75th Avenue Storm Drain Project

(Salt River to Papago Freeway (I-10))

Alternatives Analysis for Connection to Durango Regional Conveyance Channel (DRCC)

City of Phoenix Project No. ST83110051

PREPARED FOR:

City of Phoenix
Street Transportation Department

PREPARED BY:

STANTEC CONSULTING INC.
8211 South 48th Street
Phoenix, Arizona 85044
(602) 438-2200

January 2005

STANTEC CONSULTING INC.
Project No. 82000265

Stantec

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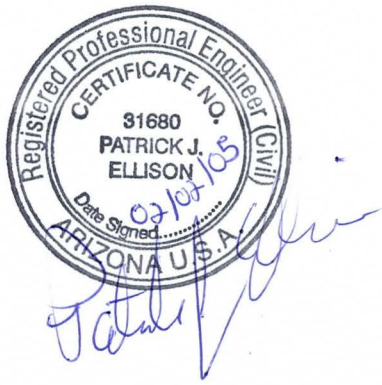

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EXECUTIVE SUMMARY

The 75th Avenue Storm Drain Project (Salt River to Papago Freeway (I-10)) Alternatives Analysis examines the potential for connecting Durango ADMP elements, namely the Durango Regional Conveyance Channel (DRCC), DRCC Basin #3, and DRCC Basin #4, to the proposed City of Phoenix (City) 75th Avenue Storm Drain. A total of six alternatives are evaluated to determine an economical arrangement of this combination. Three of the alternatives (1, 2, & 3) deal with the location and size of DRCC Basin #4 and how it connects to the 75th Avenue Storm Drain. Two other alternatives (4 & 5) deal with the location and function of DRCC Basin #3. The last alternative (6) evaluates an alternative retention basin location approximately 1/3 mi north of Broadway Road between the 69th and 71st Avenue alignments.

The study shows that three of the alternatives (1, 2, & 3) will function to reduce peak discharges entering the storm drain system. The least expensive option is Alternative 2, because it requires the least amount of storm drain pipe to drain flow from DRCC Basin #4 to the Salt River.

Through the analysis, it is demonstrated there is no need for DRCC Basin #3, the major element of Alternatives 4 and 5, and as such these two alternatives are dropped. However, there is a need for the Santa Maria Basin (Alternative 6) farther to the south to reduce the flow rates in the 75th Avenue storm drain trunk line below Broadway Road. The basin should be located to retain the flow generated in a watershed located between 71st and 67th Avenues upstream of Broadway Road.

The trunk line evaluation involves sizing the storm drain to at least convey the 10-year event, and then increasing them as necessary to convey the 100-year peak discharges from the combination of DRCC Basin #4 outflow plus flow from the laterals to the storm drain trunk line. Pipe size increases continue until the maximum water surface elevation within DRCC Basin #4 is within 1 foot of overtopping.

The recommendation (Preferred Alternative) is to combine the least expensive option (Alternative 2) with the construction of the Santa Maria Basin (Alternative 6) to carry the 100-year peak discharges from DRCC Basin #4 to the outfall on the Salt River.

SUMMARY

The 75th Avenue Storm Drain Project (Salt River to Papago Freeway (I-10)) Alternatives Analysis for Connection to Durango Regional Conveyance Channel (DRCC) involves the evaluation of alternatives for the connection of Durango Area Drainage Master Plan (ADMP) drainage facilities proposed by the Flood Control District (District) of Maricopa County to the proposed City of Phoenix (City) 75th Avenue Storm Drain. Elements of the Durango ADMP include regional detention facilities and conveyance channels. Specifically, this project evaluated the feasibility of connecting Durango ADMP elements, namely the DRCC, and DRCC Basin #3 and DRCC Basin #4, to the 75th Avenue Storm Drain. Figure 1 (page 3) shows the location of the project within Maricopa County and relative to major freeways and the Salt River. The project location and proposed ADMP elements in relation to Federal Emergency Management Agency (FEMA) flood hazard zones is depicted on Figure 2 (page 4).

A total of six alternatives are evaluated to determine an economical arrangement of combining the 75th Avenue Storm Drain and the DRCC and eliminating some of the DRCC proposed basins. Three of the alternatives deal with the location and size of DRCC Basin #4 and how it connects to the 75th Avenue Storm Drain. Two other alternatives deal with the location and function of DRCC Basin #3. The last alternative evaluates an alternative retention basin (Santa Maria Basin) location near 71st Avenue and Broadway Road.

