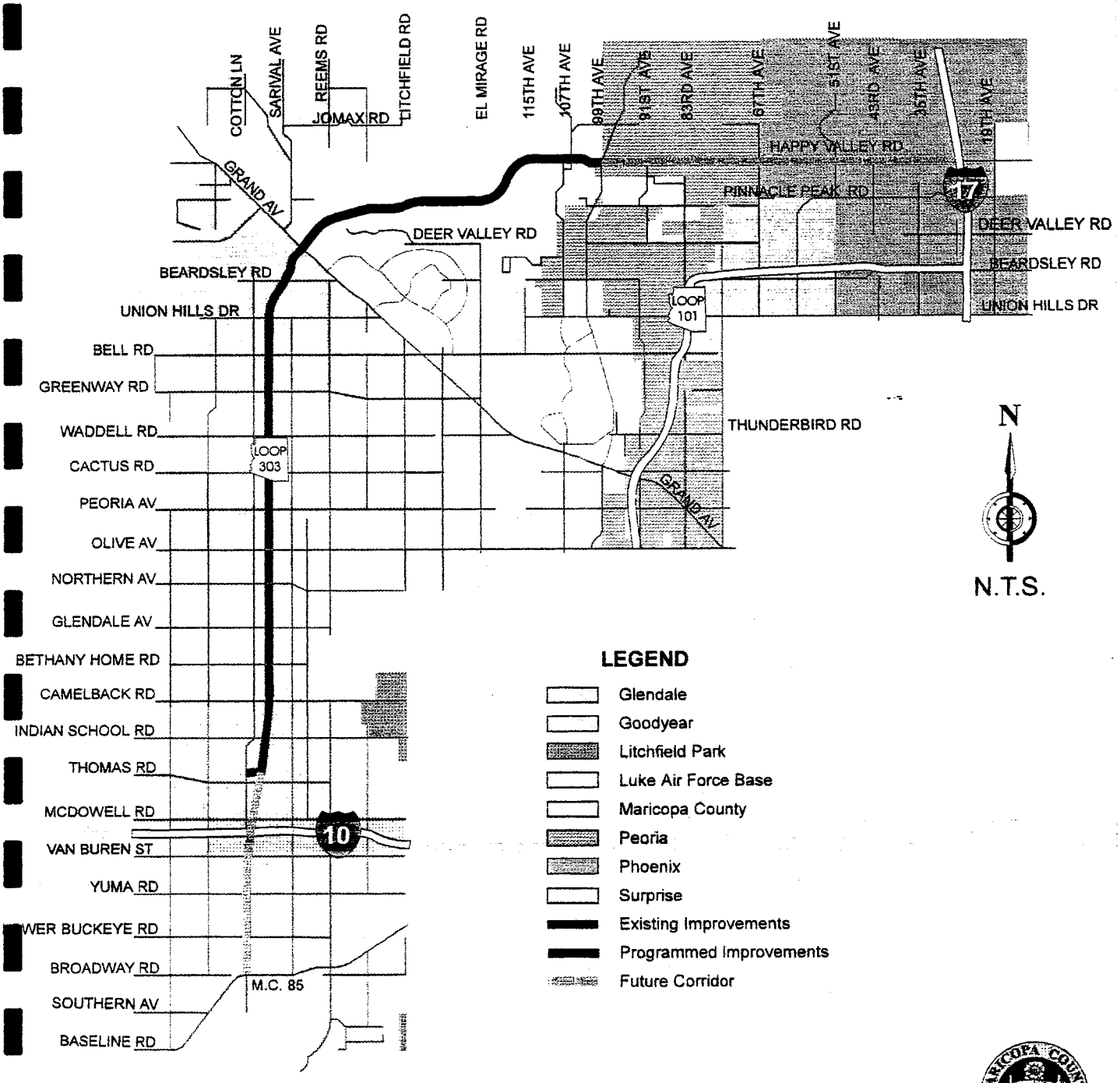


Figure 1
Project Vicinity

MR&P

2. DRAINAGE WATERSHED

This section describes the existing physical and natural environment within the drainage watershed area in terms of topography/physiology, vegetation, water resources and flood plains.

2.1 Topography/Physiology

The study area is located within the Basin and Range Province of central Arizona. The northern portion of the study area is characterized by extensively eroded intrusive basalt and granite domes, hills and mountains, that have been extensively eroded by weathering. Significant landforms in the northern portion of the study area include the Deem Hills, Ludden Mountain and hills immediately west of the Middle New River. The colluvial and alluvial slopes of these formations extend into the proposed Estrella Corridor. The lower-lying plains south of these slopes are composed of both alluvial and aeolian sands and silts that serve as rich agricultural soils. Over three-quarters of the study area (MC 85 to roughly 93rd Avenue) is located on gently undulating plains associated with these deposits, and correspondingly much of this area is in agricultural use. Much of the area between 93rd Avenue and I-17 is still largely undeveloped, with rugged basalt and granite hills and mountains forming a natural northern boundary to the corridor. Sunrise Relief Mine is located north of Happy Valley Road and 91st Avenue.

The northern portion of the study area is bisected by the Agua Fria River (west of 115th Avenue), New River (west of 75th Avenue) and Skunk Creek (east of 35th Avenue), as well as other notable washes. All of these major water courses flow generally north to south, draining the hills and mountains north of the study area and ultimately serving as tributaries to the Gila River.

2.2 Vegetation

The majority of lands within the southern portion of the corridor are under agriculture, with few natural areas present between MC 85 and Grand Avenue. The undeveloped areas present along this portion of the corridor support vegetation characteristic of the Lower Colorado River Subdivision of the Sonoran Desert Scrub Biotic Community. The desert areas in the northern portion of the corridor, between Grand Avenue and I-17, also exhibit vegetative characteristics associated with this Biotic Community.

The Lower Colorado River Subdivision of the Sonoran Desert Scrub Biotic Community includes various species of creosote *(Larrea tridentata)*, agave *(Agave* spp.*)*, bursage *(Ambrosia* spp.*)*, catclaw (*Acacia roemeriana*), and assorted grasses. Creosote and bursage are the most prevalent species found in the study area. Cactus species prevalent within this community include cholla *(Opuntia* spp.*)* and saguaro cactus *(Carnegiea gigantea)* with dense clusters of these species present on the south facing slopes of the Deem Hills, Ludden Mountain, and hills west of New River. Barrel cactus *(Ferocactus* spp.*)* and ocotillo *(Fouquieria* spp.*)* also are common. Thickets of blue palo-verde *(Cercidium floridum)* and mesquite trees *(Prosopis* spp.*)* are present within the river and creek corridors, as well as within the channels of smaller washes.

2.3 Water Resources

Water resource issues associated with the Estrella Corridor include the identification of wetlands, riparian areas, regulatory jurisdictions, sole source aquifers and unique waters. There are no sole source aquifers or unique waters within the study area. Wetlands are areas that are periodically or permanently inundated by surface or groundwater and support vegetation adapted for life in saturated soil. Wetland determination is made based on soil, hydrology and vegetation. Wetlands generally include swamps, marshes, bogs, and similar areas. During the windshield survey of the study area, a small wetland was identified on the northeast corner of Bethany Home Road and Loop 303. Dense clusters of scirpus, willow, and a variety of other riparian plants are supported by ponded irrigation water at this location.

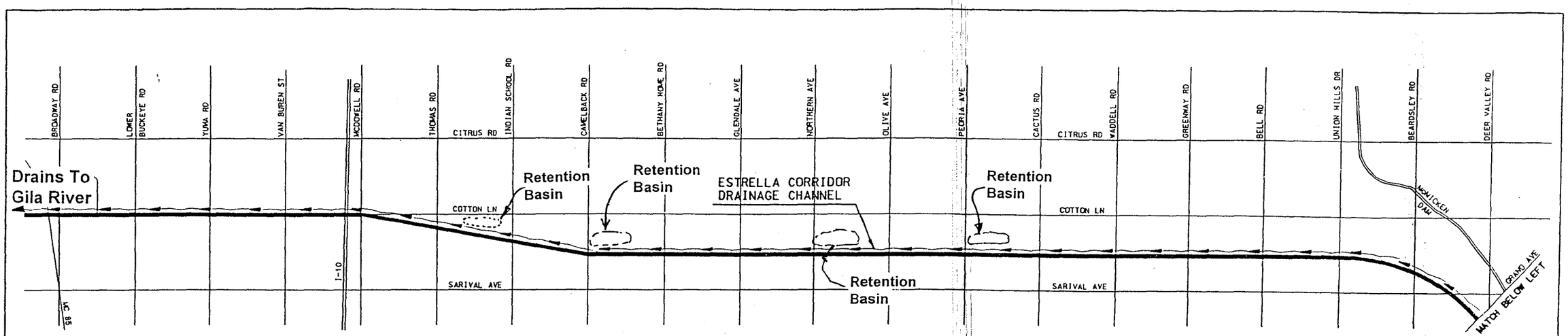
The US Army Corps of Engineers (COE) has jurisdiction of "waters of the US" within the study area. "Waters of the US" include navigable waters and their tributaries, wetlands and lakes, intermittent streams, prairie potholes and other waters that are not a part of a tributary system to interstate waters or to navigable waters of the US. In general, for Arizona, it is any stream, lake or wash that carries storm water, including the small washes typical on the alluvial fan areas that do not have constant flowing water. The northern portion of the proposed Estrella corridor, crosses several areas where these streams are evident.

When specific highway/arterial roadway construction is required, all "waters of the US" for placement of fill material require permits from the COE as part of the Section 404 permit process. The COE requires delineation of the construction impact. Small impact generally are covered under a nationwide permit where individual impacts are less than 2 ha (5.0 acres) or when the stream is disturbed for a distance of less than 150 meters (500 feet). When the impacts exceed these limits, an individual Section 404 permit will have to be obtained. The intent of this process is to protect the "waters of the US" from the adverse effects due to dredging or filling operations associated with construction. Fill material as defined by the COE includes concrete and asphalt so very little construction in the "waters of the US" can avoid the need to obtain an individual Section 404 permit.

2.4 Drainage Areas

The Estrella Corridor can be divided into two different drainage areas (see Figure 2). The drainage characteristics and concepts between MC85 and Grand Avenue are significantly different than those between Grand Avenue and I-17.

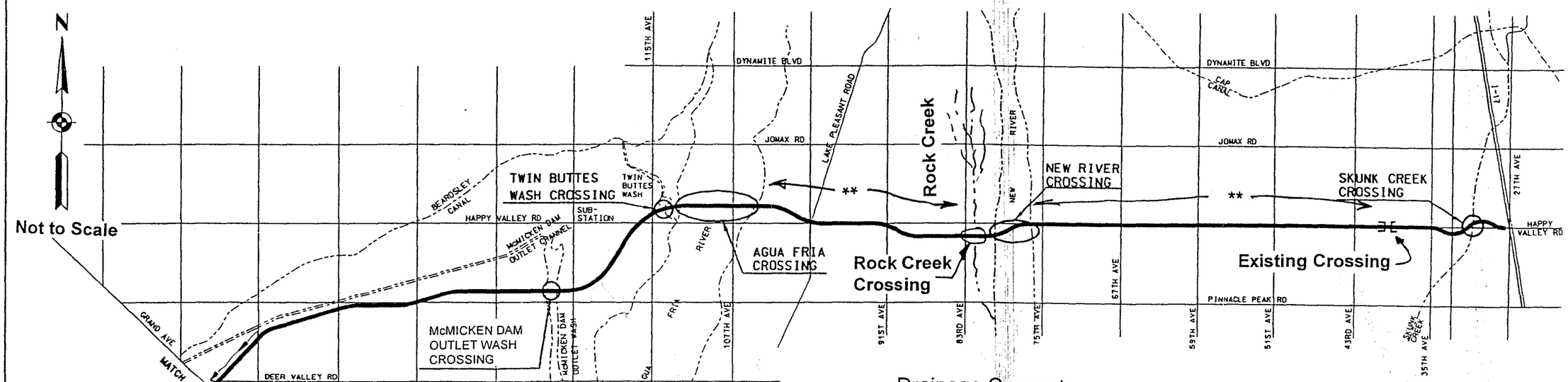
For the western area (MC 85 and Grand Avenue), the upstream drainage area of the Estrella Corridor extends from mountainous areas of the White Tanks mountains as far north as McMicken Dam. Drainage generally flows overland following agricultural field grading and the street grid system. Developed areas, either agricultural or residential, have been graded to a north-south or east-west orientation to follow the street system. Flood flows reach the corridor mostly by the street system from the west. The ultimate outlet is the Gila River; therefore the drainage concept is to collect and convey all floodwaters to the south.



Drainage Concept
Collect and Convey to Gila River

Not to Scale

***Note:** Use of retention basins is an Alternative to reduce the size of the channel.



Drainage Concept
"Pass Through"

**Note: Numerous small washes cross the corridor alignment.

Estrella Corridor Drainage Concepts Figure 2

DE LEUW, CATHER CO.

The drainage along the northern segment of the corridor (Grand Avenue to I-17) flows in a southerly direction. All of the major washes are located in the northern segment. Additionally, numerous small washes cross the corridor. Drainage concepts on the north side reflect a "pass through" system which consists of a series of cross culverts.

2.5 Previous Studies and Flood Plains

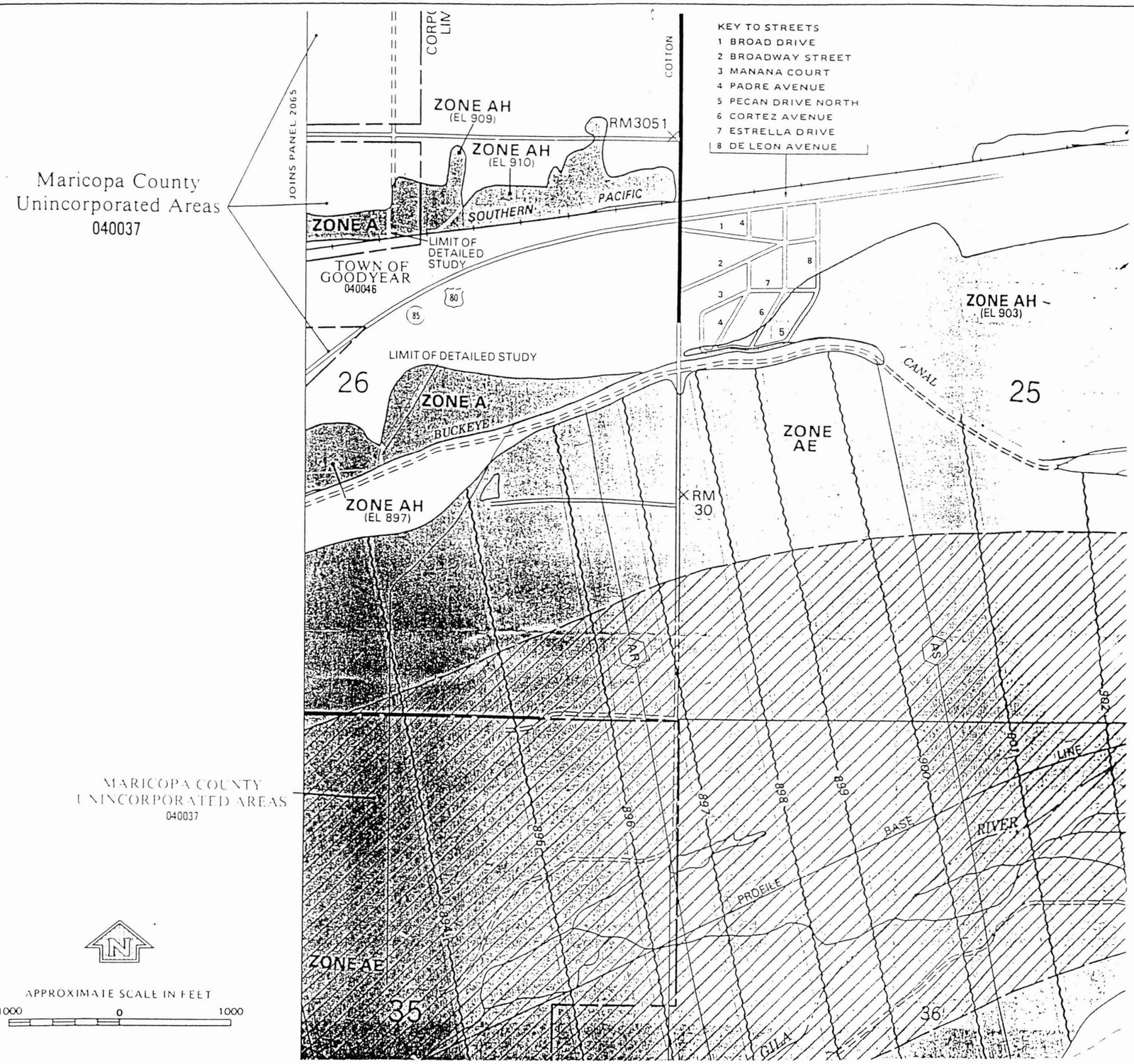
The Estrella Corridor drainage area has been studied in detail by the Flood Control District of Maricopa County and documented in several reports developed for other purposes as follows:

- "White Tanks/Agua Fria Area Master Drainage Study" by The WLB Group, 1994
- "Wittmann Area Drainage Master Study" by The WLB Group , 1994
- "Limited Scope, Design Concept Report, Estrella Interim Roadway, Deer Valley Drive to Lake Pleasant Road (99th Avenue)" By Ritoch-Powell Associates, December. 1997.
- "Drainage Channel Right-of-Way Requirement Study for West Half of Estrella Freeway Loop 303 From I-10 to Bell Road" by Entellus, March 1997.
- Agua Fria River Study, New Waddell Dam to Gila River Confluence, Arizona, Hydrologic Evaluation of Impacts of New Waddell Dam on Downstream Peak Discharges in the Agua Fria River" by U.S Army Corps of Engineers
- "New River Watershed," ACDC/ADMS Phase I, Vol. 1.2, by Kaminski Hubbard Engineering, Inc., May 1995
- "Skunk Creek Watershed," ACDC/ADMS Phase I, Vol. 1.3, by Kaminski Hubbard Engineering, Inc., February 1995

The Federal Emergency Management Agency has mapped the 100-year floodplains for the Corridor. Flood Insurance Rate Maps (FIRM) indicate the 100-year floodplains where it crosses the study area (see Figures 3 through 8). The major channels and washes of Gila River, Agua Fria River, Twin Buttes Wash, McMicken Dam Outlet Wash, New River and Skunk Creek are shown. Also shown are flooded areas caused by local flooding resulting from embankments for the Railroads and irrigation canals.

2.6 Existing Structures

There are few significant structures within the study area today. McMicken Dam is located along the northwest section of the project and has an outlet channel that crosses the corridor. There is a four barre1.5 m x 2.7 m (5 feet x 9 feet) box culvert located on the west side of 43rd Avenue that runs under Happy Valley Road. At 43rd Avenue just north of Happy Valley Road, a small berm was constructed to collect and convey flood waters, coming from the mountains to the north, to the box culvert. This culvert discharges into a channel that was constructed as part of the development to the south. This culvert will need to be extended to accommodate the additional roadway width for the Estrella Corridor.



NATIONAL FLOOD INSURANCE PROGRAM

FIRM
FLOOD INSURANCE RATE MAP

MARICOPA COUNTY,
ARIZONA AND
INCORPORATED AREAS

PANEL 2070 OF 4350

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
GOODYEAR, TOWN OF	040046	2070	F
MARICOPA COUNTY, UNINCORPORATED AREAS	040037	2070	F

MAP NUMBER
04013C2070 F

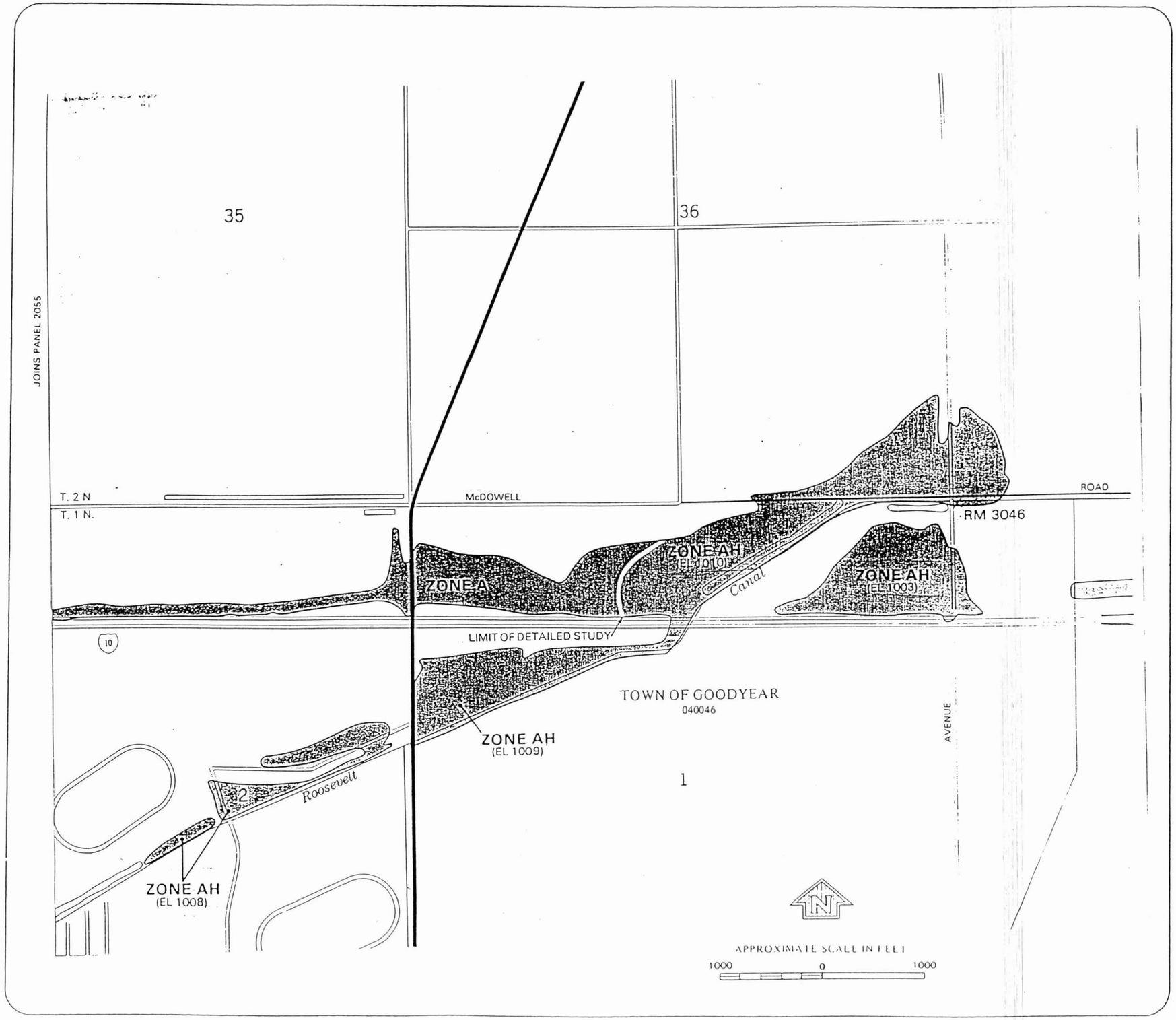
MAP REVISED:
SEPTEMBER 30, 1995

Federal Emergency Management Agency

Estrella Corridor

Flood Plains
Figure 3

PARSONS
TRANSPORTATION GROUP
Barton-Aschman • De Leuw, Cather • Steinman



NATIONAL FLOOD INSURANCE PROGRAM

FIRM

FLOOD INSURANCE RATE MAP

MARICOPA COUNTY, ARIZONA AND INCORPORATED AREAS

PANEL 2060 OF 4530

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
GOODYEAR, TOWN OF	040046	2060	E
LITCHFIELD PARK, CITY OF	040128	2060	E
MARICOPA COUNTY UNINCORPORATED AREAS	040037	2060	E

MAP NUMBER
04013C2060 E

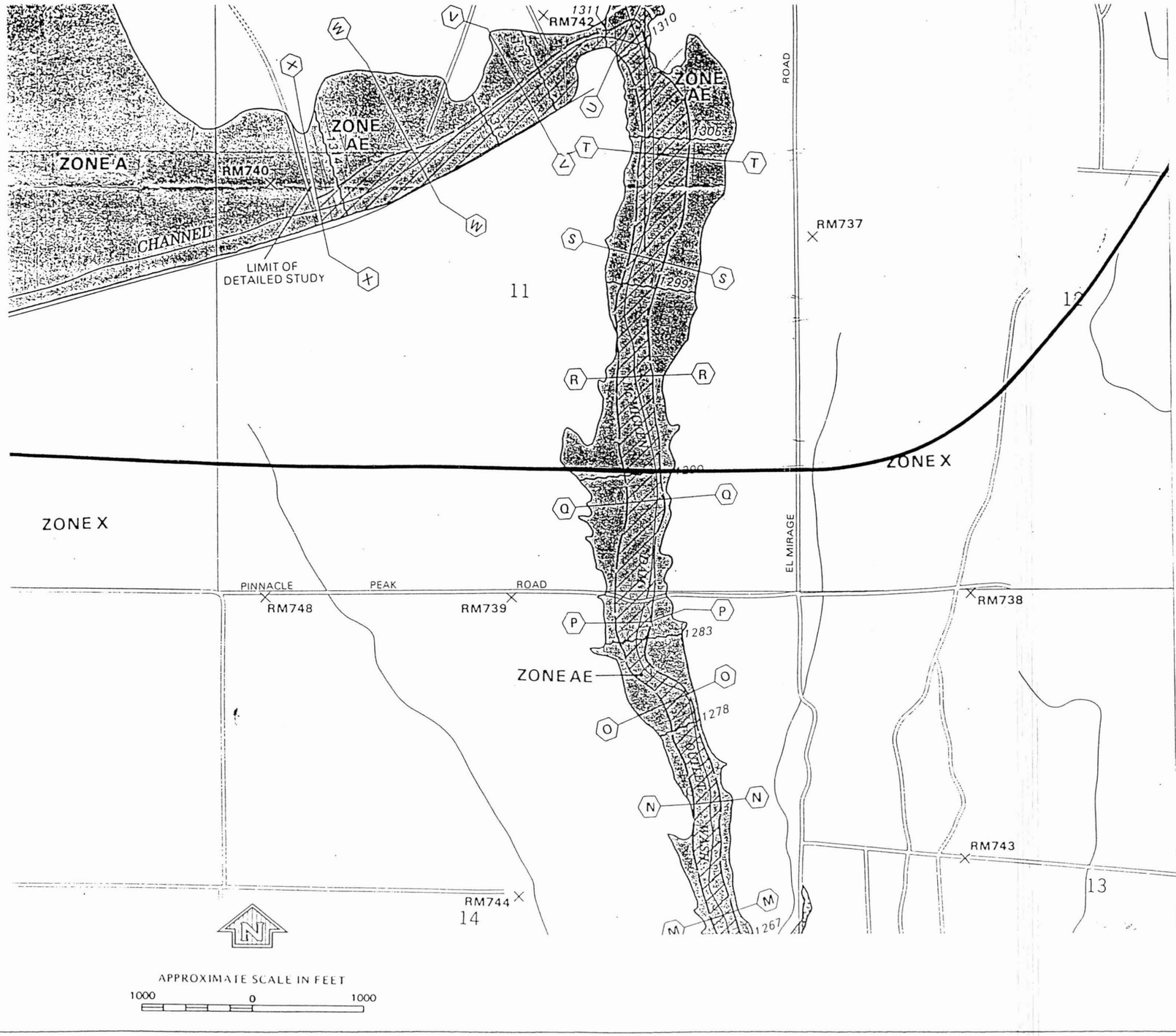
MAP REVISED:
SEPTEMBER 30, 1995

Federal Emergency Management Agency

Estrella Corridor

Flood Plains
Figure 4

PARSONS TRANSPORTATION GROUP
Barton-Aschman • De Leuw, Cather • Steinman



NATIONAL FLOOD INSURANCE PROGRAM

FIRM

FLOOD INSURANCE RATE MAP

MARICOPA COUNTY, ARIZONA AND INCORPORATED AREAS

PANEL 1155 OF 4350

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
MARICOPA COUNTY, UNINCORPORATED AREAS	040037	1155	F

MAP NUMBER
04013C1155F

MAP REVISED:
DECEMBER 3, 1993

Federal Emergency Management Agency

Estrella Corridor

Flood Plains
Figure 5

PARSONS TRANSPORTATION GROUP
Barton-Aschman • De Leuw, Cather • Steinman

NOTE:
This Floodplain is to be reduced due to new Waddell Dam.

NATIONAL FLOOD INSURANCE PROGRAM

FIRM
FLOOD INSURANCE RATE MAP

MARICOPA COUNTY, ARIZONA AND INCORPORATED AREAS

PANEL 1160 OF 4350

CONTAINS COMMUNITY	NUMBER	PANEL	SUFFIX
MARICOPA COUNTY, UNINCORPORATED AREAS	040037	1160	F
PEORIA, CITY OF	040050	1160	F

MAP NUMBER
04013C1160 F

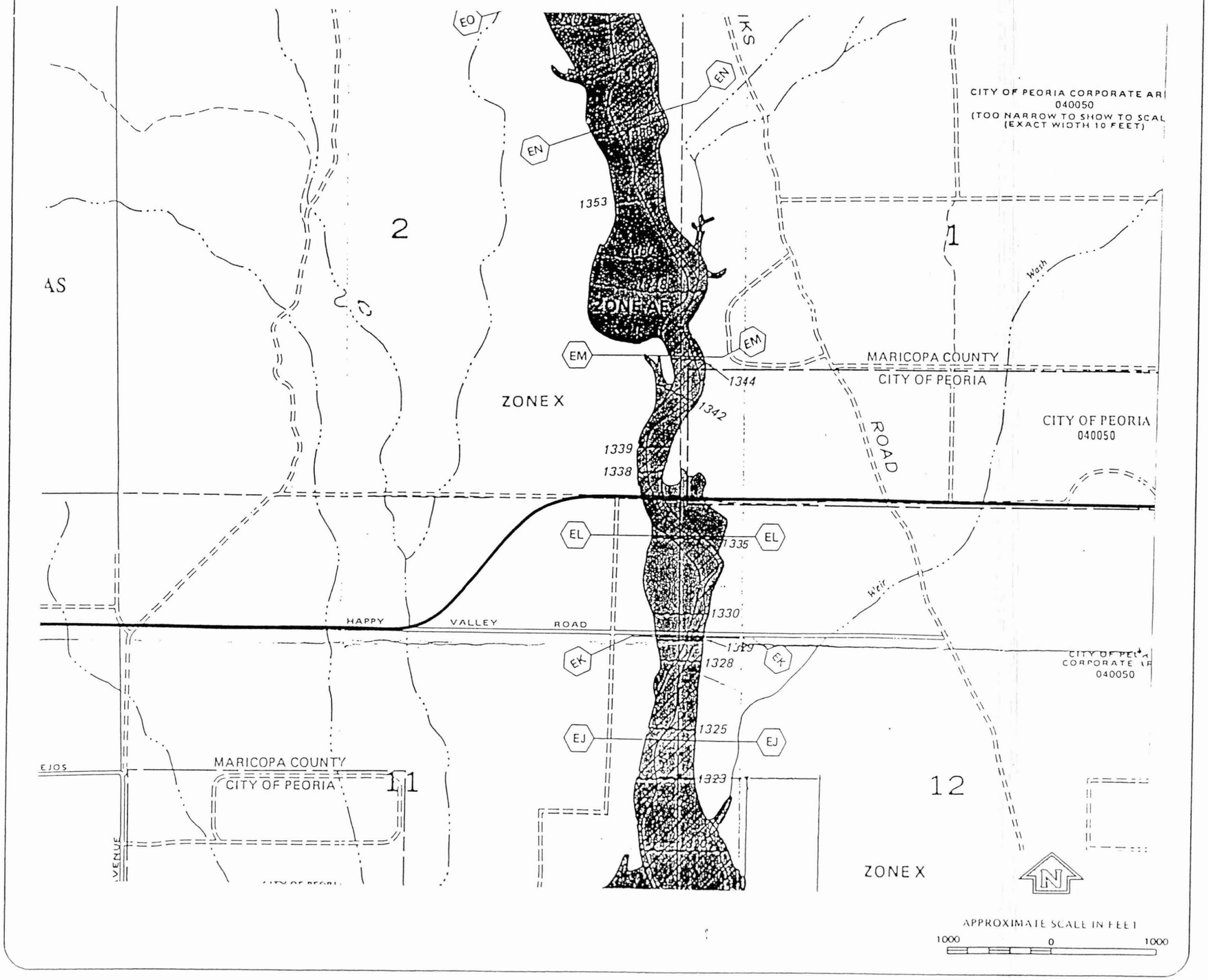
MAP REVISED:
DECEMBER 3, 1993

Federal Emergency Management Agency

Estrella Corridor

Flood Plains
Figure 6

PARSONS TRANSPORTATION GROUP
Barton-Aschman • De Leuw, Cather • Steinman



NATIONAL FLOOD INSURANCE PROGRAM

FIRM

FLOOD INSURANCE RATE MAP

MARICOPA COUNTY, ARIZONA AND INCORPORATED AREAS

PANEL 1180 OF 4350

CONTAINS

COMMUNITY	NUMBER	PANEL	SUFFIX
GLENDALE, CITY OF	040045	1180	E
MARICOPA COUNTY, UNINCORPORATED AREAS	040037	1180	E
PEORIA, CITY OF	040050	1180	E
PHOENIX, CITY OF	040051	1180	E

MAP NUMBER
04013C1180 E

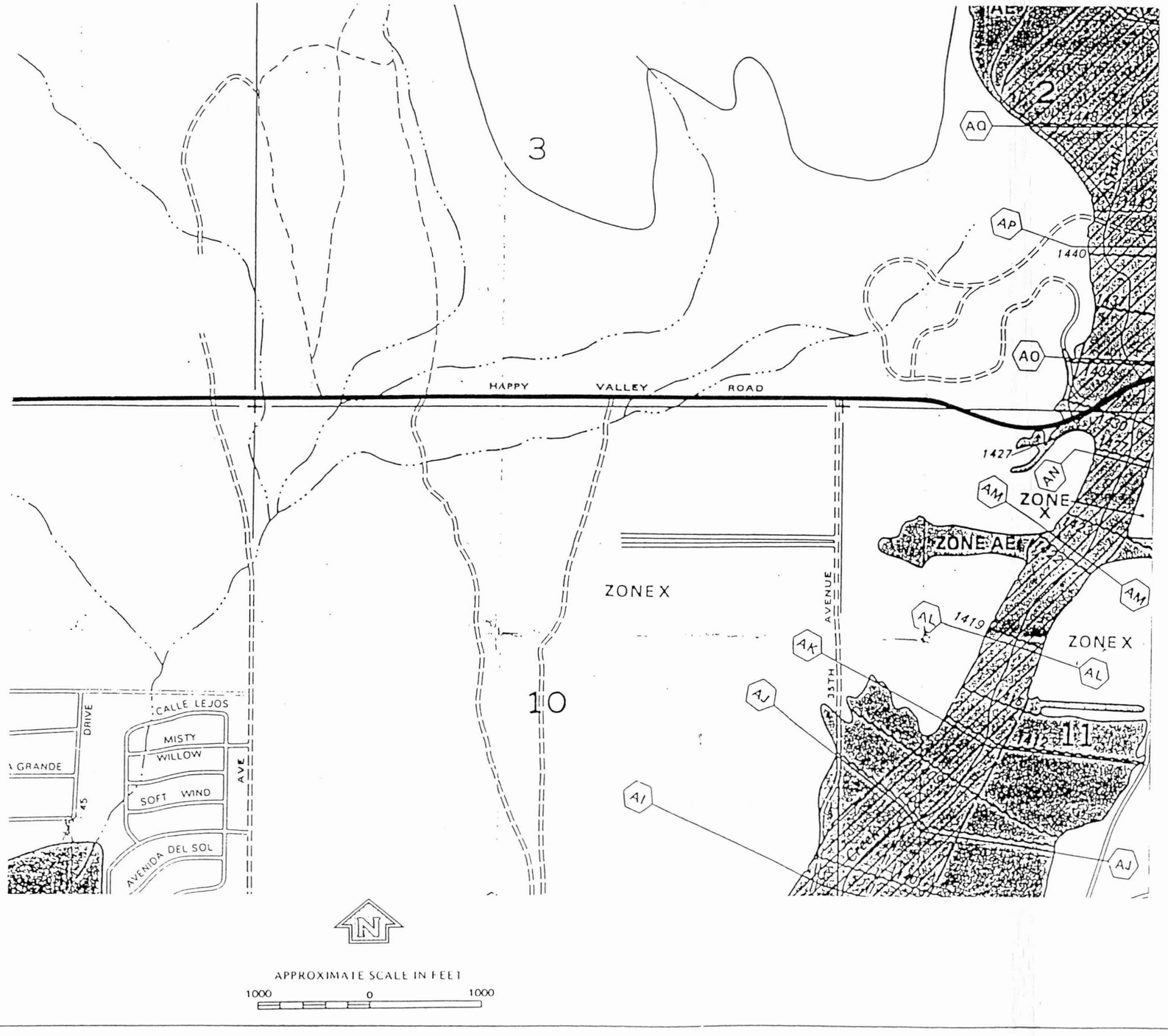
MAP REVISED:
SEPTEMBER 29, 1989

Federal Emergency Management Agency

Estrella Corridor

Flood Plains
Figure 7

PARSONS TRANSPORTATION GROUP
Barton-Aschman • De Leuw, Cather • Steinman



NATIONAL FLOOD INSURANCE PROGRAM

FIRM

FLOOD INSURANCE RATE MAP

MARICOPA COUNTY, ARIZONA AND INCORPORATED AREAS

PANEL 1185 OF 4350

CONTAINS

COMMUNITY	NUMBER	PANEL	SUFFIX
GLENDALE, CITY OF	040045	1185	F
MARICOPA COUNTY, UNINCORPORATED AREAS	040037	1185	F
PHOENIX, CITY OF	040051	1185	F

MAP NUMBER
04013C1185 F

MAP REVISED:
SEPTEMBER 4, 1991

Federal Emergency Management Agency

Estrella Corridor

Flood Plains
Figure 8

PARSONS TRANSPORTATION GROUP
Barton-Aschman • De Leuw, Cather • Steinman

3. HYDROLOGY

Hydrology for the Estrella corridor drainage watershed has been studied by the Flood Control District of Maricopa County and documented in several reports for various major washes. Analysis generally used HEC-1 methods to develop flow rates for various frequency storms.

3.1 White Tanks / Agua Fria ADMS

In the White Tanks ADMS report, The WLB Group in 1994, recommended a major flood channel just upstream of the Estrella Corridor to relieve flooding along Bullard wash, about a mile east of the Estrella Corridor. This channel would convey 13.6 to 303 m^3/sec (480 cfs to 10,700 cfs) to the Gila River during a 100-year storm event. This channel starts approximately three miles south of Grand Avenue at Bell Road and continues south past MC85 to discharge into the Gila River. Table 1 summarizes the peak 50 and 100-year flows in the channel. The channel has a top width that varies from 12 to 44 m (40 to 145 feet). Although the northern limit of the drainage area is Grand Avenue, the channel does not extend north of Bell Road. Del Webb's Sun City Grand development is located north of Bell Road and this development will use storm water retention with low flow "bleed off" systems to Bell Road.

To provide a smaller and more cost effective drainage channel system, an alternative system was considered which includes four regional retention basins. The four basins reduce the peak flows to 40% of peak channel flows shown in Table 1 (see Table 2). The four basins will require significant land but will still provide a considerable cost savings for the overall system. The basin areas also offer opportunities for regional parks or other multi use facilities. The four basins will generate approximately 3 million cubic yards of material that would need disposal.

The hydrologic investigations to determine the effect of the basins was cursory and will require further hydrologic modeling. These investigations used the HEC-1 model from the White Tanks/Agua Fria ADMS study. The basins were modeled by inserting the same retention basin and control structure codes at four locations along the channel. A copy of the computer file is attached to this report.

The assumed basins are 152 m (500 feet) wide by 304 m (1,000 feet) long and 9.1 m (30 feet) deep. The control structure is a 0.9 m (3-foot) tall weir in the middle of the channel with a 3 m (10-foot) wide opening. Operationally, the weir will back water to spill over a side weir that adjoins the basin. Only peak flows will discharge into the basin. Low flows will continue to flow in the channel. When the basin is full, another side weir downstream of the control structure will divert flood flows back into the channel. Each basin will be emptied by a small pump station after the peak flow in the channel has passed. Flows from the pump station will be insignificant when compared to the peak flow.

Table 1

Peak Flow Summary
Estrella Drainage Channel

Location	50-Year Peak Flow m^3/sec(cfs)	100-year Peak Flow m^3/sec(cfs)
Waddell Road	45.3 (1,600)	51.0 (1,800)
Cactus Road	73.6 (2,600)	93.4 (3,300)
Peoria Avenue	107.6 (3,800)	133.1 (4,700)
Olive Avenue	118.9 (4,200)	147.2 (5,200)
Northern Avenue	130.3 (4,600)	172.7 (6,100)
Glendale Avenue	169.9 (6,000)	218.0 (7,700)
Bethany Home Road	169.9 (6,000)	218.0 (7,700)
Camelback Road	189.7 (6,700)	240.7 (8,500)
Indian School Road	198.2 (7,000)	254.9 (9,000)
Thomas Road	203.9 (7,200)	263.3 (9,300)
McDowell Road / I-10	235.0 (8,300)	303.0 (10,700)
Roosevelt Canal	235.0 (8,300)	303.0 (10,700)
Yuma Road	235.0 (8,300)	303.0 (10,700)
Lower Buckeye Road	235.0 (8,300)	303.0 (10,700)
Broadway Road	235.0 (8,300)	303.0 (10,700)
Gila River Outlet	235.0 (8,300)	303.0 (10,700)

Table 2

Peak Flow Summary
Estrella Drainage Channel
with Regional Retention Basins

Location	50-Year Peak Flow m^3/sec inflow/m^3/sec outflow (cfs inflow/cfs outflow)	100-Year Peak Flow m^3/sec inflow/m^3/sec outflow (cfs inflow/cfs outflow)
Waddell Road	45.3 (1,600)	51.0 (1,800)
Cactus Road	73.6 (2,600)	93.4 (3,300)
Peoria Avenue	107.6/51.0 (3,800/1,800)	133.1/62.3 (4,700/2,200)
Olive Avenue	62.3 (2,200)	76.5 (2,700)
Northern Avenue	65.1/34.0 (2,300/1,200)	82.1/39.6 (2,900/1,400)
Glendale Avenue	82.1 (2,900)	107.6 (3,800)
Bethany Home Road	82.1 (2,900)	110.4 (3,900)
Camelback Road	101.9/48.1 (3,600/1,700)	133.1/62.3 (4,700/2,200)
Indian School Road	62.3 (2,200)	79.3 (2,800)
Thomas Road	70.8/34.0 (2,500/1,200)	90.6/42.5 (3,200/1,500)
McDowell Road / I-10	70.8 (2,500)	90.6 (3,200)
Roosevelt Canal	70.8 (2,500)	90.6 (3,200)
Yuma Road	73.6 (2,600)	93.4 (3,300\
Lower Buckeye Road	79.3 (2,800)	104.8 (3,700)
Broadway Road	79.3 (2,800)	104.8 (3,700)
Gila River Outlet	85.0 (3,000)	110.4 (3,900)

HEC-1 calculations require modifications to reflect site planning for specific basin sites and control structures. The number and configuration each basin needs to be optimized considering the size of channel, right-of-way requirements and overall cost. From a conceptual stand point, The HEC-1 calculations show that multiple retention is practical and can significantly reduce the conveyance requirements of the channel and the cost of the overall facility. The retention basin concept should be pursued further.

3.2 Wittmann ADMS

Wittmann ADMS drainage area for the Estrella Corridor is located north of Grand Avenue. Flows cross the corridor at the McMicken Dam Outfall Wash. This study was conducted by The WLB Group in 1989 for the Flood Control District of Maricopa County. The report contains the SPF flow rates for the McMicken Dam Outlet Wash (see Appendix B)

3.3 Federal Emergency Management Agency (FEMA)

Flood Insurance Studies were conducted by FEMA to delineate the flood plains for insurance purposes. Appendix C contains summaries of the 100 year discharges used for flood plain delineation.

3.4 U.S Army Corps of Engineers

As part of the New Waddell Dam, the US Army Corps of Engineers conducted hydrology studies to determine the effect on the Agua Fria River (see Appendix D). Appendix E contains summaries of the Hydrology on the New River and Skunk Creek.

3.5 Other Streams

The Estrella Corridor has been studied by Ritoch-Powell Associates Consulting Engineers, Inc. for the section of the corridor between Deer Valley Drive and Lake Pleasant Road. They have identified the need for several cross culverts. Appendix F contains an excerpt of the drainage section. There is a large wash that crosses the corridor between the Agua Fria River and Lake Pleasant Road. This wash has a drainage area of 1,400 acres of desert area. Using rational; methods, 100-year peak flows would be approximately 1,800 cfs. More detailed analysis is required during design due to the qualitative nature of the rational method and the large drainage area. For planning purposes, this method is adequate to obtain the approximate size of culvert needed.

Rock Creek is a relatively small stream that has about a 364 ha (900 acre) watershed consisting of open desert and mountainside. Hydrologically, this drainage area is small and would have been considered with the New River drainage area. Rock Creek flows parallel to New River and crosses the Estrella Corridor separately. Rock Creek and New River flow join 2.4 km (1 ½ miles) south of the corridor. Using county rational methods, runoff would range approximately 28 m^3/sec (1,000 cfs). The ACDC/ADMS also addresses this watershed.

3.6 Standard Project Flood

The flow rate for Standard Project Flood (SPF) is included as for each of the major streams. The area inundated by the SPF had been acquired by FCDMC and the COE as a flowage easement. A design object for the Estrella Corridor is not to increase the easement area that had been acquired. During final design, hydraulic calculations to determine the flood plain for the SPF flow rate will have to be conducted to assure that the flowage easement area acquired by the county is adequate. If not, increases in the culvert capacity or acquisition of additional easements will be required.

There are several minor crossings that will require cross culverts. These crossings have relatively small drainage areas. Hydrology for these crossing were conducted using rational methods. Preliminary sizing and hydrology are presented below in the drainage concepts section.

Table 3

Peak Flow Summary
Natural Drainage Channels

Stream	50-Year Peak Flow m^3/sec (cfs)	100-year Peak Flow m^3/sec (cfs)	SPF Peak Flow m^3/sec (cfs)
McMicken Dam Outlet Wash	144 (5,085)	185 (6,522)	396 (14,000)
Twin Buttes Wash	- -	61.0 (2,154)	- -
Agua Fria River	- -	850 (30,000)	1218 (43,000)*
Wash West of Lake Pleasant Road	(1,500)	(1,800)	- -
Rock Creek	23.2 (820)	28.3 (1,000)	- -
New River	227 (8,000)	340 (12,000)	680 (24,000)
Skunk Creek	820 (29,000	1100 (39,000)	1870 (66,000)

* Note: SPF flow not available but was approximated by comparing the 100-year flow with the SPF flow in reference included in Appendix D. The SPF flow is 370 m^3/sec (13,000 cfs) higher than the 100-year flow.

4. DRAINAGE CONCEPTS

Drainage design for the Estrella Corridor falls into two different concepts. On the west a collection and conveyance system will be constructed. Use of retention basins will optimize the size and cost of the channel. On the north , a pass through system will be conducted.

All of the streams, except Skunk Creek, have natural bottoms at the Estrella Corridor Crossing. Sediment transport and lateral migration of the banks is a significant concern. Any channelization or improvement for the roadway crossing would have to consider stabilization of the banks to assure that the impact of the Estrella Corridor does not increase the potential for lateral migration or unduly affect the sediment balance in the stream.

4.1 Estrella Drainage Channel

A major drainage channel is proposed to be located immediately upstream of the corridor. This channel has a maximum top width of 44 m (145 feet). Hydrology studies show a significantly smaller channel is required if retention basins are used to attenuate the peak flows of the main channel.

Main Channel

ADOT's initial planning for the corridor included predominately a pass through system supplemented by detention basins in the highway infield areas. While ADOT's concept did contain a North-South drainage channel, it was relatively small and was contained within the right-of-way identified by ADOT. This concept did not accommodate the 100-year flood flows and may have exposed ADOT to liability for flood damage. To assist in relieving flooding east of the corridor and to comply with the White Tanks/ Agua Fria ADMS, the concept was revise by MCDOT to include the channel. Extra right-of-way will be needed for the large drainage channel. This area has been quantified in "Final Report, Drainage Channel Right-of-Way Requirement Study For West Half of Estrella Freeway Loop 303, From I-10 to Bell Road" by Entellus March 1997. Approximately, 34 ha (84 acres) of right-of-way is needed between McDowell Road and Bell Road.

The Entellus study was limited and did not address an outfall south of I-10. South of McDowell Road additional rights-of-way are needed for the 44 m (145-foot) top width channel which would terminate at the Gila River.

Qualitative hydrology studies conducted at the request of the FCDMC shows that four large detention basins will significantly reduce the size of the channel system. Peak flow will reduce from 303 m^3/sec to 113 m^3/sec (10,700 cfs to 4,000 cfs). This would result in significantly less right-of-way and channel construction.

At each street crossing, a box culvert is require to convey flood flows under the street. There will be adequate numbers of box culvert barrels to span the entire width of channel. Table 4 lists the culverts needed for each street crossing without retention basins.

Table 4
Summary
Estrella Drainage Channel
Culvert Requirements Without Basins

Location	Channel Bottom Width m (ft)	Culvert Size Number-m (ft)
Greenway Road	3.0 (10)	2-2.4 m x1.8 m x 30 m (8 ft x 6 ft x98 ft)
Waddell Road	6.1 (20)	4-2.4 m x1.8 m x 30 m (8 ft x 6 ft x98 ft)
Cactus Road	7.6 (25)	4-3.7 m x 2.4 m x 30 m (12 ft x 8 ft x 98 ft)
Peoria Avenue	12.2 (40)	6-3.7 m x 2.4 m x 30 m (12 ft x 8 ft x 98 ft)
Olive Avenue	13.7 (45)	6-3.7 m x 2.4 m x 30 m (12 ft x 8 ft x 98 ft)
Northern Avenue	16.8 (55)	7-3.7 m x 2.4 m x 30 m (12 ft x 8 ft x 98 ft)
Glendale Avenue	21.3 (70)	8-3.7 m x 2.4 m x 30 m (12 ft x 8 ft x 98 ft)
Bethany Home Road	22.9 (75)	8-3.7 m x 2.4 m x 30 m (12 ft x 8 ft x 98 ft)
Camelback Road	24.4 (80)	9-3.7 m x 2.4 m x 30 m (12 ft x 8 ft x 98 ft)
Indian School Road	24.4 (80)	9-3.7 m x 2.4 m x 30 m (12 ft x 8 ft x 98 ft)
Thomas Road	25.9 (85)	9-3.7 m x 2.4 m x 30 m (12 ft x 8 ft x 98 ft)
Cotton Lane	25.9 (85)	10-3.7 m x 2.4 m x 30 m (12 ft x 8 ft x 98 ft)
McDowell Road	25.9 (85)	10-3.7 m x 2.4 m x 30 m (12 ft x 8 ft x 98 ft)
I-10 Interchange	25.9 (85)	10-3.7 m x 2.4 m x 180 m (12 ft x 8 ft x 600 ft)
Roosevelt Canal	25.9 (85)	10-3.7 m x 2.4 m x 15 m (12 ft x 8 ft x 50 ft)
Van Buren Street	25.9 (85)	10-3.7 m x 2.4 m x 30 m (12 ft x 8 ft x 98 ft)
Yuma Road	25.9 (85)	10-3.7 m x 2.4 m x 30 m (12 ft x 8 ft x 98 ft)
Lower Buckeye Road	25.9 (85)	10-3.7 m x 2.4 m x 30 m (12 ft x 8 ft x 98 ft)
Southern Pacific Railroad	25.9 (85)	10-3.7 m x 2.4 m x 30 m (12 ft x 8 ft x 98 ft)
MC85	25.9 (85)	10-3.7 m x 2.4 m x 30 m (12 ft x 8 ft x 98 ft))

I-10 Crossing

The Estrella Corridor interchange at Interstate 10 will be a diamond interchange. Interstate 10 will pass over the Estrella Corridor intersecting will be at grade. The drainage channel will be located on the west side and require new long box culverts to cross under both of the ramps and the mainline.

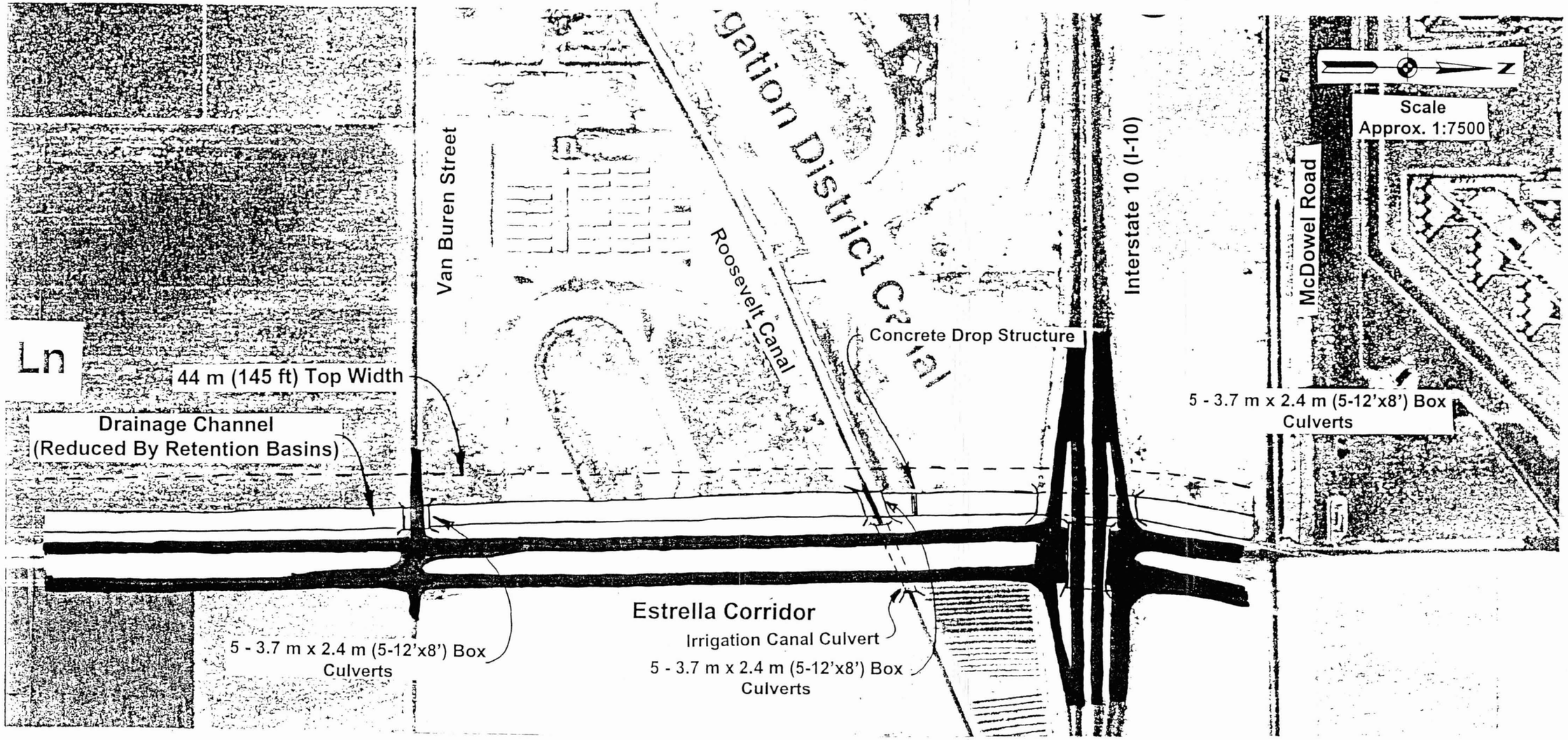
Just south of the I-10 crossing is a crossing of the Roosevelt Irrigation District Canal, see Figure 9. The WLB Group in their initial planning for the drainage channel, used a series of drop structure to assure that the channel operates in a subcritical flow condition. A drop structure was located at the Roosevelt Canal such that the drainage channel can cross under the canal. This crossing structure would consist of a box culvert crossing under a concrete channel flume, for the Roosevelt Canal. The flume would be located immediately on top of the box culvert.

Gila River Outlet

At the Estrella Corridor drainage channel, the Gila River is very wide and carries substantial flood flows. The Estrella Corridor channel will be within the 100-year flood plain for a substantial distance until it can join with the Gila River's low flow channel. The outlet structure will have to be designed and constructed to survive the transverse flows of the Gila River without resulting in additional impacts to adjacent land. Near the river bottom, the grade of the drainage channel will decrease which will slow the channel flow velocities. This will require greater channel width than further upstream. Stabilization against the transverse flow can be accomplished by construction of a Cement Stabilized Alluvium bank protection on the downstream side of the channel. The upstream side of the channel will be unprotected as bank protection could represent an obstruction to flow and could cause impacts east of the channel. The CSA bank protection will be constructed no higher than the existing ground so as to have no effect on the Gila River flood plain.

4.2 McMicken Dam Outlet Wash

The McMicken Dam Channel is a relatively small channel that is well defined. Ritoch Powell has determined that 6- 3.7 m x 2.4 m (12 ft x 8 ft) box culverts are required to convey flood waters through this crossing. As part of a commitment to the US Army Corps of Engineers, adequate rights of way has been obtained to allow flooding at the SPF event along this wash. Any improvement or crossings will have to be designed such that any increases in water surface levels during the SPF event will stay within the existing rights of way.



Estrella Corridor

Drainage Concepts
at Roosevelt Canal

Figure 9

DE LEUW, CATHER CO.

4.3 Agua Fria River Crossing

The Agua River is 1.4 km (4,500 feet) in width at the Estrella Corridor. A bridge would likely be founded on deep large diameter drilled shafts which would be long enough to accommodate the anticipated long term scour of the channel. The channel is fully braided within banks that exceed 9 meters (30 feet) tall. Until recently, the channel had a discharge rate of 3,700 m^3/sec (130,000 cfs) which has been reduced to 880 m^3/sec (31,000 cfs) due to construction of the New Waddell Dam. Flood plain studies show that the entire channel bottom area to be flooded during a 100-year event with much of the flows less than 0.6 meters (2 feet) deep. Those flood plain studies have also delineated a floodway along the west bank of the river for about 490 meters (1,600 feet). The remainder of channel bottom would be encroachable floodplain that could be filled. The ultimate bridge would have to be 490 meters (1,600 feet) long to span the floodway.

Initial planning for Estrella Corridor as it crosses the Agua Fria River uses an at grade crossing of the river. The crossing would be designed such that low flows cross under the roadway while high flows overtop the roadway. Ten 910 mm (36 inch) diameter culverts can convey 8.5 m^3/sec (300 cfs) under the roadway. This flow is significantly less the 28 m^3/sec (1,000 cfs) discharge of the 2-year flow event. The Estrella Corridor has a high probability of being frequently closed, potentially several times a year.

As currently configured, the roadway alignment crosses the channel at a skew with the ground contours and the water surface elevation contours. There is a 1.2 meter (4 foot) difference in the calculated water level at the roadway between the east and west bank of the river as well as in the channel bottom. The roadway alignment should be revised to cross the river perpendicular to the flow of the channel, otherwise flows will cross over the roadway during high flow events non uniformly and may result in flow concentrated at one point and impose more scouring forces than anticipated.

To install the 910 mm (36 inch) diameter culverts, the Estrella Corridor will need to be constructed on a 1.5 m to 1.8 m (5 to 6 feet) tall embankment in the channel bottom. The channel invert is extensively braided and has no defined or incised low flow channel. The culverts should be spaced along the west bank of the river where the existing ground appears to be lower.

A 1.8 meter (6 foot) embankment height would cause a backwater to occur just upstream of the embankment, may result in slower velocities and sediment deposition just upstream of the embankment. The overall long term sediment balance should be studied in detail to refine the cross culvert design to keep the sediment transport rate in balance with the supply.

The roadway fill also increases the floodplain and floodway by the height of the embankment, thereby increasing the designated flood plain. Flood plain studies are required to re-delineate the flood plain and flood way. Also as part of the FCDMC commitments to the US Army Corps of Engineers, flood plain studies will be required to assure that the delineated flood during the SPF does not exceed the area that has been delineated and acquired.

The roadway embankment should survive flows greater than the 10-year event of 250 m^3/sec (9,000 cfs). This would require concrete or Cement Stabilized Alluvium protection of the roadway embankment. Flows would flow over the roadway pavement and down the roadway embankment creating a scour hole downstream. Therefore, protection must be adequately deep to prevent undermining the down stream side of the embankment. It may be more appropriate to construct a true at-grade crossing with no low flow culverts.

4.4 Twin Buttes Wash

The Twin Buttes wash is a small drainage wash that crosses the corridor just before it discharges into the Agua Fria River. It has relatively small flows compared to the 4.6 meter (15 feet) deep banks. Three 3.7 meter wide by 2.4 meter high (12 feet by 8 feet) box culverts can carry the design flow and allow the transport of sediment through the structure. Due to the relatively narrow channel width, crossing this channel at grade is not practical.

4.5 Wash West of Lake Pleasant Road

There is a deep wash that is located between the Agua Fria River and Lake Pleasant Road. The Drainage area is approximately 1,400 acres (see Appendix I) and has a 100-year peak flow of approximately 1,400 cfs. This channel has deep banks which may exceed 20-foot high. This flow can be accommodated in twin 3 meter wide by 3 meter high box culverts.

4.6 Rock Creek Crossing

Just west of New River, a separate stream is evident that flows parallel and contributory to the New River at the Estrella Corridor crossing. This stream is relatively small and the drainage area would have been included in the drainage area of New River. There is about 364 ha (900 acres) a desert area that is contributory to this stream. Approximately, 28 m^3/sec (1,000 cfs) flows in this stream and requires three 2.4 meter wide by 1.8 meter high (8 feet by 6 feet) box culverts. The roadway embankment will impact about 0.3 ha (0.7 acres) of 100-year flood plain. See Appendix G for hydraulic calculations of the crossing

4.7 New River Crossing

The 100-year flood plain is 250 meters (820 feet) wide at the Estrella Corridor. The flood plain about 91 meters (300 feet) upstream and 91 meters (300 feet) downstream of the crossing is in a natural channel about 91 meters (300 feet) wide. Channelization to eliminate this breakout would reduce the size of the bridge structure. With channelization, a bridge structure 104 meters (340 feet) long would be required to cross New River.

The existing ground level between Rock Creek and New River is about 408.4 m (1340 ft) with channel inverts about at elevation 406.0 m (1332 ft). Combining both streams into one channel would be impractical without significant upstream channelization and diversion to new River. This channelization would cut off flow to the existing areas of Rock Creek and would impact the vegetation and wildlife along this stream. Since this may be considered a "Water of the United States" requiring a permit from the U.S. Corps of Engineers, this channelization would very likely

be unacceptable or require extensive justification during a permit application. See Appendix H for hydraulic calculations of the crossing.

4.8 Skunk Creek Crossing

Just west of I-17, Skunk Creek crosses the Corridor alignment. Skunk Creek has well defined banks with bank protection. Just downstream of the corridor, the City of Phoenix has a landfill operation which required the channelization of the stream. The existing Happy Valley Road crosses Skunk Creek at grade on a curvilinear alignment and runs through gaps in the bank protection. One mile to the south, Pinnacle peak road crosses Skunk Creek on a 100 m (328 ft) long bridge. A similar structure is warranted for the Estrella Corridor.

4.9 Other Highway Crossings

The previous text addresses the several major washes cross the project. Along the north leg of the Corridor, the concept is to "pass through" offsite runoff using bridges, box or pipe culverts. Many of the areas between the larger washes are not defined. Typically, they are small washes that braid on the alluvial fan areas north of the Estrella Corridor.

In places where the corridor is aligned through areas where there are significant streams or rills, a cross drainage system may be constructed by locating a small diameter pipe at each stream. The area between 67th and 99th Avenues is an example of this. The profile of the corridor will have to be high enough to allow the pipe to cross yet low enough to reduce the fill demands on the roadway embankment. The culverts will have to be constructed on a steep enough slope to accommodate the high amount of sediment that is transported by these small streams. They should be located such that future development can incorporate them in the design for the drainage facilities as the area develops.

Onsite flows that are collected on the roadway pavement will have to be conveyed to low points in the roadway where there is adequate cover to cross the pavement with a culvert.

ESTRELLA CORRIDOR STUDY

Drainage

Technical Memorandum

Appendix A

Estrella Channel Hydrology

PARSONS TRANSPORTATION GROUP
DE LEUW, CATHER & COMPANY

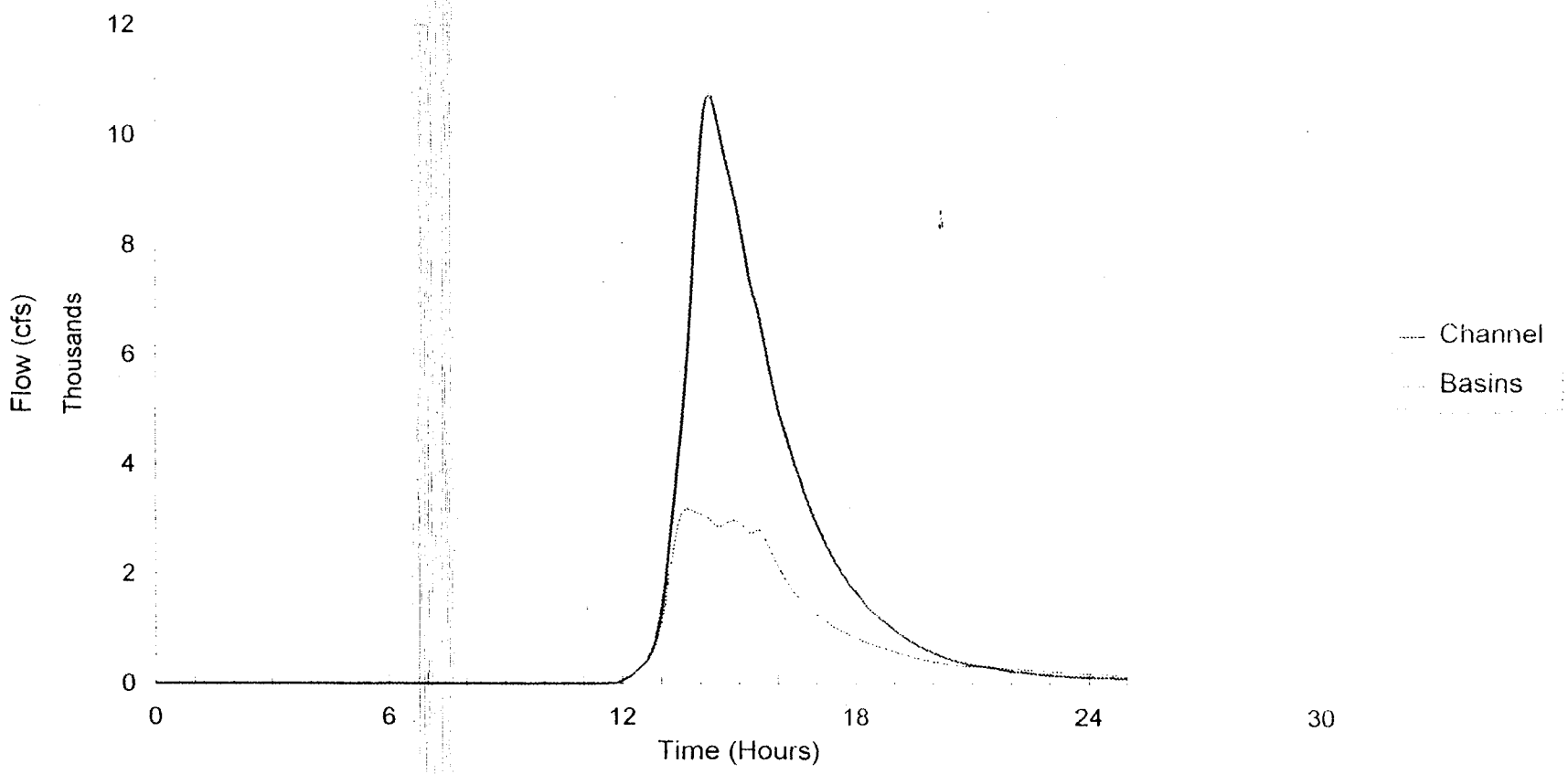
Estrella Corridor

Drainage Channel Concept Planning
Drainage Channel Concept Planning
Detention Basin Alternative
Hydrology Summary

Location	HEC-1 Node	Channel Flow		
		No Basins (cfs)	Up Stream (cfs)	Down Stream (cfs)
Waddel Road	CP131A	1,874	1,874	- -
Cactus Road	CP145A	3,216	3,216	- -
Peoria Avenue	CP164A	4,617	4,617	2,145
Olive Avenue	CP177A	5,111	2,624	- -
Northern Avenue	CP192A	6,061	2,810	1,344
Glendale Avenue	CP204A	7,644	3,776	- -
Bethany Home Road	CP219	7,682	3,828	- -
Camelback Road	CP237	8,442	4,659	2,165
Indian School Road	CP250	8,965	2,772	- -
Thomas Road	CP265	9,250	3,144	1,488
I-10	CP279	10,656	3,149	- -
Van Buren Avenue	CP295	10,617	3,125	- -
Yuma Road	CP311	10,643	3,308	- -
Lower Buckeye Road	CP330	10,679	3,632	- -
Broadway Avenue	CP346A	10,602	3,582	- -
Gila River	CP378B	10,569	3,893	- -

Channel Hydrograph

Estrella Corridor At I-10

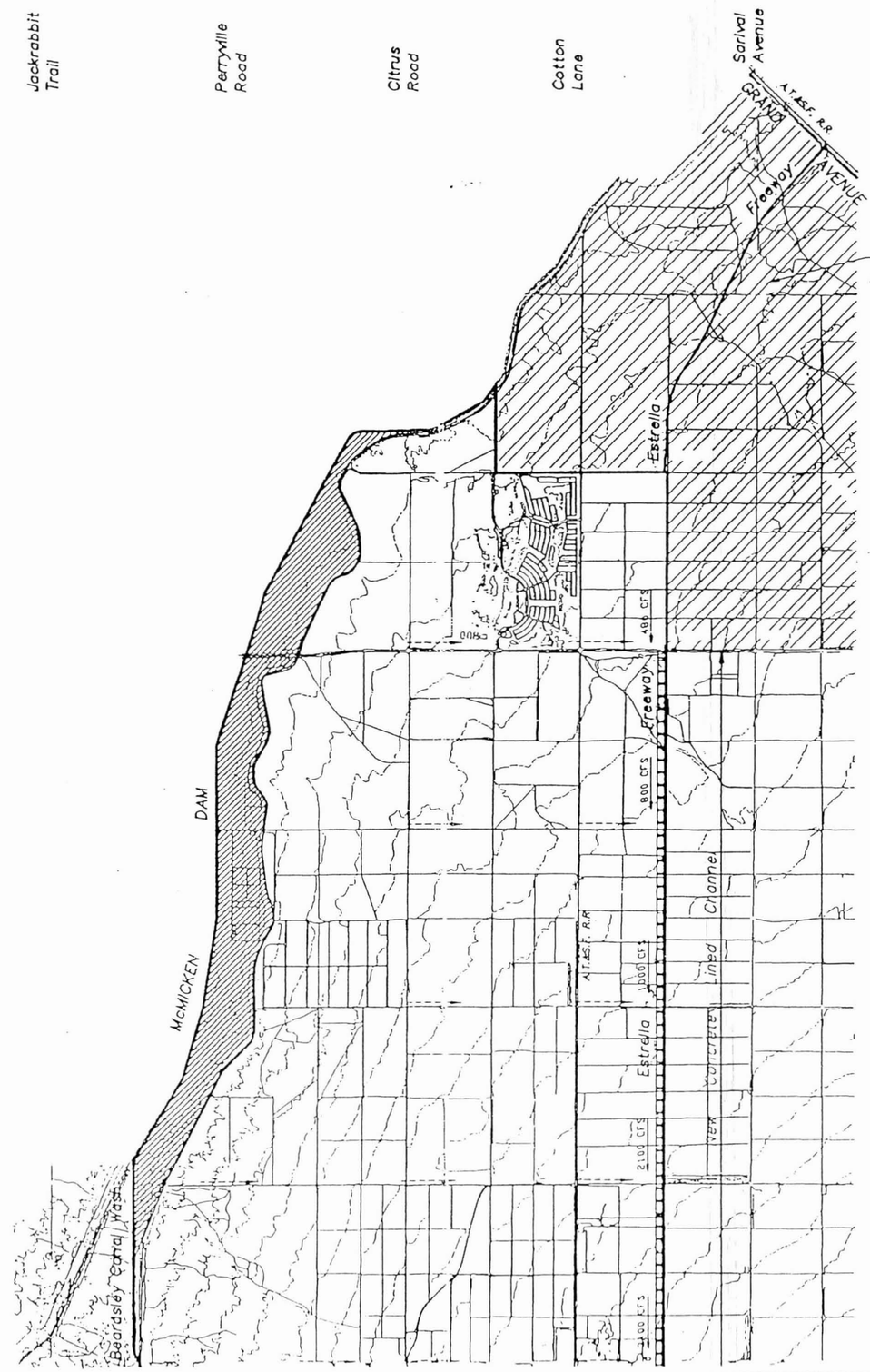


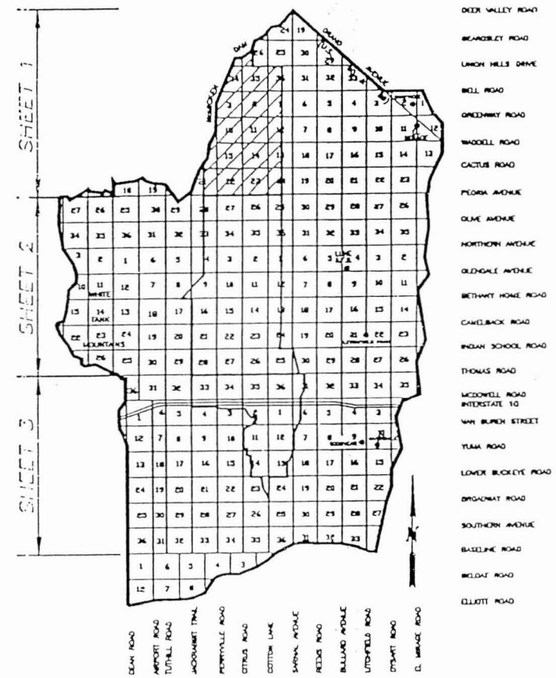
HYDRO.WK4

Figure 7.2-1

Area Drainage Master Plan for Estrella Freeway Watershed Sheet 1 of 3

WHITE TANKS/AGUA FRIA
AREA DRAINAGE MASTER STUDY





Location Map

Legend

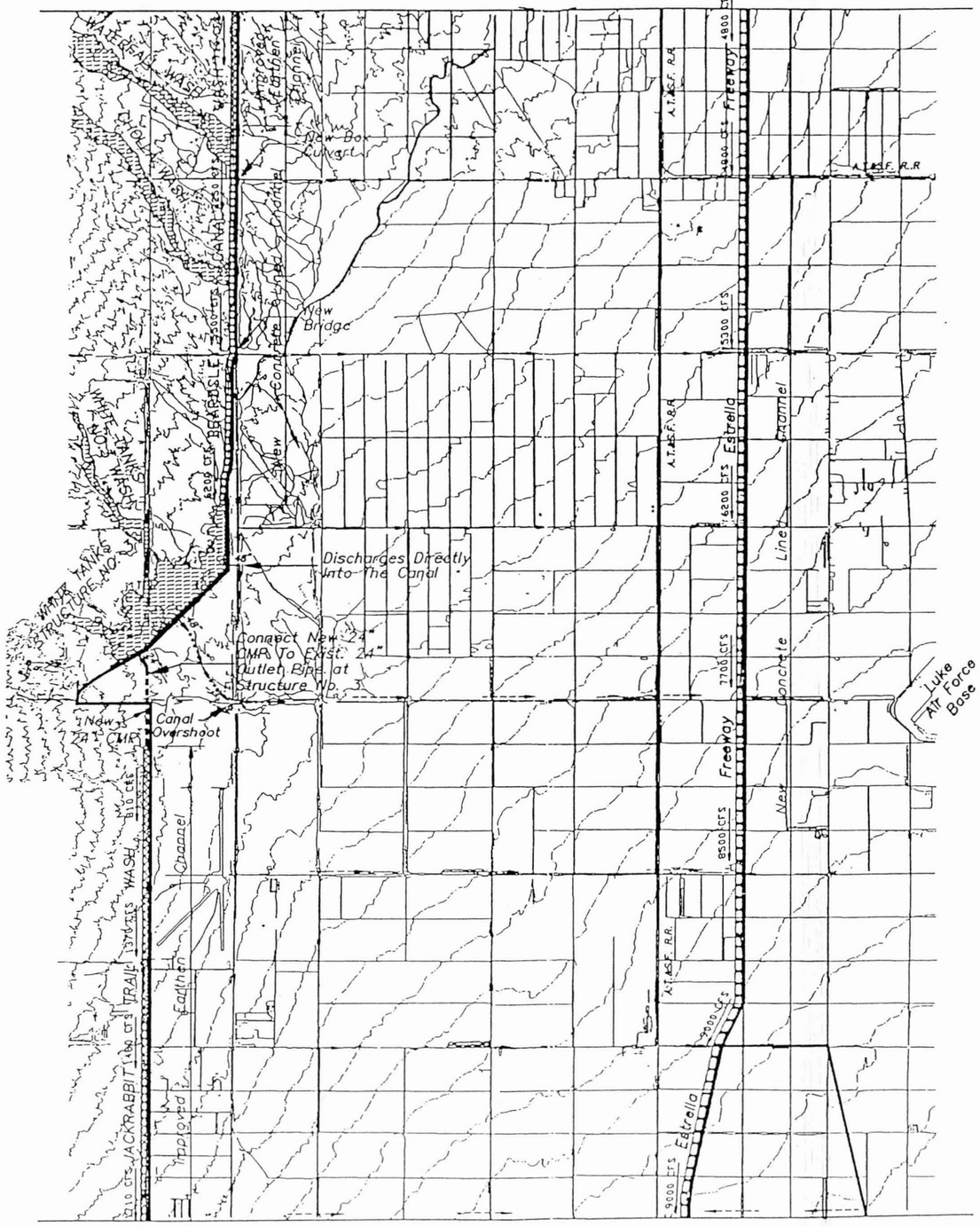
1800 CFS	Proposed Condition Peak Flow
	100 – Year Floodplain
	Retained Area Behind Beardsley Canal
48"	48" C.M.P. Gated Outlet
	Watershed Boundary
	Railroads
	Existing Channels
	Future Local Drainage System

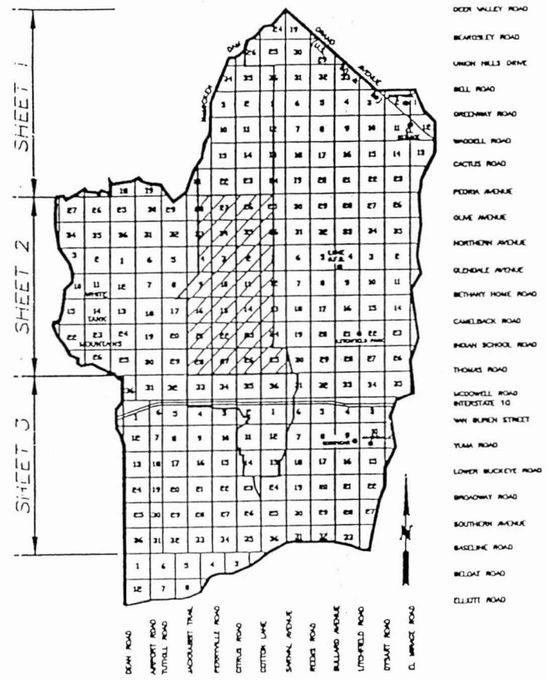
The WLB Group P.C. **WLB**

Figure 7.2-2

Area Drainage Master Plan
for
Estrella Freeway Watershed
Sheet 2 Of 3

WHITE TANKS/AGUA FRIA
AREA DRAINAGE MASTER STUDY





Location Map

Legend

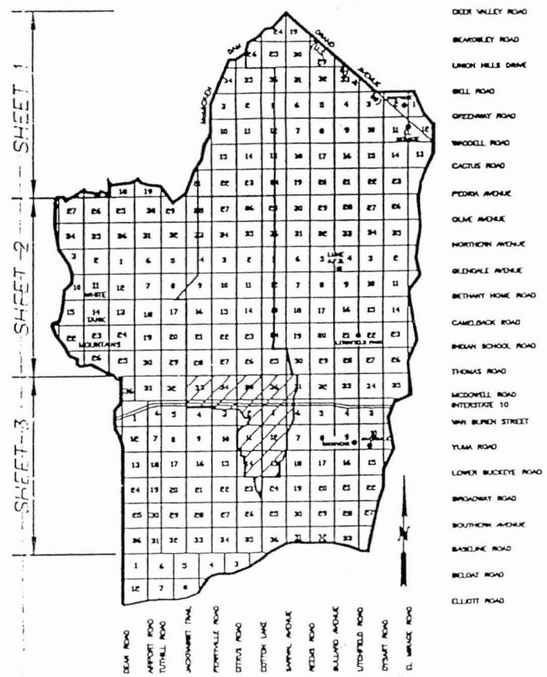
- 1800 CFS — Proposed Condition Peak Flow
- 100 – Year Floodplain
- Retained Area Behind Boardsley Canal
- 48" — 48" C.M.P. Gated Outlet
- Watershed Boundary
- Railroads
- Existing Channels
- Future Local Drainage System

The WLB Group D.C. **WLB**

Figure 7.2-3

Area Drainage Master Plan
for
Estrella Freeway Watershed
Sheet 3 of 3

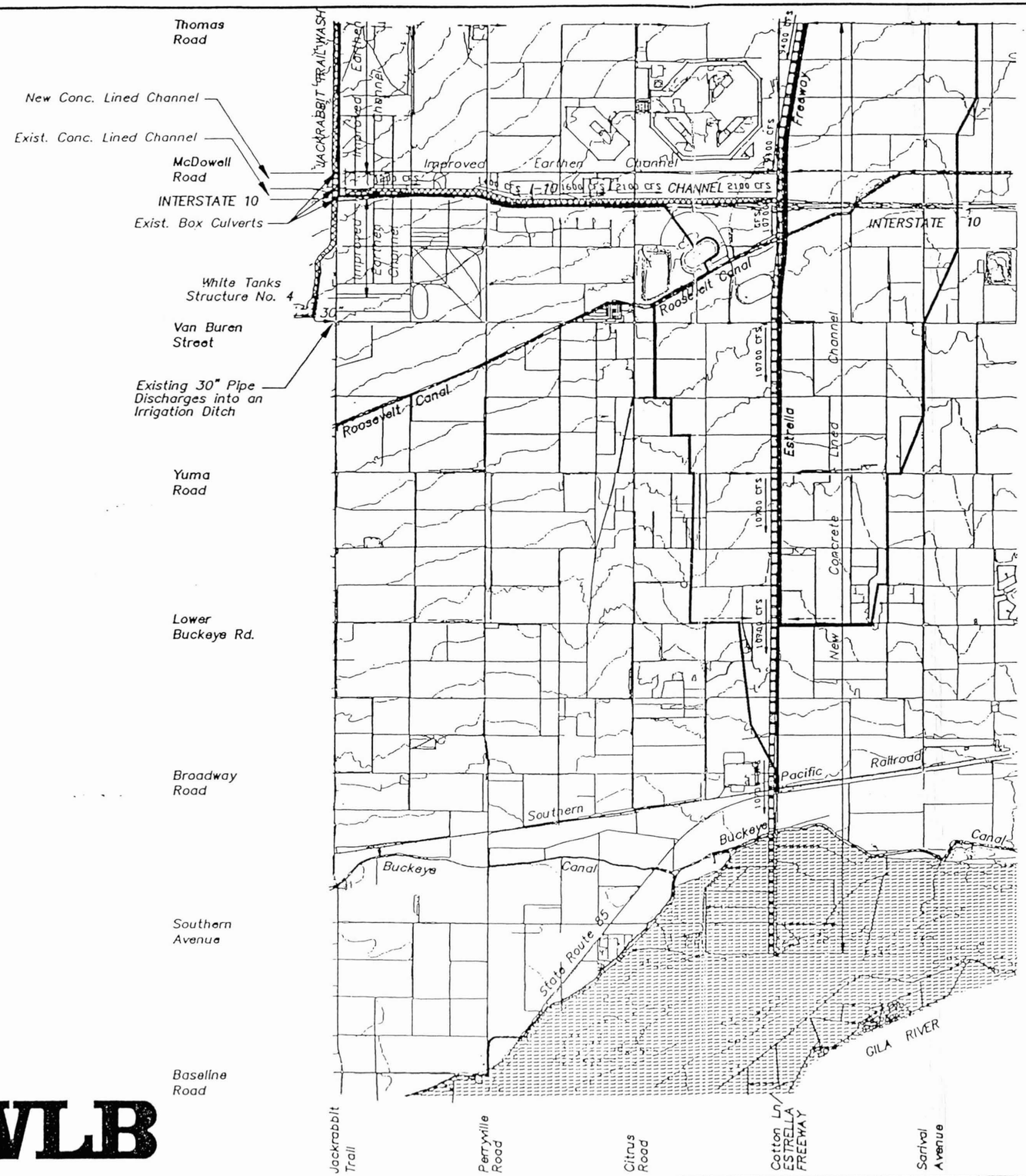
WHITE TANKS/AGUA FRIA
AREA DRAINAGE MASTER STUDY



Location Map

Legend

1800 CFS	Proposed Condition Peak Flow
	100 – Year Floodplain
	Retained Area Behind Beardsley Canal
48"	48" C.M.P. Gated Outlet
	Watershed Boundary
	Railroads
	Existing Channels
	Future Local Drainage System



The WLB Group P.C. WLB

HEC-1 KEY MAP

WHITE TANKS/AGUA FRIA
AREA DRAINAGE MASTER STUDY

LEGEND

- DRAINAGE AREA BOUNDARY
- SUBBASIN BOUNDARY
- SUBBASIN IDENTIFICATION
- CONCENTRATION POINT
- FLOW PATH
- RETAINED AREA
- DIVERSION

R3W R2W R1W

T4N T3N T2N T1N T1S

DEER VALLEY ROAD
BEARDSLEY ROAD
UNION HILLS DRIVE
DRAINAGE AREA BOUNDARY
GRAND AVENUE (U.S. 60 & U.S. 89)
ATCHISON TOPEKA & SANTA FE RAILROAD
MCMICKEN DAM
MCMICKEN
WHITE TANK MOUNTAINS
BEARDSLEY
WHITE TANKS
WT #3
WT #4
WHITE TANKS STRUCTURE #4
LUKE AUXILIARY FIELD NO. 1
LUKE AIR FORCE BASE
SURPRISE
EL MIRAGE
GOODYEAR
LITCHFIELD PARK
LITCHFIELD PARK GOLF COURSE
AGUA FRIA RIVER
GILA RIVER
GILA AND SALT RIVER MERIDIAN
ATCHISON TOPEKA & SANTA FE RAILROAD
SOUTHERN PACIFIC RAILROAD
SR 101
INTERSTATE 10
ROOSEVELT
OLIVE AVENUE
NORTHERN AVENUE
GLENDALE AVENUE
BETHANY HOME ROAD
CAMELBACK ROAD
INDIAN SCHOOL ROAD
THOMAS ROAD
McDOWELL ROAD
VAN BUREN STREET
YUMA ROAD
LOWER BUCKEYE ROAD
BROADWAY ROAD
SOUTHERN AVENUE
BASELINE
STATE ROUTE 85
BUCKEYE
BELOAT ROAD
CEMETERY ROAD
WATSON ROAD
RAINBOW ROAD
OCEAN ROAD
AIRPORT ROAD
TOTHILL ROAD
JACKRABBIT TRAIL
PERRYVILLE ROAD
CITRUS ROAD
COTTON LANE
ESTRELLA PARKWAY
BULLARD AVENUE
LITCHFIELD ROAD
DYSART ROAD
116TH AVENUE
MIRAGE ROAD
SIERRA ESTRELLA MOUNTAINS

WLB

HEC-1 KEY MAP

WHITE TANKS/AGUA FRIA
AREA DRAINAGE MASTER STUDY

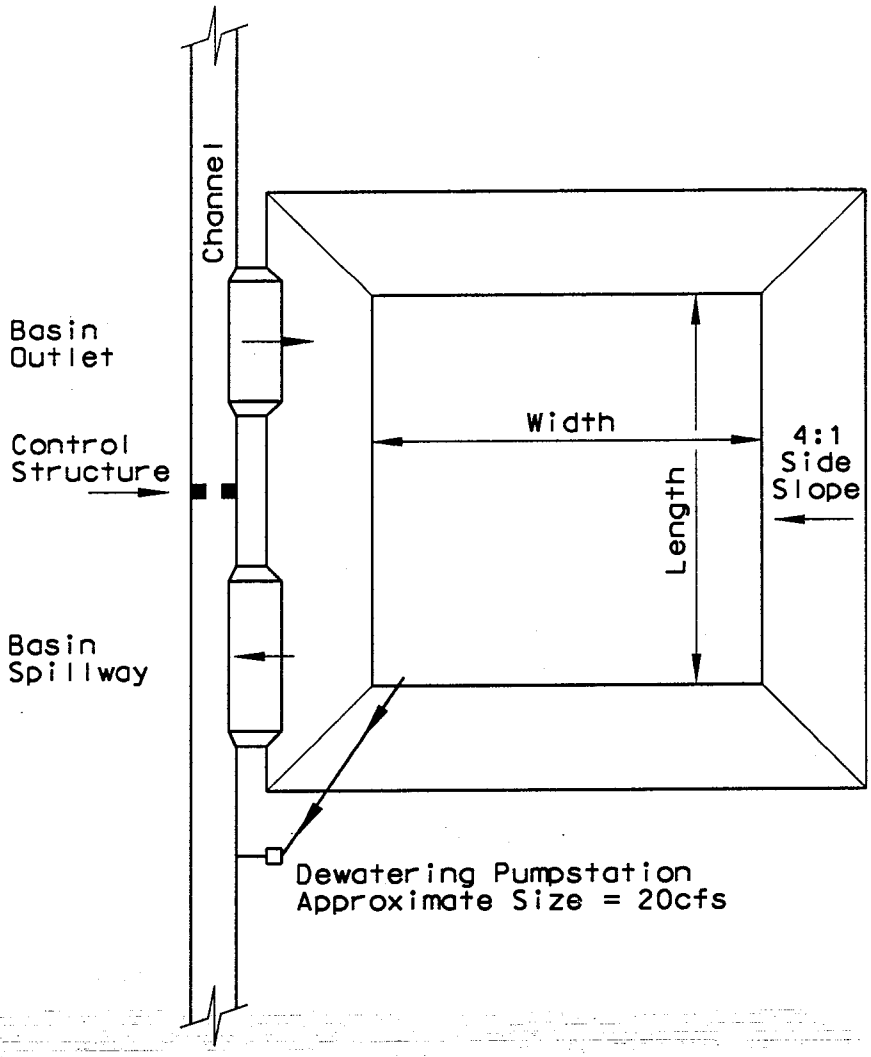
R3W — R2W

LEGEND

- DRAINAGE AREA BOUNDARY
- SUBBASIN BOUNDARY
- SUBBASIN IDENTIFICATION
- CONCENTRATION POINT
- FLOW PATH
- RETAINED AREA
- DIVERSION

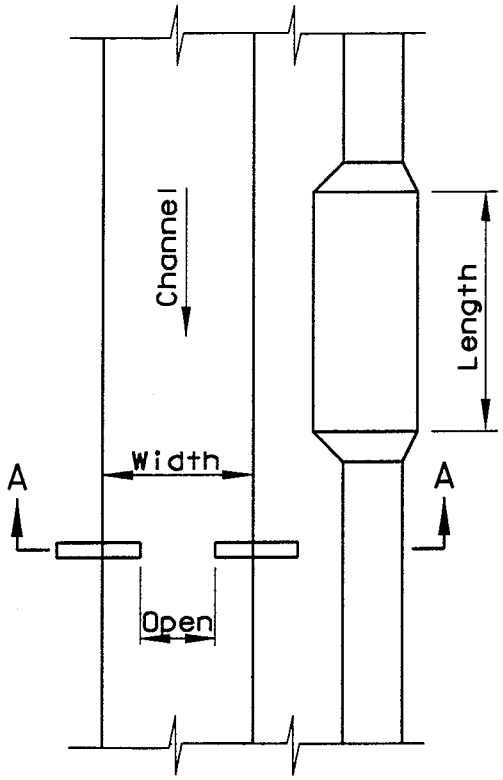
DRAINAGE AREA BOUNDARY

18774 18774 3216 3216 4617 2145 5111 2674 6061 1344 7644 3776 8442 7682 3328 2165 8965 2772 9250 1488 10,659 3149 10617 3125 10643 3308 10678 10602 3582 10569 3892

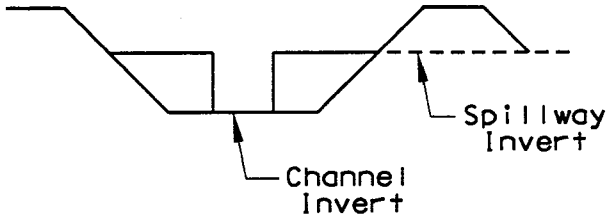


DE LEUW, CATHER

BASIN SCHEMATIC



PLAN

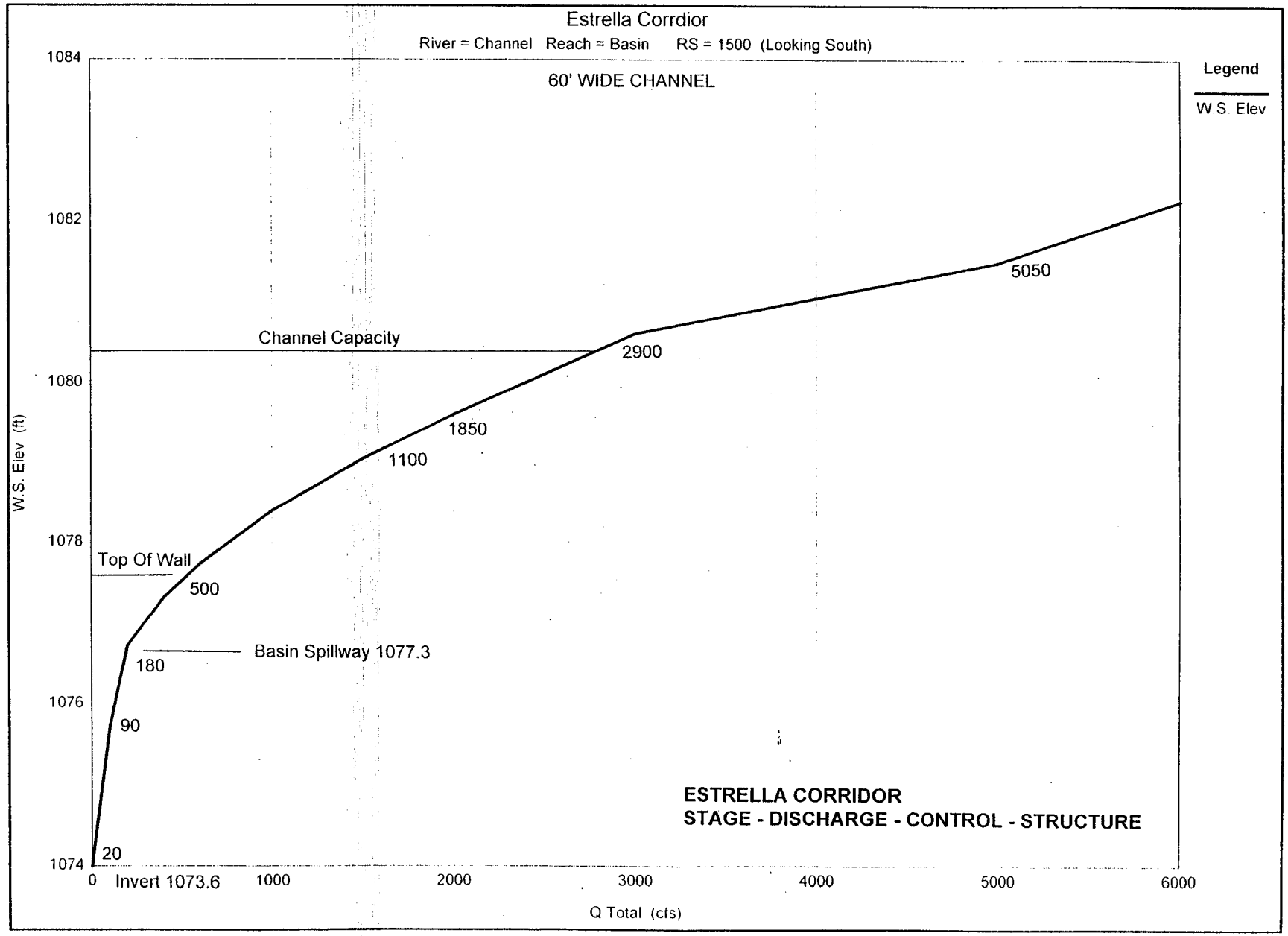


SECTION A-A

NOTE:

The Diversion Relationship will be Determined by Developing a Stage Discharge Relationship for the Control Structure and a Stage Discharge Relationship for the Spillway Inlet.