For all alternatives, it is assumed that the trunk line in 75th Avenue is sized to convey, at a minimum, the 10-year runoff event from the contributing drainage area.

Alternatives evaluated are:

Alternative 1

In this alternative, DRCC Basin #4 will be connected to the 75th Avenue Storm Drain trunk line just upstream of the Union Pacific Railroad crossing of 75th Avenue. The basin will be designed to attenuate the peak discharge from the 100-year and 10-year runoff

events. The intent of this alternative is to determine the feasibility of eliminating or reducing in size the DRCC and associated drainage improvements that drain storm water flow between DRCC Basin #3 and DRCC Basin #4. DRCC Basin #3 may also be downsized or eliminated. The alignment of Alternative 1 is depicted in Figure 3 (page 8).

Alternative 2

Alternative 2 involves utilizing DRCC Basin #4 as described in Alternative 1, along with utilizing the existing Target site retention basin located immediately west of DRCC Basin #4. This alternative is included to determine if there is benefit in increasing the storage volume beyond what was obtainable in Alternative 1 and to provide a closer location for the basin outlet works to the storm drain trunk line. The alignment of Alternative 2 is depicted in Figure 4 (page 9).

Alternative 3

A major element of Alternative 3 includes utilizing DRCC Basin #4 as described in Alternative 1; however, the storm drain trunk line draining the basin is relocated. In this alternative, the trunk line draining the basin extends from the basin to the south, following the 71st Avenue alignment to Buckeye Road then continuing westerly within the Buckeye Road Right-of-Way to the intersection of Buckeye Road and 75th Avenue. The intent of this alternative is to determine the benefit of moving the basin outfall east to a location where jacking and boring under the tracks and the canal is easier, and also to reduce the cost of the trunk line. The alignment of Alternative 3 is depicted in Figure 5 (page 10).

Alternative 4

Alternative 4 consists of utilizing DRCC Basin #4 as described in Alternative 1 and/or Alternative 2, along with DRCC Basin #3. DRCC Basin #3 will also be connected to the 75th Avenue trunk line. The intent of this alternative is to evaluate opportunities to reduce the size of the trunk line. The alignment of Alternative 4 is depicted in Figure 6 (page 11).

Alternative 5

Alternative 5 consists of utilizing DRCC Basin #4 as described in Alternative 1 and/or Alternative 2, along with a flow-splitter or bubble-up structure within 75th Avenue. The flow-splitter or bubble-up structure would be constructed ½ mile south of Lower Buckeye Road to discharge flows to a detention basin located along the west side of 75th Avenue (which involves the relocation of DRCC Basin #3). DRCC Basin #3 would be incorporated into the proposed DRCC. The intent is to evaluate opportunities to reduce the size of the trunk line where it crosses the existing and future sewer lines in Broadway Road. This may simplify construction and reduce the cost of construction at this crossing. The alignment of Alternative 5 is depicted in Figure 7 (page 12).

Alternative 6

Alternative 6, the Santa Maria Basin (SM Basin) alternative, consists of a retention basin on an 6-acre site (located approximately 1/3 mi north of Broadway Road between the 69th and 71st Avenue alignments) located in Sub-basin JC2. The purpose of the retention basin is to retain flow from the area known as Santa Maria. The intent of this alternative is to evaluate opportunities to reduce the size of the 75th Avenue trunk line from Broadway Road to the Salt River. Beyond reducing the size of a future lateral to the 75th Avenue trunk line within Broadway Road, this alternative will reduce flooding along Broadway Road. The alignment of Alternative 6 is depicted in Figure 8 (page 13).

Conclusions

Relative to Alternative 1 and 3 the least expensive alternative is Alternative 2, because it requires the least amount of storm drain pipe to drain flow from DRCC Basin #4 to the Salt River.

The study shows that Alternatives 1, 2, and 3 will function to reduce peak discharges entering the storm drain system. The significance of one alternative over another is the location of the outlet works to the storm drain. The cost of the overall system is reduced when the outlet works are closer to 75th Avenue. Alternative 2 provides a reach of the storm drain that is shorter than what was estimated as needed for Alternatives 1 and 3.