DE LEUW, CATHER	BASIN CONTROL STRUCTURE



Polasik 9/26/97

Estrella Corridor

Hydrology - FCD Multiple Basin Alternative

BASIN PROPERTIES

Side Slope	4	:1	4	:1	4	:1	4	:1	4	:1	4	:1
Depth	30	feet	29	feet	28	feet	27	feet	26.5	feet	26	feet
Bot. width	500	feet	500	feet	500	feet	500	feet	500	feet	500	feet
Bot Length	1000	feet	1000	feet	1000	feet	1000	feet	1000	feet	1000	feet
Top Width	740	feet	732	feet	724	feet	716	feet	712	feet	708	feet
Top Length	1240	feet	1232	feet	1224	feet	1216	feet	1212	feet	1208	feet
Bot Area	11.47842057	Acres	11.4784206	Acres	11.4784206	Acres	11.4784206	Acres	11.4784206	Acres	11.4784206	Acres
Top Area	21.06519743	Acres	20.7030303	Acres	20.3438017	Acres	19.9875115	Acres	19.8104683	Acres	19.6341598	Acres
Total Volume	488.15427	Acre Feet	466.631038	Acre Feet	445.511111	Acre Feet	424.790083	Acre Feet	414.577778	Acre Feet	404.463545	Acre Feet
Pump Out Flo	20	cfs	20	cfs	20	cfs	20	cfs	20	cfs	20	cfs

Side Slope	4	:1	4	:1	4	:1	4	:1
Depth	31	feet	32	feet	33	feet	34	feet
Bot. width	500	feet	500	feet	500	feet	500	feet
Bot Length	1000	feet	1000	feet	1000	feet	1000	feet
Top Width	748	feet	756	feet	764	feet	772	feet
Top Length	1248	feet	1256	feet	1264	feet	1272	feet
Bot Area	11.47842057	Acres	11.4784206	Acres	11.4784206	Acres	11.4784206	Acres
Top Area	21.43030303	Acres	21.7983471	Acres	22.1693297	Acres	22.5432507	Acres
Total Volume	510.0852158	Acre Feet	532.428283	Acre Feet	555.187879	Acre Feet	578.368411	Acre Feet
Pump Out Flo	20	cfs	20	cfs	20	cfs	20	cfs

CHANNEL PROPERTIES

Base Width	60	
Max Depth	7	
Slope	0.002	ft/ft
Side Slope	2	:1
Top Width	88	ft
Channel Area	518	sf
Mannings	0.02	
Perimeter	91.30495168	
Max Q ND	5475.080687	
Vel	10.56965384	

Estrella Corridor
Hydrology - FCD Multiple Basin Alternative

Control Structure

Assume short wall in channel with notch for low flows
See HEC-RAS Calculations

Spillway

	4
	10
Spillway Elev	1076.6
Wier top width	150
Weir Cooef	2.8
Channel Inver	1073.6

Outflow

Elevation	Depth	Control Structur	CS Discharge	Spillway Dept	Wier Flow	Total Flow	Channel Dept	Channel Area	Channel Peri	Channel Flow	Basin Depth	Basin Area	Basin Spillwa	Pump Outflow	Total Spillway
1073.6	0	0	0	0	0.00	0.00	0	0	60	0	26	19.6341598		20	20
1074.1	0.5	0.5	20	0	0.00	20.00	0.5	30.5	62.236068	62.9953915	26.5	19.8104683		20	20
1074.6	1	1	50	0	0.00	50.00	1	62	64.472136	200.712886	27	19.9875115		20	20
1075.6	2	2	90	0	0.00	90.00	2	128	68.9442719	642.473128	28	20.3438017		20	20
1076.6	3	3	180	0	0.00	180.00	3	198	73.4164079	1274.72658	29	20.7030303	0	20	20
1077.6	4	3.5	500	1	420.00	920.00	4	272	77.8885438	2080.3493	30	21.0651974	420	20	440
1078.6	5	5	1100	2	1187.94	2287.94	5	350	82.3606798	3051.1995	31	21.430303	1187.93939	20	1207.93939
1079.6	6	6	1850	3	2182.38	4032.38	6	432	86.8328157	4183.31724	32	21.7983471	2182.38402	20	2202.38402
1080.6	7	7	2900	4	3360.00	6260.00	7	518	91.3049517	5475.08069	33	22.1693297	3360	20	3380
1081.6	8	8	5050	5	4695.74	9745.74	8	608	95.7770876	6926.3116	34	22.5432507	4695.74275	20	4715.74275

HEC-1 Card Inputs

Diversion Elevation	1073.6	1074.1	1074.6	1075.6	1076.6	1077.6	1078.6	1079.6	1080.6	1081.6
DI	0.0	20.0	50.0	90.0	180.0	920.0	2287.9	4032.4	6260.0	9745.7
DQ	0.0	20.0	50.0	90.0	180.0	500.0	1100.0	1850.0	2900.0	5050.0

Storage

SA	0.0000	11.4784	20.7030	21.0652	21.4303	21.7983	22.1693	22.5433
SE	1047.60	1048.60	1076.60	1077.60	1078.60	1079.60	1080.60	1081.60
SQ	0	20	20	440	1208	2202	3380	4716

Estrella Corridor

Drainage Channel Concept Planning
Detention Basin Alternative
Hydrology Summary

Location	HEC-1 Node	100-YR Channel Flow			50-YR Channel Flow			10-YR Channel Flow		
		No Basins (cfs)	Up Stream (cfs)	Down Stream (cfs)	No Basins (cfs)	Up Stream (cfs)	Down Stream (cfs)	No Basins (cfs)	Up Stream (cfs)	Down Stream (cfs)
Waddel Road	CP131A	1,874	1,874	--	1,586	1,586	--	1,028	1,028	--
Cactus Road	CP145A	3,216	3,216	--	2,614	2,614	--	1,601	1,601	--
Peoria Avenue	CP164A	4,617	4,617	2,145	3,759	3,759	1,753	2,128	2,128	1,050
Olive Avenue	CP177A	5,111	2,624	--	4,161	2,163	--	2,332	1,259	--
Northern Avenue	CP192A	6,061	2,810	1,344	4,529	2,275	1,114	2,364	1,301	687
Glendale Avenue	CP204A	7,644	3,776	--	5,952	2,837	--	3,014	1,388	--
Bethany Home Road	CP219	7,682	3,828	--	5,961	2,893	--	2,986	1,407	--
Camelback Road	CP237	8,442	4,659	2,165	6,601	3,604	1,686	3,409	1,871	937
Indian School Road	CP250	8,965	2,772	--	7,000	2,141	--	3,544	1,127	--
Thomas Road	CP265	9,250	3,144	1,488	7,207	2,419	1,176	3,615	1,250	441
I-10	CP279	10,656	3,149	--	8,267	2,448	--	4,082	1,287	--
Van Buren Avenue	CP295	10,617	3,125	--	8,231	2,440	--	4,065	1,284	--
Yuma Road	CP311	10,643	3,308	--	8,210	2,578	--	4,034	1,334	--
Lower Buckeye Road	CP330	10,679	3,632	--	8,211	2,786	--	4,035	1,419	--
Broadway Avenue	CP346A	10,602	3,582	--	8,157	2,749	--	3,994	1,398	--
Gila River	CP378B	10,569	3,893	--	8,098	2,974	--	3,952	1,522	--

ESTRELLA CORRIDOR STUDY

Drainage

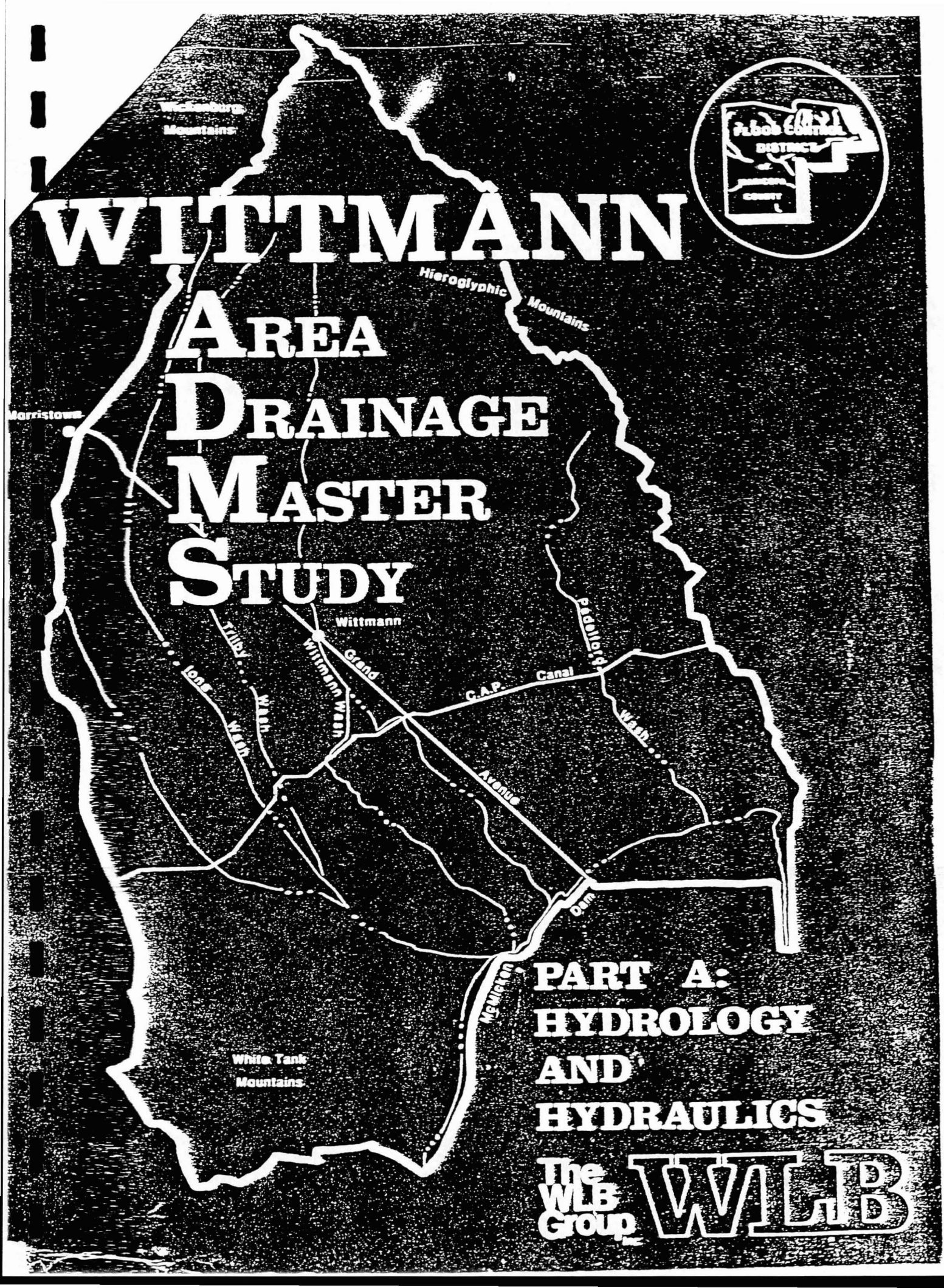
Technical Memorandum

Appendix B

McMicken Dam Outlet Wash

SPF Hydrology Summary

PARSONS TRANSPORTATION GROUP
DE LEUW, CATHER & COMPANY



WITTMANN AREA DRAINAGE MASTER STUDY

PART A: HYDROLOGY AND HYDRAULICS

The WLB Group WLB

Description	Wittmann ADMS Results	U.S. Army Corps of Engineers Design
McMicken Dam		
100-Year Peak Inflow	20,431 CFS	Not Calculated
100-Year Peak Outflow	2,998 CFS	Not Calculated
100-Year Peak Stage	1349.92 FT	Not Calculated
100-Year Peak Volume	13,374 AC-FT	Not Calculated
SPF Peak Inflow	37,503 CFS	35,000 CFS
SPF Peak Outflow	15,518 CFS	4,450 CFS
SPF Peak Stage	1354.98 FT	1356.0 FT
SPF Peak Volume	24,013 AC-FT	32,800 AC-FT
PMF Peak Inflow	110,374 CFS	120,000 CFS
PMF Peak Outflow	95,042 CFS	Not Calculated
PMF Peak Stage	1360.46 FT	Not Calculated
PMF Peak Volume	39,098 AC-FT	Not Calculated
Outlet Channel		
→ SPF Upstream of confluence with Agua Fria River	16,443 CFS	14,000 CFS

Note: Top of Dam Elevation = 1360.7 FT
Top of Spillway Elevation = 1353.65 FT

Wittmann Wash Split Flow

A split flow analysis was performed on Wittmann Wash approximately 1/2 mile upstream of the CAP Canal and it was determined that 542 cfs splits to the west and continues to the Patton Road Bridge area where it flows across Patton Road and continues to flow south to the CAP2WEST Wash. The remaining 1722 cfs continues in the main channel to the east and flows to the CAP1WEST Overchute on the CAP Canal.

ESTRELLA CORRIDOR STUDY

Drainage

Technical Memorandum

Appendix C

FEMA Hydrology

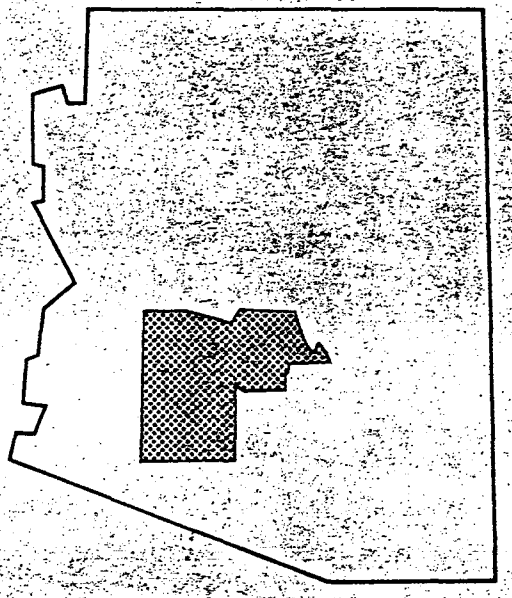
Twin Buttes Wash
McMicken Dam Outlet Wash
New River
Skunk Creek

PARSONS TRANSPORTATION GROUP
DE LEUW, CATHER & COMPANY

AMM

FLOOD INSURANCE STUDY

MARICOPA COUNTY, ARIZONA
AND INCORPORATED AREAS
VOLUME 1 OF 12



COMMUNITY NAME	COMMUNITY NUMBER
AVONDALE, CITY OF	040038
BUCKEYE, TOWN OF	040039
CAREFREE, TOWN OF	040126
CAVE CREEK, TOWN OF	040129
CHANDLER, CITY OF	040040
EL MIRAGE, TOWN OF	040041
GILA BEND, TOWN OF	040043
GILBERT, TOWN OF	040044
GLENDALE, CITY OF	040045
GOODYEAR, TOWN OF	040046
GUADALUPE, TOWN OF	040111
LITCHFIELD PARK, CITY OF	040128
MARICOPA COUNTY UNINCORPORATED AREAS	040037
MESA, CITY OF	040048
PARADISE VALLEY, TOWN OF	040049
PEORIA, CITY OF	040050
PHOENIX, CITY OF	040051
QUEEN CREEK, TOWN OF	040132
SCOTTSDALE, CITY OF	045012
SURPRISE, TOWN OF	045053
TEMPE, CITY OF	040054
TOLLESON, CITY OF	040055
WICKENBURG, TOWN OF	040056
YOUNGSTOWN, TOWN OF	040057

REVISED: SEPTEMBER 30,1995

Federal Emergency Management Agency

Table 3. Summary of Discharges (Cont'd)

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (cfs) 10-Year	50-Year	100-Year	500-Year
Southwest Side of Southern Pacific Railroad					
From Germann Road to confluence of East Maricopa Floodway	--[2]	--[1]	--[1]	313	--[1]
Caterpillar Tank Wash					
Immediately downstream from CAP Canal	1.03	--[1]	--[1]	489	--[1]
At Beardsley Canal	3.03	--[1]	--[1]	1,375	--[1]
At confluence with Agua Fria River	3.36	--[1]	--[1]	1,315	--[1]
Twin Buttes Wash					
Immediately downstream from CAP Canal	3.03	--[1]	--[1]	2,154	--[1]
Above confluence with Garambullo Wash	3.32	--[1]	--[1]	2,163	--[1]
Above confluence with White Peak Wash	4.65	--[1]	--[1]	2,424	--[1]
At Beardsley Canal	8.04	--[1]	--[1]	2,779	--[1]
At confluence with Agua Fria River	8.77	--[1]	--[1]	2,746	--[1]
Garambullo Wash					
At confluence with Twin Buttes Wash	0.99	--[1]	--[1]	651	--[1]
East Garambullo Wash					
Immediately downstream from CAP Canal	0.15	--[1]	--[1]	93	--[1]
At confluence with Garambullo Wash	0.37	--[1]	--[1]	259	--[1]
West Garambullo Wash					
Immediately downstream from CAP Canal	0.12	--[1]	--[1]	94	--[1]
At confluence with Garambullo Wash	0.62	--[1]	--[1]	483	--[1]
White Peak Wash					
Immediately downstream from CAP Canal	0.38	--[1]	--[1]	97	--[1]
Above confluence with West Fork of White Peak Wash	0.69	--[1]	--[1]	395	--[1]
At confluence with Twin Buttes Wash	1.59	--[1]	--[1]	721	--[1]

[1]Not Computed
[2]Not Available

Table 3. Summary of Discharges (Cont'd)

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (cfs) 10-Year	50-Year	100-Year	500-Year
Southern Pacific Railroad (Watershed 4)					
At Main Street	--[3]	--[4]	--[4]	506	--[4]
At Southern Avenue	--[3]	--[4]	--[4]	1,293	--[4]
At Southern Avenue[2]	--[3]	--[4]	--[4]	1,195	--[4]
At Freeway[1]	--[3]	--[4]	--[4]	1,209	--[4]
East Maricopa Floodway					
At Guadalupe Road	--[3]	--[4]	--[4]	4,900	--[4]
At Baseline Road	--[3]	--[4]	--[4]	4,800	--[4]
At Southern Road	--[3]	--[4]	--[4]	3,500	--[4]
At Broadway Avenue	--[3]	--[4]	--[4]	3,500	--[4]
Wittmann Wash at AT&SFRR					
At confluence with Wittmann Wash South Split	0.28	55	128	172	--[4]
McMicken Dam Outlet Wash					
At confluence with Aqua Fria River	322.99	2,917[5]	5,085[5]	6,522[5]	--[4]
4,200 feet south of Deer Valley Drive	320.56	2,876	4,916	6,273	--[4]
1,700 feet north of Deer Valley Drive	318.13	2,835	4,747	6,023	--[4]
McMicken Dam Outlet Channel confluence with McMicken Dam Outlet Wash	304.92	2,613	4,279	5,087	--[4]

44 See also SPF

[1]Includes Overflow From Watershed 1, 4 and 3
[2]After Diversion of 237-Acre-Feet, Total Storage in Kingsborough, Emerald and Sherwood Parks Detention Basins
[3]Not Available
[4]Not Computed
[5]Due to Storage Behind McMicken Dam and CAP Canal

Table 3. Summary of Discharges (Cont'd)

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (cfs) 10-Year	50-Year	100-Year	500-Year
Agua Fria River (cont'd)					
At confluence with Gila River	--[2]	22,000	68,000	94,000	183,000
Above downstream end of COE levee (0.7 mile below Lower Buckeye Road)	--[2]	22,000	69,000	95,000	184,000
New River					
Near Rock Springs	--[2]	--[1]	--[1]	34,500	--[1]
At New River Road	--[2]	--[1]	--[1]	32,000	--[1]
At Interstate 17	--[2]	--[1]	--[1]	33,400	--[1]
Above confluence with Sweat Canyon Wash	--[2]	--[1]	--[1]	33,000	--[1]
At Carefree Highway	--[2]	--[1]	--[1]	35,800	--[1]
Upstream of New River Dam	--[2]	--[1]	--[1]	49,300	--[1]
At Outflow of New River Dam	0	1,700	2,200	2,350	--[1]
Above Beardsley Road	10.3	2,400	6,500	9,800	--[1]
Above confluence with Skunk Creek	17.3	2,700	8,000	12,000	--[1]
Below confluence with Skunk Creek	--[2]	13,500	31,000	41,000	75,000
Sweat Canyon Wash					
Above confluence with New River	--[2]	--[1]	--[1]	19,800	--[1]
Powder House Wash					
At Jack Burden Road	1.9	300	1,300	1,900	4,400
Martinez Wash					
At Mouth	103.0	9,220	27,400	32,000	45,000
Mockingbird Wash					
At U.S. Highways 60, 70, and 89	6.9	2,750	4,040	5,060	7,400
Little San Domingo Wash					
At U.S. Highways 60, 70, and 89	6.2	1,690	2,620	3,090	4,250
Wittmann Drainage					
At Atchison, Topeka & Santa Fe Railway	8.6	1,760	2,770	3,060	4,350

[1]Not Computed
[2]Not Available

See also SPF

Table 3. Summary of Discharges (Cont'd)

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (cfs) 10-Year	50-Year	100-Year	500-Year
Skunk Creek					
At Inflow of Adobe Dam	89.6	15,000	29,000	39,000	85,000
At Outflow of Adobe Dam	0.0	1,370	1,650	1,730	2,000
Above confluence with Scatter Wash	0.9	1,600	2,200	2,600	4,600
Below confluence with Scatter Wash (At 59th Avenue)	0.4	2,000	5,500	8,400	22,000
At confluence with Arizona Canal	19.9	2,200	6,700	11,000	33,000
Buchanan Wash					
800 feet downstream of Central Arizona Project Canal	9.17	1,065	1,253	1,308	1,407
At confluence with Skunk Creek	11.29	1,422	2,005	2,304	3,067
Scatter Wash					
At Mouth	8.5	580	3,500	6,100	17,000
Above Black Canyon Highway (State Highway 17)	6.3	540	3,200	5,700	16,000
Salt River					
At Granite Reef Dam	--[1]	--[1]	--[1]	245,000	--[1]
At Gilbert Road	12,593.0	100,000	170,000	230,000	345,000
At Country Club Drive	--[1]	--[1]	--[1]	225,000	--[1]
At Tempe Bridge	12,783.0	93,000	160,000	215,000	330,000
At Central Avenue	12,831.0	91,000	155,000	200,000	325,000
At 67th Avenue	12,931.0	90,000	150,000	190,000	315,000
Above confluence with Gila River	12,962.0	85,000	145,000	185,000	310,000
East Fork Cave Creek					
At confluence with Cave Creek	14.4	2,300	6,400	9,000	19,000
Below 7th Avenue Extended	13.8	2,300	6,300	8,900	18,000
Below 7th Street	12.4	2,200	5,900	8,400	17,000
Above 7th Street	10.0	1,900	5,300	7,500	15,200
At Bell Road	3.4	1,100	2,900	4,200	8,200
Below Cave Creek Road	3.0	1,000	2,800	3,900	7,900
At Utopia Road	1.8	800	2,100	3,000	5,800
At Beardsley Road	1.0	600	1,500	2,100	4,300

[1]Data Not Available

ESTRELLA CORRIDOR STUDY

Drainage

Technical Memorandum

Appendix D

U.S Corps of Engineers Hydrology

Hydrologic Evaluation
of
Impacts of New Waddell Dam
on
Downstream Peak Discharges
in the
Agua Fria River

PARSONS TRANSPORTATION GROUP
DE LEUW, CATHER & COMPANY

(21)

AGUA FRIA RIVER STUDY
NEW WADDELL DAM TO GILA RIVER CONFLUENCE, ARIZONA

HYDROLOGIC EVALUATION OF IMPACTS OF NEW WADDELL DAM ON DOWNSTREAM PEAK DISCHARGES IN THE AGUA FRIA RIVER

U.S. ARMY CORPS OF ENGINEERS

LOS ANGELES DISTRICT

JULY 1995

TABLE 1. SUMMARY OF DISCHARGES ON THE AGUA FRIA RIVER[1] - PRESENT CONDITIONS With New Waddell Dam versus (Without New Waddell Dam)

LOCATION	DRAINAGE AREA[5], sq.mi.	DISCHARGE IN FT^3/S WITH (WITHOUT) NEW WADDELL DAM								
		SPF[2,3]	500-YR	200-YR	100-YR	50-YR	25-YR	10-YR	5-YR	2-YR
U/S of New Waddell Dam	1459	158,000 (158,000)	182,000 (182,000)	155,000 (155,000)	135,000 (135,000)	110,000 (110,000)	90,000 (90,000)	48,000 (48,000)	16,000 (16,000)	0 (N/A)
D/S of New Waddell Dam	0	22,000 * (158,000)	46,500 (182,000)	17,000 (155,000)	9000 (135,000)	9000 (110,000)	9000 (90,000)	0 (48,000)	0 (16,000)	0 (N/A)
@ Bell Rd. CP 1037	171	(N/A)	59,000 (182,000)	46,500 (152,000)	37,500 (115,000)	29,000 (87,000)	20,500 (64,000)	11,000 (23,000)	5200 (5200)	1200 (N/A)
@ Grand Ave CP 1038	183	(N/A)	53,000 (181,000)	43,000 (144,000)	34,500 (109,000)	26,500 (82,000)	19,000 (59,000)	10,000 (22,000)	4800 (4800)	780 (N/A)
U/S New R. CP 1039U	231	(N/A)	48,000 (177,000)	38,000 (120,000)	30,000 (90,000)	23,000 (66,000)	16,000 (45,000)	8700 (18,000)	4600 (4600)	820 (N/A)
DOWNSTREAM OF CONFLUENCE WITH NEW RIVER										
D/S New R. CP 1039D	392	94,000 102,000[4]	130,000 (N/A)	80,000 (N/A)	54,400 (95,000)	39,000 (N/A)	26,000 (N/A)	16,100 (N/A)	10,000 (N/A)	5500 (N/A)
@ I-10 Fwy CP 1040	474	90,000 99,000[4]	125,000 (N/A)	75,000 (N/A)	52,000 (91,000)	38,000 (N/A)	25,000 (N/A)	15,300 (N/A)	10,000 (N/A)	5400 (N/A)
@ Avondale CP 1042	485	88,000 97,000[4]	115,000 (N/A)	74,000 (N/A)	50,900 (90,000)	37,000 (N/A)	25,000 (N/A)	15,000 (N/A)	10,000 (N/A)	5300 (N/A)
Above Gila R. CP 1043	485	83,000 92,000[4]	110,000 (N/A)	70,000 (N/A)	48,200 (89,000)	35,000 (N/A)	23,000 (N/A)	14,200 (N/A)	9000 (N/A)	5000 (N/A)

Notes: (1) Starting Elevation for all flood routings is 1694 based upon USBR Standing Operating Procedures, Appendix C.
(2) SPF discharges D/S of New Waddell Dam based upon routing of flood produced by centering the August 1951 storm over the U/S drainage area. See reference 3.
(3) SPF discharges U/S of New Waddell Dam based upon centering of local storm (Queen Creek, Aug 19, 1954) over the area D/S of New Waddell Dam. See Appendix A.
(4) Future conditions SPF discharges from Appendix A.
(5) Effective drainage area. For locations D/S of New Waddell Dam the effective drainage area does not include the drainage areas controlled by the dams.
N/A Discharge not available.

* Note 13,000 cfs more than 100YR flow.
At CP 1039U (near Estrella Corridor) SPF Assumed to be 43,000 cfs

ESTRELLA CORRIDOR STUDY

Drainage

Technical Memorandum

Appendix E

U.S Corps of Engineers Hydrology

100-year and SPF

New River

Skunk Creek

PARSONS TRANSPORTATION GROUP
DE LEUW, CATHER & COMPANY

GILA RIVER BASIN
NEW RIVER
AND PHOENIX CITY STREAMS
ARIZONA

DESIGN MEMORANDUM NO. 2

HYDROLOGY

Part 2

U.S. Army Engineer District, Los Angeles
Corps of Engineers
1982

TABLE 1 (Continued)

DESIGN PEAK DISCHARGES
FUTURE CONDITIONS WITH PROJECT

CP	LOCATION	DRAINAGE AREA (mi^2)	SPF (ft^3/s)	100-YEAR FLOOD (ft^3/s)
	ACDC			
1016U	Above Cave Creek	19.7	15,000(6)	15,000(2)
1016D	Below Cave Creek	61.1(8)	25,000(6)	25,000(5,8)
1018	Near 51st Ave.	70.3	26,000(6)	26,000(5)
1019	Above Skunk Creek	85.4	29,000(6)	29,000(5)
	SKUNK CREEK			
1031U	Inflow - Adobe Dam	89.6	66,000(9)	39,000(2)
1031D	Outflow - Adobe Dam	0	1890(9)	1730(9)
1021U	Above Scatter Wash	0.9	4500(9)	2800(9)
1021D	Below Scatter Wash	9.4(5)	21,000(5)	10,000(5)
1022U	Above ACDC	24.9(10)	26,000(5,10)	13,000(5,10)
1022D	Below ACDC	110.3(11)	55,000(5,11)	35,000(5,11)
1029	Above New River	111.2(11)	55,000(5,11)	35,000(5,11)
	NEW RIVER			
1033U	Inflow - New River Dam	164	76,000(3)	53,000(2)
1033D	Outflow - New River Dam	0	2665(5)	2350(5)
1025	Above Beardsley Rd.	10.3	24,000(7)	12,000(7)
1029U	Above Skunk Creek	20.7(12)	38,000(5,12)	19,000(5,12)
1029D	Below Skunk Creek	123.6	68,000(5,13)	41,000(5,13)
1039	Above Agua Fria River	159.7	69,000(5,13)	39,000(5,13)
	AGUA FRIA RIVER(14)			
1034U	Inflow - Waddell Dam	1459	158,000(5)	135,000(5)
1034D	Outflow - Waddell Dam	1459	158,000(5)	135,000(5)
1037	At Bell Rd.	1870	151,000(5)	115,000(5)

ESTRELLA CORRIDOR STUDY

Drainage

Technical Memorandum

Appendix F

Estrella Interim Roadway
Deer Valley Drive to Lake Pleasant

Drainage Concepts

PARSONS TRANSPORTATION GROUP
DE LEUW, CATHER & COMPANY

Limited Scope Design Concept Report

Estrella Interim Roadway

Deer Valley Drive to Lake Pleasant Road (99th Avenue)

Contract No. 68840

September 1996

Prepared for

Maricopa County Department of Transportation
2901 West Durango Street, Phoenix, Arizona 85009

RITOCH-POWELL associates
consulting engineers, inc.
3120 N. 19th Ave-Suite 200-Phoenix, AZ-85015 (602) 253-0177

SECTION 7

CONCEPTUAL DRAINAGE REPORT

CONCEPT DRAINAGE REPORT

ESTRELLA INTERIM ROADWAY

DEER VALLEY DRIVE

to

LAKE PLEASANT ROAD (99TH Ave.)

Maricopa County Project No. 68840

September, 1996

Prepared by: RITOCH-POWELL & Associates
3120 N. 19th Avenue, Ste. 200
Phoenix, Arizona 85015-6052

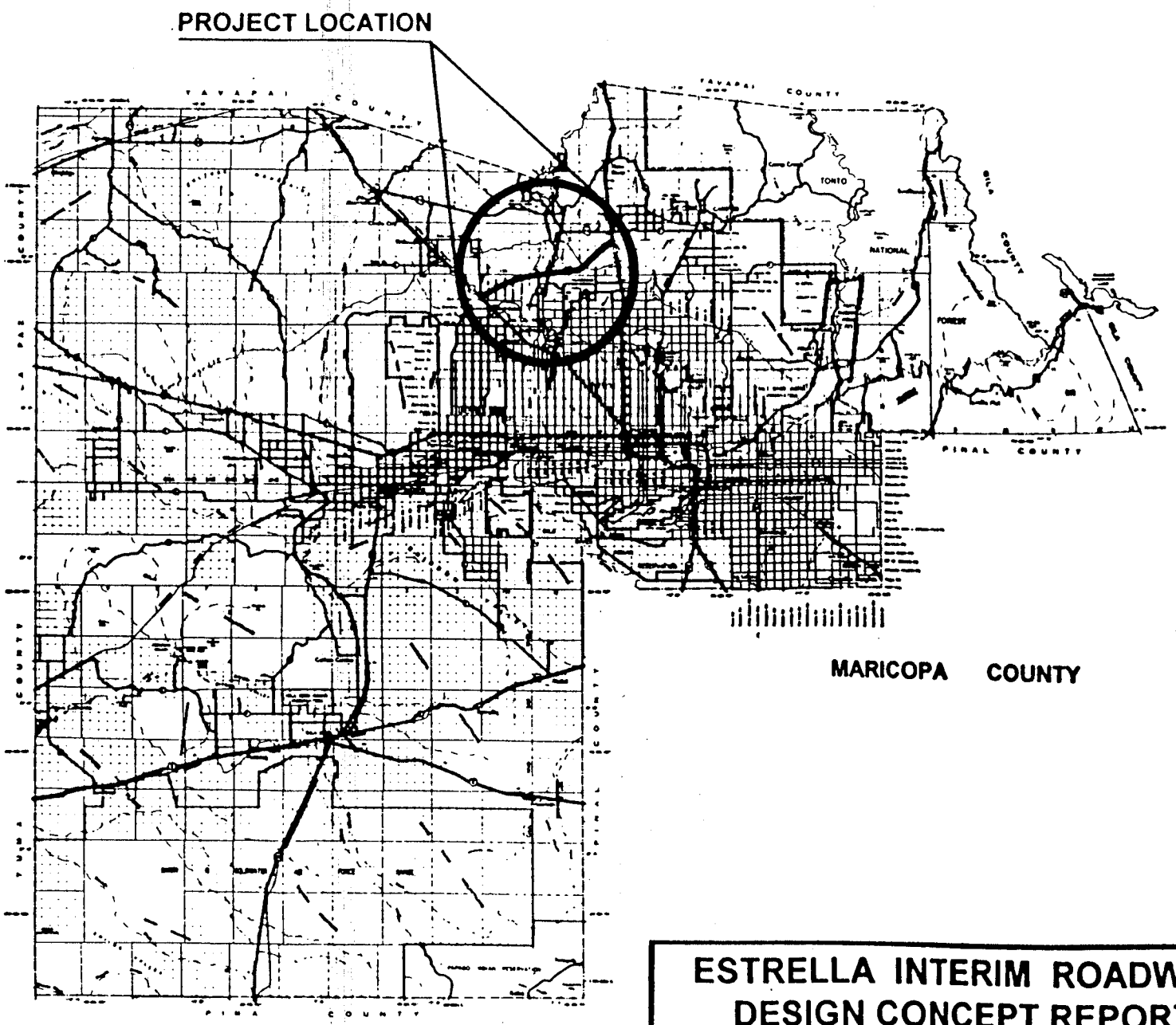
INDEX

INTRODUCTION

This drainage report is to analyze the preliminary drainage requirements for the Estrella Interim Roadway from Deer Valley Drive, just east of Grand Avenue, to Lake Pleasant Road (99th Avenue).

The Estrella Interim Roadway follows the alignment that was a part of Loop 303 of the MAG Freeway System. No roadway exists along this route at the present time. The ultimate roadway will consist of a 6-lane divided roadway in 300 feet (91 m) of Right of Way. The first phase of construction for the Interim Roadway will build two lanes of a two way roadway. These lanes will eventually become the west bound lanes of the divided highway. The alignment used for this report and shown on the Drainage Area map is the preferred location for the roadway.

The drainage concept followed in this report calls for cross culverts to be placed in washes and natural drainage ways to pass the design storm flows under the proposed roadway with little or no effect on the flow upstream or downstream. Where drainage pipes or box culverts are needed, the roadway profile has been set approximately 6 feet (1.8 m) above existing ground to allow the drainage under the roadway.



ESTRELLA INTERIM ROADWAY DESIGN CONCEPT REPORT

PROJECT VICINITY MAP

EXISTING CONDITIONS

Drainage in the area is from north to south and toward the Agua Fria River which this project crosses near the east end of the alignment. The drainage areas to the north of this project are undeveloped desert land. Small intermittent washes approximately 1 to 3 feet(0.3 to 0.9 m) in depth and 5 to 25 feet (1.5 to 7.6 m) in width cross through the area. Soils are primarily fine textured alluviums containing sandy loam with surface gravels present in some areas. Light to moderate vegetation cover consisting of creosote bushes, other desert shrubs and seasonal grasses grow in this area.

There are three major drainage crossings within the project limits. At approximate Station 1376+80, the proposed roadway crosses the McMicken Dam Outlet Wash. This wash carries the flow from the McMicken Dam Outlet Channel which is parallel to and north of the proposed alignment from Grand Avenue to the outlet wash. The wash then flows south through the proposed roadway alignment to the Agua Fria River. The McMicken Dam and outlet structures are sized to carry the 100 year flows to the outlet wash. The McMicken Dam Outlet Channel forms the northern boundary for the minor drainage areas for this project from Grand Avenue to the outlet wash (see drainage area maps).

The second major drainage crossing is at station 1471+20, just west of the Agua Fria River and is called the Twin Buttes Wash. This wash joins the Agua Fria River just south of the proposed alignment. The third major crossing is the Agua Fria River located one to one and one-half miles west of Lake Pleasant Road.

PROCEDURES

Hydrology

The design flows were calculated using the HEC 1 program as set forth in the Drainage Design Manual for Maricopa County, Arizona, Volume I, Hydrology. The Clark Unit Hydrograph was used.

The runoff losses were estimated using the following variables;

- The surface retention Loss IA used was 0.35, for natural desert and rangeland, flat slope.
- The Green and Ampt loss rate parameters used were those for sandy loam (dry) as found in Table 4.2 of the above referenced manual.
- The impervious area was considered to be zero.
- The resistance coefficient k_b was calculated using the parameters for Type B, Moderately low roughness, in Table 5.4 of the reference.
- Design flows for the 50 and 100 year storms were calculated.

The design flows for the McMicken Dam Outlet Wash, 6,522 cfs (184.7 m^3/s), and the Twin Buttes Wash, 2,746 cfs (77.8 m^3/s), were taken from the Federal Emergency Management Agency, Flood Insurance Study, Maricopa County, Arizona and Incorporated Areas, Volume 1 of 12. The design flow for the Agua Fria River, 28,000 cfs (792.9 m^3/s), was taken from the Agua Fria River Study, New Waddell Dam to Gila River Confluence, Arizona, U.S. Army Corps of Engineers, Los Angeles District, July, 1995.

The Design Flow Summary on the following page gives the 50 year and 100 year design flows for each drainage crossing and the method used to establish it.

Hydraulics

The culverts were sized using the procedures found in the Drainage Design Manual for Maricopa County, Arizona, Volume II, Hydraulics and the HY 8 Culvert Program, Federal Highway Administration.

SIGN FLOW SUMMARY

Drainage Area	Area mi.^{2} (km^2)	Q_{50} cfs(cms)	Q_{100} cfs(cms)	Comments
1	.052 (.135)	103 (2.92)	132 (3.74)	HEC 1
2	.047 (.122)	66 (1.87)	85 (2.41)	HEC 1
3	.034 (.088)	33 (.93)	45 (1.27)	HEC 1
4	.024 (.062)	34 (.96)	44 (1.25)	HEC 1
5	.031 (.080)	64 (1.81)	80 (2.27)	HEC 1
6	.029 (.075)	60 (1.70)	75 (2.12)	HEC 1
7	.060 (.155)	112 (3.17)	144 (4.08)	HEC 1
8	.045 (.117)	71 (2.01)	93 (2.63)	HEC 1
9	.048 (.124)	80 (2.27)	101 (2.86)	HEC 1
10	.053 (.137)	96 (2.72)	120 (3.40)	HEC 1
11	.045 (.117)	83 (2.35)	105 (2.97)	HEC 1
12	.042 (.109)	70 (1.98)	92 (2.61)	HEC 1
13	.105 (.272)	151 (4.28)	196 (5.55)	HEC 1
14	.136 (.352)	186 (5.27)	249 (7.05)	HEC 1
15	.139 (.360)	204 (5.78)	272 (7.70)	HEC 1
McMICKEN DAM OUTLET WASH #16	323 (837)	-	6,522 (184.70)	FEMA
17	.646 (1.67)	417(11.81)	582 (16.48)	HEC 1
18	.118 (.306)	75 (2.12)	104 (2.94)	HEC 1
19	.060 (.155)	60 (1.70)	82 (2.32)	HEC 1
TWIN BUTTES WASH #21	8.77 (22.7)	-	2,746 (77.76)	FEMA
22	.058 (.150)	120 (3.40)	149 (4.22)	HEC 1
23	.053 (.137)	110 (3.11)	135 (3.82)	HEC 1
24	1.580 (4.09)	1.229 (34.80)	1.829 (51.79)	HEC 1
AGUA FRIA RIVER	-	-	28,000 (792.9)	Agua Fria River Study

PROPOSED DESIGN

The cross culverts for this project were sized to convey the 50 year peak discharge with no flow crossing over the roadway. The 100 year peak discharge was also analyzed to limit any flow over the roadway to a depth of 0.5 feet (0.15 m). The following Culvert Summary tabulates the location, design flows and the resultant culvert size for each of the culvert crossings.

The concrete box culverts for the McMicken Dam Outlet Wash and the Twin Buttes Wash were sized to convey the 100 year peak discharge.

Ultimately, when the roadway is upgraded to its 4 or 6 lane configuration, a bridge structure will be designed and built to convey the expected 100 year peak discharge in the Agua Fria River. At this time, for the interim 2 lane roadway, a dip section will be used at the Agua Fria River crossing which will allow flows to cross over the roadway. A low flow culvert placed in the Agua Fria River under the interim roadway will allow smaller nuisance flows to pass under the roadway. Culverts consisting of 10-36" (900 mm) pipes will allow flows up to 300 cfs (8.50 m^3/s) to pass under the roadway. Headwalls and cut-off walls will need to be included at this culvert to prevent damage to the culvert during flows larger than 300 cfs (8.50 m^3/s).

Estrella Interim Roadway Drainage Report

CULVERT SUMMARY

Station	DA #	Q_{50} cfs(cms)	Q_{100} cfs(cms)	Proposed Culvert
1169+50	1	103 (2.92)	132 (3.74)	3-36" Pipe (900 mm)
1182+50	2	66 (1.87)	85 (2.41)	1-48" Pipe (1 200 mm)
1215+00	3	33 (.93)	45 (1.27)	1-30" Pipe (750 mm)
1226+40	4	34 (.96)	44 (1.25)	1-36" Pipe (900 mm)
1235+00	5	64 (1.81)	80 (2.27)	1-42" Pipe (1 050 mm)
1250+00	6	60 (1.70)	75 (2.12)	1-42" Pipe (1 050 mm)
1265+50	7	112 (3.17)	144 (4.08)	1-54" Pipe (1 350 mm)
1278+50	8	71 (2.01)	93 (2.63)	1-42" Pipe (1 050 mm)
1287+00	9	80 (2.27)	101 (2.86)	1-48" Pipe (1 200 mm)
1295+00	10	96 (2.72)	120 (3.40)	1-48" Pipe (1 200 mm)
1303+00	11	83 (2.35)	105 (2.97)	1-42" Pipe (1 050 mm)
1313+50	12	70 (1.98)	92 (2.61)	1-48" Pipe (1 200 mm)
1331+50	13	151 (4.28)	196 (5.55)	1-66" Pipe (1 650 mm)
1345+00	14	186 (5.27)	249 (7.05)	1-66" Pipe (1 650 mm)
1359+50	15	204 (5.78)	272 (7.70)	1-72" Pipe (1 800 mm)
1376+80	16 McMicken	-	6.522(184.7)	6-12'x8' CBC (3 600 mm x 2 400 mm)
1394+00	17	417 (11.81)	582 (16.48)	2-8'x3' CBC (2 400 mm x900 mm)
1411+00	18	75 (2.12)	104 (2.94)	1-48" Pipe (1 200 mm)
1424+00	19	60 (1.70)	82 (2.32)	1-42" Pipe (1 050 mm)
1471+20	21 Twin Buttes	-	2.746(77.76)	3-12'x8' CBC (3 600 mm x 2 400 mm)
1496+00	Agua Fria River	-	Low Flow 300 (8.50)	10-36" Pipes (900 mm)
1554+30	23	110 (3.11)	135 (3.82)	3-36" Pipes (900 mm)
1570+50	24	1.229 (34.80)	1.829 (51.79)	5-6'x5' CBC (1 800 x 1 500 mm)

ESTRELLA CORRIDOR STUDY

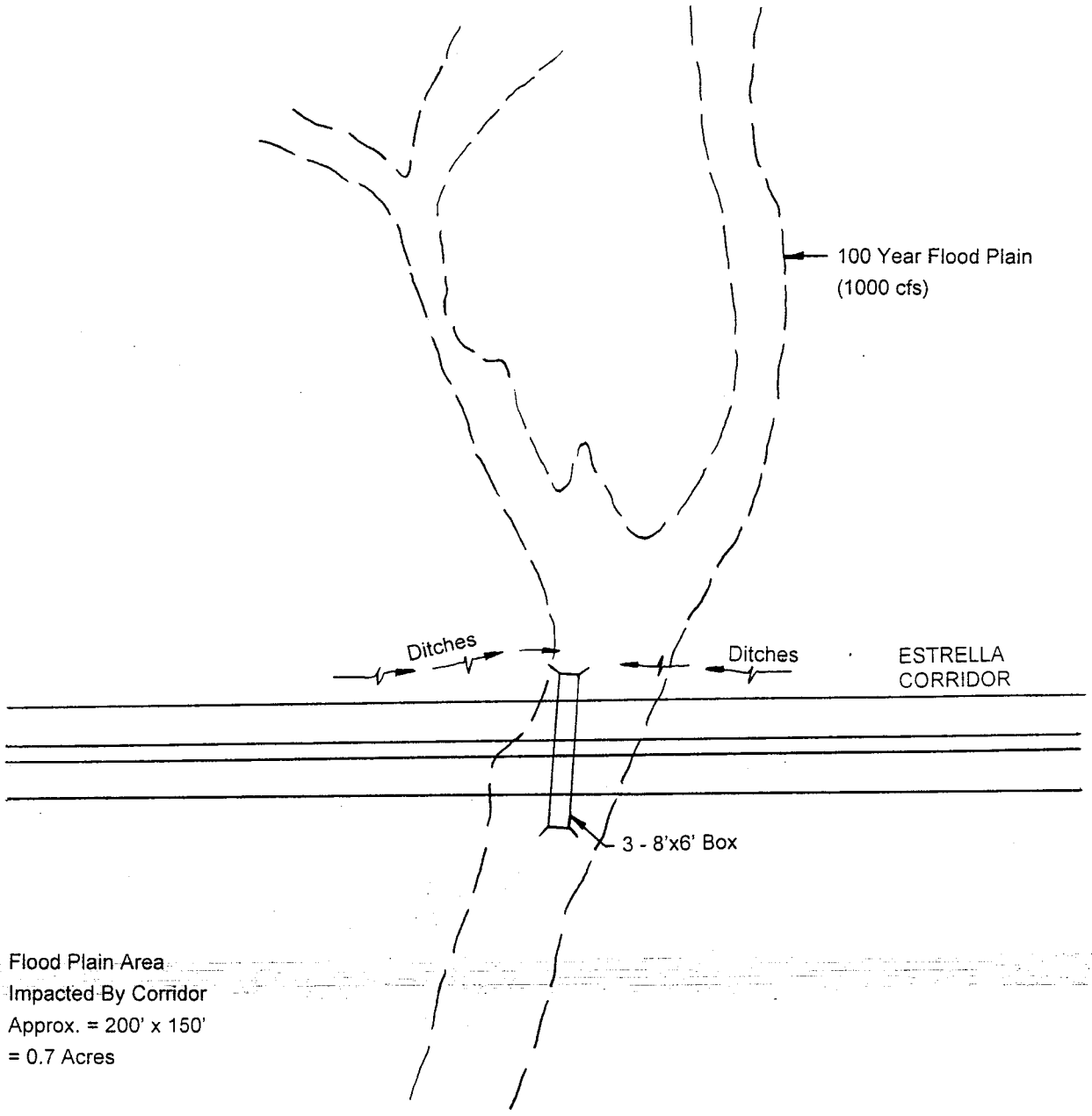
Drainage

Technical Memorandum

Appendix G

Rock Creek Crossing

PARSONS TRANSPORTATION GROUP
DE LEUW, CATHER & COMPANY

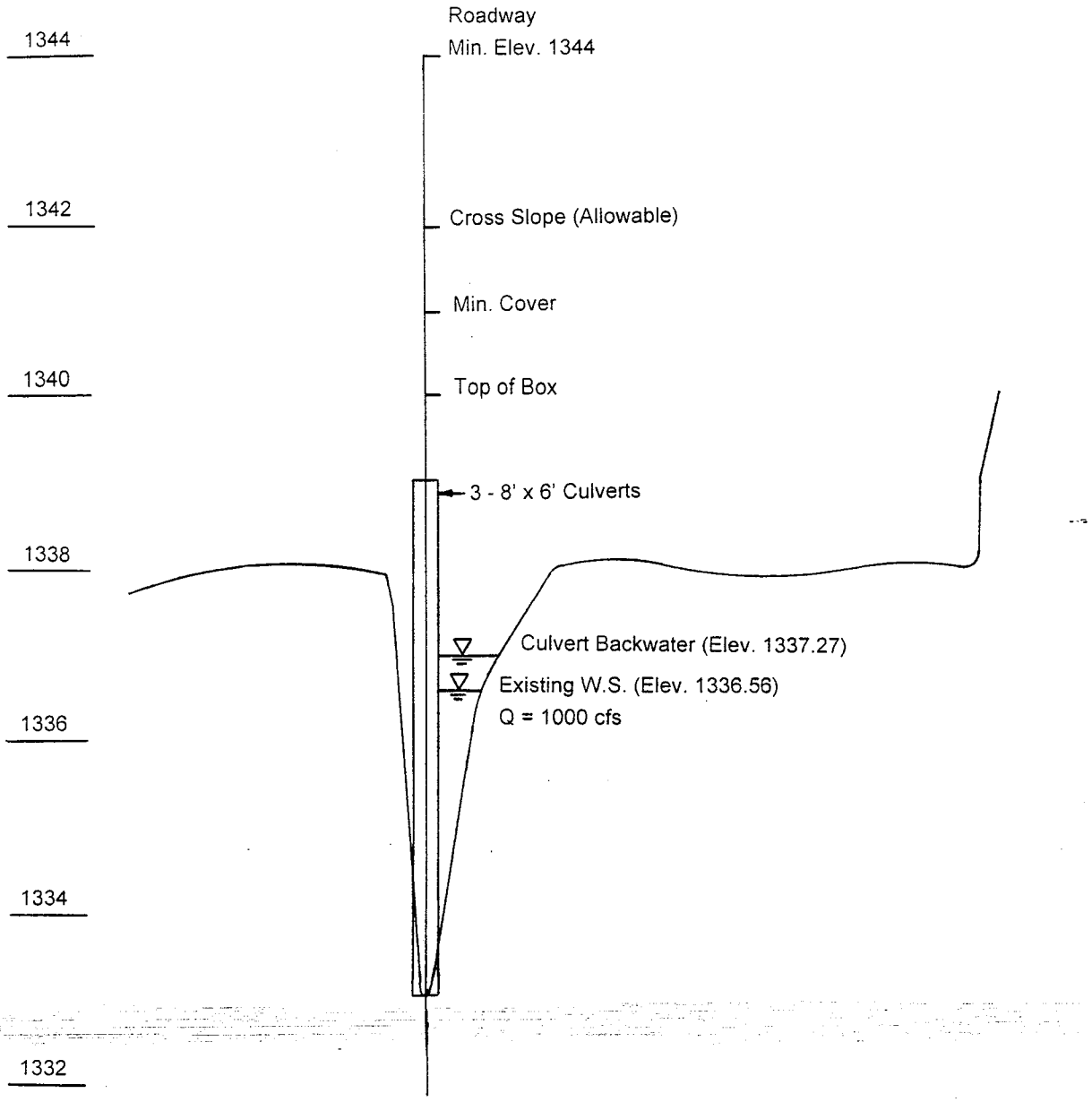


Flood Plain Area
Impacted By Corridor
Approx. = 200' x 150'
= 0.7 Acres

PLAN
1" = 20'

DE LEUW, CATHER

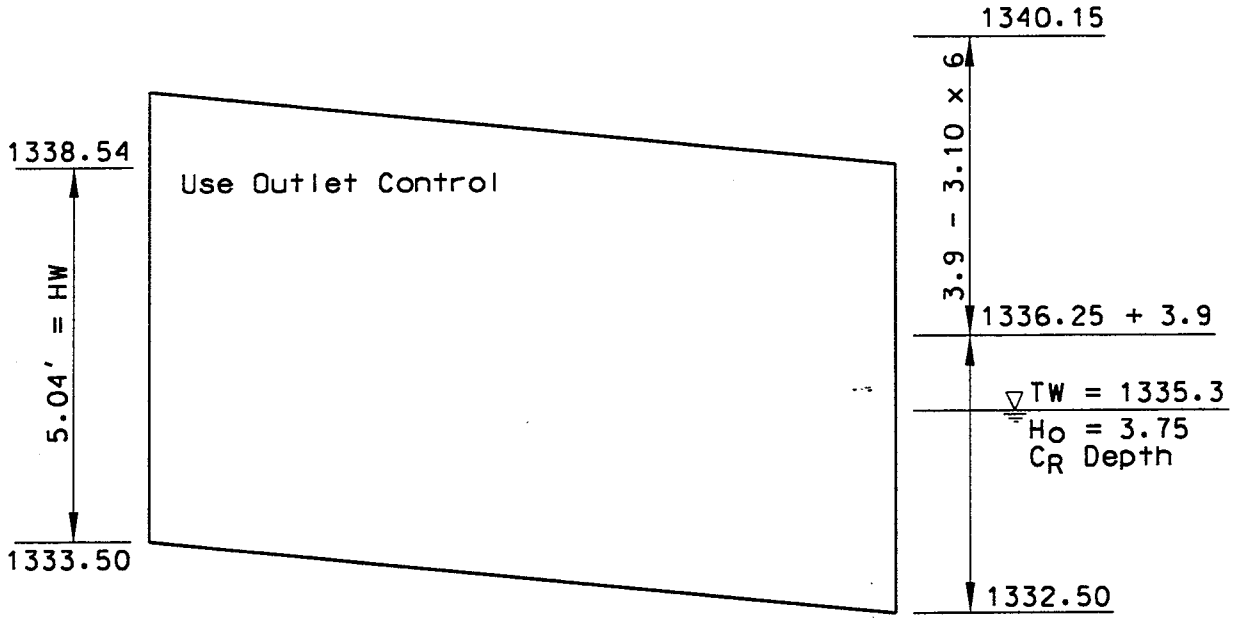
ROCK CREEK CROSSING



ELEVATION
Horiz. Scale: 1" = 100'
Vert. Scale: 1" = 2'

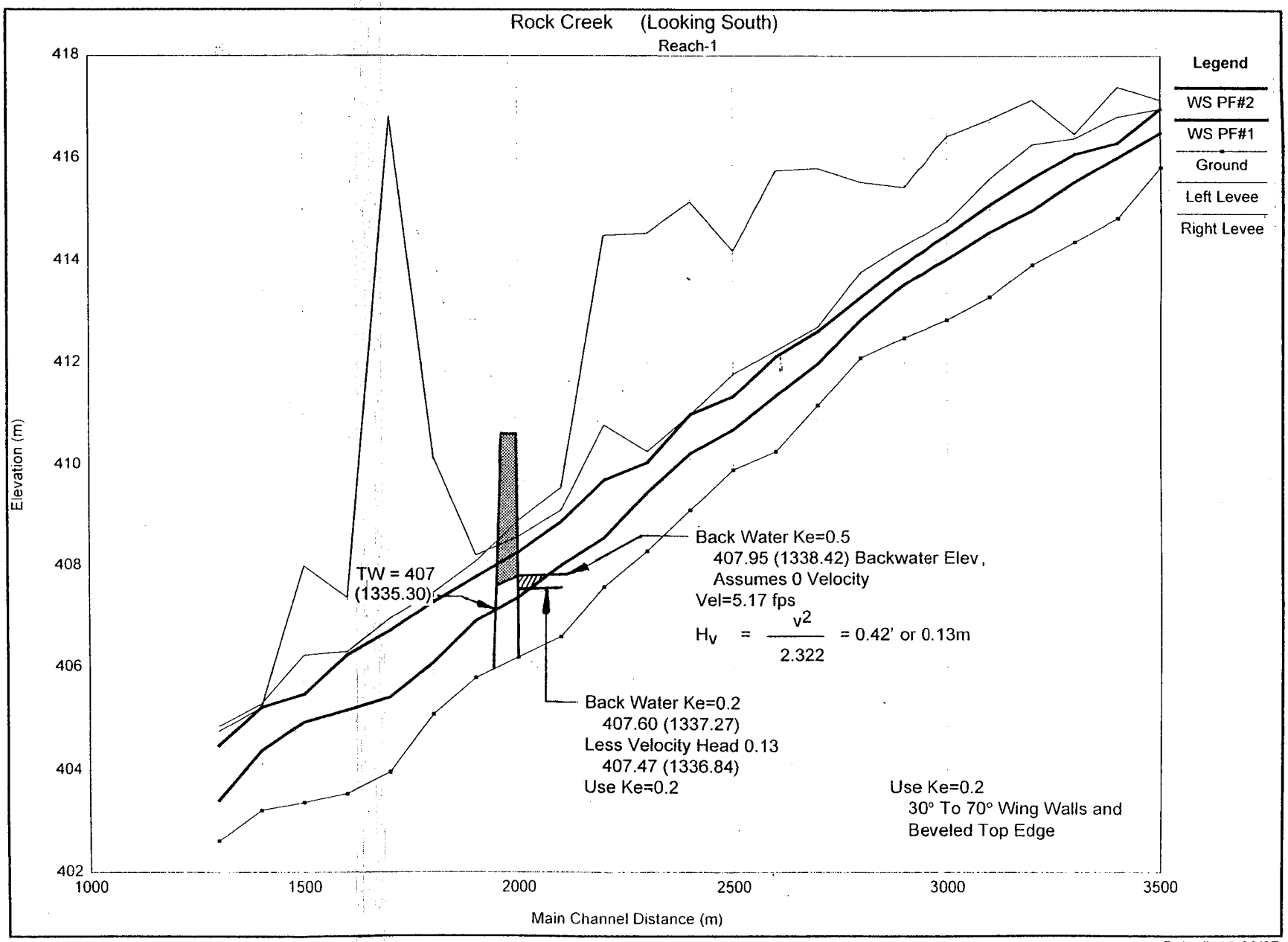
DE LEUW, CATHER

ROCK CREEK CROSSING



DE LEUW, CATHER

ROCK CREEK CULVERT



Polasik 10/28/97

Flood Control District of Maricopa County
Hydrologic Design Manual Rational Method

Computed by: S. POLASIK Date: 12-22-1997

QUALITATIVE ANALYSIS. DRAINAGE AREA GREATOR THAN 160 ACRES.

LOCATION DATA

Location: ESTRELLA CORRIDOR NEAR LACE PLEASANT ROAD

Project Name: ESTRELLA CORRIDOR Subarea id: ———

Drainage Area Cover: DESERT

DESIGN DATA

Drainage Area	%1400.00 acres
Watercourse Length	12000.0 feet
Top Elevation	1420.0 feet
Bottom Elevation	1310.0 feet
Slope	.00917 feet/feet
Roughness Coefficient (Kb)	.07140
10-Year, 6-Hour Rainfall	2.07 inches

Hydrological Summary Table

Parameter	2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr
Q (cfs)	268	516	828	1187	1479	1802
C	0.400	0.400	0.400	0.440	0.480	0.500
Tc (min)	93.1	81.0	67.7	61.2	58.2	54.8
i (in/hr)	0.5	0.9	1.5	1.9	2.2	2.6

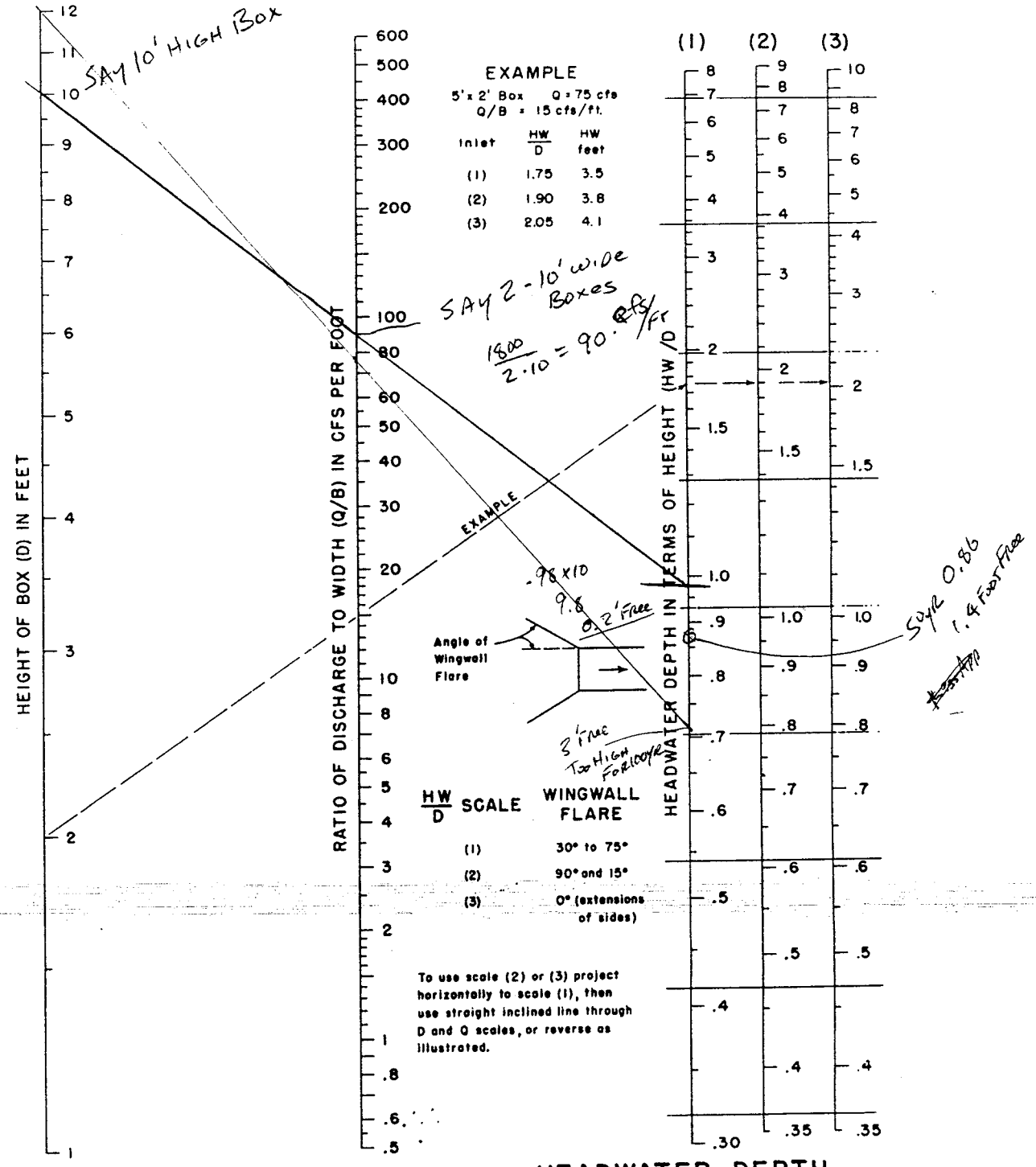
SAY 1,800 cfs

Spokasile 12/22/97

Q_{100} = 1800 cfs, 2-10 x 10 Box Culverts - Freeboard 0.2'

Use 2-10x10 Box culverts

CHART 8



HEADWATER DEPTH FOR BOX CULVERTS WITH INLET CONTROL

BUREAU OF PUBLIC ROADS JAN. 1963

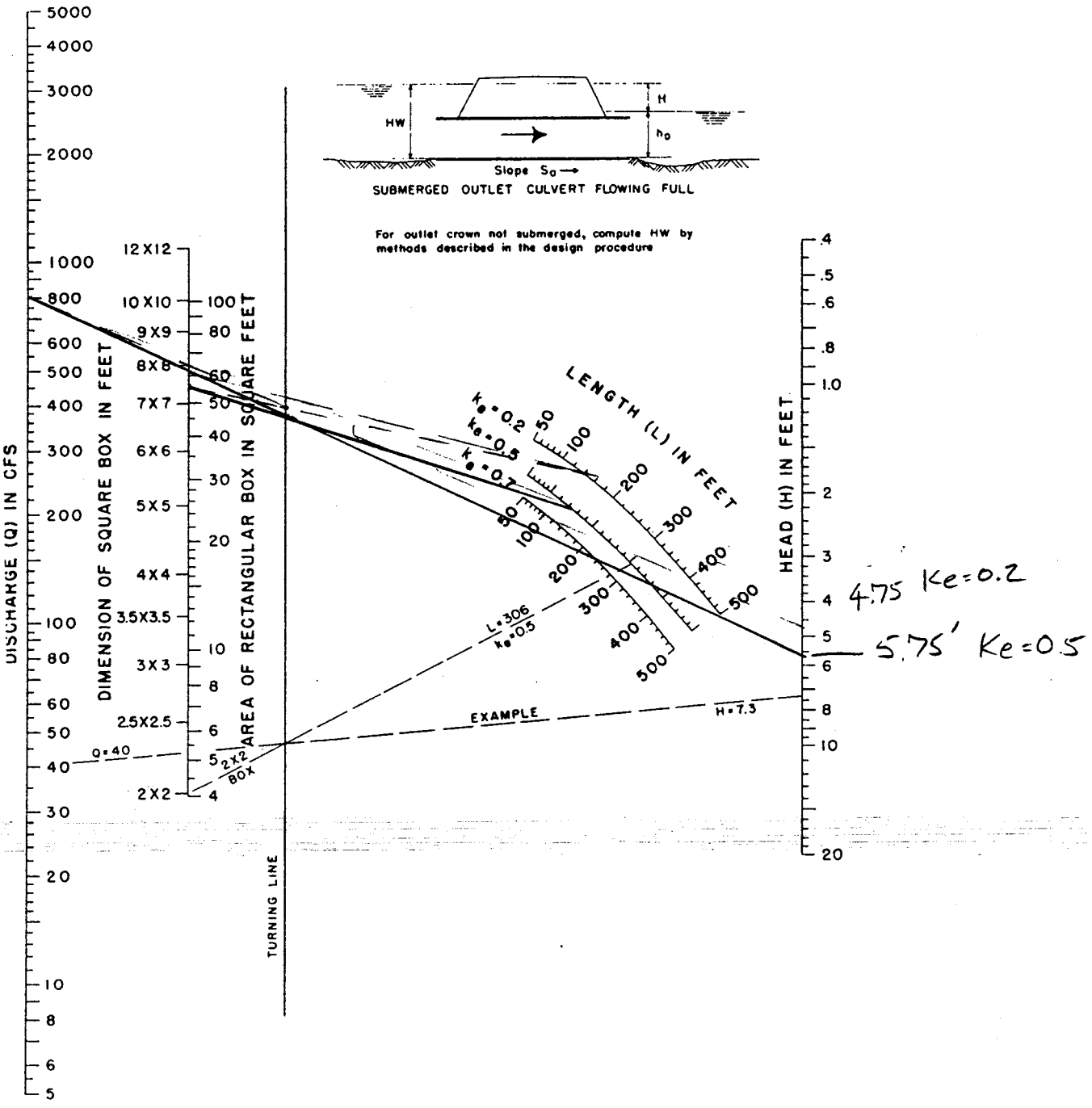
Q = 2900 cfs

3 BARRELS

Q_{BARREL} = 800'

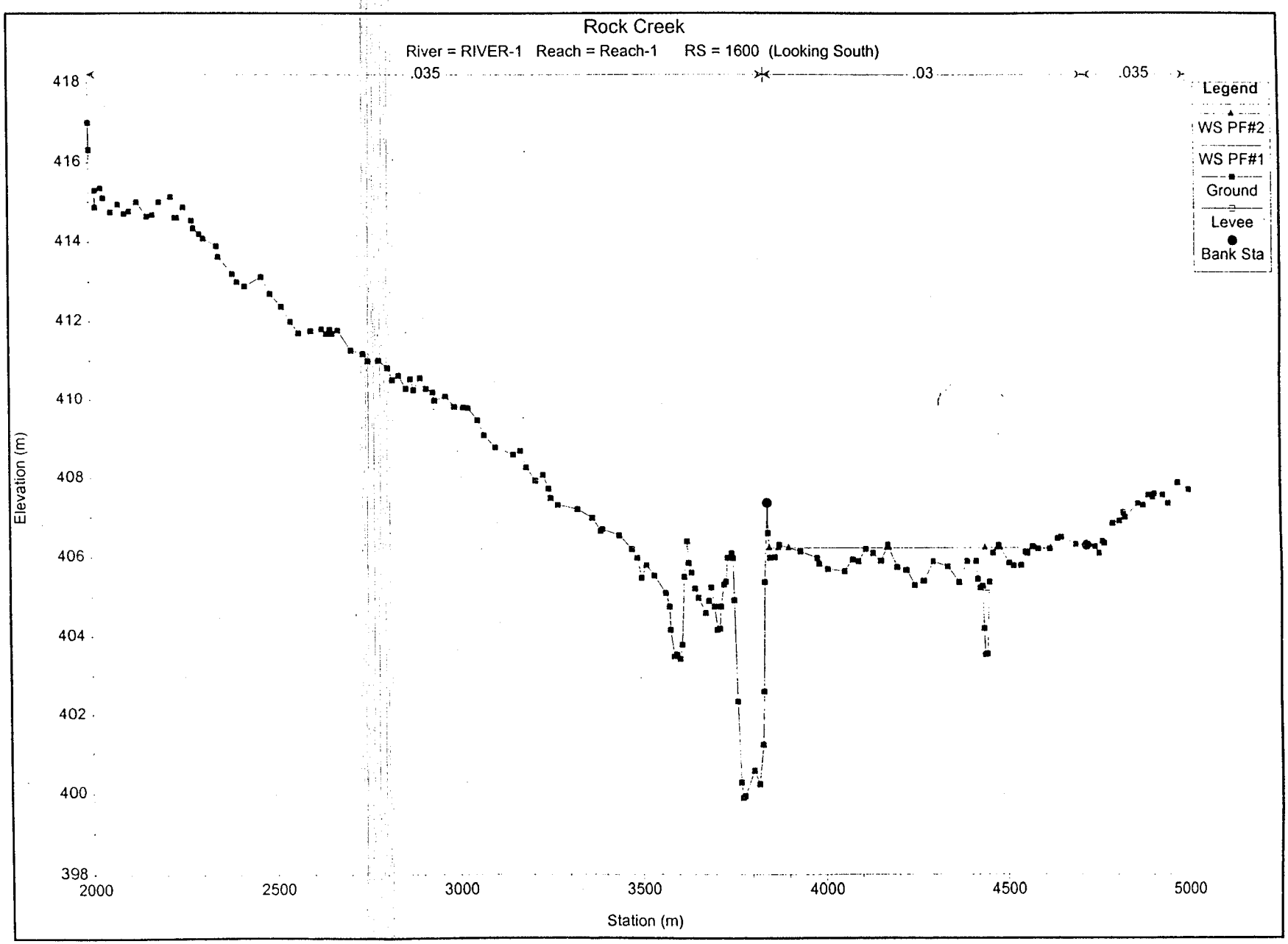
4 x 6 = 5' 5"

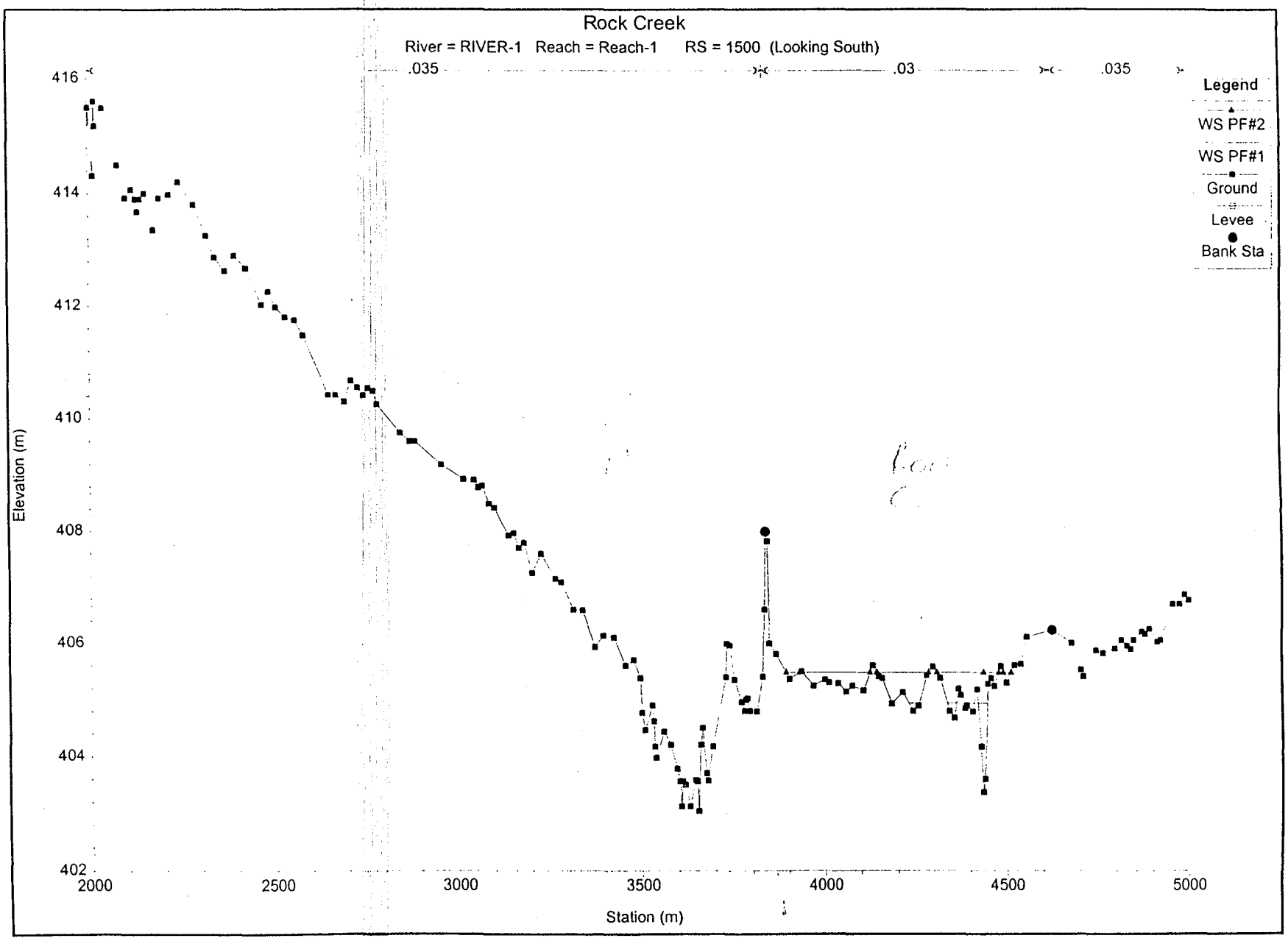
CHART 15

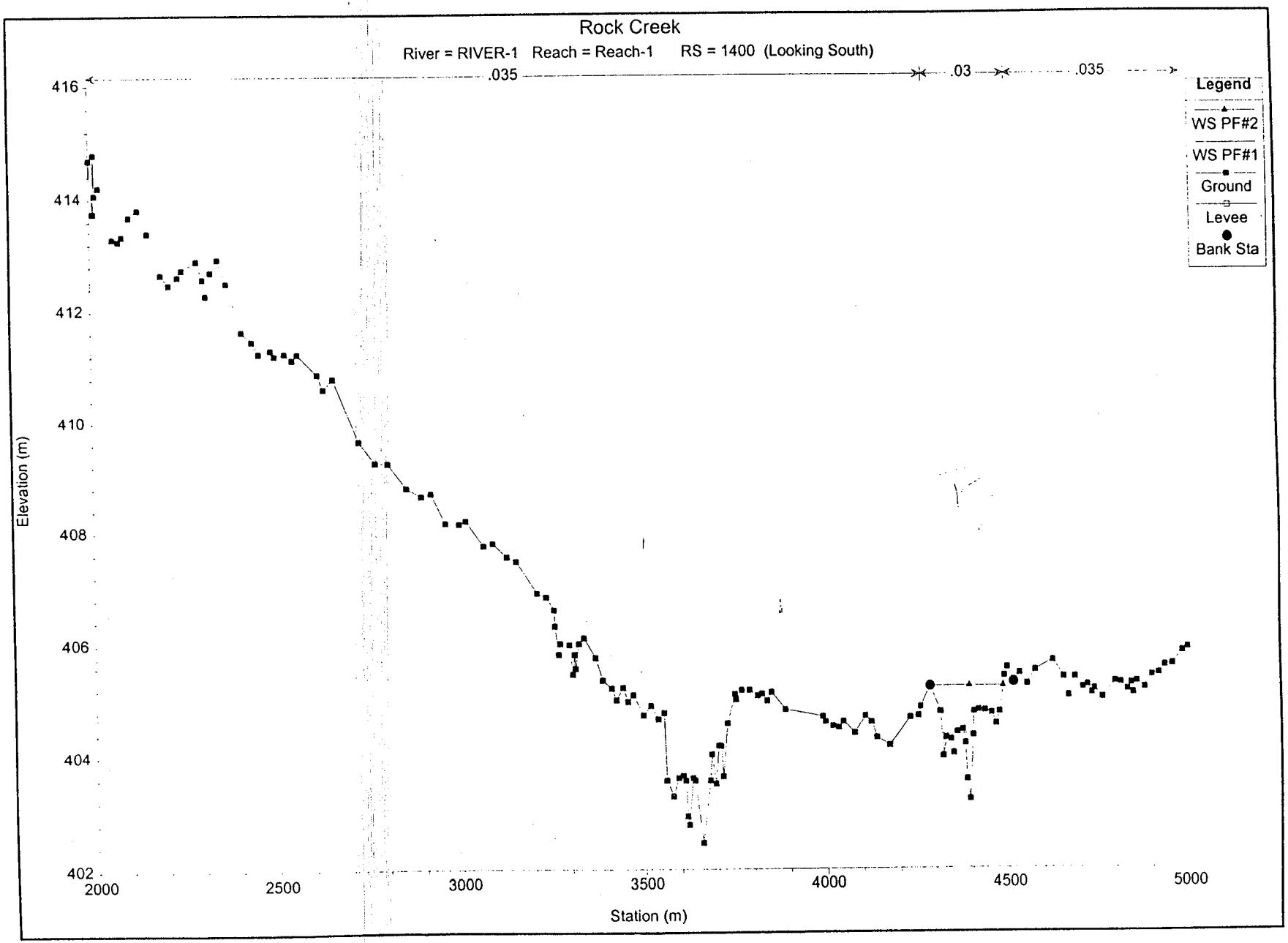


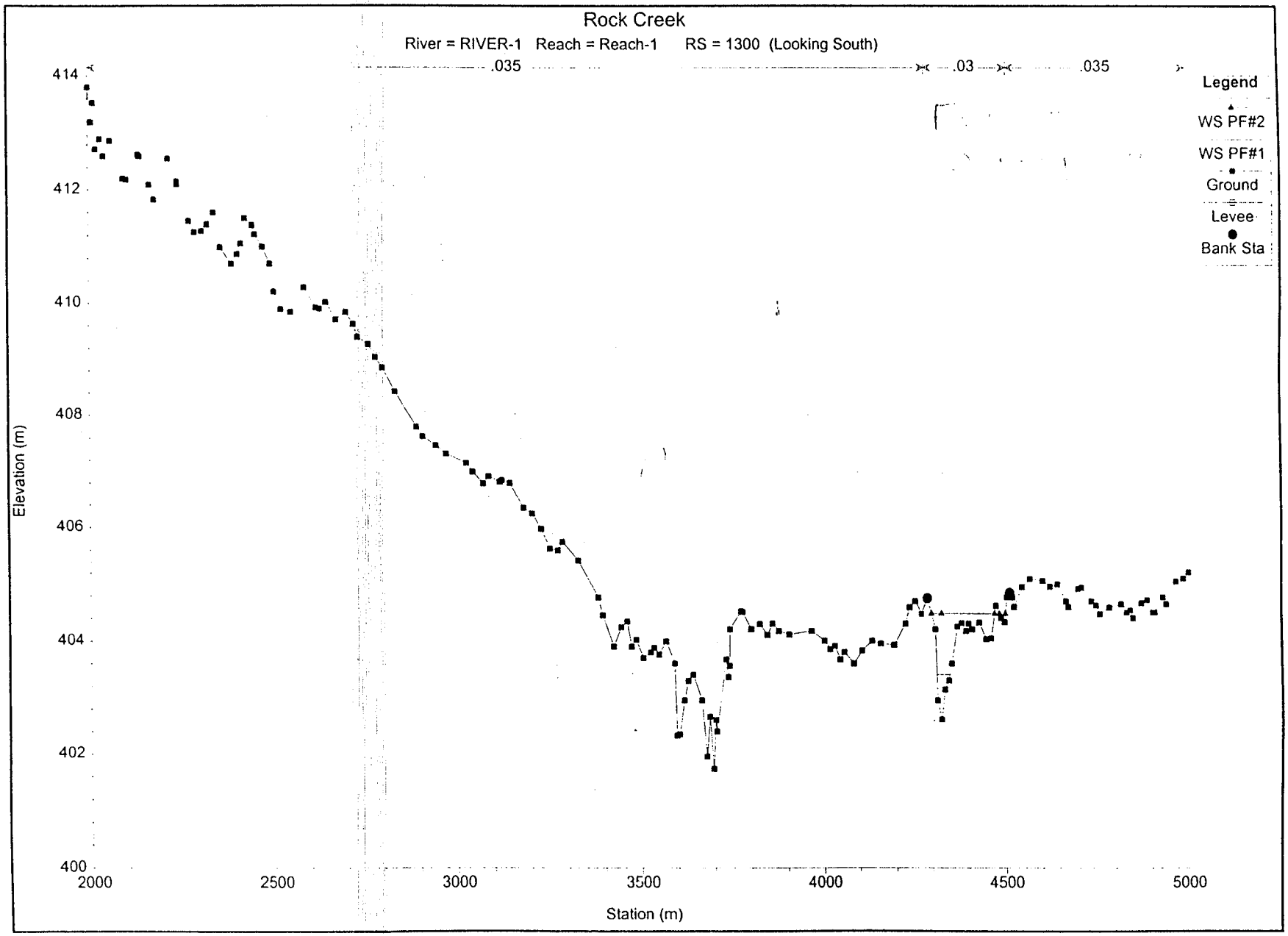
HEAD FOR CONCRETE BOX CULVERTS FLOWING FULL n = 0.012

AU OF PUBLIC ROADS JAN. 1963


Rock Creek
River = RIVER-1 Reach = Reach-1 RS = 1600 (Looking South)
.035
.03
.035
Legend
WS PF#2
WS PF#1
Ground
Levee
Bank Sta
Elevation (m)
418
416
414
412
410
408
406
404
402
400
398
2000
2500
3000
3500
4000
4500
5000
Station (m)


Rock Creek
River = RIVER-1 Reach = Reach-1 RS = 1500 (Looking South)
.035
.03
.035
Legend
WS PF#2
WS PF#1
Ground
Levee
Bank Sta
Elevation (m)
416
414
412
410
408
406
404
402
2000
2500
3000
3500
4000
4500
5000
Station (m)


Rock Creek
River = RIVER-1 Reach = Reach-1 RS = 1400 (Looking South)
.035
.03
.035
Legend
WS PF#2
WS PF#1
Ground
Levee
Bank Sta
Elevation (m)
416
414
412
410
408
406
404
402
2000
2500
3000
3500
4000
4500
5000
Station (m)


Rock Creek
River = RIVER-1 Reach = Reach-1 RS = 1300 (Looking South)
.035
.03
.035
Legend
WS PF#2
WS PF#1
Ground
Levee
Bank Sta
414
412
410
408
406
404
402
400
Elevation (m)
2000
2500
3000
3500
4000
4500
5000
Station (m)

ESTRELLA CORRIDOR STUDY

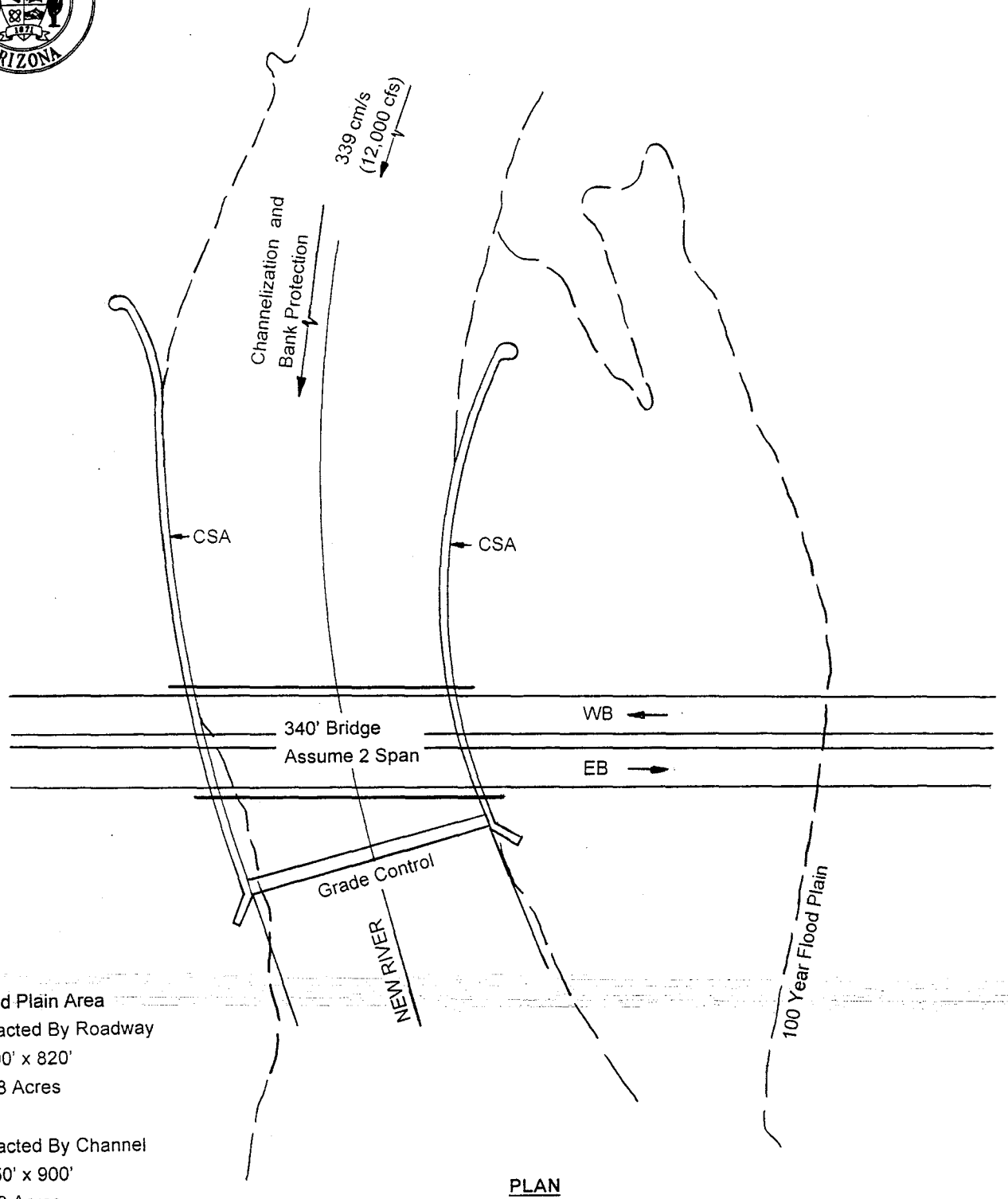
Drainage

Technical Memorandum

Appendix H

New River Crossing

PARSONS TRANSPORTATION GROUP
DE LEUW, CATHER & COMPANY



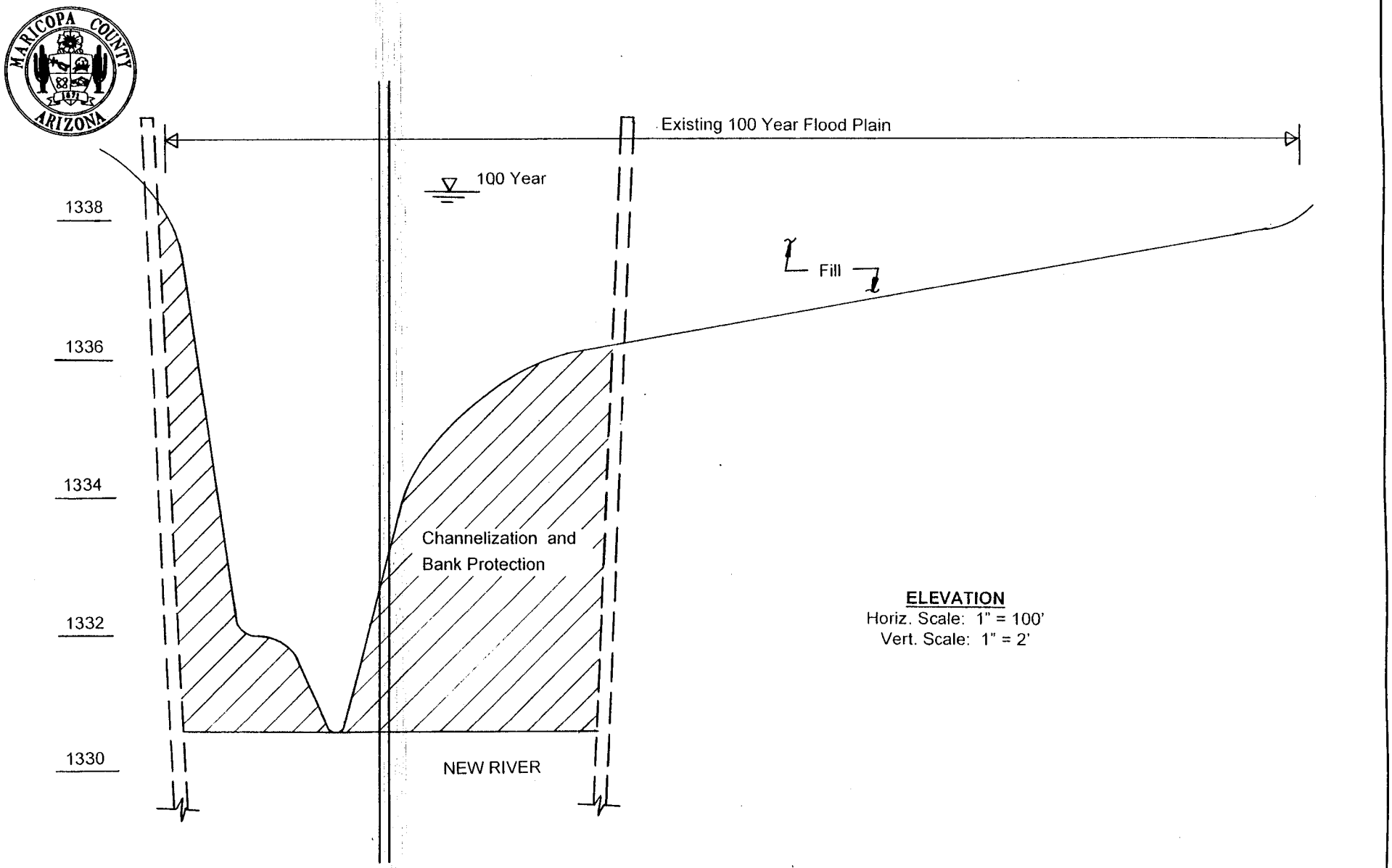
Flood Plain Area
Impacted By Roadway
= 200' x 820'
= 3.8 Acres

Impacted By Channel
= 350' x 900'
= 7.3 Acres

PLAN
1" = 20'

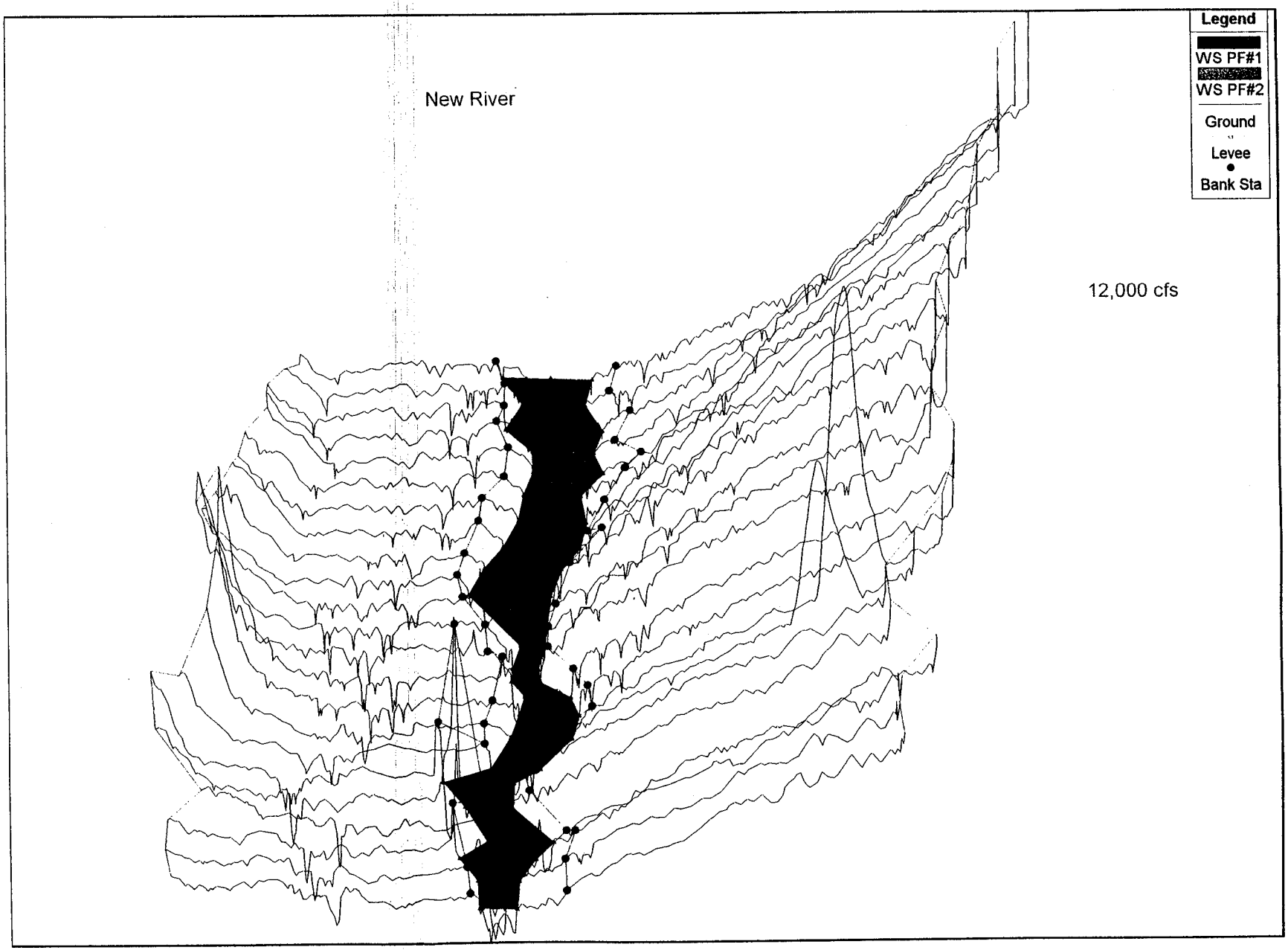
DE LEUW, CATHER

NEW RIVER CROSSING



DE LEUW, CATHER

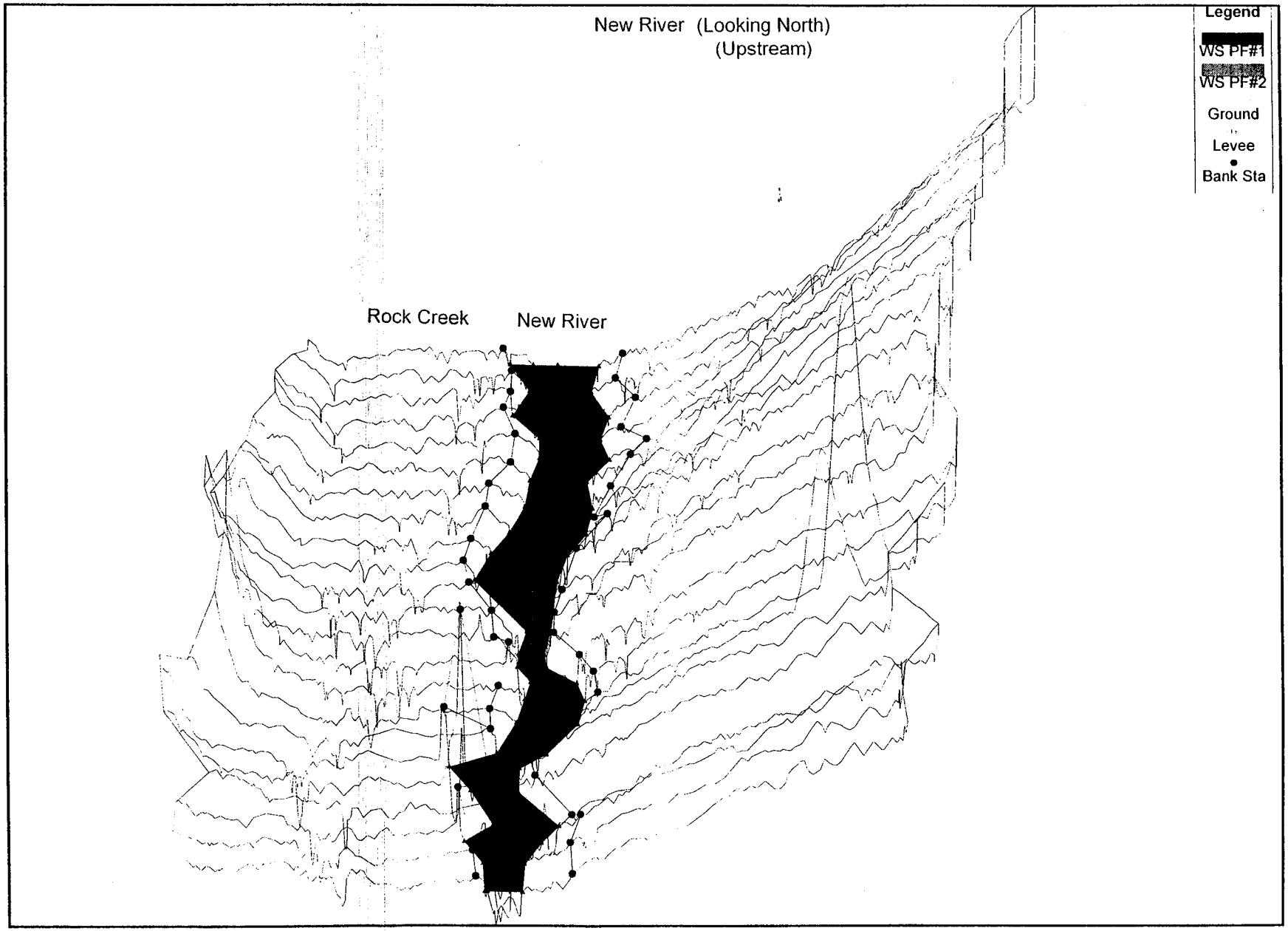
NEW RIVER CROSSING

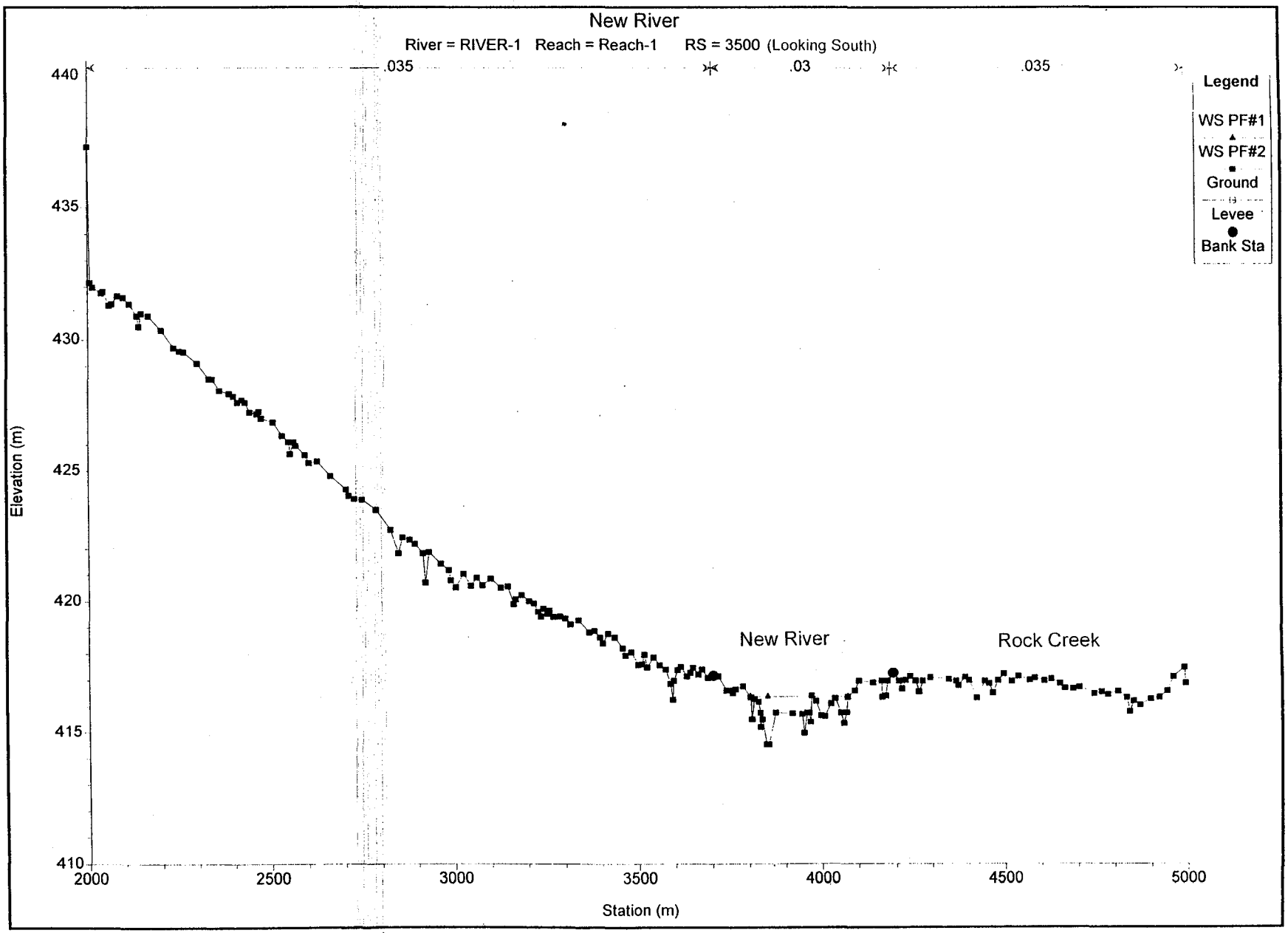

Legend
WS PF#1
WS PF#2
Ground
Levee
Bank Sta
New River
12,000 cfs

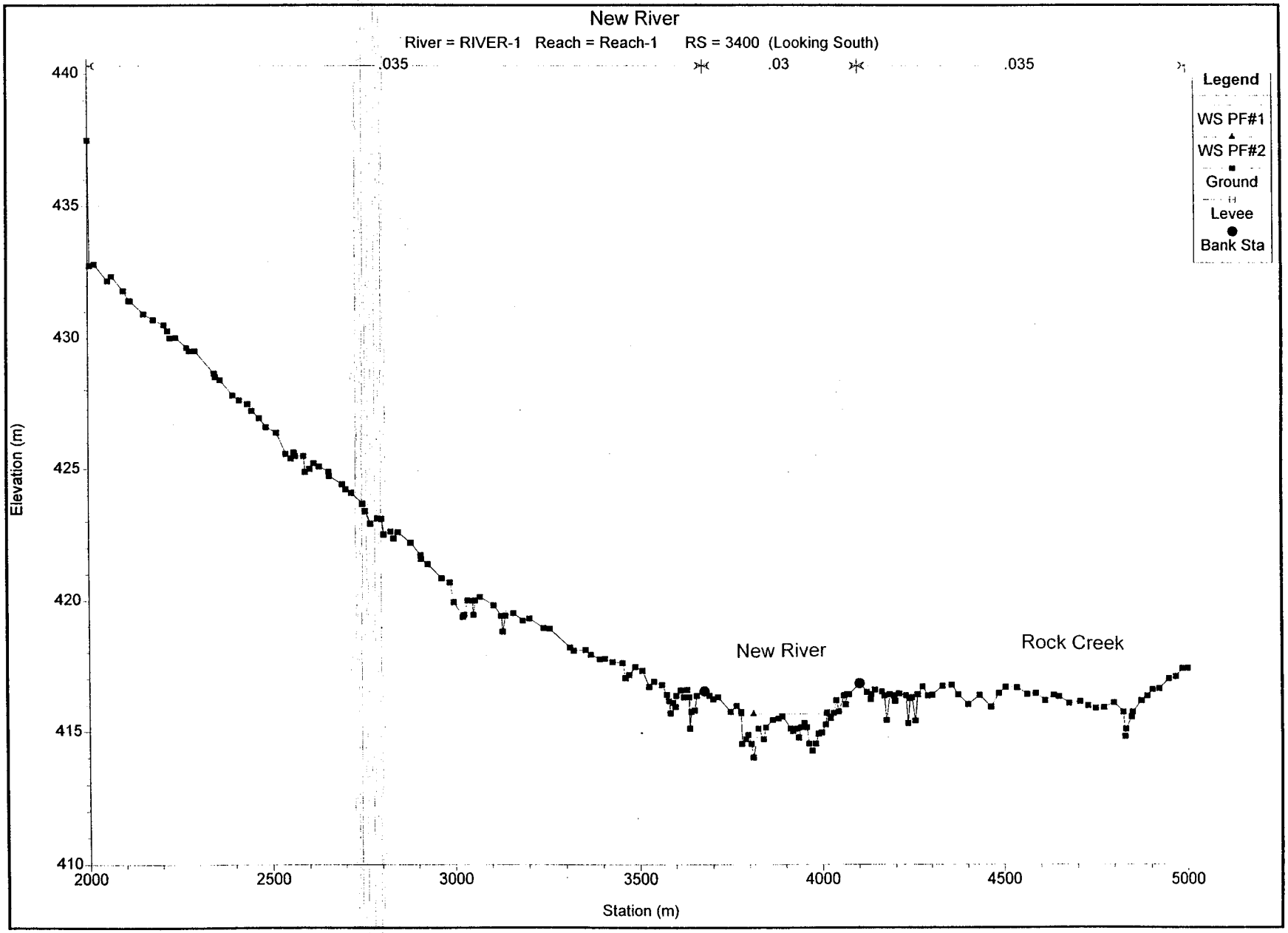
HEC-RAS Plan: Imported Pla River: RIVER-1 Reach: Reach-1