Through the analysis, it was demonstrated there is no need for DRCC Basin #3, the major element of Alternatives 4 and 5. . The analysis shows that without the benefit of DRCC Basin #3 (located approximately at 75th Avenue and Lower Buckeye Road), the 100-year flow under Alternative 2 that drains to the DRCC proposed as part of the Durango ADMP is approximately 711 cfs. Under the Durango ADMP plan with DRCC Basin #3 in place the proposed DRCC would require a conveyance capacity of 1043.

Alternative 6 is a combination of Alternative 2 and the Santa Maria Basin. Construction of the Santa Maria Basin element of Alternative 6 reduces the flow rates in the 75th Avenue storm drain trunk line below Broadway Road by retaining the flow generated in a watershed located between 71st and 67th Avenues upstream of Broadway. The study shows the Santa Maria Basin decreases the 10-year peak design discharge for a future lateral storm drain in Broadway Road from 345 cfs to 42 cfs, ultimately reducing the lateral storm drain pipe size and the amount of flooding along Broadway Road. The lateral storm drain is to be evaluated and designed in a future project. Construction of the Santa Maria Basin also reduces the design peak discharge for the 75th Avenue Storm Drain trunk line from Broadway Road to the Salt River from 345 cfs to 256 cfs, allowing reduction of the trunk line pipe size.

Recommendation

A combination of the least expensive option (Alternative 2) with the construction of the Santa Maria Basin (Alternative 6) is recommended. Alternative 2 reduces the 75th Avenue Storm Drain trunk line pipe size between the Salt River and Broadway Road and the construction of the Santa Maria Basin reduces the flow rates in the 75th Avenue storm drain trunk line below Broadway Road, providing the least expensive option overall (taking into consideration the future cost of a 10-year storm drain lateral within Broadway Road.

The recommended alternative as mentioned above has been selected as the Preferred Alternative.

INTRODUCTION

Stantec Consulting Inc. is retained by the City of Phoenix (City) to conduct hydrologic and hydraulic analyses and to provide construction drawings for the 75th Avenue Storm Drain Project (Salt River to Papago Freeway (I-10)) Alternatives Analysis for Connection to Durango Regional Conveyance Channel (DRCC, City of Phoenix Project No. ST83110051). In addition to the hydrologic and hydraulic analyses conducted for the storm drain, alternative analyses are performed to evaluate the feasibility and benefits of connecting the 75th Avenue Storm Drain to regional detention facilities proposed as part of the Flood Control District (District) of Maricopa County's Durango Area Drainage Master Plan (ADMP).

PURPOSE

The purpose of this task item in the project is to evaluate alternatives for the connection of proposed Durango ADMP elements (regional detention facilities and conveyance channel) to the proposed 75th Avenue Storm Drain. The purpose of the report is to present results of the alternative analyses and construction cost estimates for each alternative evaluated. This report also provides technical documentation of the hydrologic and hydraulic analyses performed in the design of the 75th Avenue Storm Drain Project and in the evaluation of storm drain and detention basin alternatives. Another purpose is to determine if the project still removes structures from the floodplain.

LOCATION

The 75th Avenue Storm Drain Project is located within the City of Phoenix and unincorporated Maricopa County. The proposed storm drain alignment along 75th Avenue extends from the Papago Freeway (Interstate 10) to a single outfall at the Salt River. The boundaries of the drainage area for the design event are defined on the north by Interstate 10 and on the east and west by 63th Avenue and 75th Avenue, respectively. The drainage area is bounded on the south by the Salt River. The location of the project

relative to Maricopa County and City of Phoenix boundaries is displayed on Figure 1 (page 3).

The 75th Avenue Storm Drain Project is also located within the District's Durango ADMP project area. The Durango ADMP presents proposed drainage facilities that, when implemented, will minimize flood hazards to the businesses and residences within the project area. The proposed elements of the Durango ADMP that have an impact on the design of the 75th Avenue Storm Drain are DRCC Basin #3, DRCC Basin #4, and the DRCC. DRCC Basin #4 is located between 75th and 67th Avenues approximately along the 71st Avenue alignment and north of the Union Pacific Railroad. DRCC Basin #3 is located south of DRCC Basin #4 along the 71st Avenue alignment between Buckeye and Lower Buckeye Roads. The DRCC is located primarily along the 71st Avenue alignment within the storm drain project area and drains storm water flow concentrated upstream of the Union Pacific Railroad to DRCC Basin #3 and DRCC Basin #4. The DRCC collects additional flow downstream of DRCC Basin #3 that ultimately outfalls to the Agua Fria River. Proposed Durango ADMP facilities that impact the 75th Avenue Storm Drain Project area are displayed on Figure 2 (page 4).

SPECIAL FLOOD HAZARD ZONES

Portions of the 75th Avenue Storm Drain Project watershed are within Federal Emergency Management Agency (FEMA) special flood hazard zones. Figure 2 also depicts the location of FEMA special flood hazard zones within the project area.

VAN BUREN ST

BUCKEYE RD

75TH AVE

67TH AVE

LOWER BUCKEYE RD

BROADWAY RD

SALT RIVER

10

17

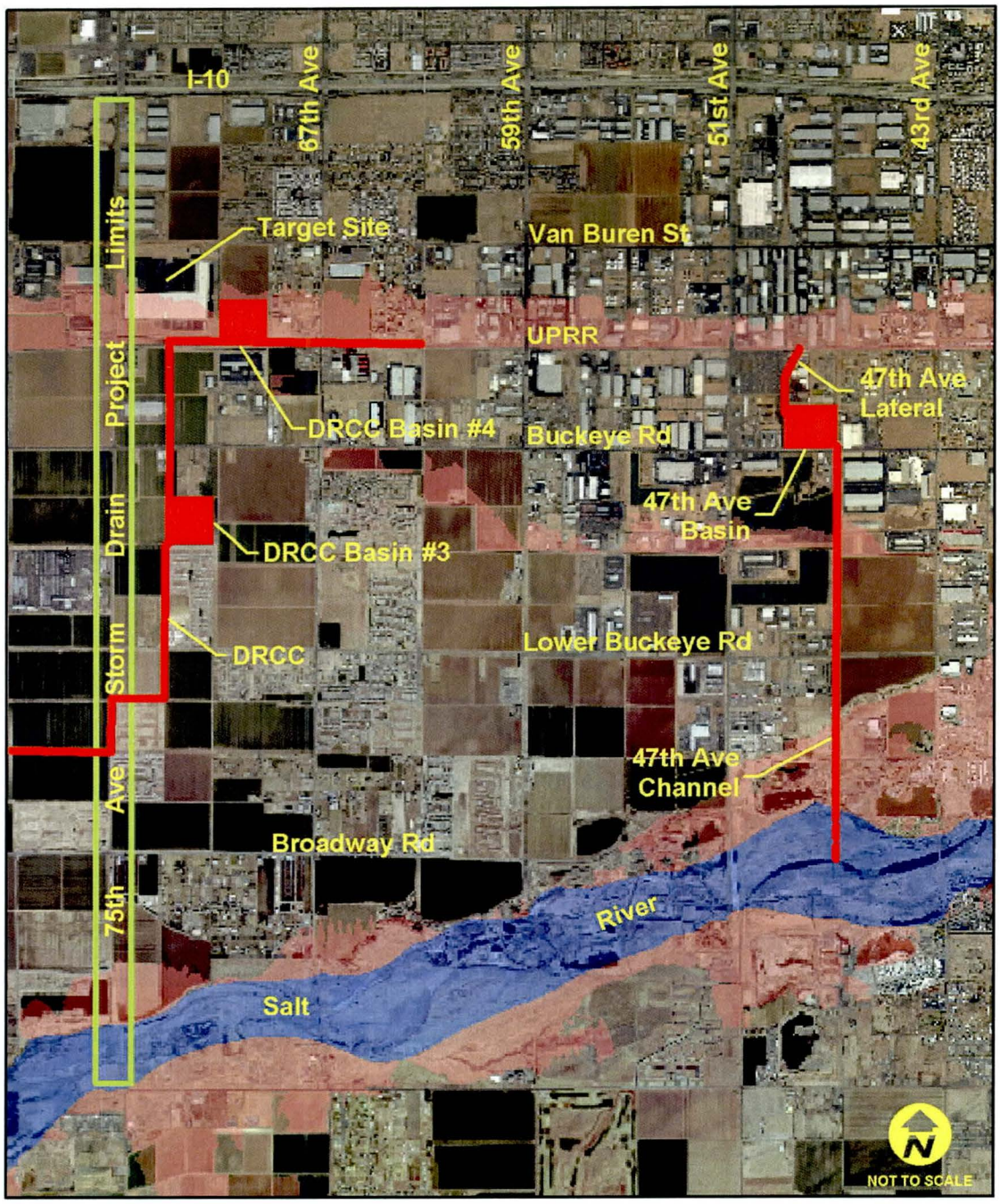
PROJECT AREA

8

MARICOPA COUNTY

FIGURE 1. LOCATION MAP

Figure 2. Location of Proposed 75th Ave. Storm Drain & Durango ADMP Elements in Relation to FEMA Flood Hazard Zones. Flood hazard zones are depicted in pink and blue (Salt River Floodway is depicted in blue).