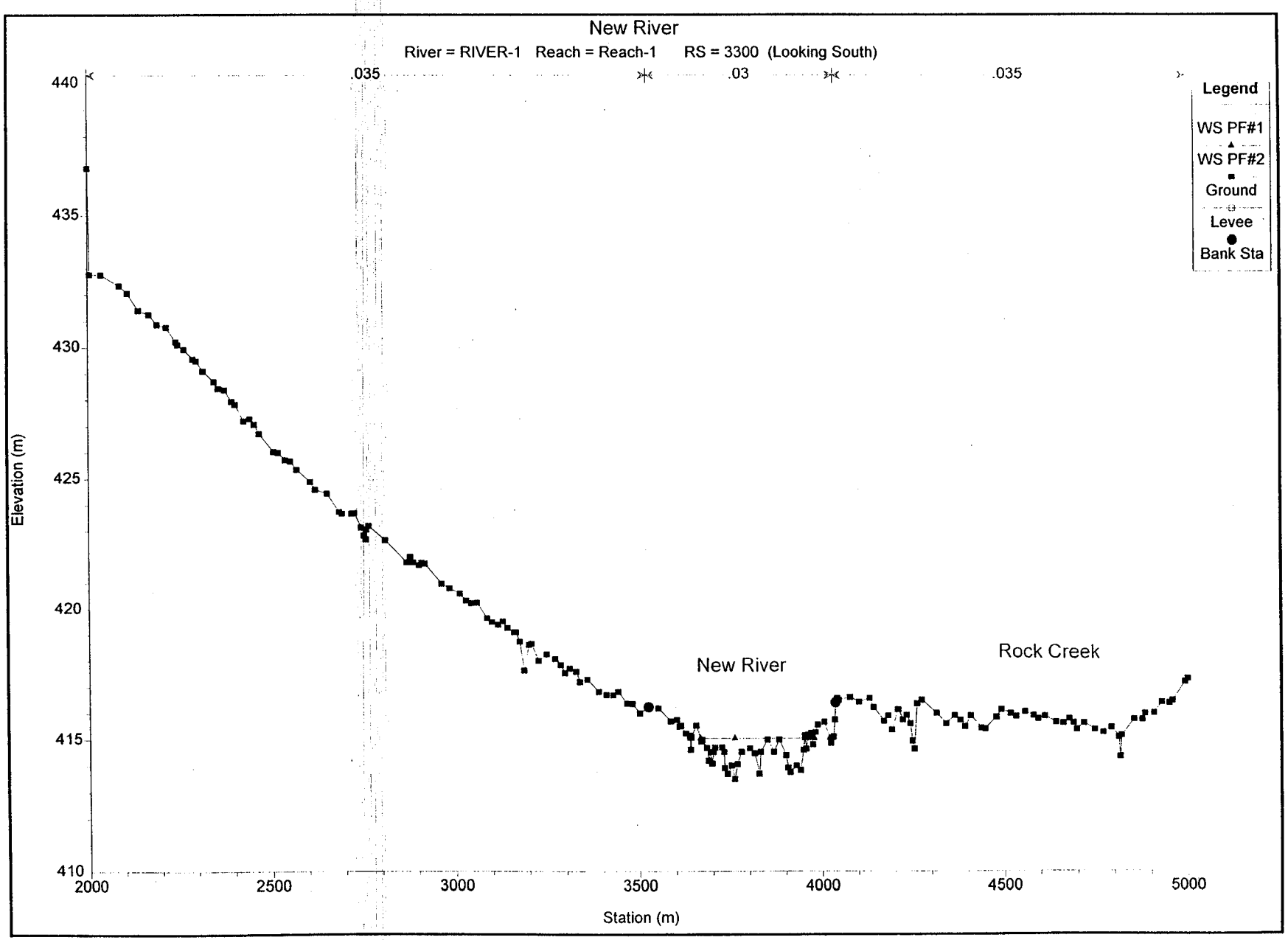
Reach	River Sta	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
Reach-1	3500	339.80	414.53	416.37	416.23	416.56	0.005814	1.93	176.51	266.99	0.76
Reach-1	3500	339.80	414.53	416.37	416.23	416.56	0.005814	1.93	176.51	266.99	0.76
Reach-1	3400	339.80	414.01	415.66	415.58	415.89	0.007554	2.14	158.70	249.24	0.86
Reach-1	3400	339.80	414.01	415.66	415.58	415.89	0.007554	2.14	158.70	249.24	0.86
Reach-1	3300	339.80	413.50	415.04	414.91	415.21	0.005892	1.81	187.32	313.12	0.75
Reach-1	3300	339.80	413.50	415.04	414.91	415.21	0.005892	1.81	187.32	313.12	0.75
Reach-1	3200	339.80	412.70	414.57	414.33	414.73	0.003882	1.75	193.67	249.04	0.64
Reach-1	3200	339.80	412.70	414.57	414.33	414.73	0.003882	1.75	193.67	249.04	0.64
Reach-1	3100	339.80	412.09	414.24	413.91	414.36	0.003297	1.58	215.50	287.04	0.58
Reach-1	3100	339.80	412.09	414.24	413.91	414.36	0.003297	1.58	215.50	287.04	0.58
Reach-1	3000	339.80	411.48	413.72	413.57	413.93	0.005704	2.02	168.41	234.15	0.76
Reach-1	3000	339.80	411.48	413.72	413.57	413.93	0.005704	2.02	168.41	234.15	0.76
Reach-1	2900	339.80	410.87	413.00	412.95	413.23	0.008700	2.14	158.66	276.93	0.90
Reach-1	2900	339.80	410.87	413.00	412.95	413.23	0.008700	2.14	158.66	276.93	0.90
Reach-1	2800	339.80	410.23	412.31	412.19	412.50	0.006094	1.91	177.66	281.46	0.77
Reach-1	2800	339.80	410.23	412.31	412.19	412.50	0.006094	1.91	177.66	281.46	0.77
Reach-1	2700	339.80	409.50	411.88	411.58	412.02	0.003700	1.64	207.31	284.34	0.61
Reach-1	2700	339.80	409.50	411.88	411.58	412.02	0.003700	1.64	207.31	284.34	0.61
Reach-1	2600	339.80	408.34	411.13	411.13	411.41	0.010685	2.38	142.60	247.20	1.00
Reach-1	2600	339.80	408.34	411.13	411.13	411.41	0.010685	2.38	142.60	247.20	1.00
Reach-1	2500	339.80	407.67	409.06	409.30	409.94	0.019360	4.14	82.13	97.26	1.44
Reach-1	2500	339.80	407.67	409.06	409.30	409.94	0.019360	4.14	82.13	97.26	1.44
Reach-1	2400	339.80	407.00	408.57	408.43	408.97	0.005865	2.80	121.45	105.60	0.83
Reach-1	2400	339.80	407.00	408.57	408.43	408.97	0.005865	2.80	121.45	105.60	0.83
Reach-1	2300	339.80	406.20	408.61	407.52	408.71	0.000780	1.46	233.42	118.90	0.33

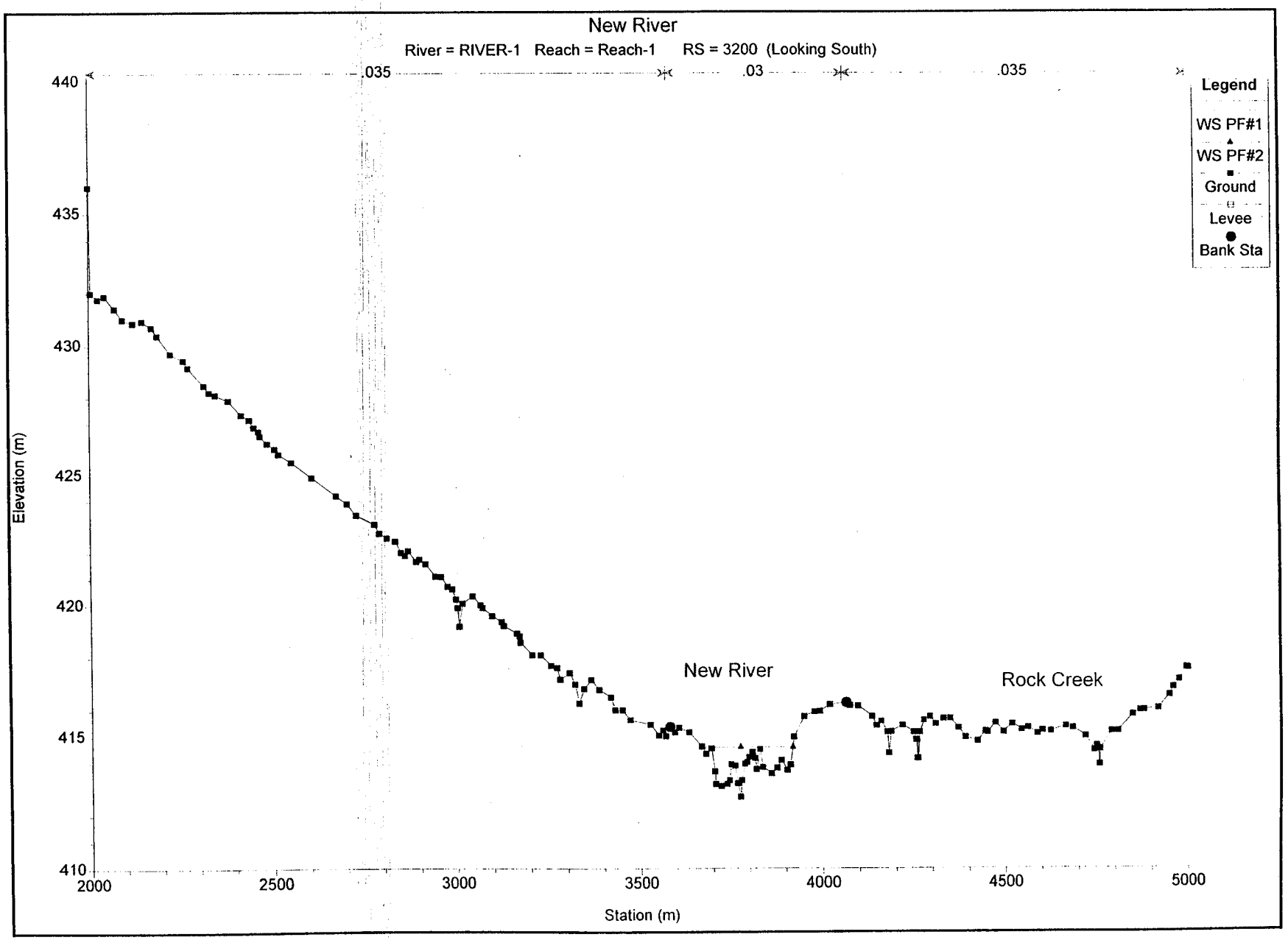
Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach-1	2300	339.80	406.20	408.61	407.52	408.71	0.000780	1.46	233.42	118.90	0.33
Reach-1	2200	339.80	405.30	408.56	406.94	408.64	0.000537	1.22	278.24	138.72	0.28
Reach-1	2200	339.80	405.30	408.56	406.94	408.64	0.000537	1.22	278.24	138.72	0.28
Reach-1	2100	339.80	406.23	408.35	408.07	408.52	0.003804	1.83	185.69	220.67	0.64
Reach-1	2100	339.80	406.23	408.35	408.07	408.52	0.003804	1.83	185.69	220.67	0.64
Reach-1	2000	339.80	405.85	407.80	407.71	408.02	0.006641	2.06	165.07	250.06	0.81
Reach-1	2000	339.80	405.85	407.80	407.71	408.02	0.006641	2.06	165.07	250.06	0.81
Reach-1	1900	339.80	405.38	406.84	406.84	407.21	0.009681	2.71	125.47	166.86	1.00
Reach-1	1900	339.80	405.38	406.84	406.84	407.21	0.009681	2.71	125.47	166.86	1.00
Reach-1	1800	339.80	403.56	406.78	405.63	406.85	0.000944	1.17	290.56	236.45	0.34
Reach-1	1800	339.80	403.56	406.78	405.63	406.85	0.000944	1.17	290.56	236.45	0.34
Reach-1	1700	339.80	404.00	406.25	406.25	406.60	0.010096	2.62	129.92	187.81	1.00
Reach-1	1700	339.80	404.00	406.25	406.25	406.60	0.010096	2.62	129.92	187.81	1.00
Reach-1	1600	339.80	399.90	405.11	401.78	405.14	0.000214	0.80	423.56	198.58	0.18
Reach-1	1600	339.80	399.90	405.11	401.78	405.14	0.000214	0.80	423.53	198.56	0.18
Reach-1	1500	339.80	403.04	404.90	404.63	405.07	0.004428	1.84	184.37	243.05	0.68
Reach-1	1500	339.80	403.04	404.90	404.63	405.07	0.004433	1.84	184.30	242.98	0.68
Reach-1	1400	339.80	402.46	404.44	404.19	404.65	0.003861	2.04	166.95	171.04	0.66
Reach-1	1400	339.80	402.46	404.44	404.19	404.65	0.003839	2.03	167.25	171.07	0.66
Reach-1	1300	339.80	401.73	403.66	403.66	404.06	0.009505	2.78	122.36	154.47	1.00
Reach-1	1300	339.80	401.73	403.66	403.66	404.06	0.009620	2.79	121.80	154.10	1.00

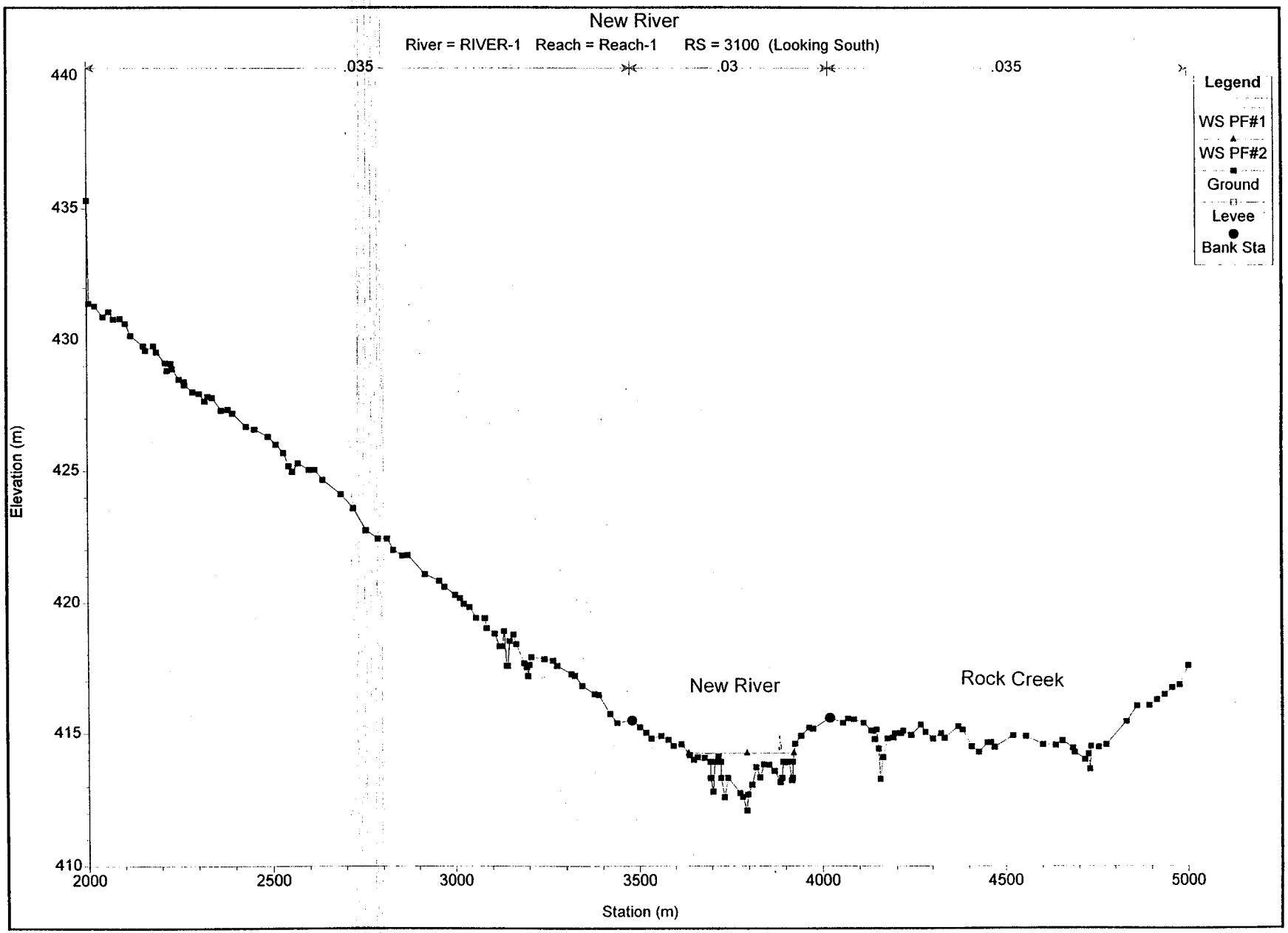

New River (Looking North)
(Upstream)
Legend
WS PF#1
WS PF#2
Ground
Levee
Bank Sta
Rock Creek
New River

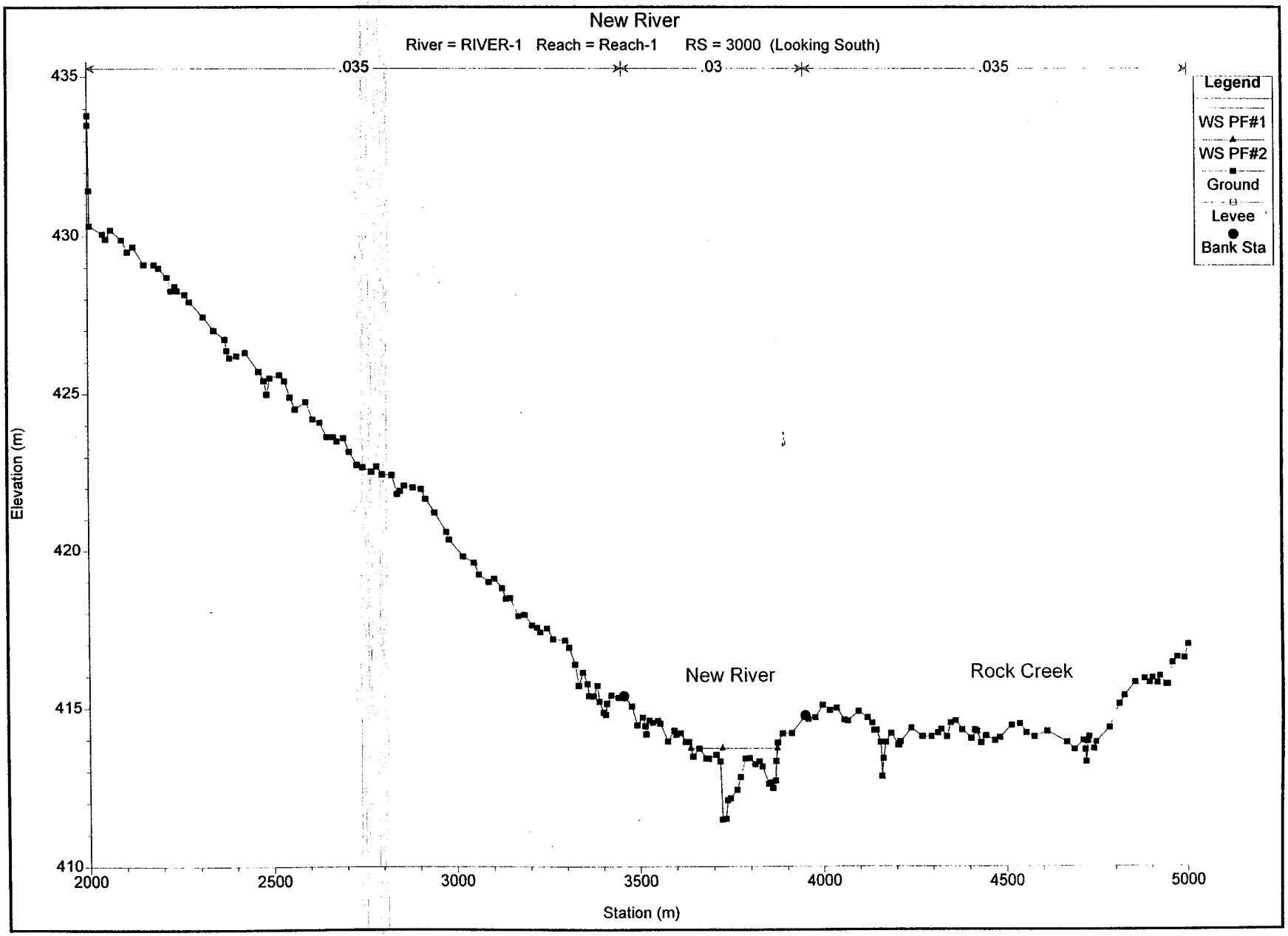

New River
River = RIVER-1 Reach = Reach-1 RS = 3500 (Looking South)
.035
.03
.035
Legend
WS PF#1
WS PF#2
Ground
Levee
Bank Sta
440
435
430
425
420
415
410
Elevation (m)
New River
Rock Creek
2000
2500
3000
3500
4000
4500
5000
Station (m)

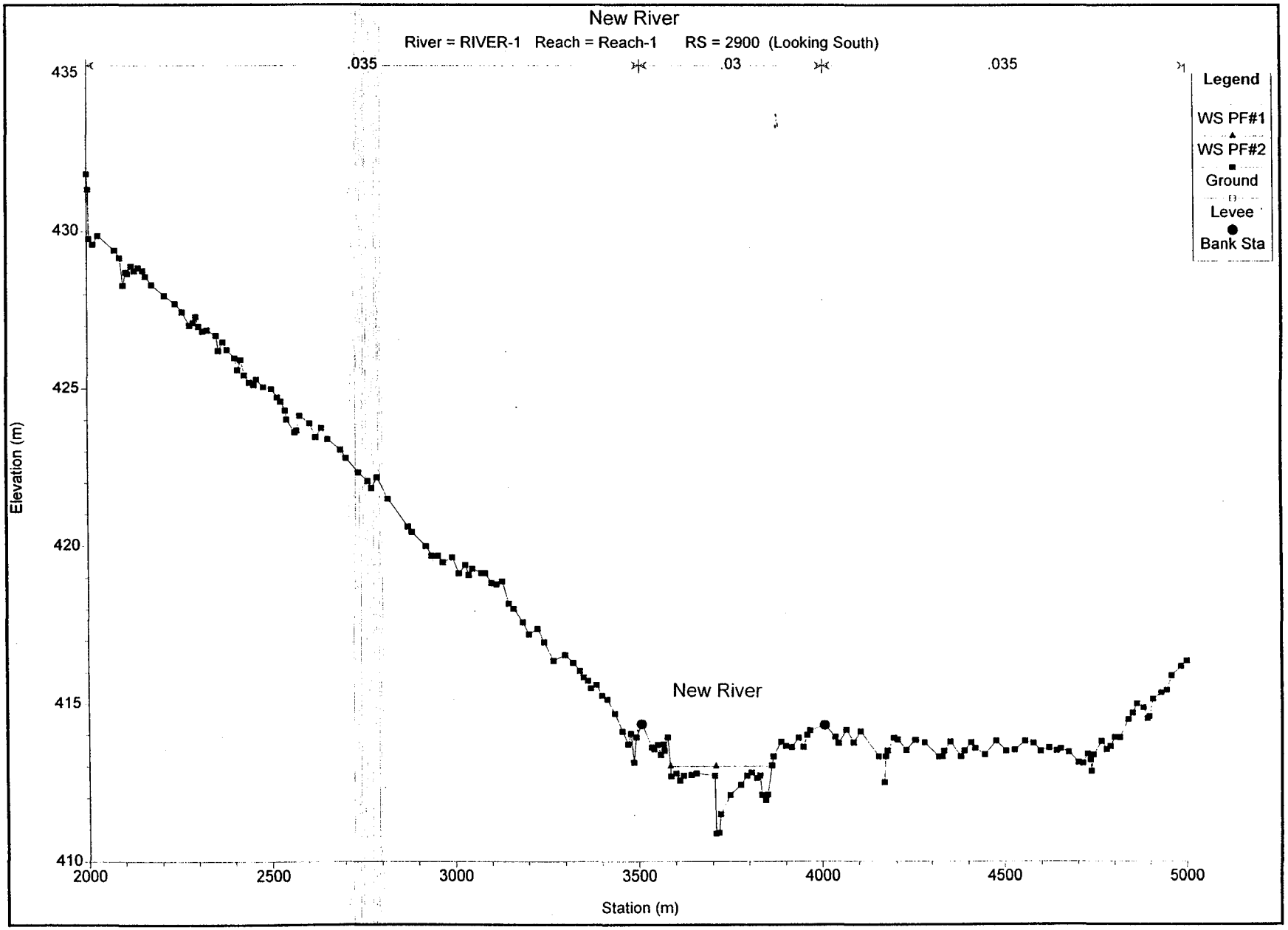

New River
River = RIVER-1 Reach = Reach-1 RS = 3400 (Looking South)
.035
.03
.035
Legend
WS PF#1
WS PF#2
Ground
Levee
Bank Sta
Elevation (m)
440
435
430
425
420
415
410
New River
Rock Creek
2000
2500
3000
3500
4000
4500
5000
Station (m)

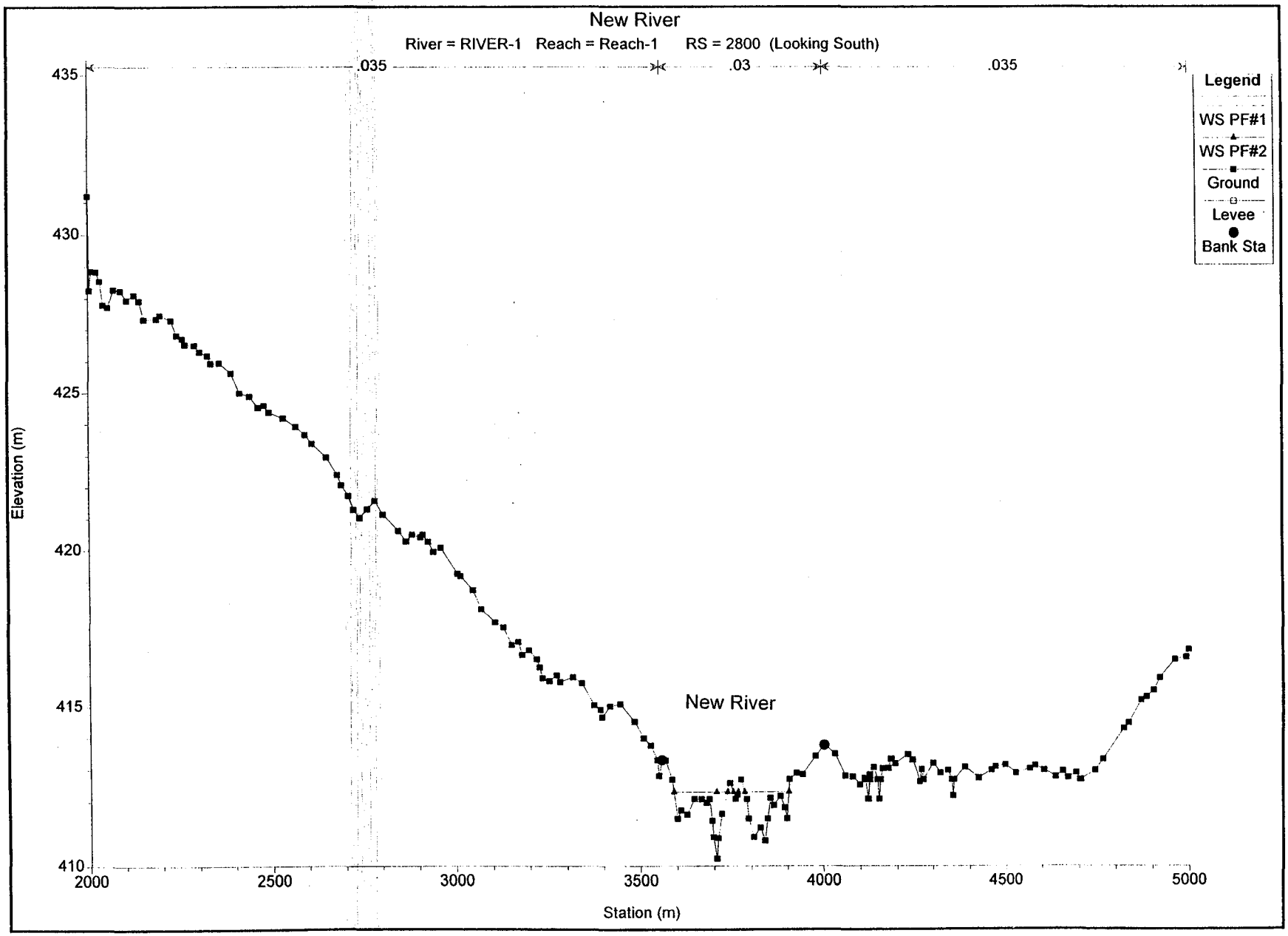

New River
River = RIVER-1 Reach = Reach-1 RS = 3300 (Looking South)
.035
.03
.035
Legend
WS PF#1
WS PF#2
Ground
Levee
Bank Sta
Elevation (m)
440
435
430
425
420
415
410
New River
Rock Creek
2000
2500
3000
3500
4000
4500
5000
Station (m)

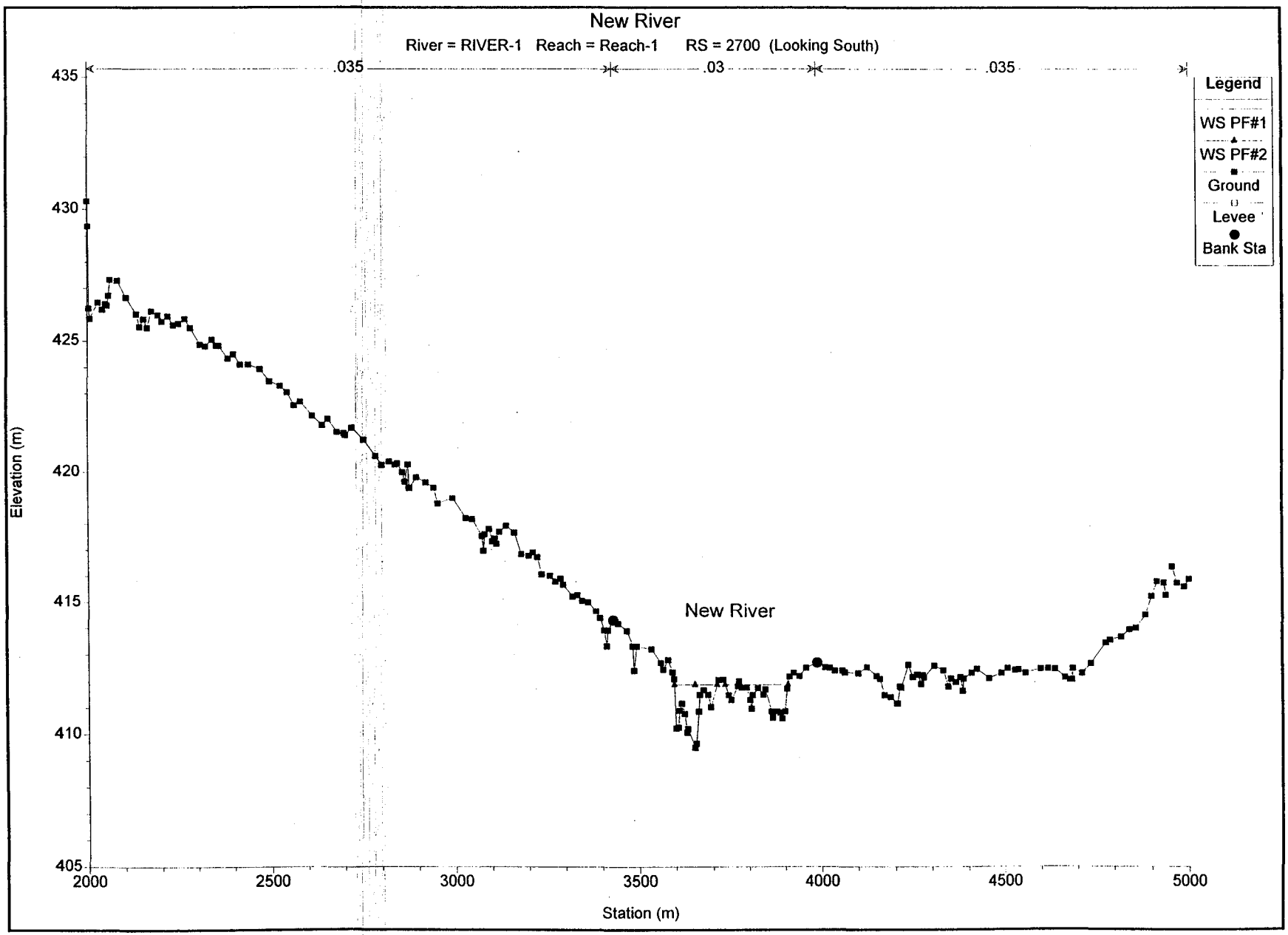

New River
River = RIVER-1 Reach = Reach-1 RS = 3200 (Looking South)
.035
.03
.035
Legend
WS PF#1
WS PF#2
Ground
Levee
Bank Sta
440
435
430
425
420
415
410
Elevation (m)
New River
Rock Creek
2000
2500
3000
3500
4000
4500
5000
Station (m)

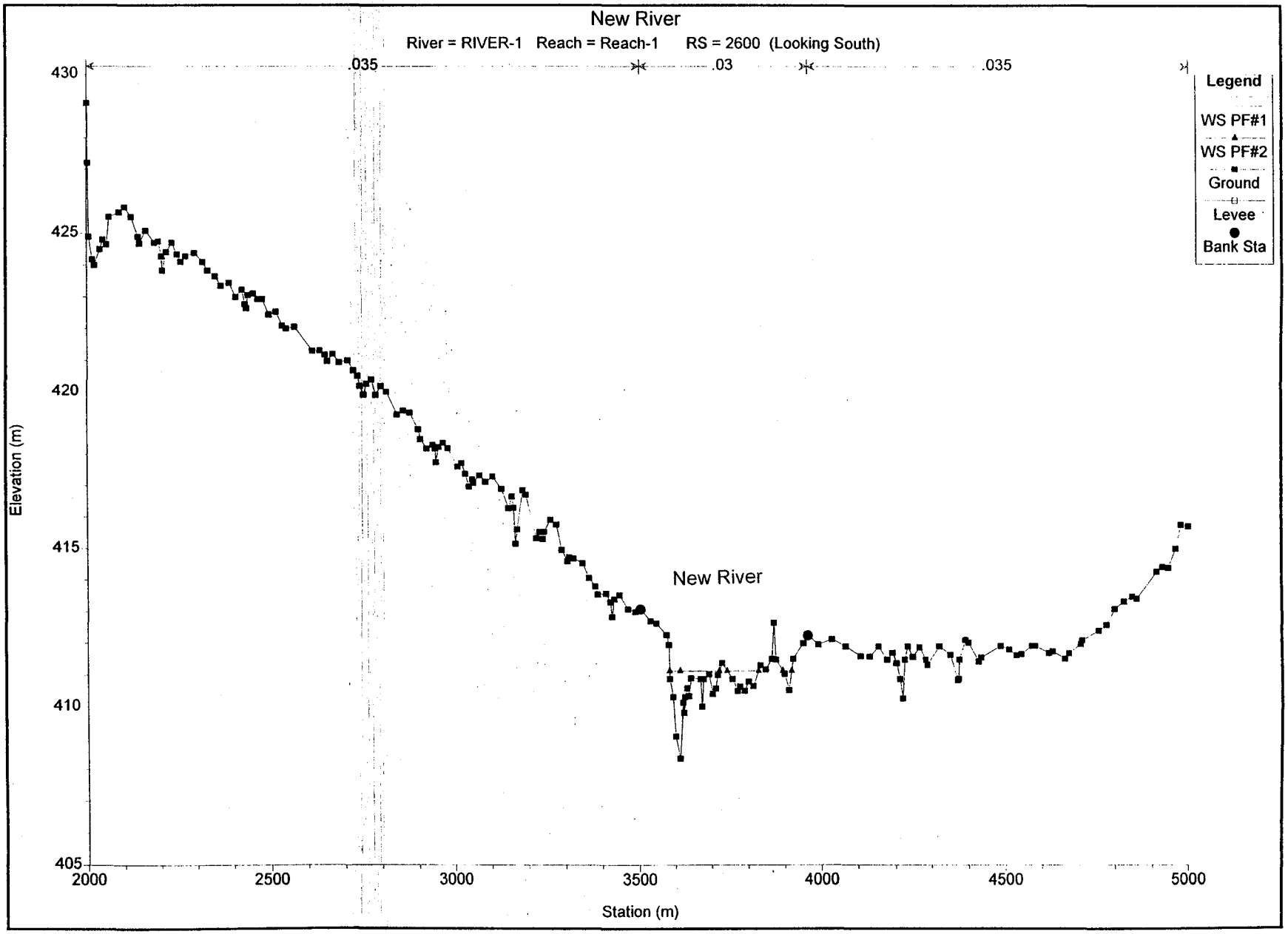

New River
River = RIVER-1 Reach = Reach-1 RS = 3100 (Looking South)
.035
.03
.035
Legend
WS PF#1
WS PF#2
Ground
Levee
Bank Sta
440
435
430
425
420
415
410
Elevation (m)
New River
Rock Creek
2000
2500
3000
3500
4000
4500
5000
Station (m)

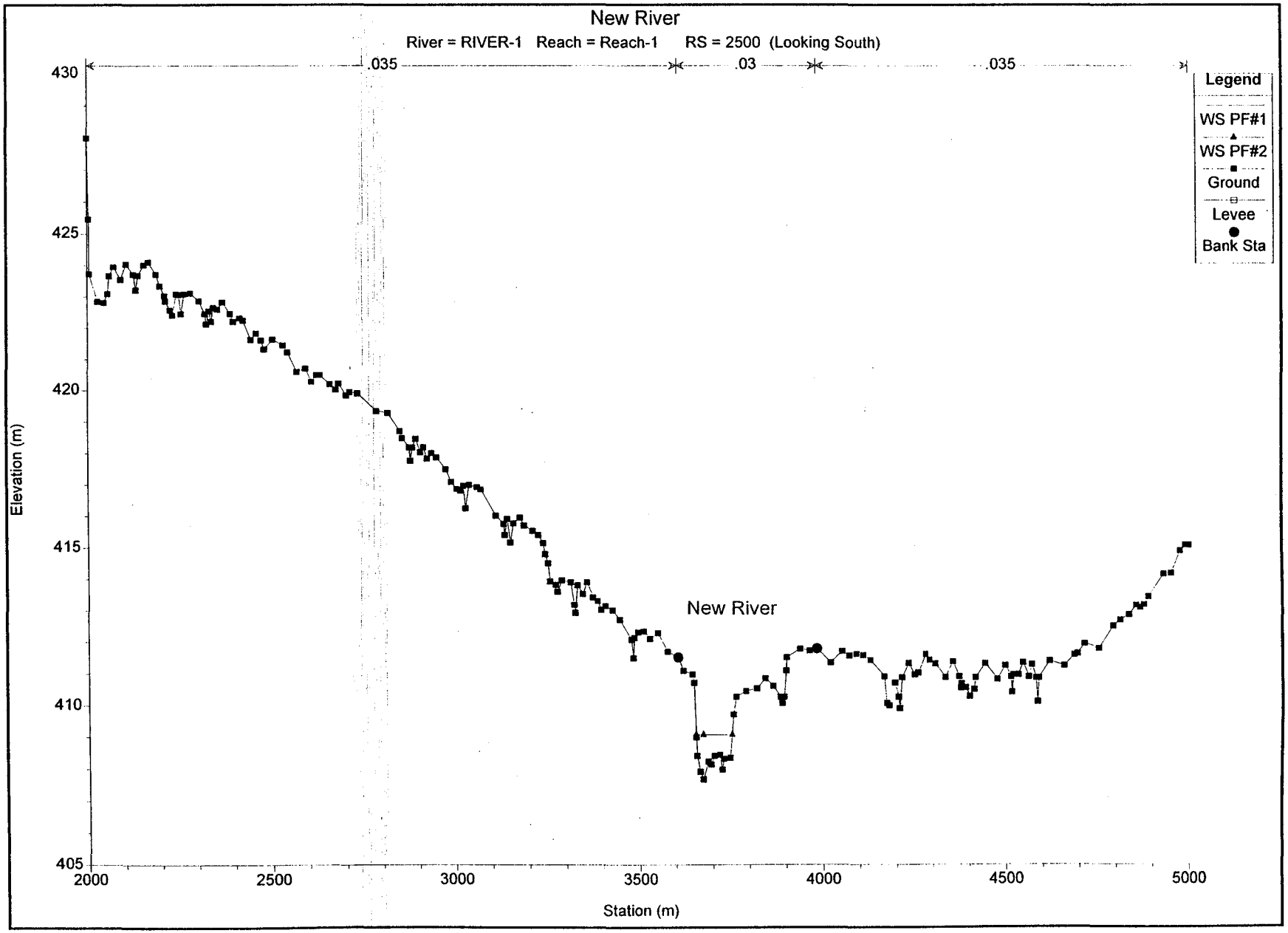

New River
River = RIVER-1 Reach = Reach-1 RS = 3000 (Looking South)
.035
.03
.035
Legend
WS PF#1
WS PF#2
Ground
Levee
Bank Sta
435
430
425
420
415
410
Elevation (m)
New River
Rock Creek
2000
2500
3000
3500
4000
4500
5000
Station (m)

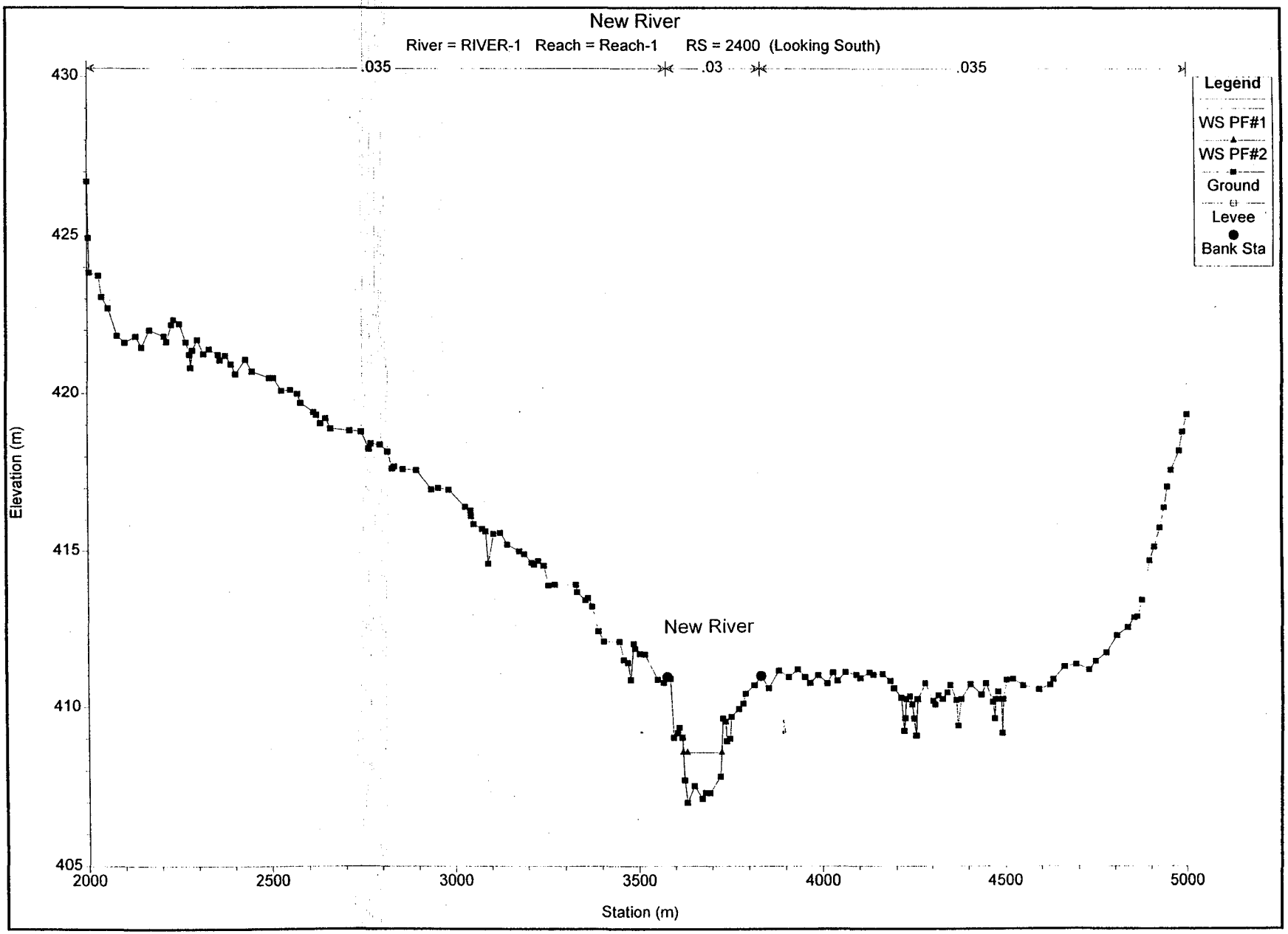

New River
River = RIVER-1 Reach = Reach-1 RS = 2900 (Looking South)
.035
.03
.035
Legend
WS PF#1
WS PF#2
Ground
Levee
Bank Sta
435
430
425
420
415
410
Elevation (m)
New River
2000
2500
3000
3500
4000
4500
5000
Station (m)

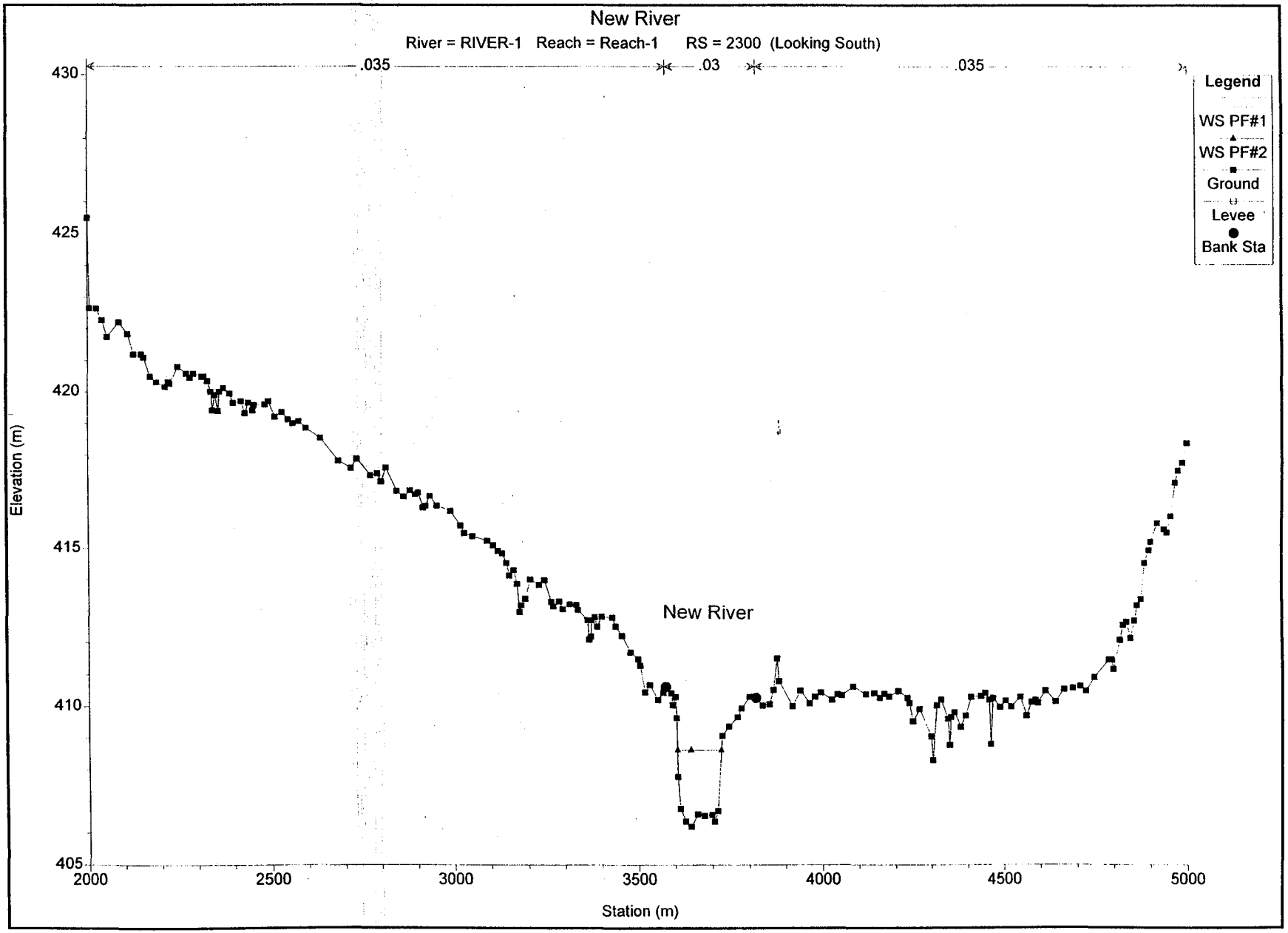

New River
River = RIVER-1 Reach = Reach-1 RS = 2800 (Looking South)
.035
.03
.035
Legend
WS PF#1
WS PF#2
Ground
Levee
Bank Sta
435
430
425
420
415
410
Elevation (m)
New River
2000
2500
3000
3500
4000
4500
5000
Station (m)