ALTERNATIVE ANALYSIS

INTRODUCTION

Drainage alternative analyses were conducted to determine the feasibility of connecting the 75th Avenue Storm Drain to regional drainage facilities proposed in the Durango ADMP. Should connecting the proposed regional facilities to the storm drain be feasible, there may be a cost benefit realized by reducing the size or need of some of the Durango ADMP drainage elements and/or the 75th Avenue Storm Drain. The following six alternatives were considered:

Alternative 1

In this alternative, DRCC Basin #4 (comprised of approximately 43 acres) will be connected to the 75th Avenue Storm Drain (trunk line) just upstream of the Union Pacific Railroad crossing of 75th Avenue. The basin is proposed to attenuate the peak discharge from the 100-year and 10-year runoff events. DRCC Basin #4 is proposed to allow the incorporation of a regional City park. The intent of this alternative is to eliminate or reduce in size the DRCC and associated drainage improvements that drain flow between DRCC Basin #3 and DRCC #4. DRCC Basin #3 may also be downsized or eliminated. The alignment and location of Alternative 1 elements are depicted on Figure 3 (page 8).

Alternative 2

Alternative 2 consists of utilizing DRCC Basin #4 as described in Alternative 1 along with utilizing the existing Target site retention basin located immediately west of DRCC Basin #4. The Target Basin will be utilized for additional storage or for conveyance of flows to the storm drain. This may require modifications to the existing basin including additional excavation for storage or for conveyance and construction of basin outlet works connecting to the trunk line. The perceived benefit of this alternative is to increase the storage volume over what was obtainable in Alternative 1 and to have a closer location for the basin outlet works to the storm drain trunk line. The Target Basin is

approximately 15 acres in size. The alignment of Alternative 2 is depicted in Figure 4 (page 9).

Alternative 3

A major element of Alternative 3 involves utilizing DRCC Basin #4 as described in Alternative 1; however, the storm drain trunk line draining the basin is relocated. In this alternative, the trunk line draining the basin extends from the basin southerly, following the 71st Avenue alignment to Buckeye Road then westerly within the Buckeye Road Right-of-Way to the intersection of Buckeye Road and 75th Avenue. The trunk line draining the basin would connect with the 75th Avenue Storm Drain at the Buckeye Road intersection. The intent of this alternative is to move the basin outfall east to a location where jacking and boring under the tracks and the canal is easier and to reduce the cost of the trunk line. The alignment of Alternative 3 is depicted in Figure 5 (page 10).

Alternative 4

Alternative 4 consists of utilizing DRCC Basin #4 as described in Alternative 1 and/or Alternative 2 and DRCC Basin #3. DRCC Basin #3 would also be connected to the 75th Avenue trunk line. The intent of this alternative is to evaluate opportunities to reduce the size of the trunk line. The alignment of Alternative 4 is depicted in Figure 6 (page 11).

Alternative 5

Alternative 5 consists of utilizing DRCC Basin #4 as described in Alternative 1 and/or Alternative 2 along with a flow splitter or bubble up structure within in 75th Avenue that would be constructed ½ mile south of Lower Buckeye Road to discharge flows to a detention basin located along the west side of 75th Avenue (this would be a relocation of DRCC Basin #3). This basin would be incorporated into the proposed DRCC. The intent is to evaluate opportunities to reduce the size of the trunk line where it crosses the existing and future sewer lines in Broadway Road. This may simplify the construction and reduce the cost of construction at this crossing. The alignment of Alternative 5 is depicted in Figure 7 (page 12).