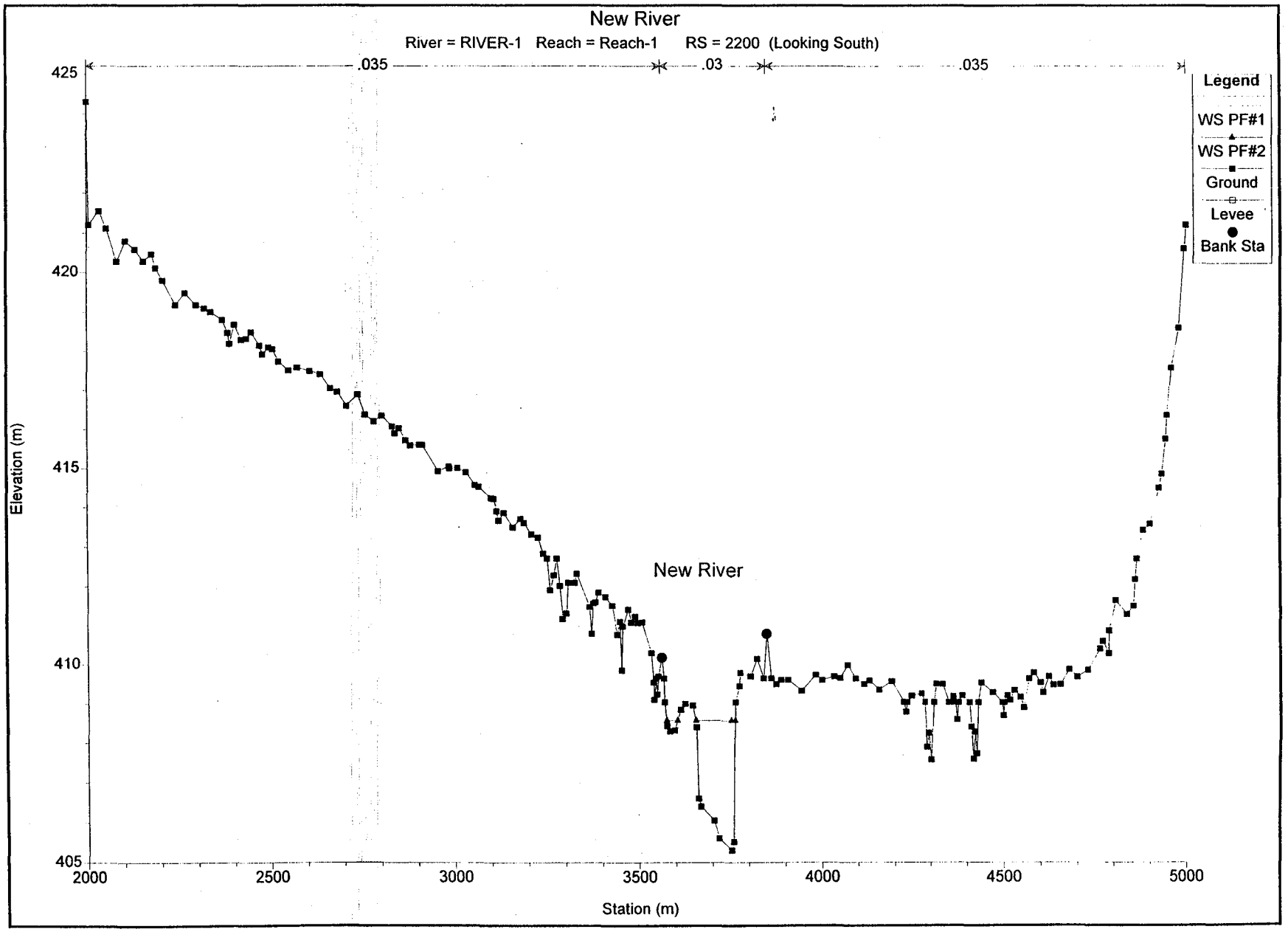

New River
River = RIVER-1 Reach = Reach-1 RS = 2700 (Looking South)
.035
.03
.035
Legend
WS PF#1
WS PF#2
Ground
Levee
Bank Sta
435
430
425
420
415
410
405
Elevation (m)
New River
2000
2500
3000
3500
4000
4500
5000
Station (m)

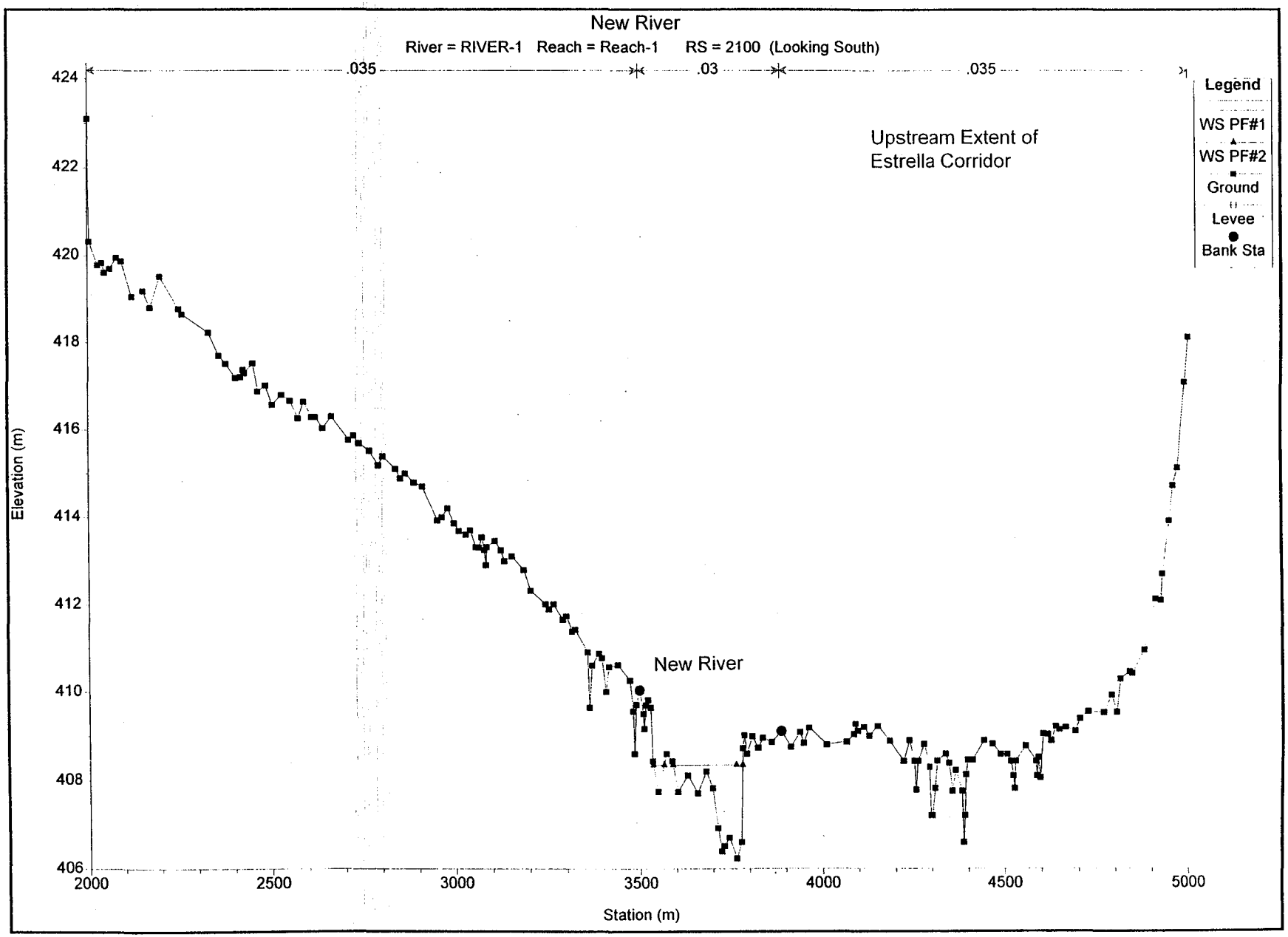

New River
River = RIVER-1 Reach = Reach-1 RS = 2600 (Looking South)
.035
.03
.035
Legend
WS PF#1
WS PF#2
Ground
Levee
Bank Sta
New River
Elevation (m)
Station (m)
430
425
420
415
410
405
2000
2500
3000
3500
4000
4500
5000

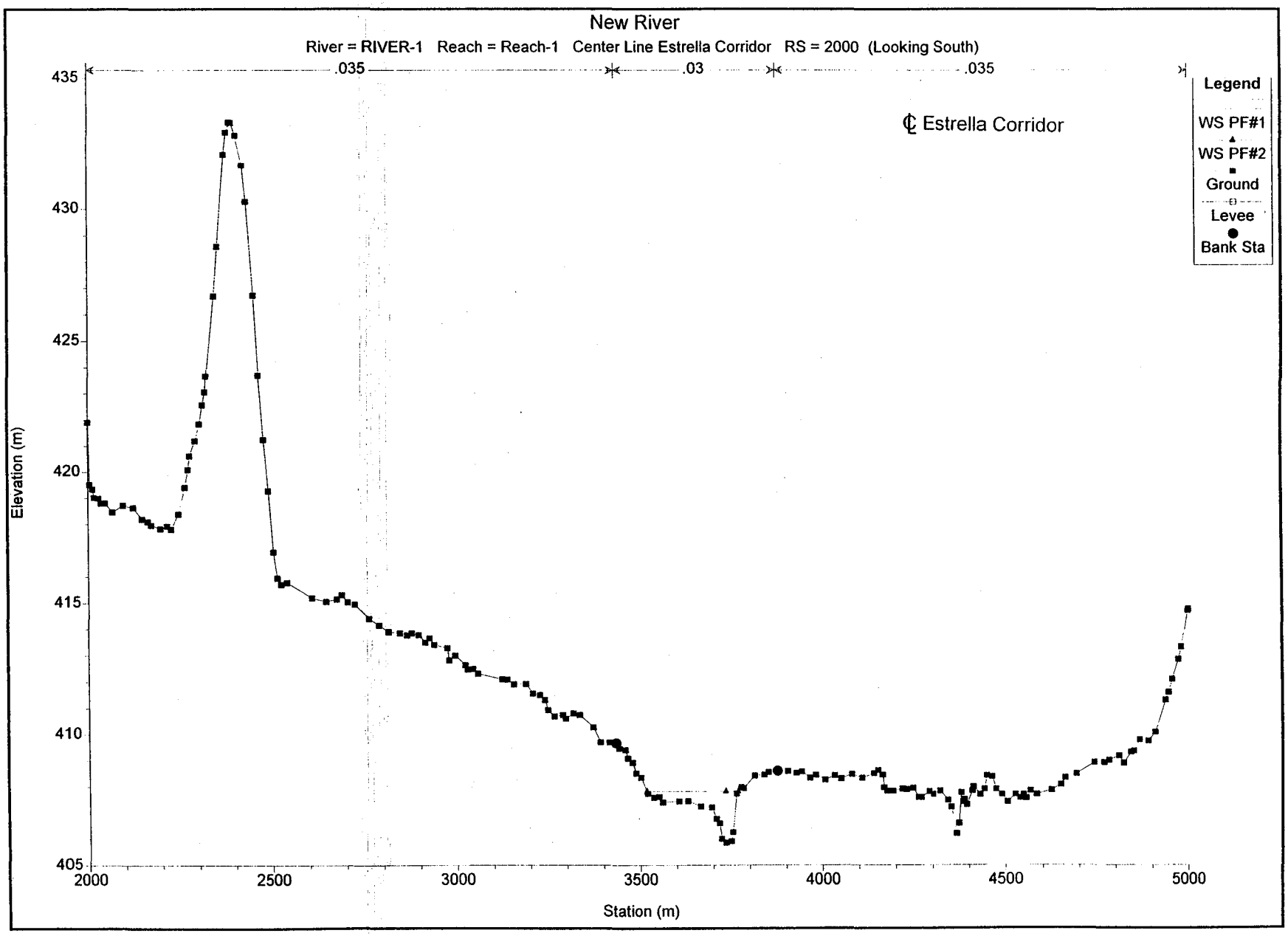

New River
River = RIVER-1 Reach = Reach-1 RS = 2500 (Looking South)
.035
.03
.035
Legend
WS PF#1
WS PF#2
Ground
Levee
Bank Sta
New River
Elevation (m)
Station (m)
430
425
420
415
410
405
2000
2500
3000
3500
4000
4500
5000

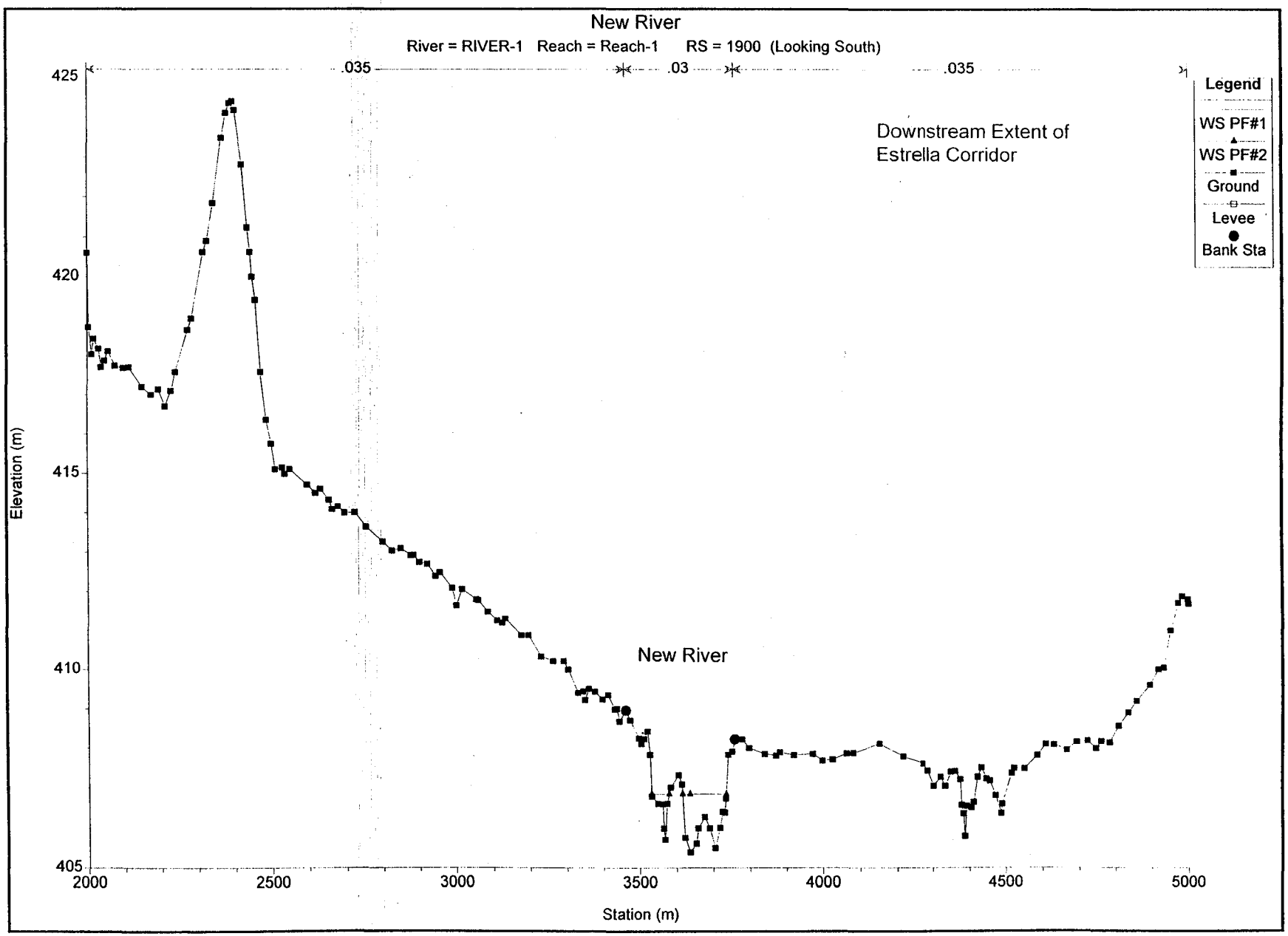

New River
River = RIVER-1 Reach = Reach-1 RS = 2400 (Looking South)
.035
.03
.035
Legend
WS PF#1
WS PF#2
Ground
Levee
Bank Sta
New River
Elevation (m)
Station (m)
430
425
420
415
410
405
2000
2500
3000
3500
4000
4500
5000

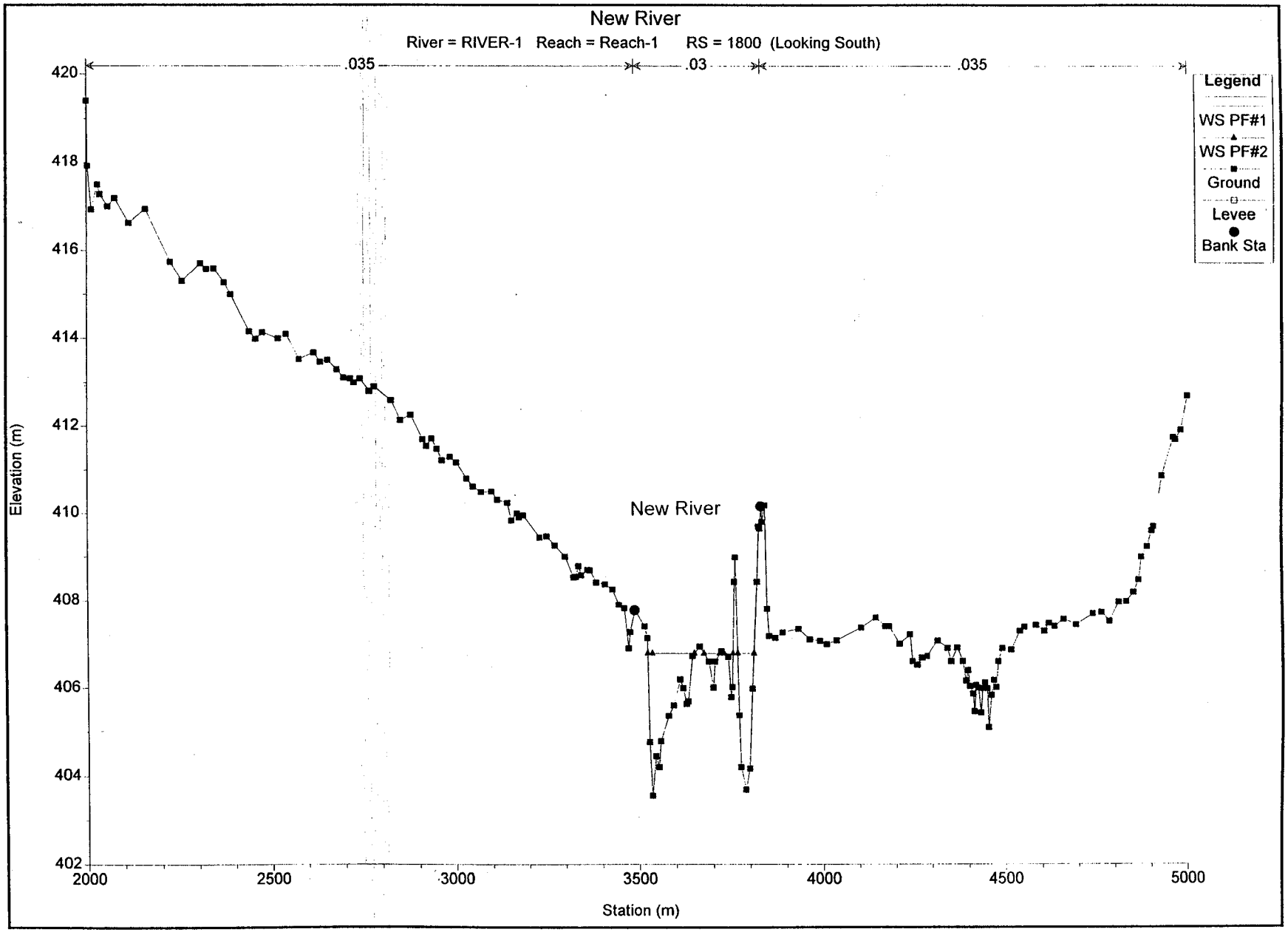

New River
River = RIVER-1 Reach = Reach-1 RS = 2300 (Looking South)
.035
.03
.035
Legend
WS PF#1
WS PF#2
Ground
Levee
Bank Sta
New River
Elevation (m)
Station (m)
430
425
420
415
410
405
2000
2500
3000
3500
4000
4500
5000

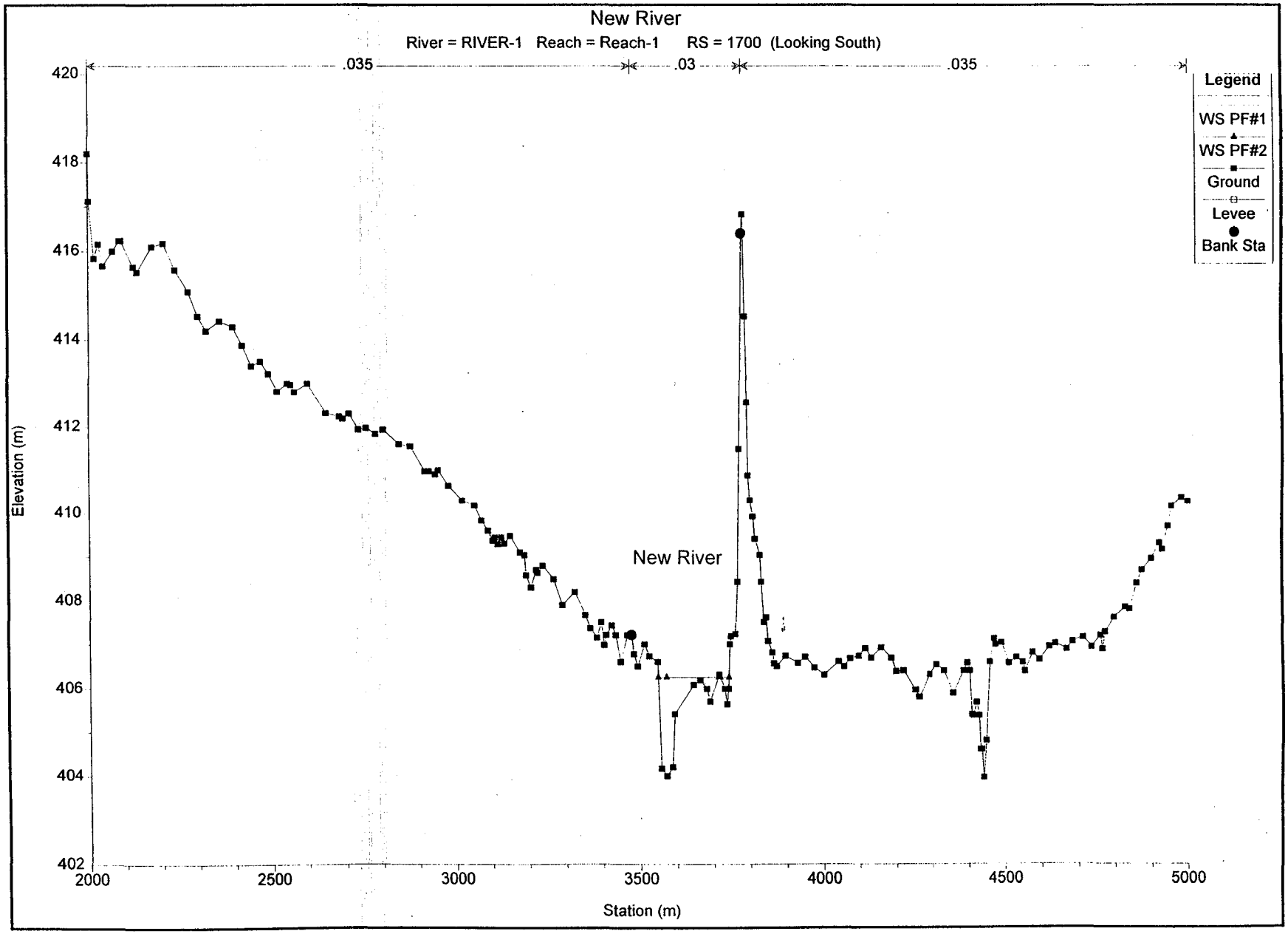

New River
River = RIVER-1 Reach = Reach-1 RS = 2200 (Looking South)
.035
.03
.035
Legend
WS PF#1
WS PF#2
Ground
Levee
Bank Sta
425
420
415
410
405
Elevation (m)
New River
2000
2500
3000
3500
4000
4500
5000
Station (m)

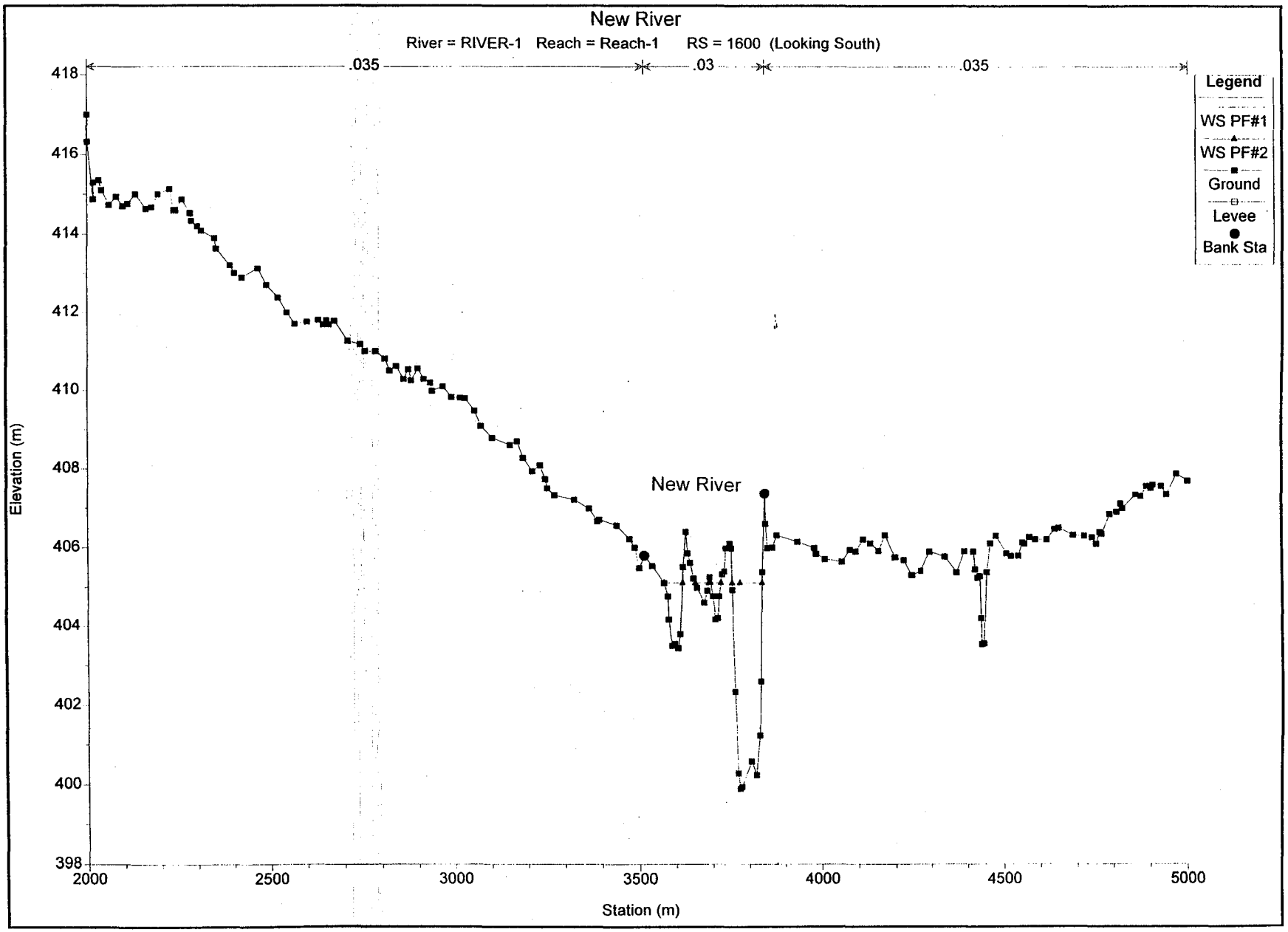

New River
River = RIVER-1 Reach = Reach-1 RS = 2100 (Looking South)
.035
.03
.035
Legend
WS PF#1
WS PF#2
Ground
Levee
Bank Sta
Upstream Extent of
Estrella Corridor
New River
Elevation (m)
424
422
420
418
416
414
412
410
408
406
2000
2500
3000
3500
4000
4500
5000
Station (m)

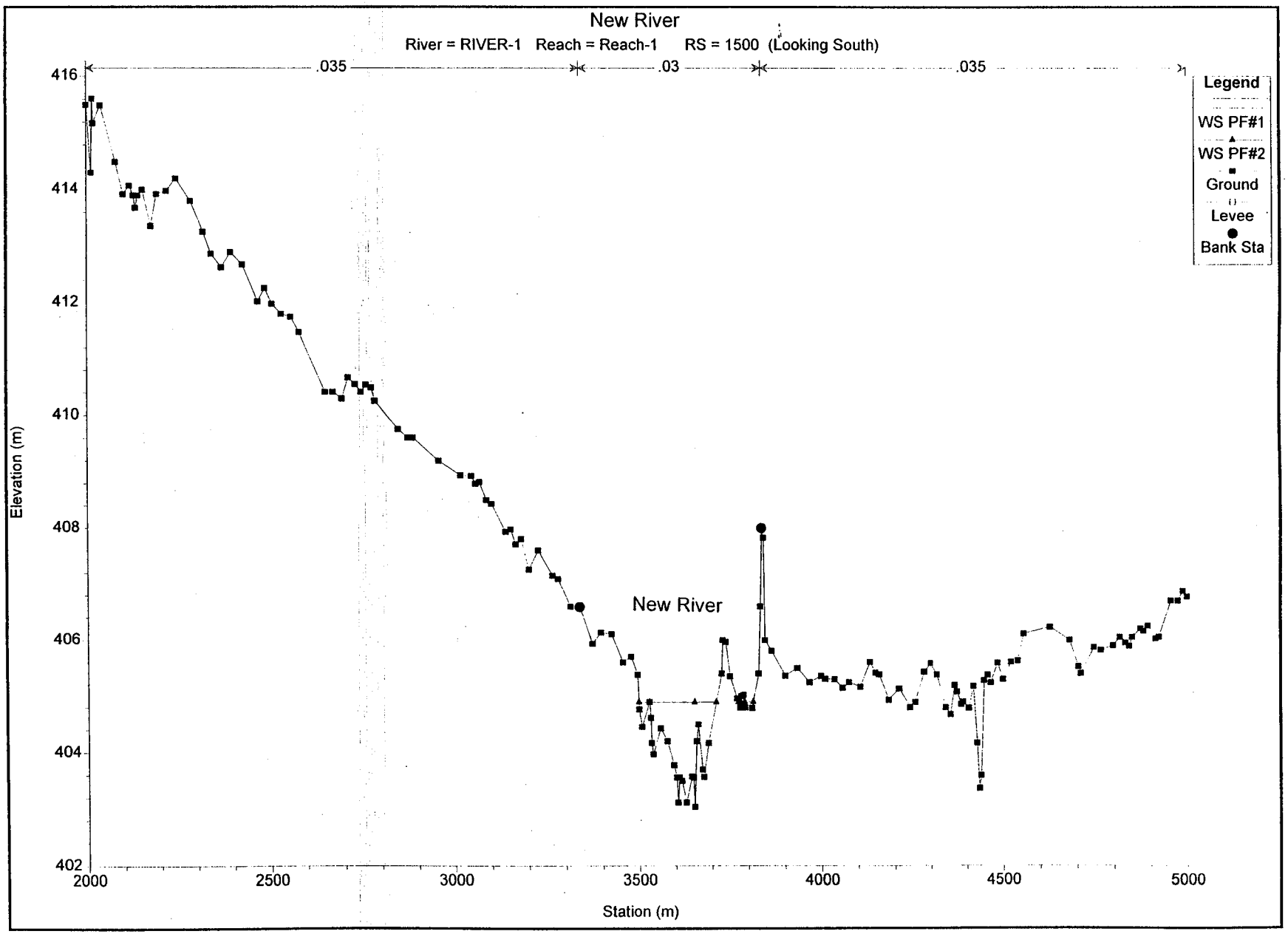

New River
River = RIVER-1 Reach = Reach-1 Center Line Estrella Corridor RS = 2000 (Looking South)
.035
.03
.035
℄ Estrella Corridor
Legend
WS PF#1
WS PF#2
Ground
Levee
Bank Sta
Elevation (m)
435
430
425
420
415
410
405
2000
2500
3000
3500
4000
4500
5000
Station (m)

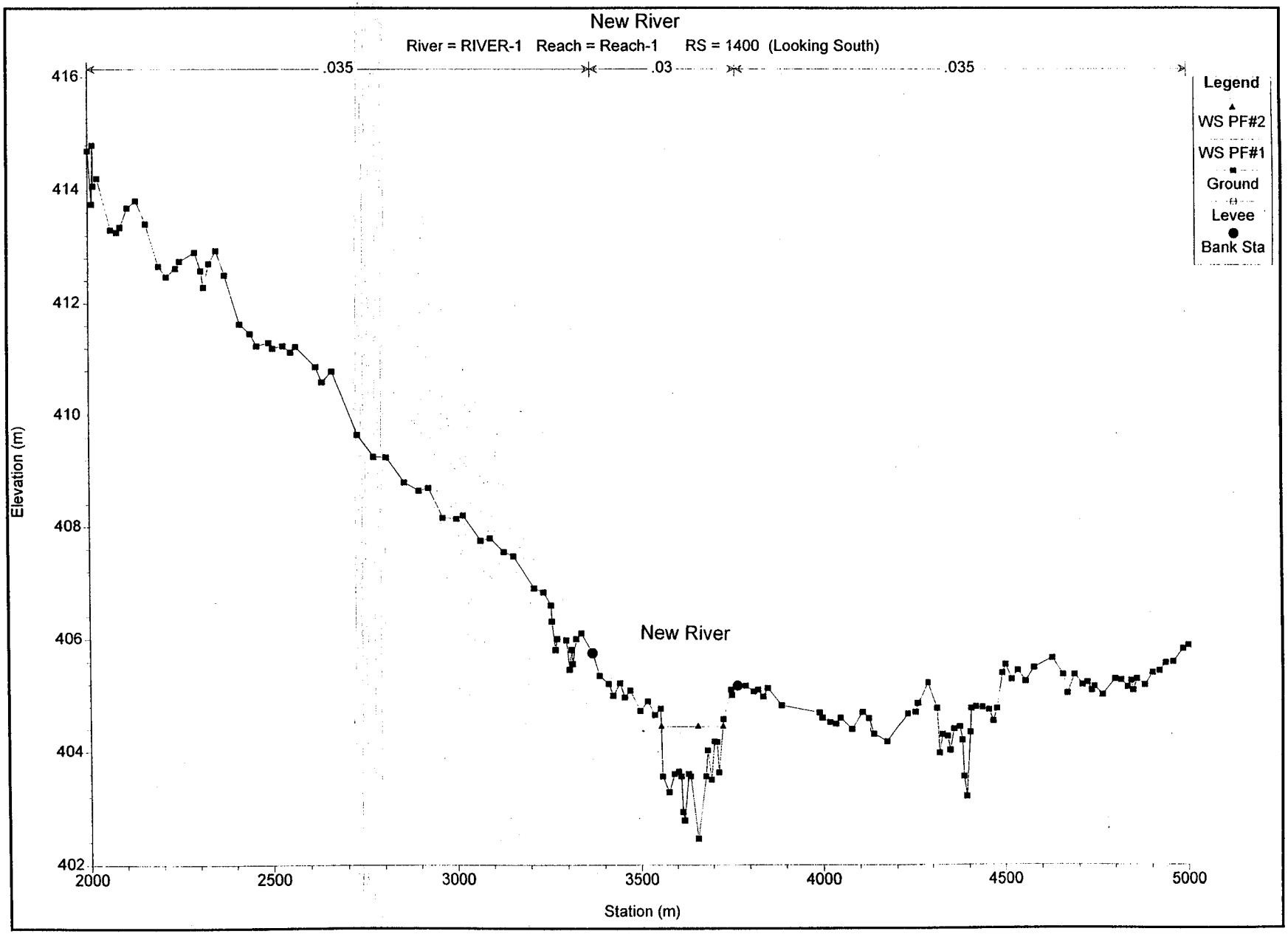

New River
River = RIVER-1 Reach = Reach-1 RS = 1900 (Looking South)
.035
.03
.035
Legend
WS PF#1
WS PF#2
Ground
Levee
Bank Sta
Downstream Extent of
Estrella Corridor
New River
Elevation (m)
425
420
415
410
405
2000
2500
3000
3500
4000
4500
5000
Station (m)


New River
River = RIVER-1 Reach = Reach-1 RS = 1800 (Looking South)
.035
.03
.035
Legend
WS PF#1
WS PF#2
Ground
Levee
Bank Sta
New River
Elevation (m)
Station (m)
420
418
416
414
412
410
408
406
404
402
2000
2500
3000
3500
4000
4500
5000


New River
River = RIVER-1 Reach = Reach-1 RS = 1700 (Looking South)
.035
.03
.035
Legend
WS PF#1
WS PF#2
Ground
Levee
Bank Sta
New River
Elevation (m)
Station (m)
420
418
416
414
412
410
408
406
404
402
2000
2500
3000
3500
4000
4500
5000


New River
River = RIVER-1 Reach = Reach-1 RS = 1600 (Looking South)
.035
.03
.035
Legend
WS PF#1
WS PF#2
Ground
Levee
Bank Sta
New River
Elevation (m)
418
416
414
412
410
408
406
404
402
400
398
2000
2500
3000
3500
4000
4500
5000
Station (m)


New River
River = RIVER-1 Reach = Reach-1 RS = 1500 (Looking South)
.035
.03
.035
Legend
WS PF#1
WS PF#2
Ground
Levee
Bank Sta
New River
Elevation (m)
Station (m)
416
414
412
410
408
406
404
402
2000
2500
3000
3500
4000
4500
5000


New River
River = RIVER-1 Reach = Reach-1 RS = 1400 (Looking South)
.035
.03
.035
Legend
WS PF#2
WS PF#1
Ground
Levee
Bank Sta
Elevation (m)
416
414
412
410
408
406
404
402
New River
2000
2500
3000
3500
4000
4500
5000
Station (m)

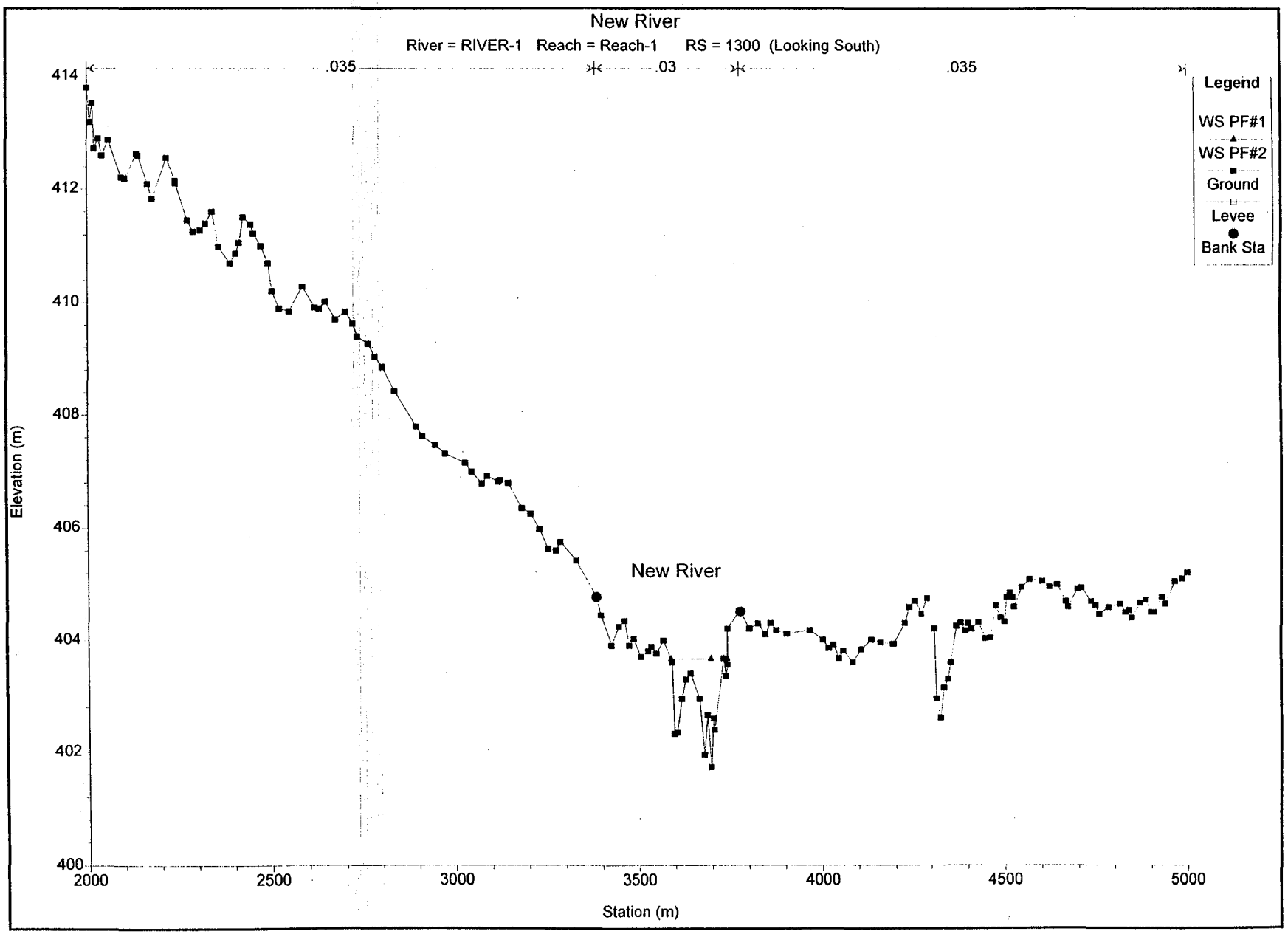
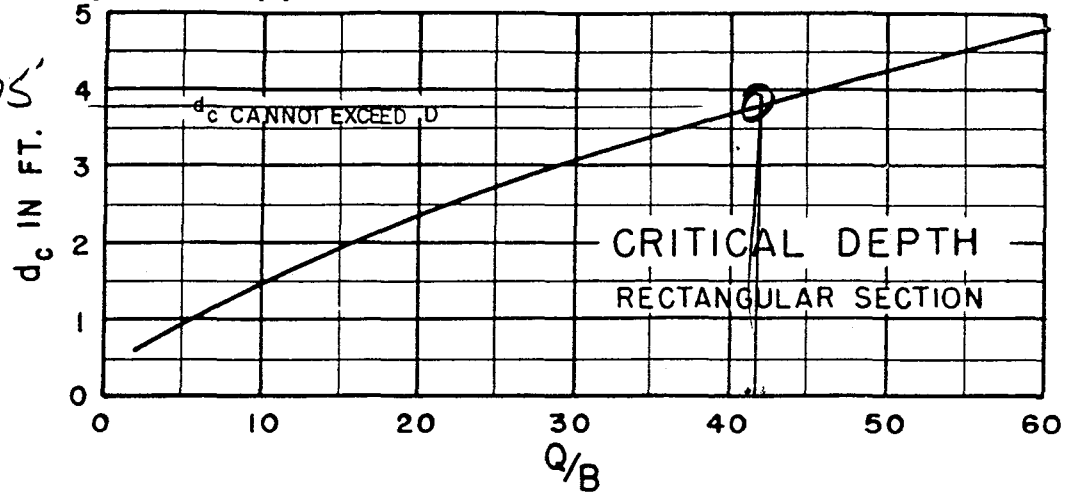
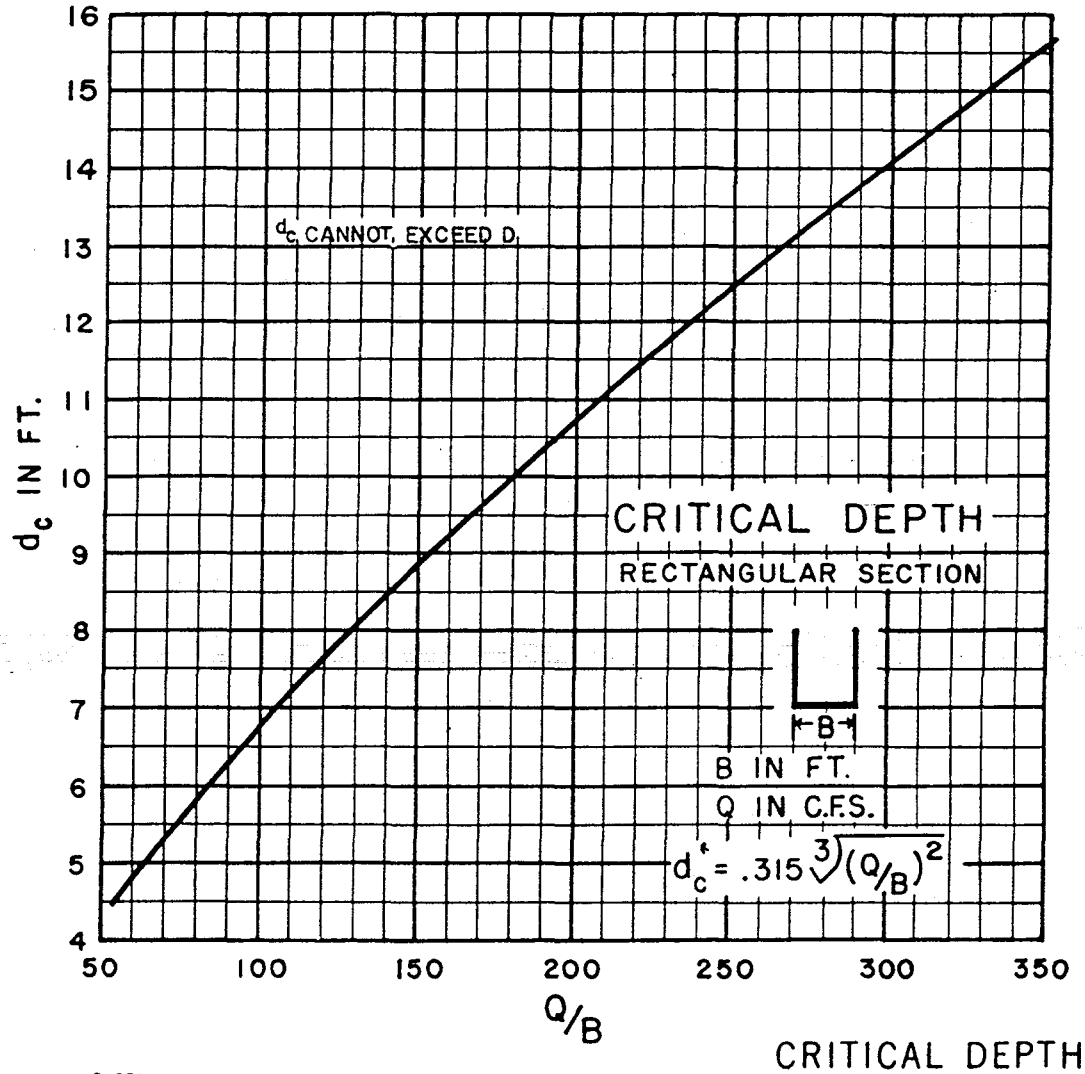

New River
River = RIVER-1 Reach = Reach-1 RS = 1300 (Looking South)
.035
.03
.035
Legend
WS PF#1
WS PF#2
Ground
Levee
Bank Sta
New River
Elevation (m)
414
412
410
408
406
404
402
400
2000
2500
3000
3500
4000
4500
5000
Station (m)

CHART 14

3.75'





CRITICAL DEPTH
RECTANGULAR SECTION

BUREAU OF PUBLIC ROADS JAN 1963

Q = 1000
B = 24
Q/B = 41.67

TABLE 12 - ENTRANCE LOSS COEFFICIENTS

Outlet Control, Full or Partly Full

$$H_e = k_e \left[\frac{V^2}{2g} \right]$$

Type of Structure and Design of Entrance	Coefficient k_e
Pipe, Concrete	
Mitered to conform to fill slope	0.7
*End-Section conforming to fill slope	0.5
Projecting from fill, sq. cut end	0.5
Headwall or headwall and wingwalls	
Square-edge	0.5
Rounded (radius = 1/12D)	0.2
Socket end of pipe (groove-end)	0.2
Projecting from fill, socket end (groove-end)	0.2
Beveled edges, 33.7° or 45° bevels	0.2
Side-or slope-tapered inlet	0.2
Pipe, or Pipe-Arch, Corrugated Metal	
Projecting from fill (no headwall)	0.9
Mitered to conform to fill slope, paved or unpaved slope	0.7
Headwall or headwall and wingwalls square-edge	0.5
*End-Section conforming to fill slope	0.5
Beveled edges, 33.7° or 45° bevels	0.2
Side-or slope-tapered inlet	0.2
Box, Reinforced Concrete	
Wingwalls parallel (extension of sides)	
Square-edged at crown	0.7
Wingwalls at 10° to 25° or 30° to 75° to barrel	
Square-edged at crown	0.5
Headwall parallel to embankment (no wingwalls)	
Square-edged on 3 edges	0.5
Rounded on 3 edges to radius of 1/12 barrel dimension, or beveled edges on 3 sides	0.2
Wingwalls at 30° to 75° to barrel	
Crown edge rounded to radius of 1/12 barrel dimension, or beveled top edge	0.2
Side-or slope-tapered inlet	0.2

*Note: "End Section conforming to fill slope," made of either metal or concrete, are the sections commonly available from manufacturers. From limited hydraulic tests they are equivalent in operation to a headwall in both inlet and outlet control. Some end sections, incorporating a closed taper in their design have a superior hydraulic performance. These latter sections can be designed using the information given for the beveled inlet.

Rock Creek

HEC-RAS Plan: Imported Pla River: RIVER-1 Reach: Reach-1

Reach	River Sta	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
Reach-1	3500	28.31	415.82	416.50	416.41	416.55	0.005529	0.91	31.07	139.31	0.62
Reach-1	3500	339.80	415.82	416.97	416.97	416.99	0.000467	0.39	564.62	911.00	0.20
Reach-1	3400	28.31	414.83	416.01	415.81	416.05	0.004462	0.83	34.26	151.17	0.55
Reach-1	3400	339.80	414.83	416.30	416.46	416.78	0.046504	3.09	110.05	390.33	1.86
Reach-1	3300	28.31	414.37	415.53	415.45	415.57	0.005223	0.82	34.64	174.91	0.59
Reach-1	3300	339.80	414.37	416.08	415.95	416.16	0.005135	1.27	268.28	694.31	0.65
Reach-1	3200	28.31	413.92	414.98	414.88	415.02	0.005682	0.97	29.33	122.71	0.63
Reach-1	3200	339.80	413.92	415.61	415.47	415.69	0.004465	1.26	270.57	638.46	0.62
Reach-1	3100	28.31	413.29	414.56	414.35	414.59	0.003315	0.73	38.84	165.52	0.48
Reach-1	3100	339.80	413.29	415.08	414.97	415.18	0.005756	1.39	245.06	603.12	0.69
Reach-1	3000	28.31	412.84	414.03	413.98	414.08	0.008794	0.95	29.74	176.62	0.74
Reach-1	3000	339.80	412.84	414.51	414.40	414.60	0.005823	1.36	249.06	633.59	0.69
Reach-1	2900	28.31	412.49	413.53	413.38	413.55	0.003370	0.60	47.40	276.16	0.46
Reach-1	2900	339.80	412.49	413.93	413.84	414.02	0.005856	1.29	264.19	737.60	0.69
Reach-1	2800	28.31	412.10	412.84	412.84	412.90	0.017711	1.11	25.59	205.21	1.00
Reach-1	2800	339.80	412.10	413.28	413.21	413.38	0.006931	1.40	242.83	677.77	0.75
Reach-1	2700	28.31	411.17	411.98	411.75	412.03	0.002995	0.95	29.73	78.69	0.49
Reach-1	2700	339.80	411.17	412.61	412.53	412.70	0.006636	1.34	253.28	729.04	0.73
Reach-1	2600	28.31	410.26	411.36	411.31	411.51	0.010362	1.77	16.01	42.31	0.92
Reach-1	2600	339.80	410.26	412.12	411.97	412.19	0.004059	1.15	294.50	735.00	0.58
Reach-1	2500	28.31	409.90	410.69	410.59	410.75	0.005473	1.07	26.35	91.32	0.64
Reach-1	2500	339.80	409.90	411.34	411.34	411.53	0.012046	1.90	178.84	477.28	0.99
Reach-1	2400	28.31	409.10	410.22	410.01	410.28	0.003995	1.10	25.74	67.28	0.57
Reach-1	2400	339.80	409.10	410.99	410.99	411.00	0.000091	0.18	798.36	913.32	0.09
Reach-1	2300	28.31	408.29	409.45	409.45	409.61	0.012982	1.79	15.80	48.27	1.00

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Reach	River Sta	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
Reach-1	2300	339.80	408.29	410.04	410.26	410.89	0.051704	4.07	83.51	211.53	2.07
Reach-1	2200	28.31	407.58	408.55	408.40	408.65	0.004658	1.43	19.78	39.15	0.64
Reach-1	2200	339.80	407.58	409.70	409.54	409.77	0.004608	1.19	285.11	744.93	0.61
Reach-1	2100	28.31	406.60	408.01	407.87	408.11	0.006443	1.42	20.00	51.39	0.72
Reach-1	2100	339.80	406.60	408.87	408.87	409.05	0.012171	1.90	179.26	483.41	0.99
Reach-1	2000	28.31	406.20	407.38	407.17	407.51	0.005565	1.58	17.97	35.52	0.71
Reach-1	2000	339.80	406.20	408.28	408.06	408.35	0.002949	1.24	274.93	487.03	0.53
Reach-1	1900	28.31	405.80	406.92	406.79	406.98	0.004675	1.12	25.20	72.65	0.61
Reach-1	1900	339.80	405.80	407.78	407.64	407.92	0.006677	1.66	205.14	432.35	0.77
Reach-1	1800	28.31	405.10	406.10	406.10	406.23	0.013692	1.60	17.65	66.68	1.00
Reach-1	1800	339.80	405.10	407.29	407.08	407.38	0.004316	1.32	257.32	549.17	0.62
Reach-1	1700	28.31	403.96	405.42	405.08	405.53	0.003480	1.48	19.19	29.30	0.58
Reach-1	1700	339.80	403.96	406.72	406.61	406.83	0.007025	1.48	229.15	592.08	0.76
Reach-1	1600	28.31	403.54	405.17	404.61	405.28	0.001848	1.50	18.82	17.04	0.46
Reach-1	1600	339.80	403.54	406.23	406.03	406.30	0.003967	1.16	292.55	710.32	0.58
Reach-1	1500	28.31	403.37	404.94	404.49	404.98	0.004721	0.95	29.68	110.16	0.59
Reach-1	1500	339.80	403.37	405.47	405.47	405.64	0.012646	1.81	187.46	557.10	1.00
Reach-1	1400	28.31	403.21	404.37	404.23	404.45	0.006057	1.24	22.75	68.34	0.69
Reach-1	1400	339.80	403.21	405.22	405.22	405.23	0.000221	0.39	760.62	1076.84	0.15
Reach-1	1300	28.31	402.61	403.41	403.41	403.61	0.012042	1.98	14.27	35.67	1.00
Reach-1	1300	339.80	402.61	404.47	404.66	405.09	0.026396	3.49	97.41	188.25	1.55

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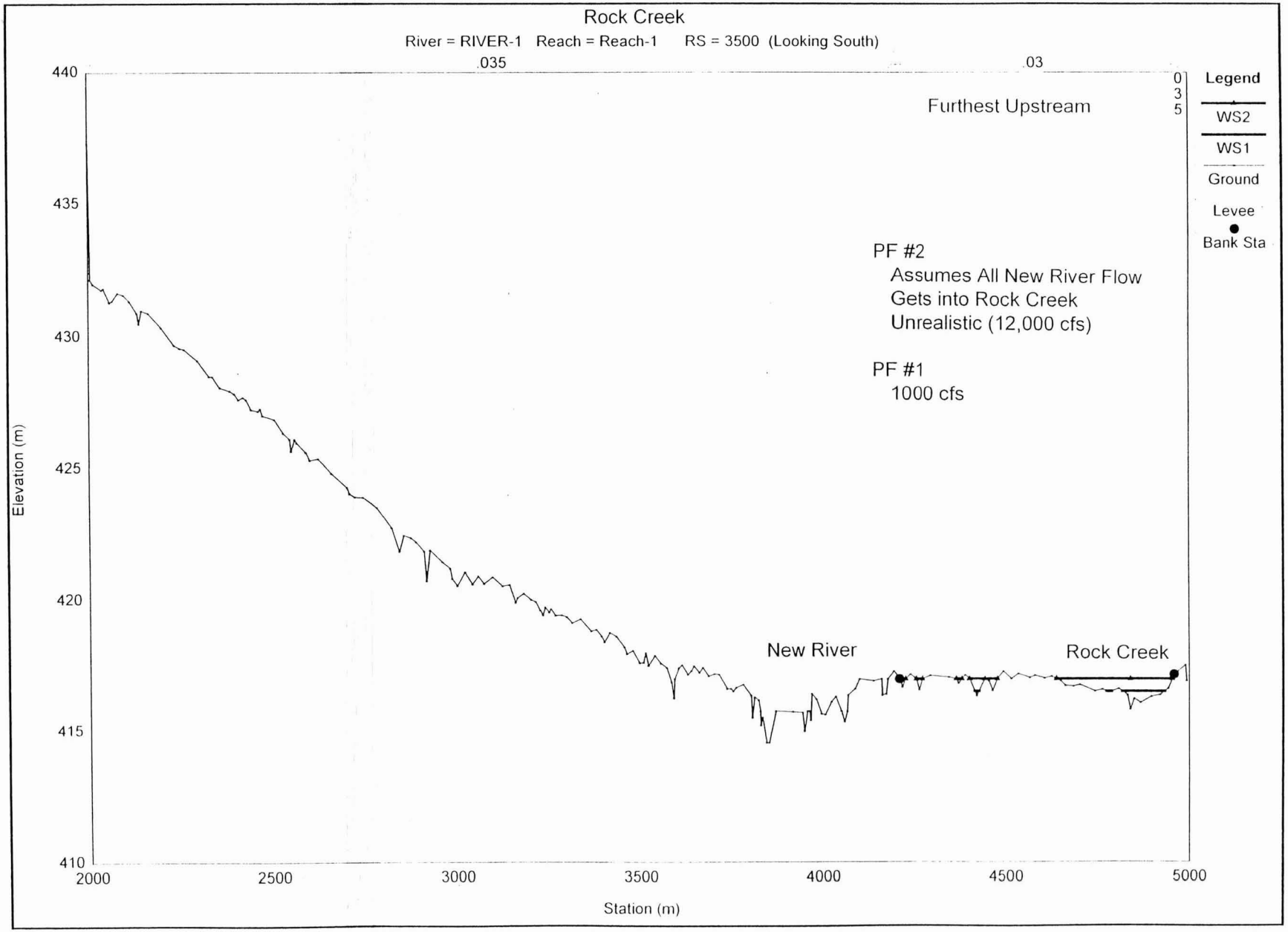
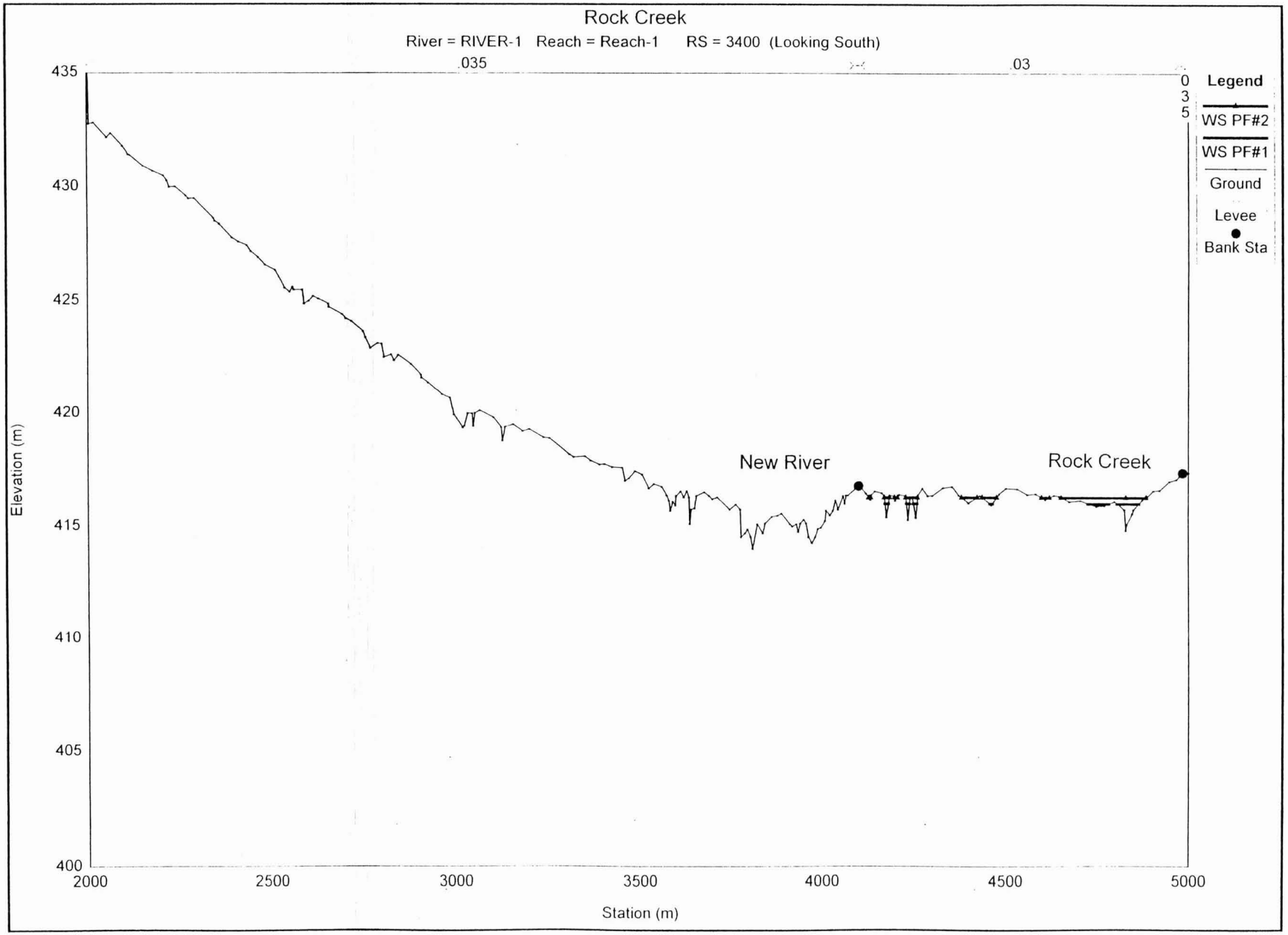
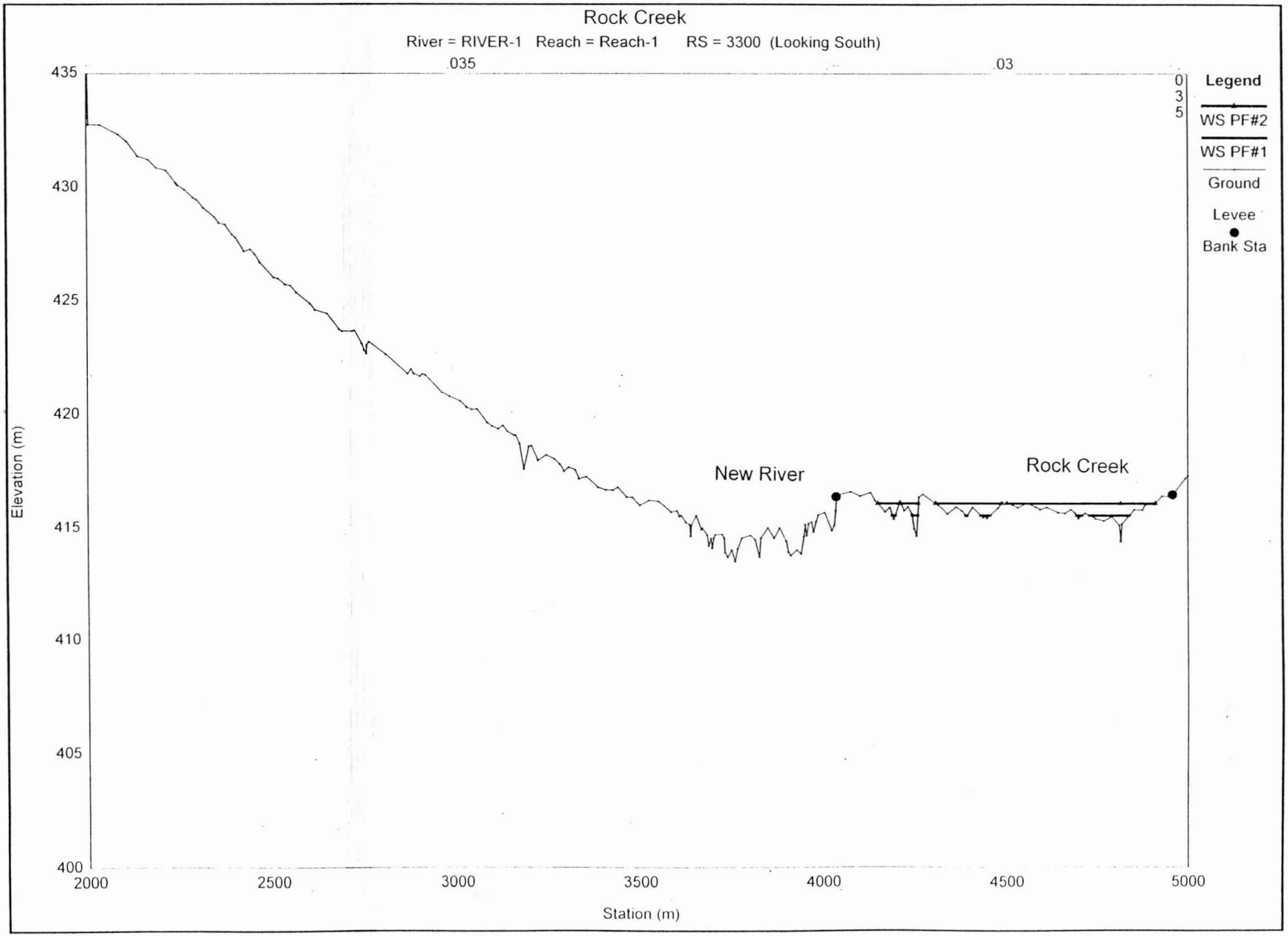
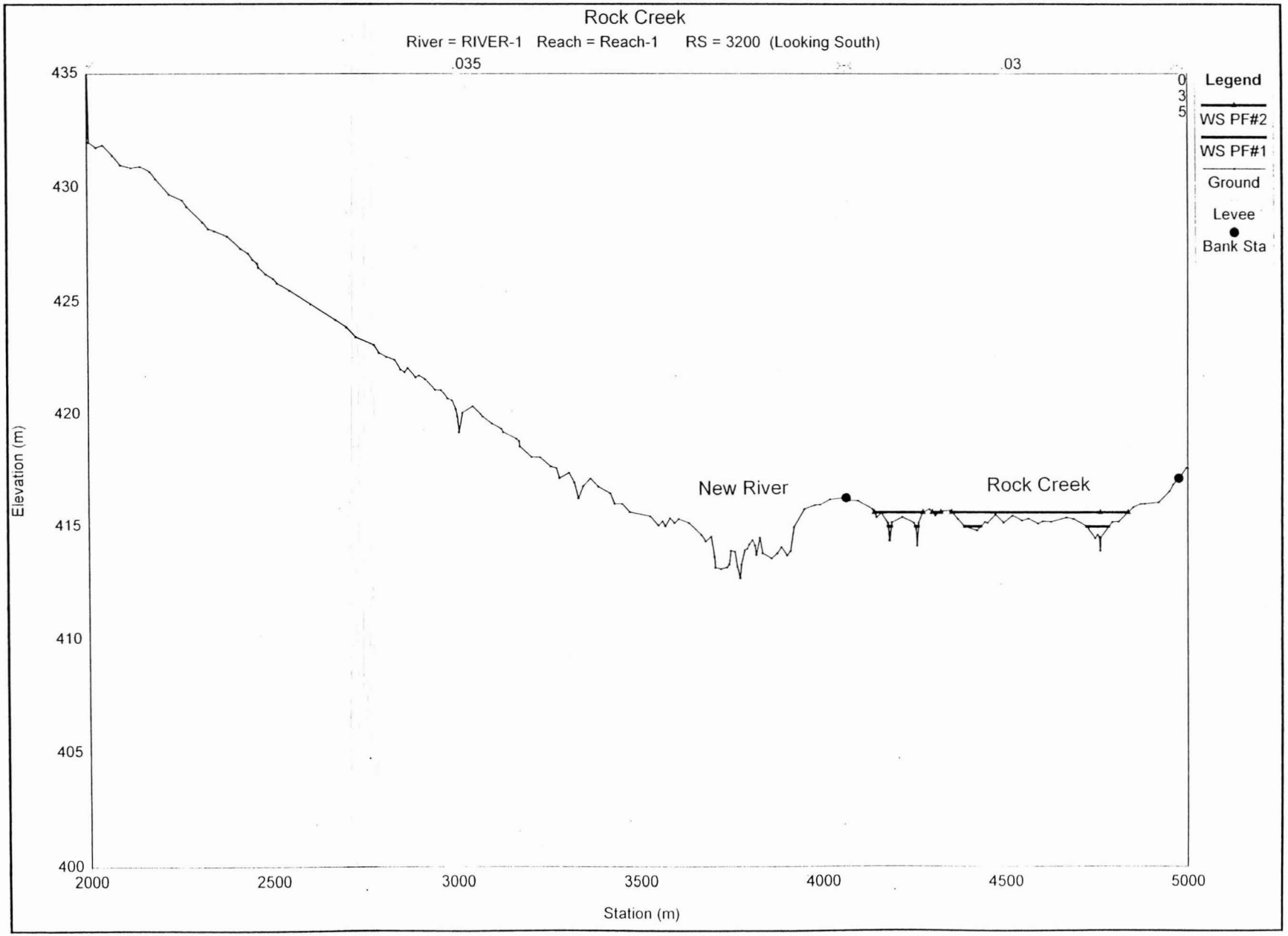
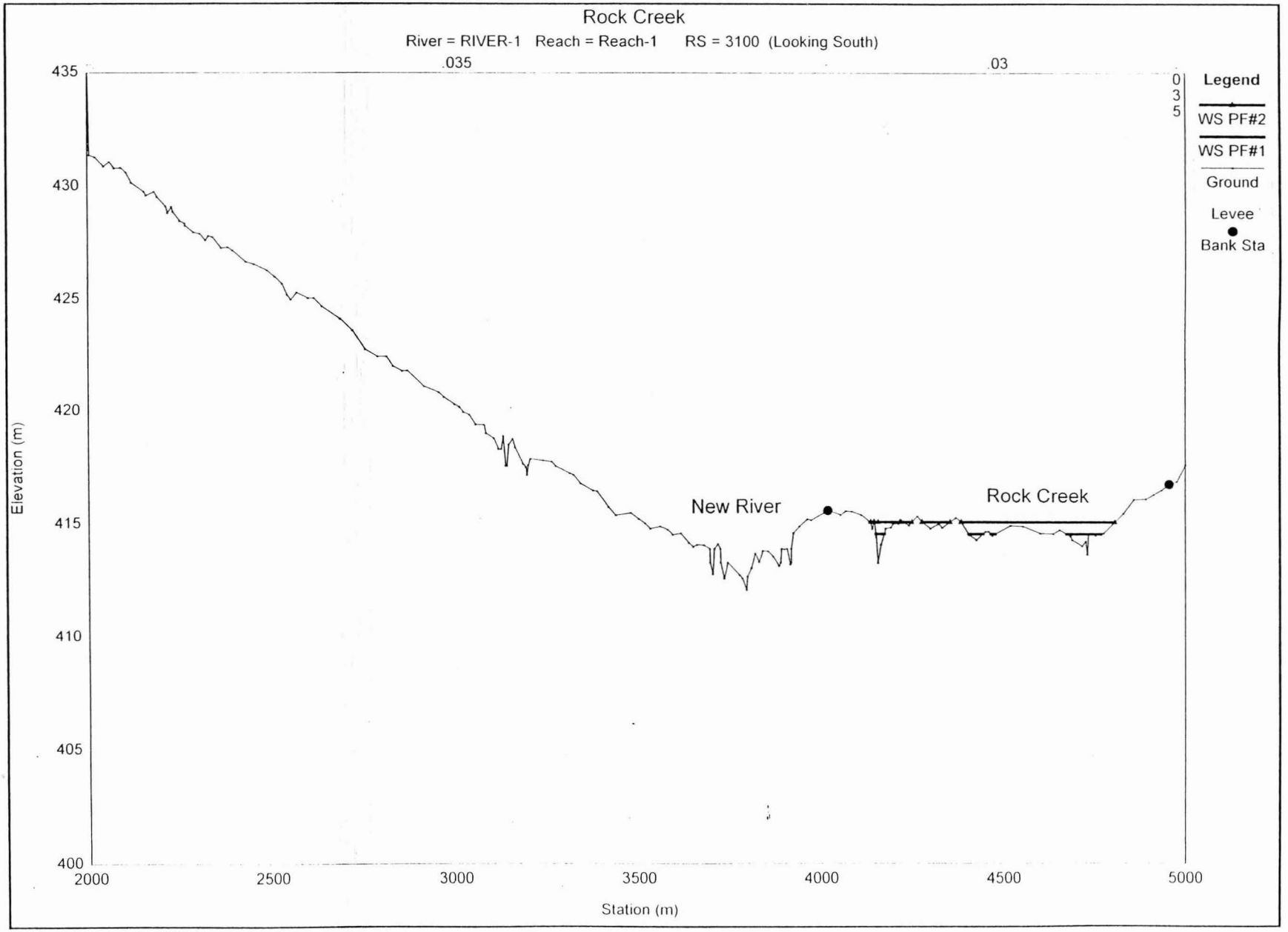
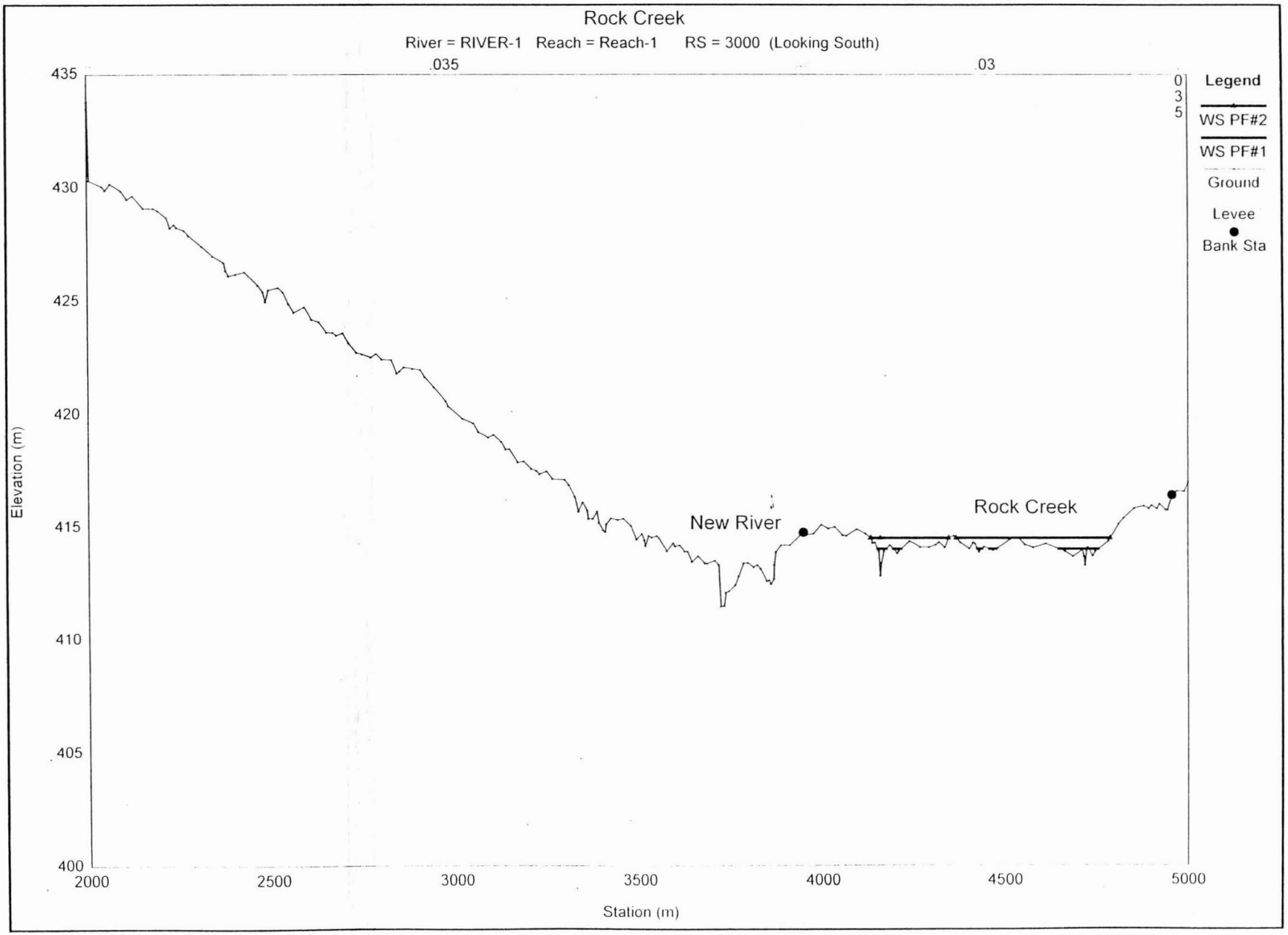

Rock Creek
River = RIVER-1 Reach = Reach-1 RS = 3500 (Looking South)
.035
.03
Furthest Upstream
Legend
WS2
WS1
Ground
Levee
Bank Sta
PF #2
Assumes All New River Flow
Gets into Rock Creek
Unrealistic (12,000 cfs)
PF #1
1000 cfs
New River
Rock Creek
Elevation (m)
Station (m)
440
435
430
425
420
415
410
2000
2500
3000
3500
4000
4500
5000

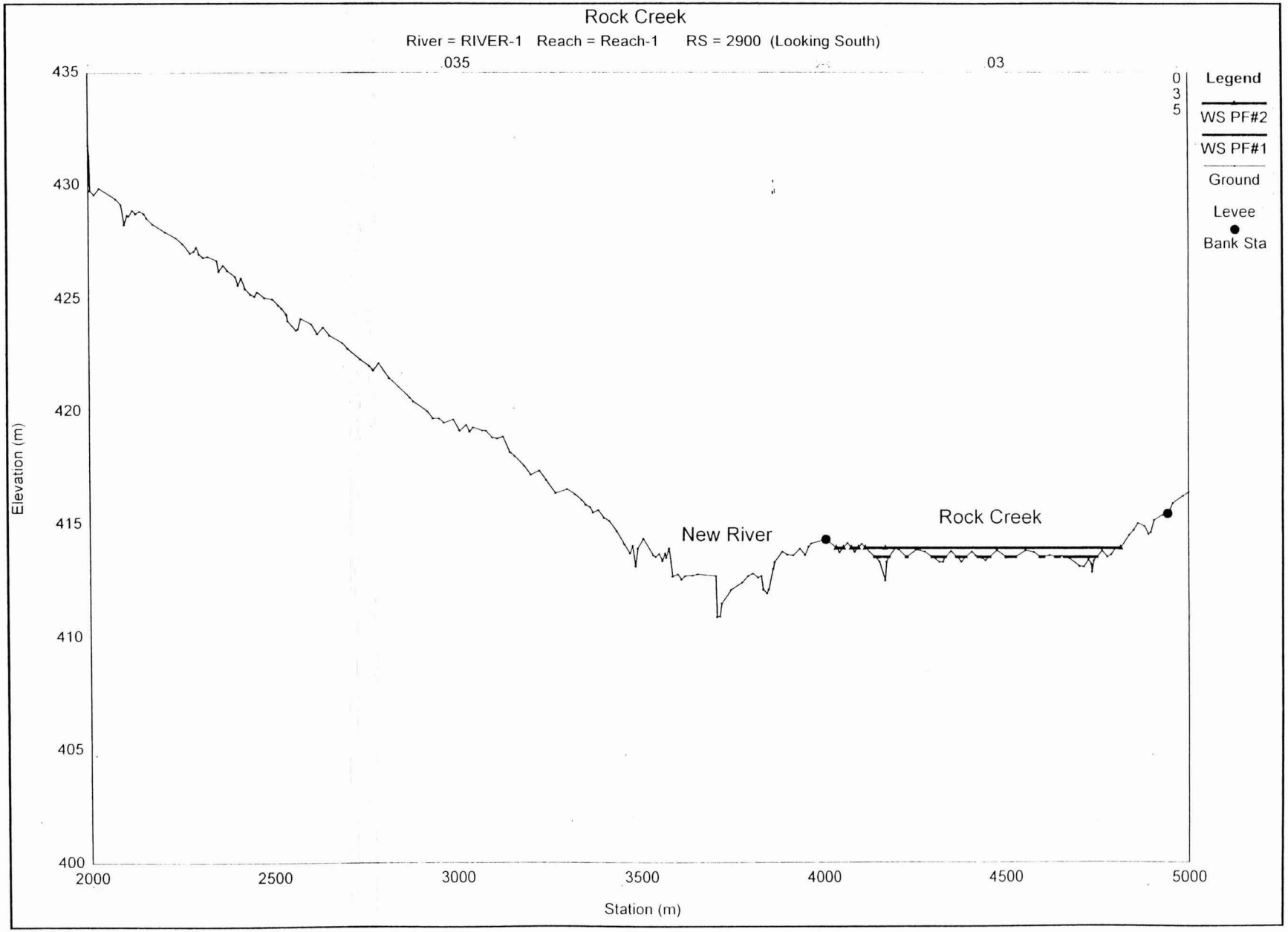

Rock Creek
River = RIVER-1 Reach = Reach-1 RS = 3400 (Looking South)
.035
.03
Legend
WS PF#2
WS PF#1
Ground
Levee
Bank Sta
New River
Rock Creek
Elevation (m)
Station (m)
435
430
425
420
415
410
405
400
2000
2500
3000
3500
4000
4500
5000

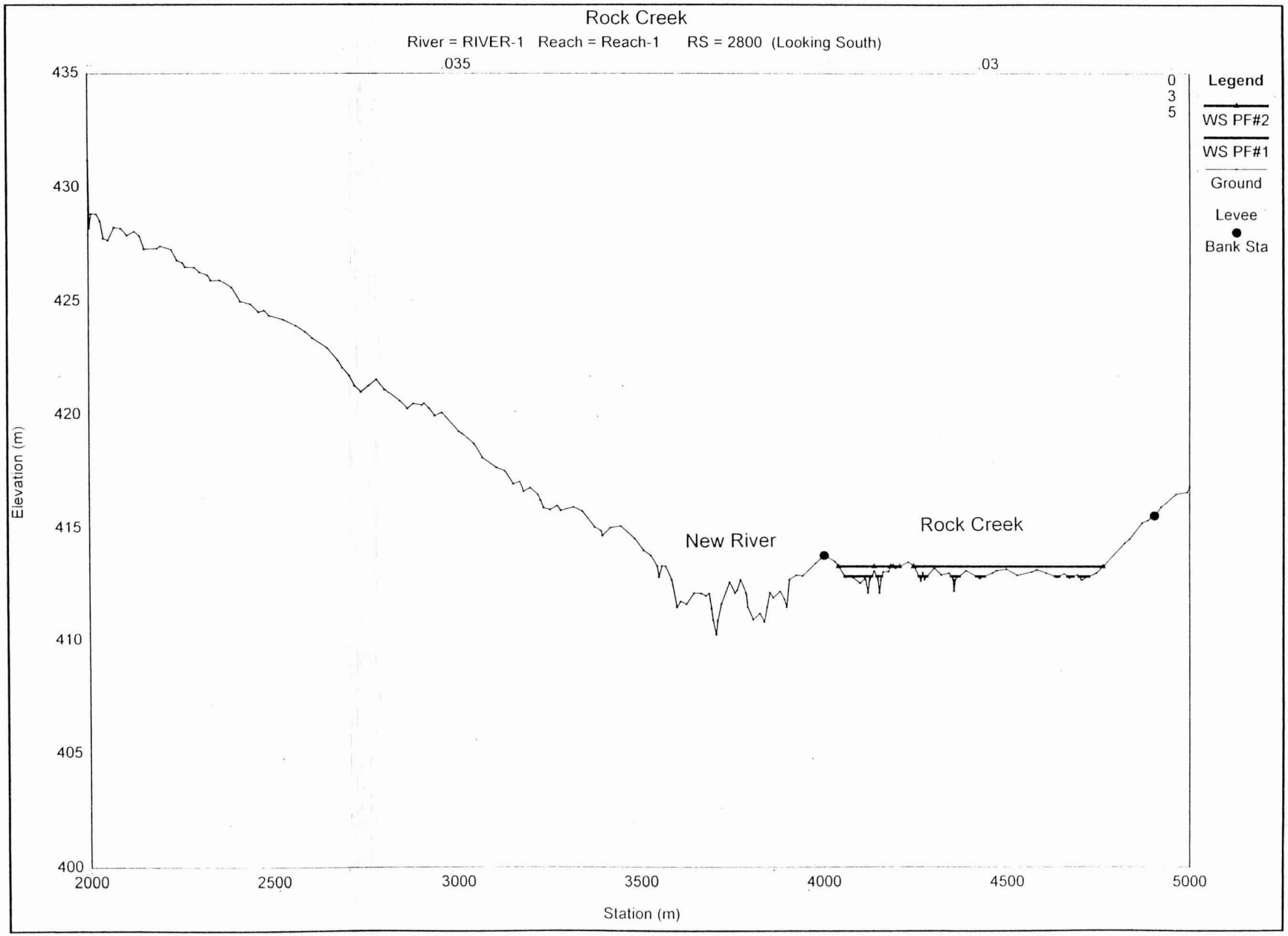

Rock Creek
River = RIVER-1 Reach = Reach-1 RS = 3300 (Looking South)
.035
.03
Legend
WS PF#2
WS PF#1
Ground
Levee
Bank Sta
New River
Rock Creek
Elevation (m)
Station (m)
435
430
425
420
415
410
405
400
2000
2500
3000
3500
4000
4500
5000

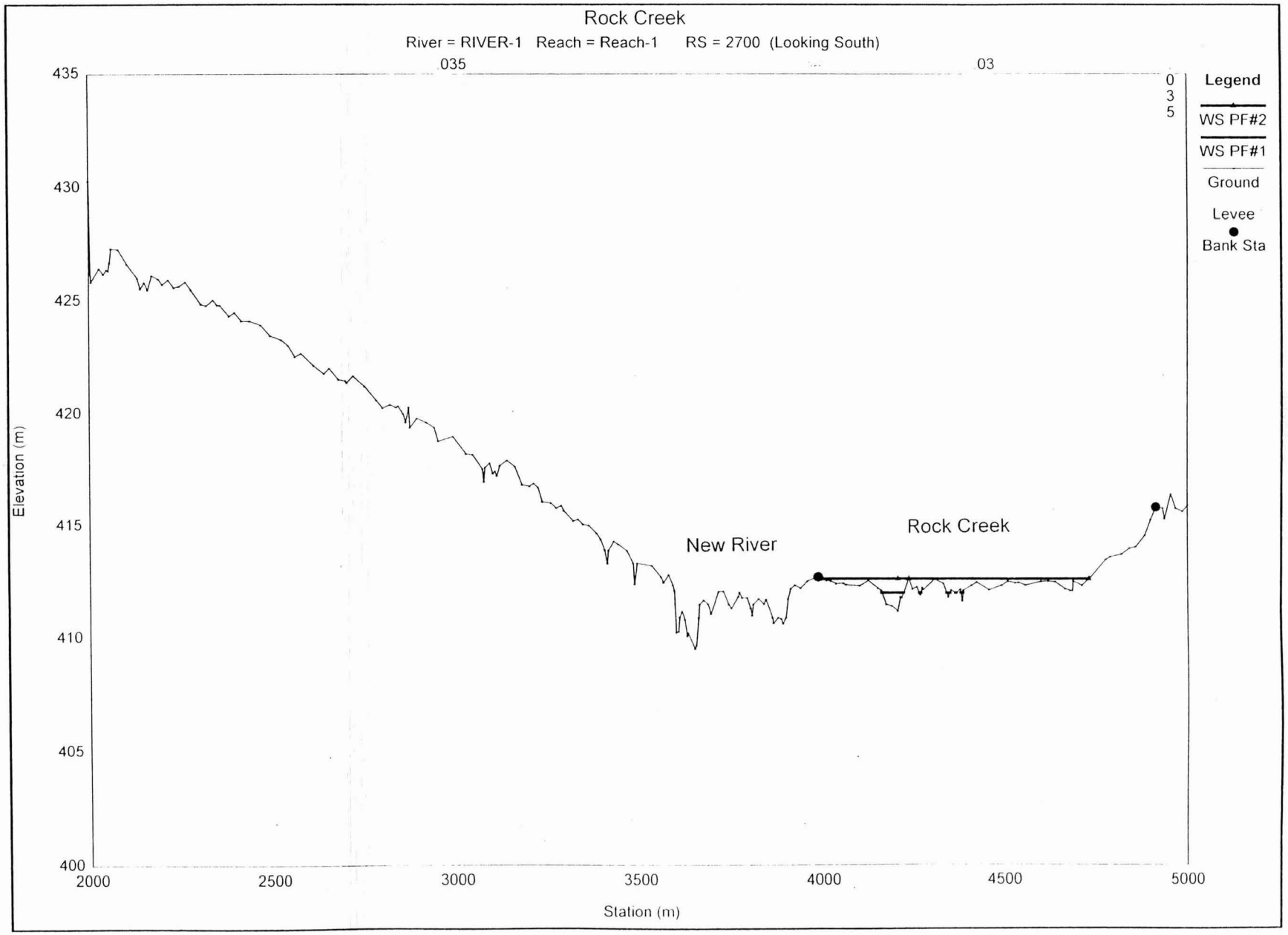

Rock Creek
River = RIVER-1 Reach = Reach-1 RS = 3200 (Looking South)
.035
.03
Legend
WS PF#2
WS PF#1
Ground
Levee
Bank Sta
New River
Rock Creek
Elevation (m)
Station (m)
435
430
425
420
415
410
405
400
2000
2500
3000
3500
4000
4500
5000

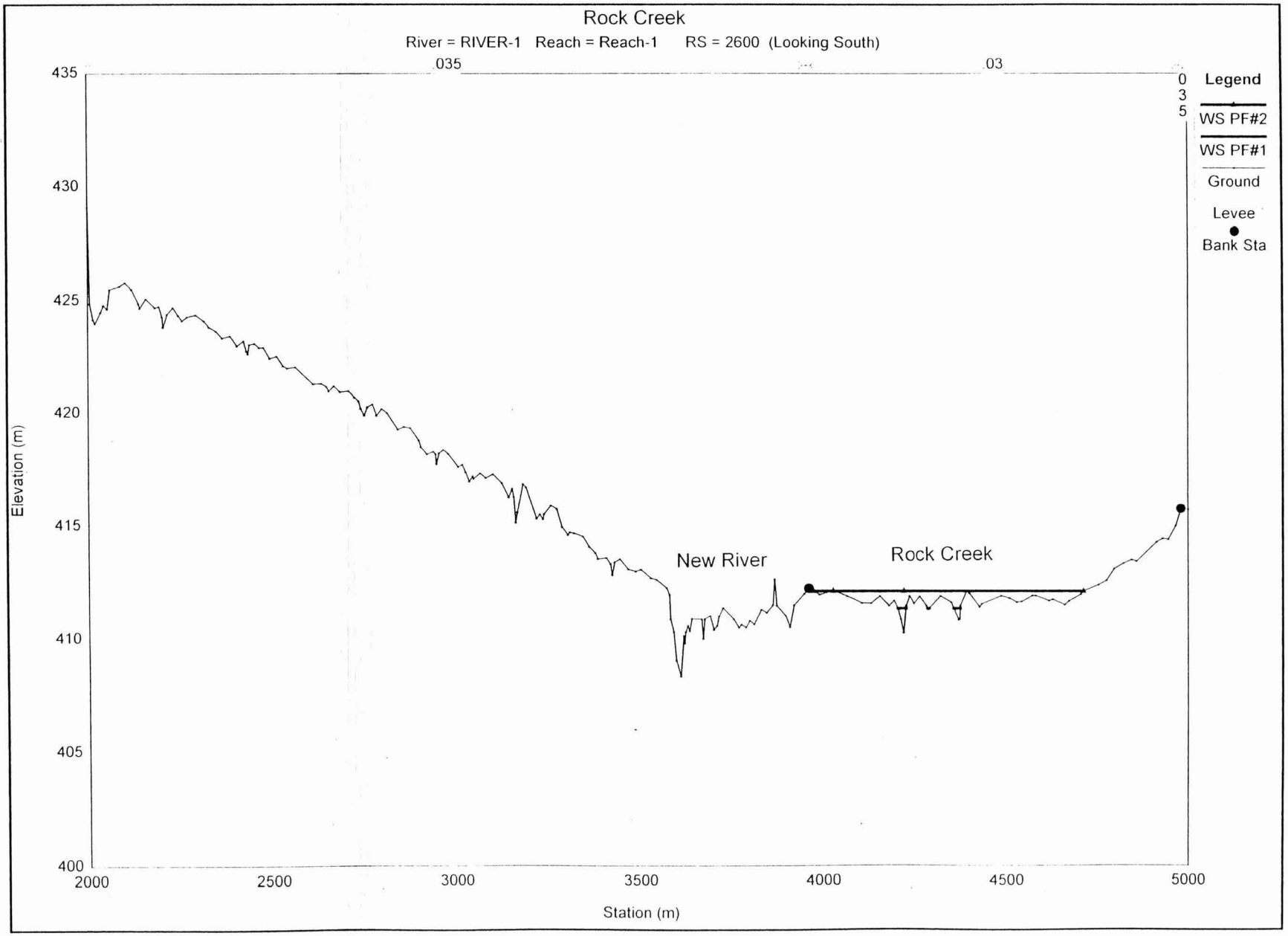

Rock Creek
River = RIVER-1 Reach = Reach-1 RS = 3100 (Looking South)
.035
.03
Legend
WS PF#2
WS PF#1
Ground
Levee
Bank Sta
Elevation (m)
435
430
425
420
415
410
405
400
2000
2500
3000
3500
4000
4500
5000
Station (m)
New River
Rock Creek

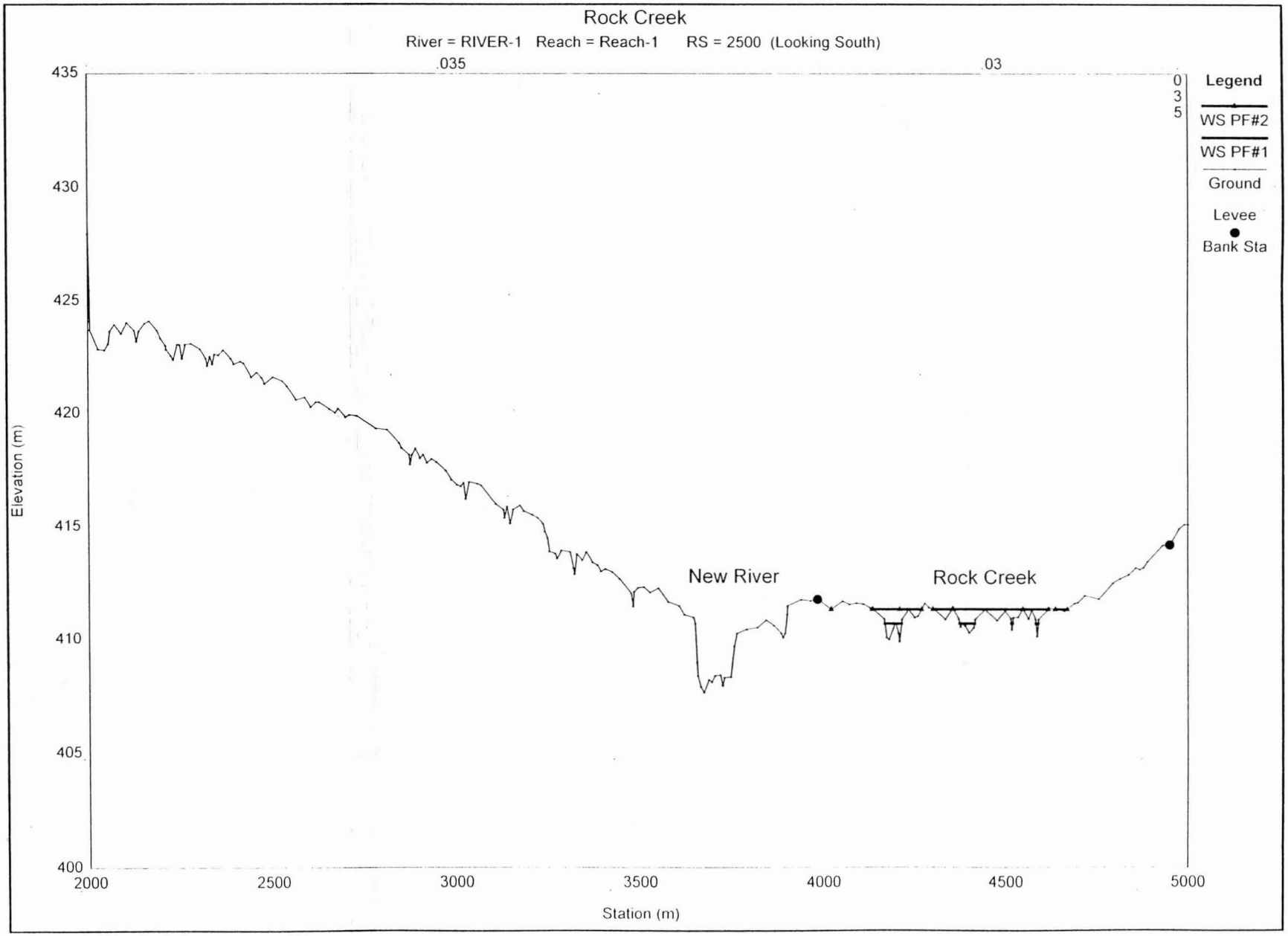

Rock Creek
River = RIVER-1 Reach = Reach-1 RS = 3000 (Looking South)
.035
.03
Legend
WS PF#2
WS PF#1
Ground
Levee
Bank Sta
New River
Rock Creek
Elevation (m)
Station (m)
435
430
425
420
415
410
405
400
2000
2500
3000
3500
4000
4500
5000

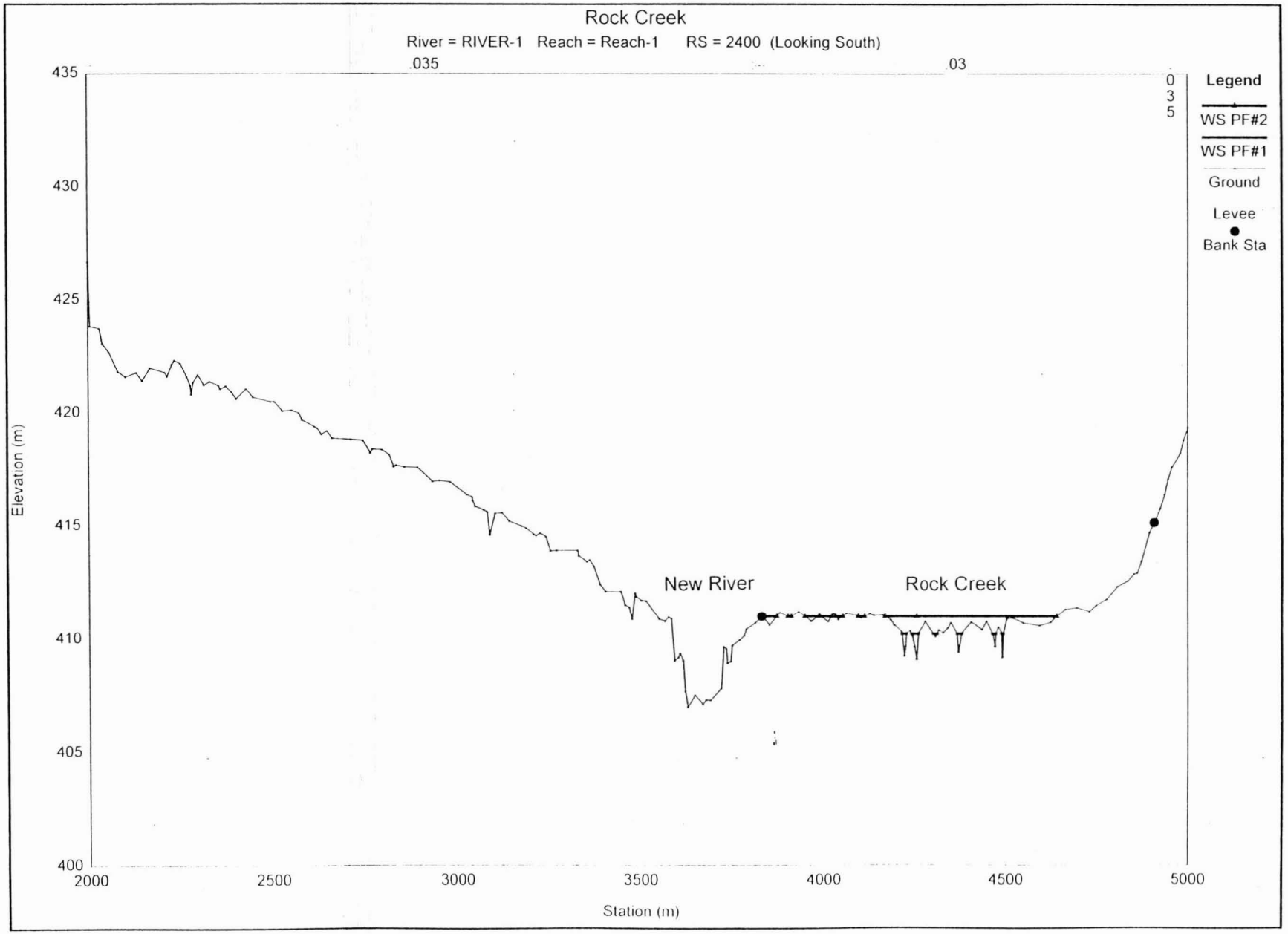

Rock Creek
River = RIVER-1 Reach = Reach-1 RS = 2900 (Looking South)
035
03
035
Legend
WS PF#2
WS PF#1
Ground
Levee
Bank Sta
Elevation (m)
435
430
425
420
415
410
405
400
2000
2500
3000
3500
4000
4500
5000
Station (m)
New River
Rock Creek

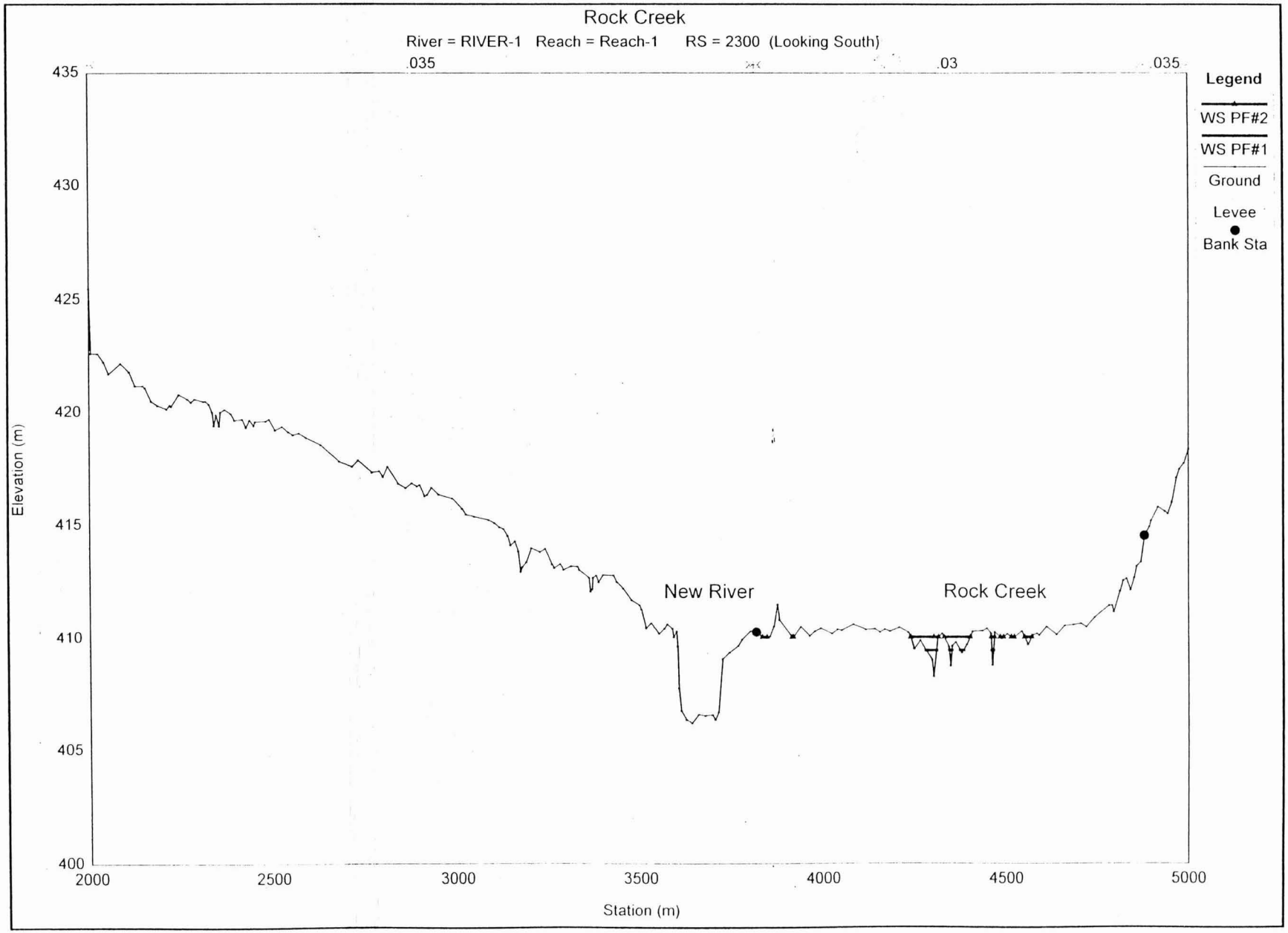

Rock Creek
River = RIVER-1 Reach = Reach-1 RS = 2800 (Looking South)
.035
.03
0
3
5
Legend
WS PF#2
WS PF#1
Ground
Levee
Bank Sta
435
430
425
420
415
410
405
400
Elevation (m)
New River
Rock Creek
2000
2500
3000
3500
4000
4500
5000
Station (m)

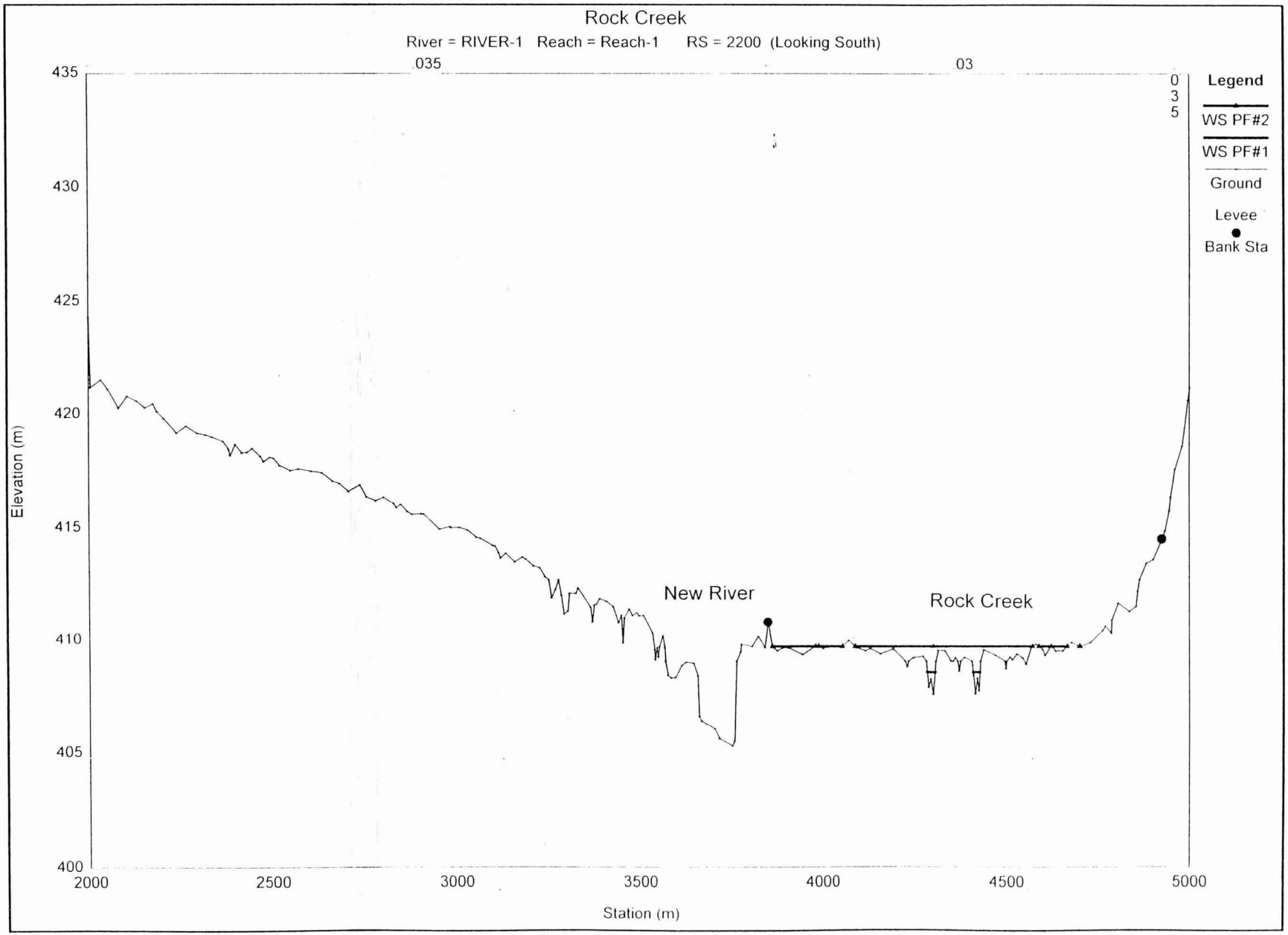

Rock Creek
River = RIVER-1 Reach = Reach-1 RS = 2700 (Looking South)
035
03
035
Legend
WS PF#2
WS PF#1
Ground
Levee
Bank Sta
435
430
425
420
415
410
405
400
Elevation (m)
New River
Rock Creek
2000
2500
3000
3500
4000
4500
5000
Station (m)

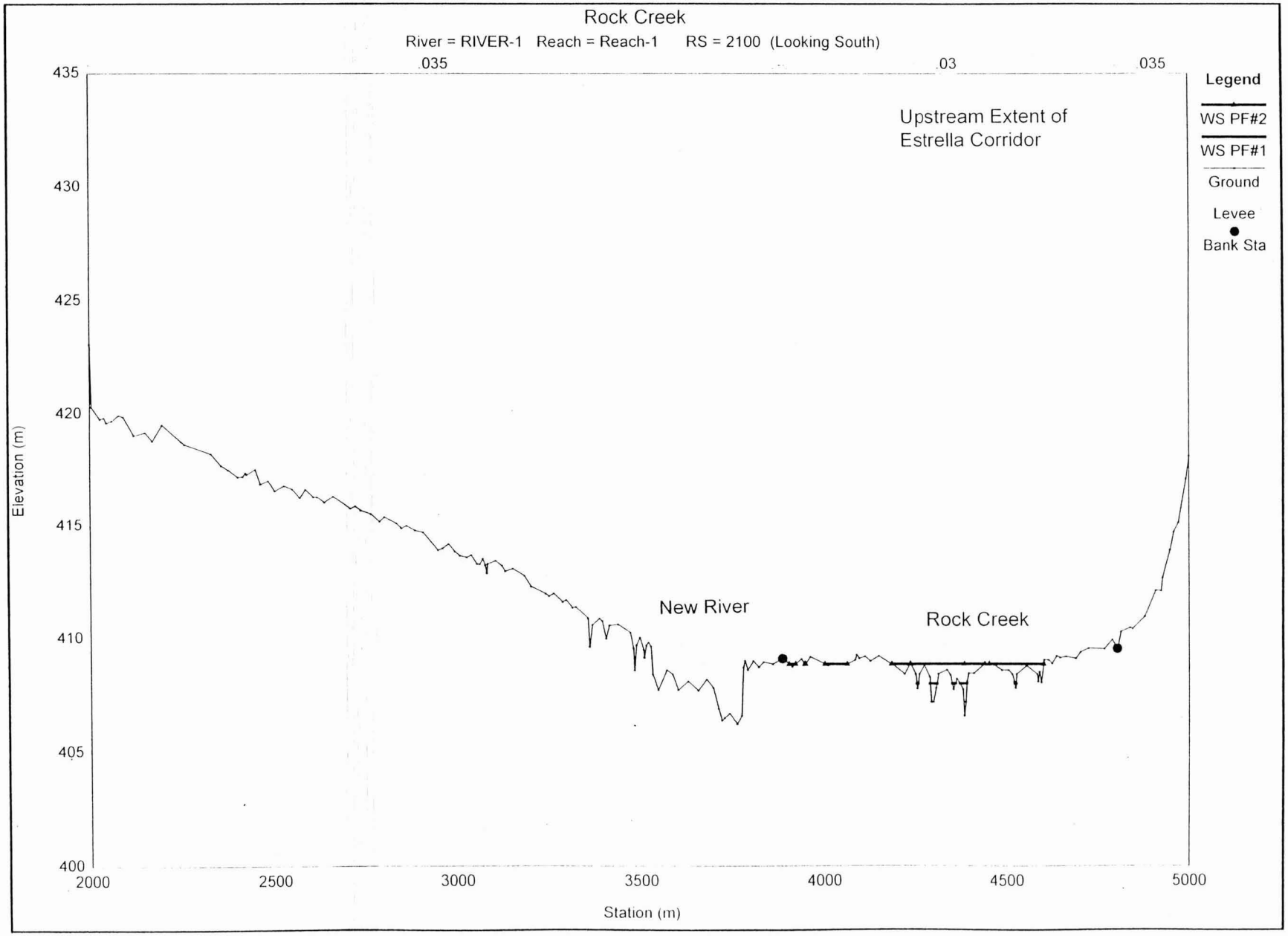

Rock Creek
River = RIVER-1 Reach = Reach-1 RS = 2600 (Looking South)
035
03
Legend
WS PF#2
WS PF#1
Ground
Levee
Bank Sta
Elevation (m)
435
430
425
420
415
410
405
400
2000
2500
3000
3500
4000
4500
5000
Station (m)
New River
Rock Creek

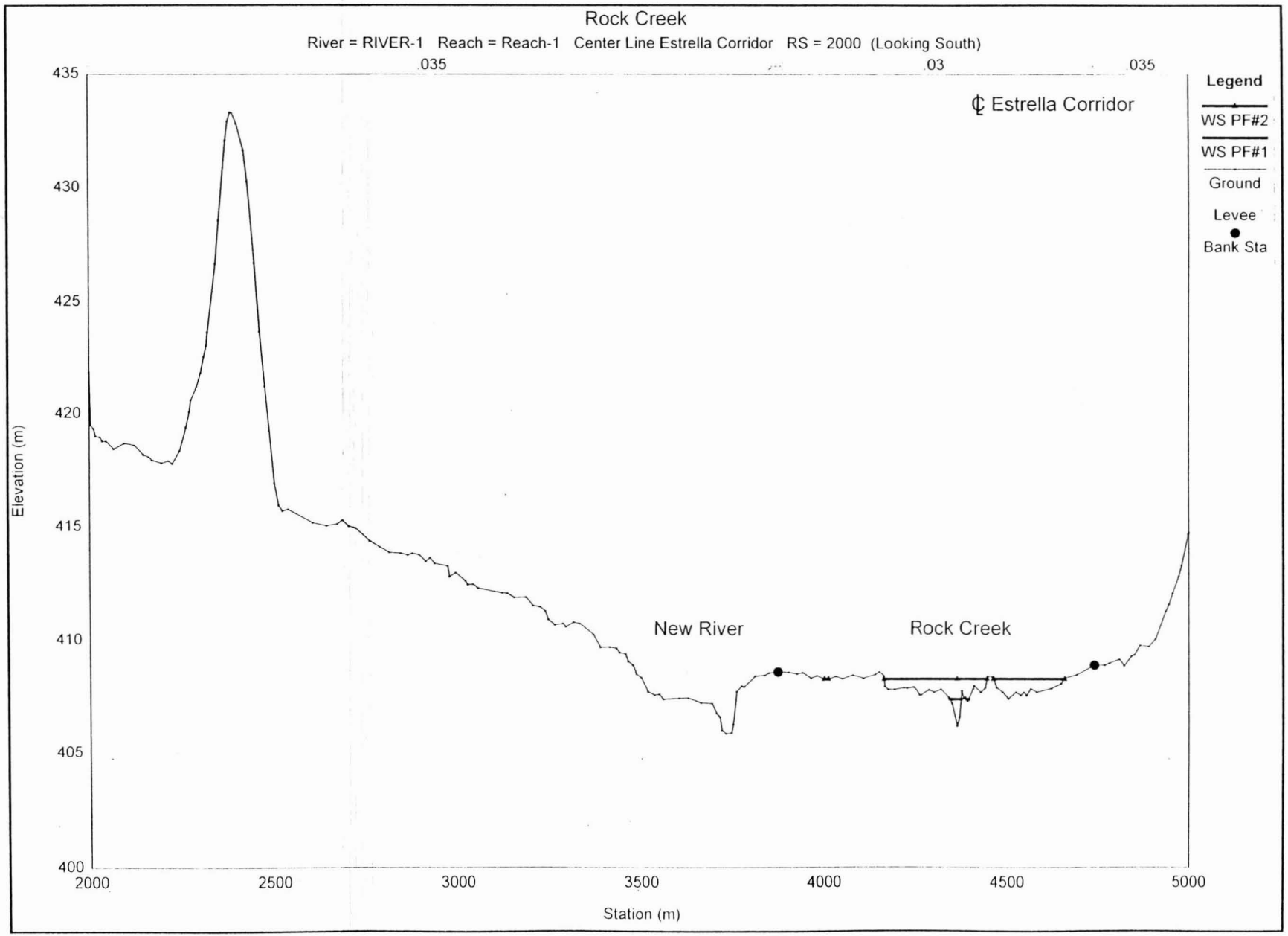

Rock Creek
River = RIVER-1 Reach = Reach-1 RS = 2500 (Looking South)
.035
.03
0
3
5
Legend
WS PF#2
WS PF#1
Ground
Levee
Bank Sta
435
430
425
420
415
410
405
400
Elevation (m)
New River
Rock Creek
2000
2500
3000
3500
4000
4500
5000
Station (m)

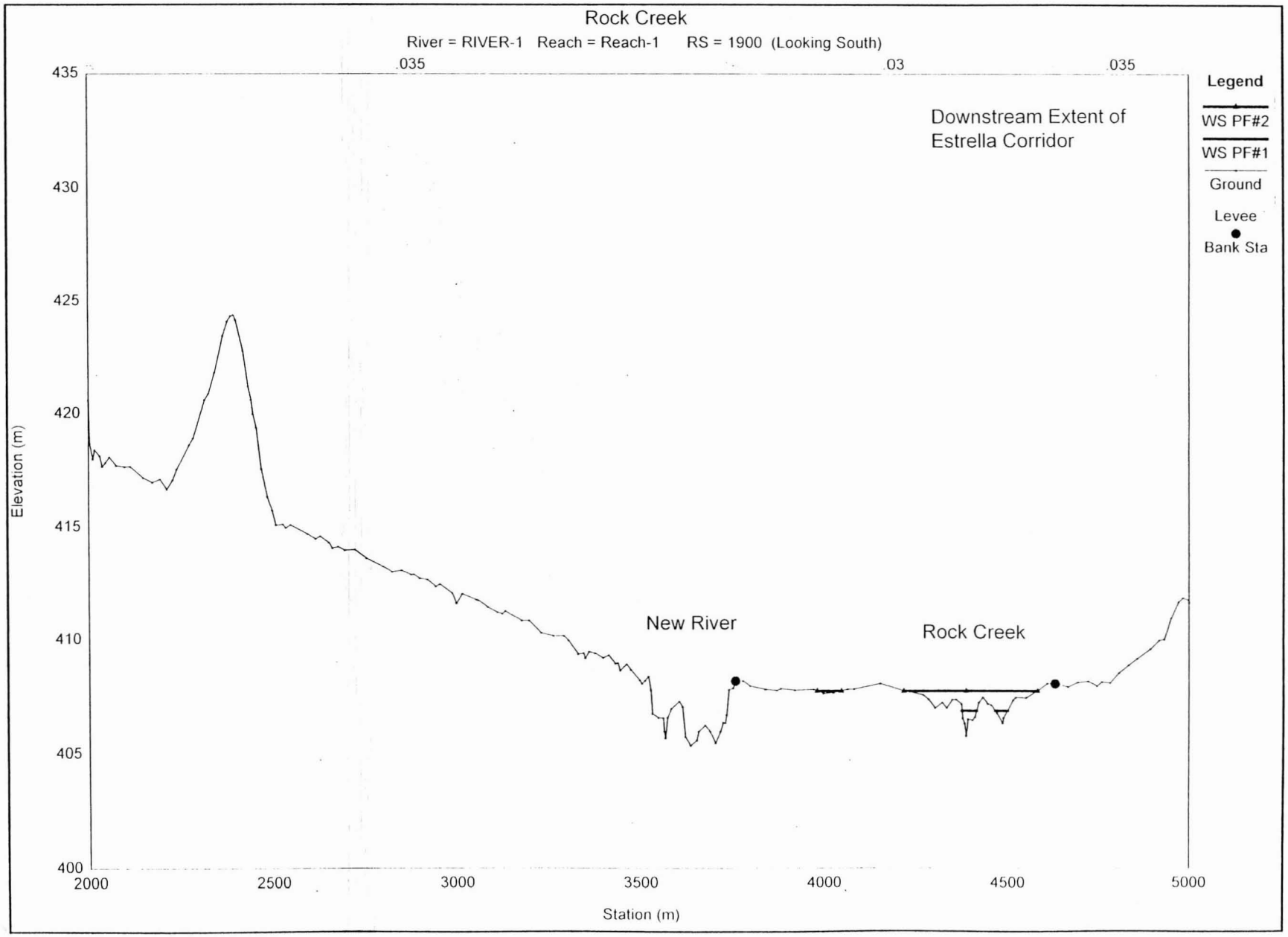

Rock Creek
River = RIVER-1 Reach = Reach-1 RS = 2400 (Looking South)
.035
.03
0
3
5
Legend
WS PF#2
WS PF#1
Ground
Levee
Bank Sta
435
430
425
420
415
410
405
400
Elevation (m)
New River
Rock Creek
2000
2500
3000
3500
4000
4500
5000
Station (m)

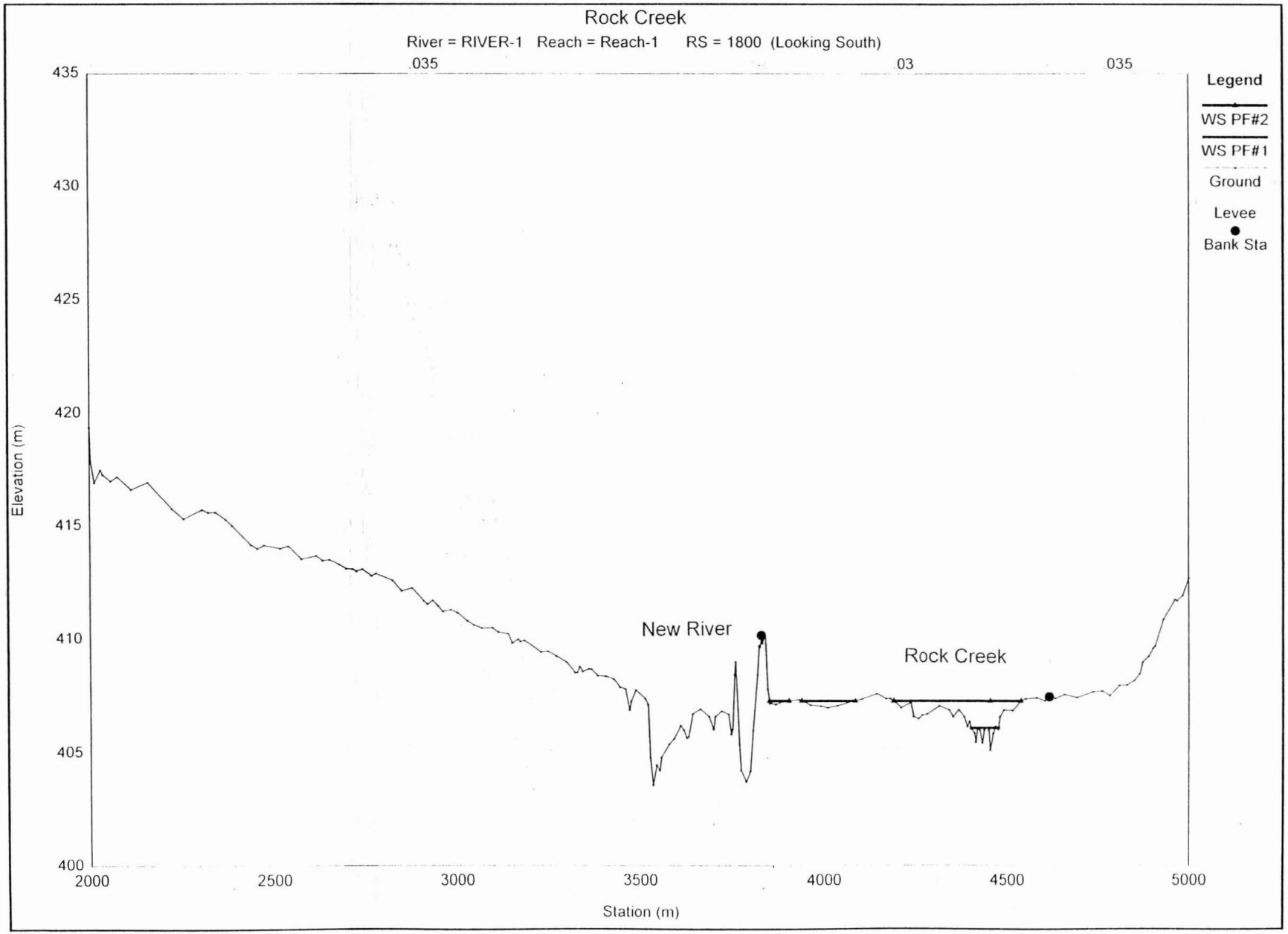

Rock Creek
River = RIVER-1 Reach = Reach-1 RS = 2300 (Looking South)
.035
.03
.035
Legend
WS PF#2
WS PF#1
Ground
Levee
Bank Sta
435
430
425
420
415
410
405
400
Elevation (m)
New River
Rock Creek
2000
2500
3000
3500
4000
4500
5000
Station (m)

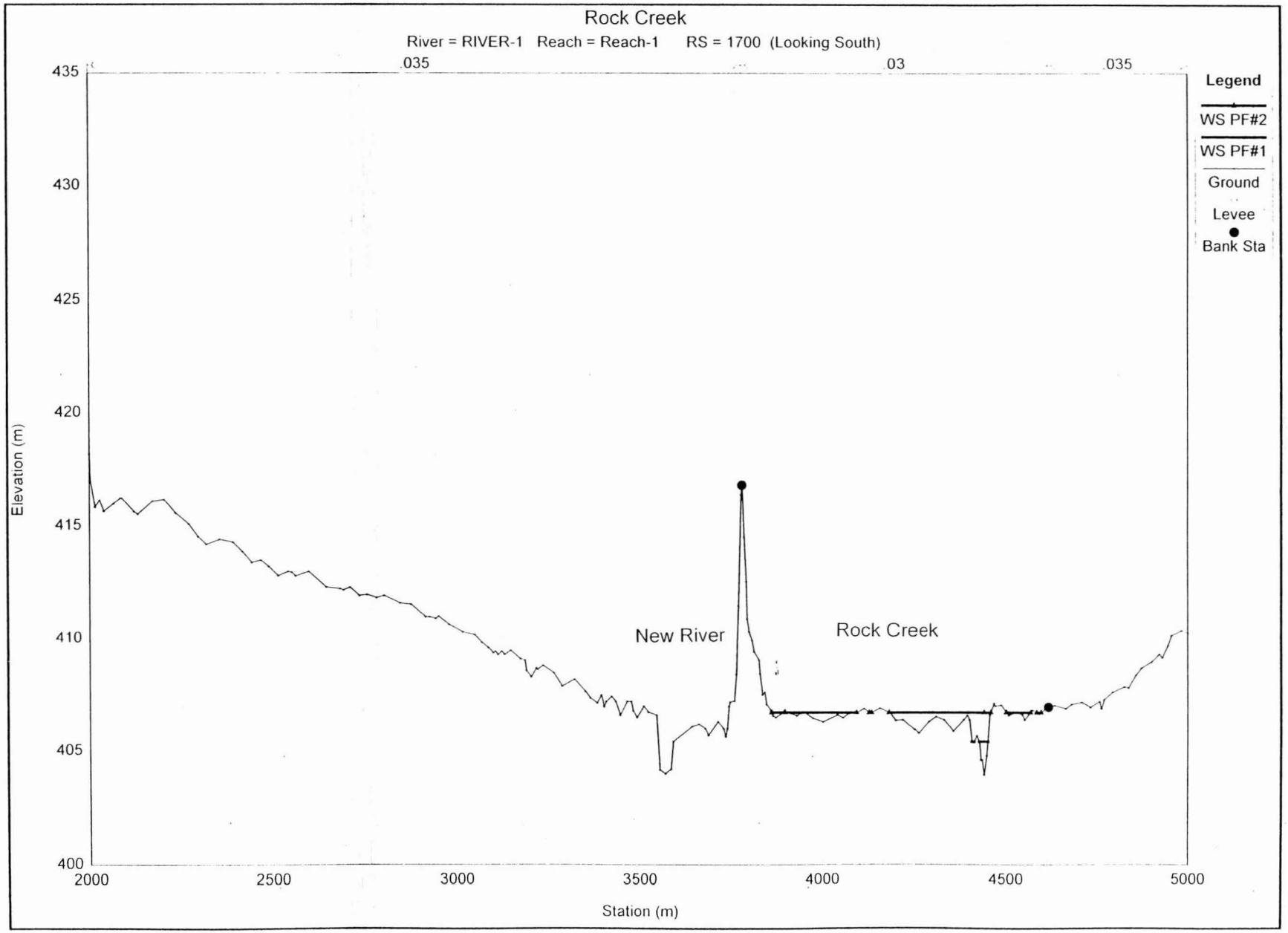

Rock Creek
River = RIVER-1 Reach = Reach-1 RS = 2200 (Looking South)
035
03
035
Legend
WS PF#2
WS PF#1
Ground
Levee
Bank Sta
435
430
425
420
415
410
405
400
Elevation (m)
New River
Rock Creek
2000
2500
3000
3500
4000
4500
5000
Station (m)

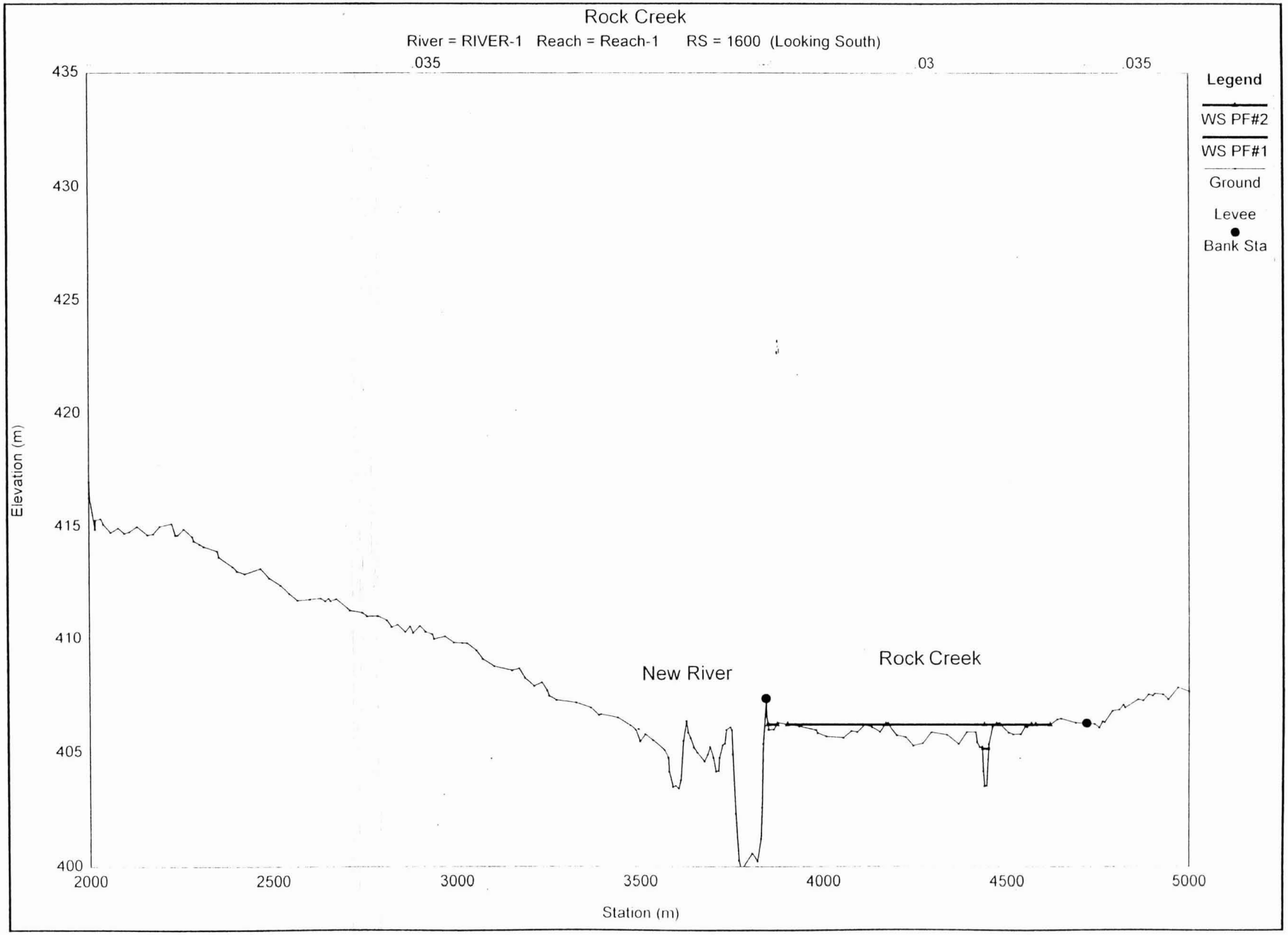

Rock Creek
River = RIVER-1 Reach = Reach-1 RS = 2100 (Looking South)
.035
.03
.035
Legend
WS PF#2
WS PF#1
Ground
Levee
Bank Sta
Upstream Extent of
Estrella Corridor
New River
Rock Creek
Elevation (m)
435
430
425
420
415
410
405
400
2000
2500
3000
3500
4000
4500
5000
Station (m)

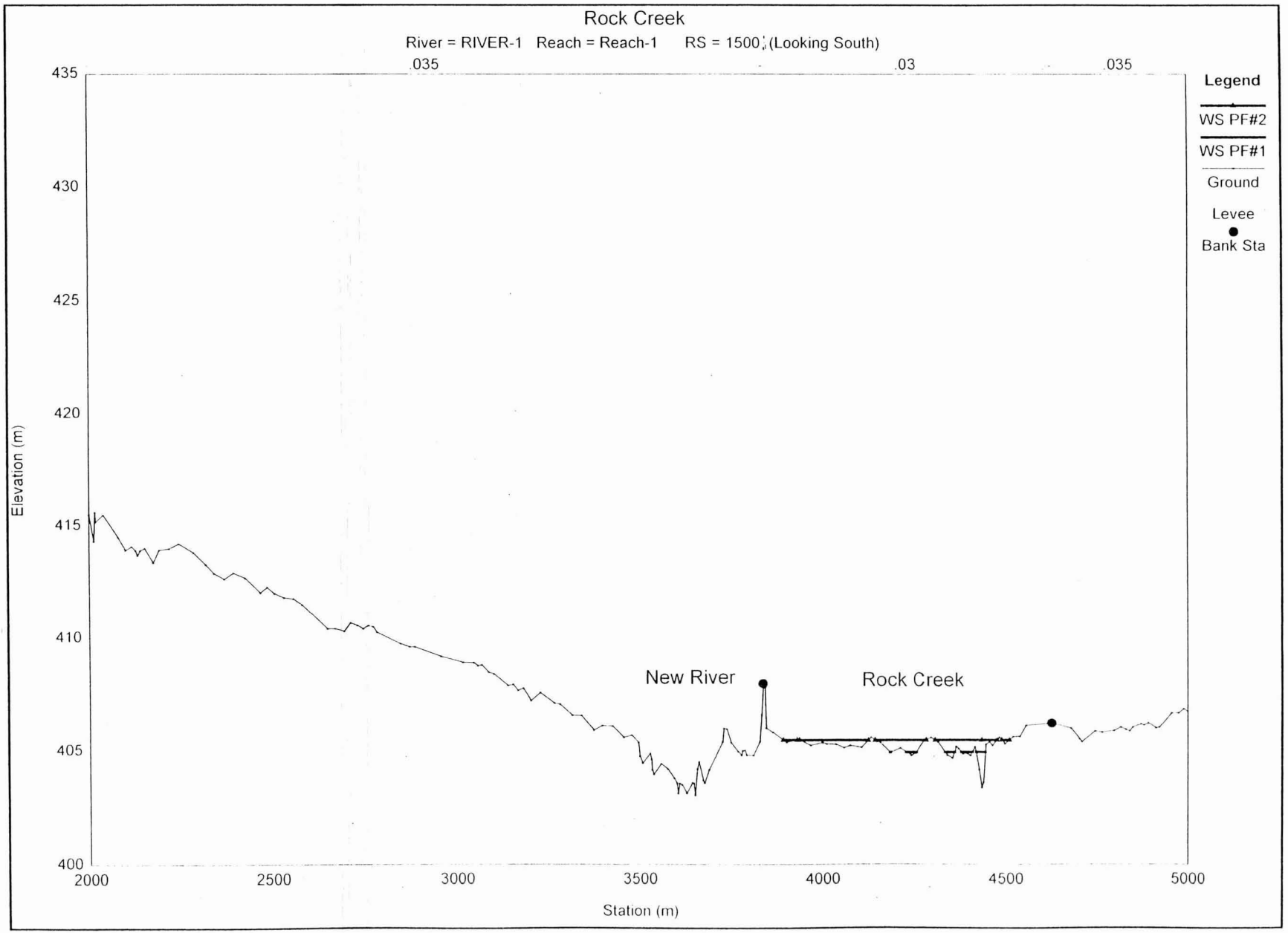

Rock Creek
River = RIVER-1 Reach = Reach-1 Center Line Estrella Corridor RS = 2000 (Looking South)
035
03
035
Legend
℄ Estrella Corridor
WS PF#2
WS PF#1
Ground
Levee
Bank Sta
New River
Rock Creek
Elevation (m)
435
430
425
420
415
410
405
400
2000
2500
3000
3500
4000
4500
5000
Station (m)

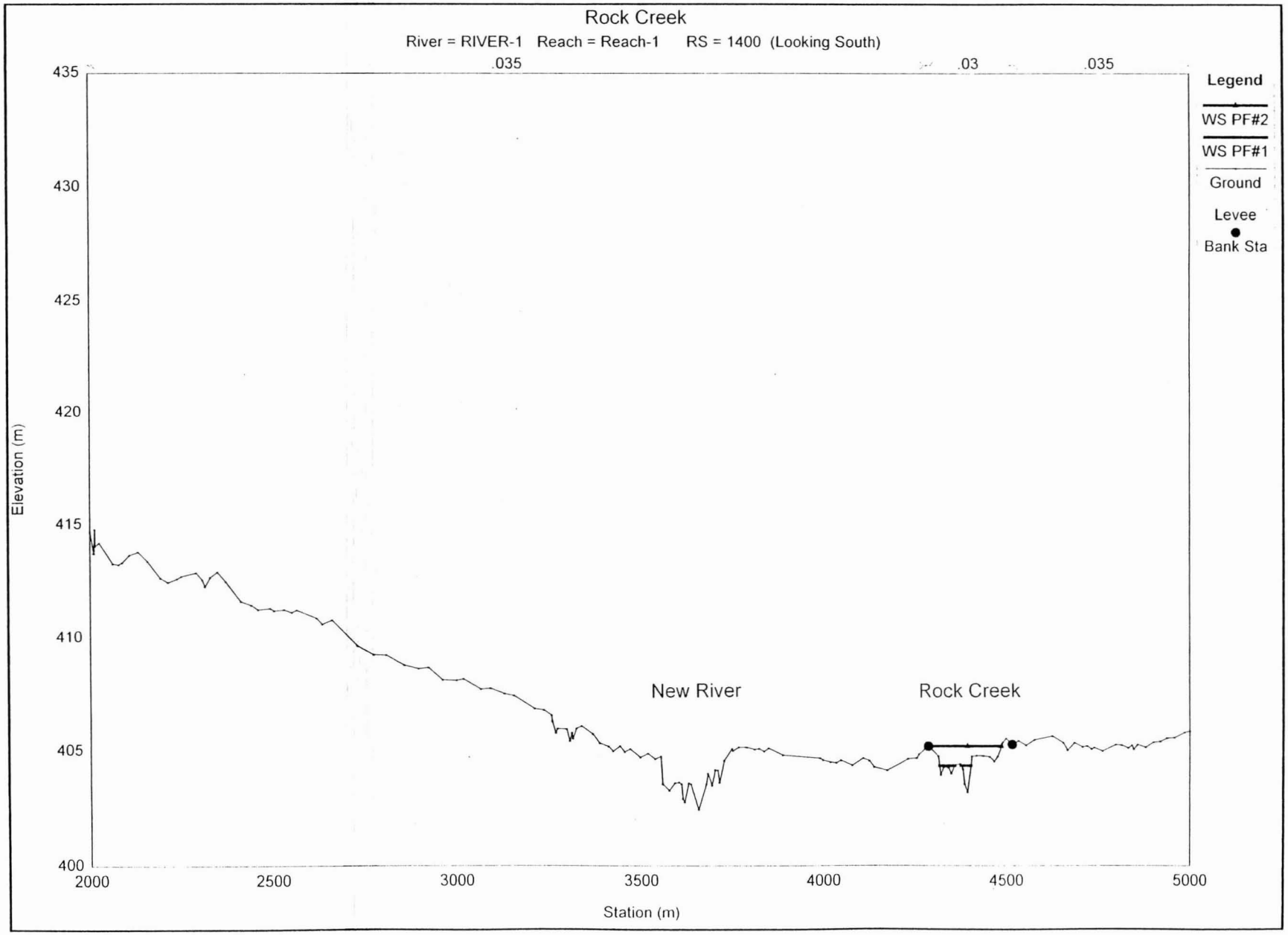

Rock Creek
River = RIVER-1 Reach = Reach-1 RS = 1900 (Looking South)
.035
.03
.035
Legend
WS PF#2
WS PF#1
Ground
Levee
Bank Sta
Downstream Extent of
Estrella Corridor
New River
Rock Creek
Elevation (m)
435
430
425
420
415
410
405
400
2000
2500
3000
3500
4000
4500
5000
Station (m)

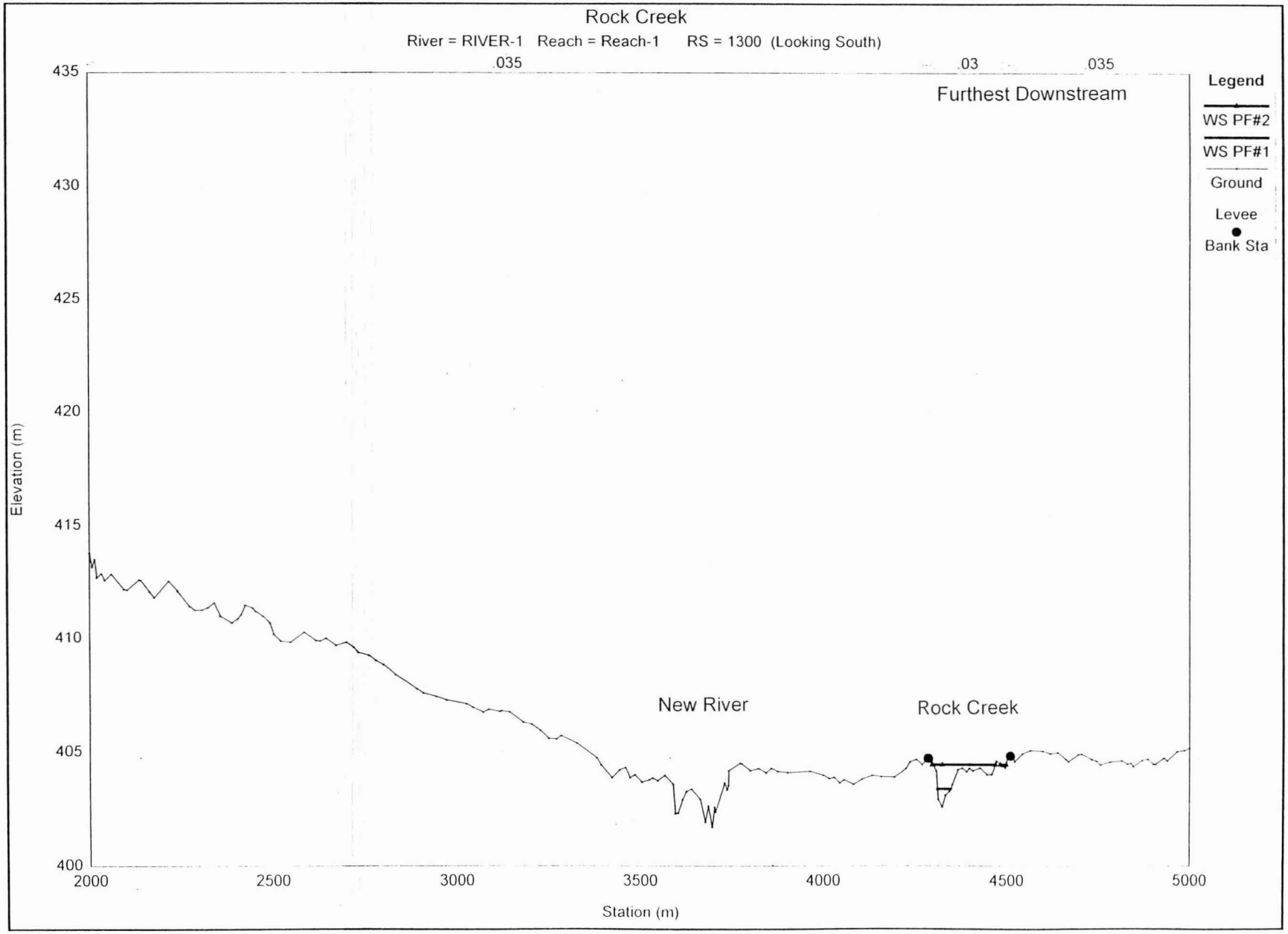

Rock Creek
River = RIVER-1 Reach = Reach-1 RS = 1800 (Looking South)
.035
.03
.035
Legend
WS PF#2
WS PF#1
Ground
Levee
Bank Sta
Elevation (m)
435
430
425
420
415
410
405
400
2000
2500
3000
3500
4000
4500
5000
Station (m)
New River
Rock Creek


Rock Creek
River = RIVER-1 Reach = Reach-1 RS = 1700 (Looking South)
.035
.03
.035
Legend
WS PF#2
WS PF#1
Ground
Levee
Bank Sta
Elevation (m)
435
430
425
420
415
410
405
400
2000
2500
3000
3500
4000
4500
5000
Station (m)
New River
Rock Creek


Rock Creek
River = RIVER-1 Reach = Reach-1 RS = 1600 (Looking South)
.035
.03
.035
Legend
WS PF#2
WS PF#1
Ground
Levee
Bank Sta
Elevation (m)
435
430
425
420
415
410
405
400
2000
2500
3000
3500
4000
4500
5000
Station (m)
New River
Rock Creek


Rock Creek
River = RIVER-1 Reach = Reach-1 RS = 1500 (Looking South)
.035
.03
.035
Legend
WS PF#2
WS PF#1
Ground
Levee
Bank Sta
Elevation (m)
435
430
425
420
415
410
405
400
2000
2500
3000
3500
4000
4500
5000
Station (m)
New River
Rock Creek


Rock Creek
River = RIVER-1 Reach = Reach-1 RS = 1400 (Looking South)
.035
.03
.035
Legend
WS PF#2
WS PF#1
Ground
Levee
Bank Sta
Elevation (m)
435
430
425
420
415
410
405
400
New River
Rock Creek
2000
2500
3000
3500
4000
4500
5000
Station (m)


Rock Creek
River = RIVER-1 Reach = Reach-1 RS = 1300 (Looking South)
.035
.03
.035
Furthest Downstream
Legend
WS PF#2
WS PF#1
Ground
Levee
Bank Sta
Elevation (m)
435
430
425
420
415
410
405
400
2000
2500
3000
3500
4000
4500
5000
Station (m)
New River
Rock Creek

ESTRELLA CORRIDOR STUDY

Drainage

Technical Memorandum

Appendix I

Drainage Area

Wash West of Lake Pleasant Road

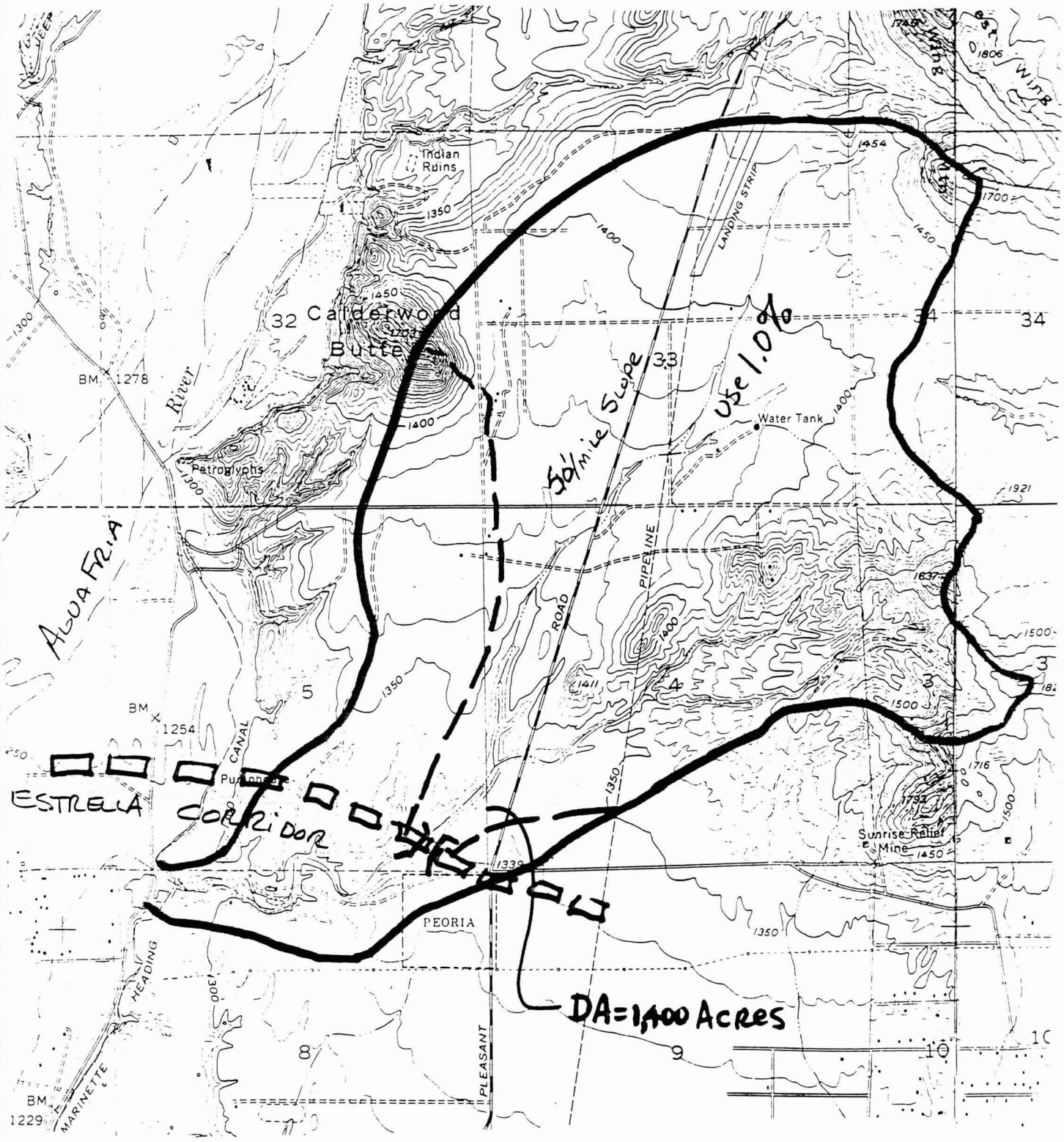
PARSONS TRANSPORTATION GROUP
DE LEUW, CATHER & COMPANY

PARSONS TRANSPORTATION GROUP
Barton-Aschman • De Leuw, Cather • Steinman

SUBJECT ESTRELLA CORRIDOR JOB NO. 641365 00100

SHEET NO. _____ OF _____

MADE BY POLASIK DATE 12/22/97 CHECKED BY _____ DATE _____



DRAINAGE AREA
SCALE = 1:24000