Alternative 6

Alternative 6, the Santa Maria Basin alternative, consists of a retention basin on an 8-acre site (located approximately 1/3 mi north of Broadway Road between the 69th and 71st Avenue alignments) located in Sub-basin JC2. The purpose of the retention basin is to retain flow from the area known as Santa Maria. The intent is to evaluate opportunities to reduce the size of the 75th Avenue trunk line from Broadway Road to the Salt River. The size of a future lateral to the 75th Avenue trunk line within Broadway Road would also be reduced. The location of the Santa Maria Basin can vary as long as it is located downstream of the existing developed area within Sub-basin JC2 that does not have retention. Approximately 17 acre-feet of storage are required. The basin could be constructed on an 8-acre lot. Alternative 2 serves as the base for the Santa Maria Basin alternative. The alignment of Alternative 6 is depicted in Figure 8 (page 13).

For all alternatives, it is assumed that the trunk line in 75th Avenue is sized to convey, at a minimum, the 10-year runoff event from the contributing drainage area. With the combination of the DRCC and the 75th Avenue Storm Drain the trunk line could be increased to convey more than just the 10-year runoff event.

Figure 3. Location and Alignment of Alternative 1 Drainage Facilities

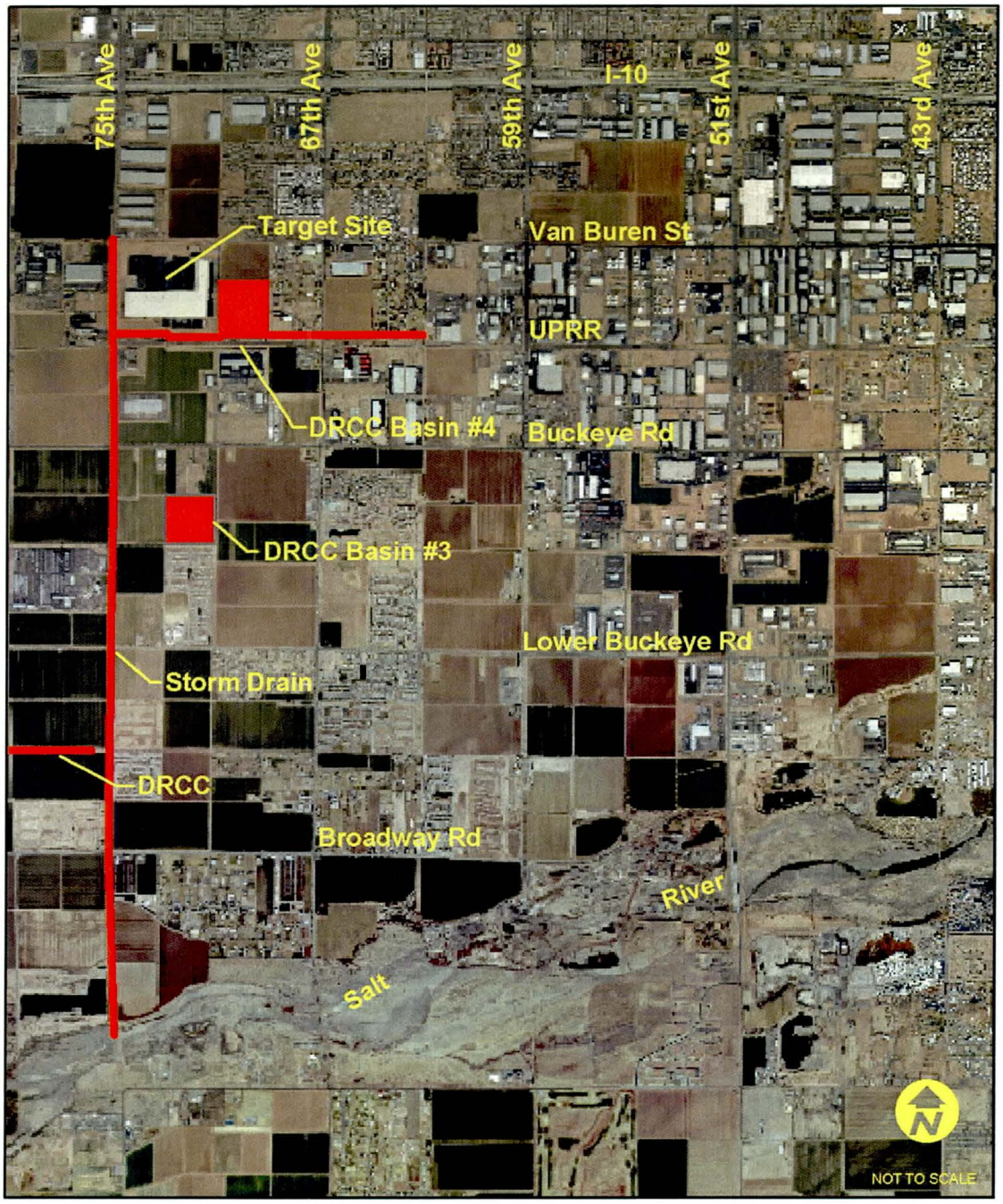


Figure 4. Location and Alignment of Alternative 2 Drainage Facilities

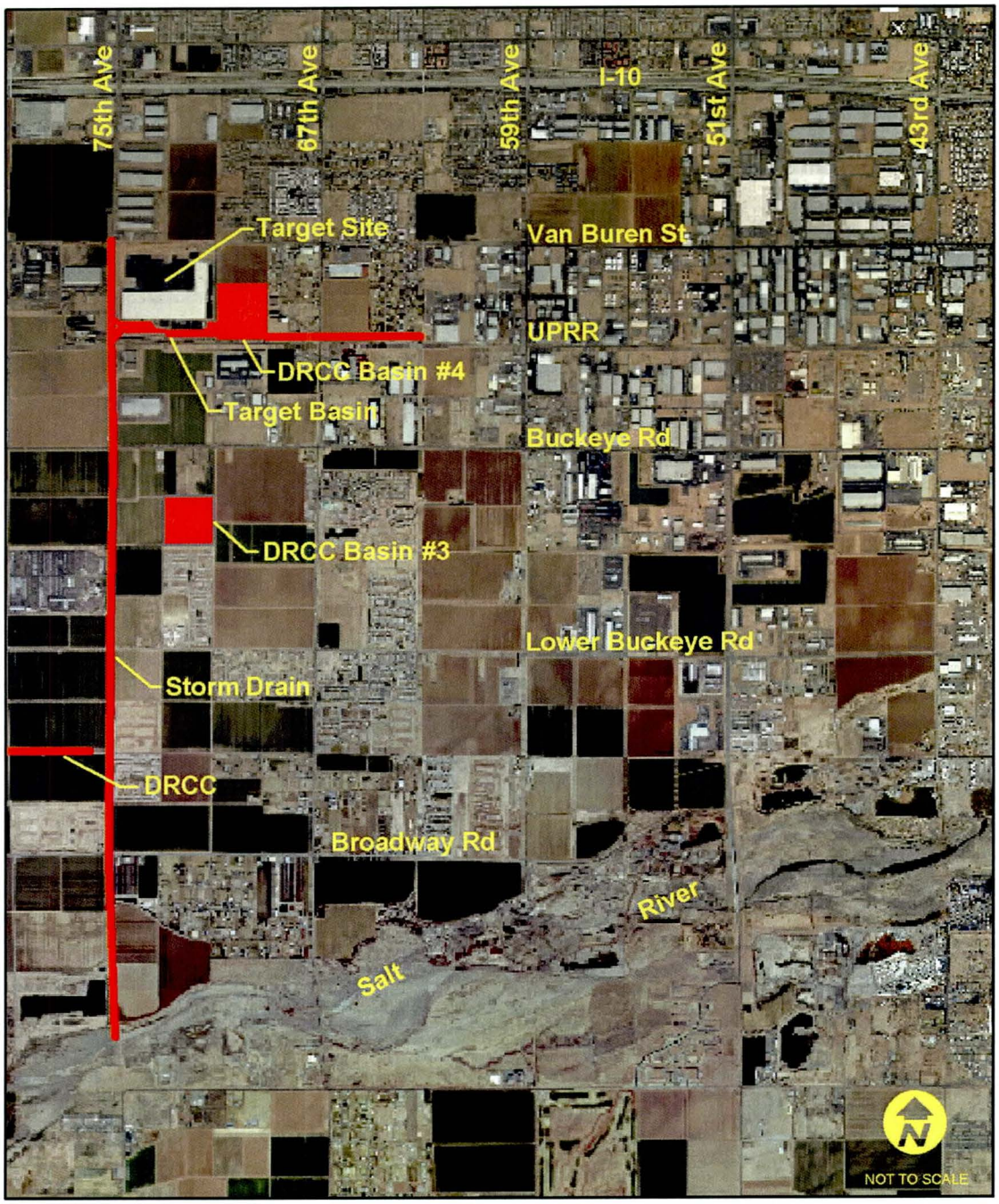


Figure 5. Location and Alignment of Alternative 3 Drainage Facilities

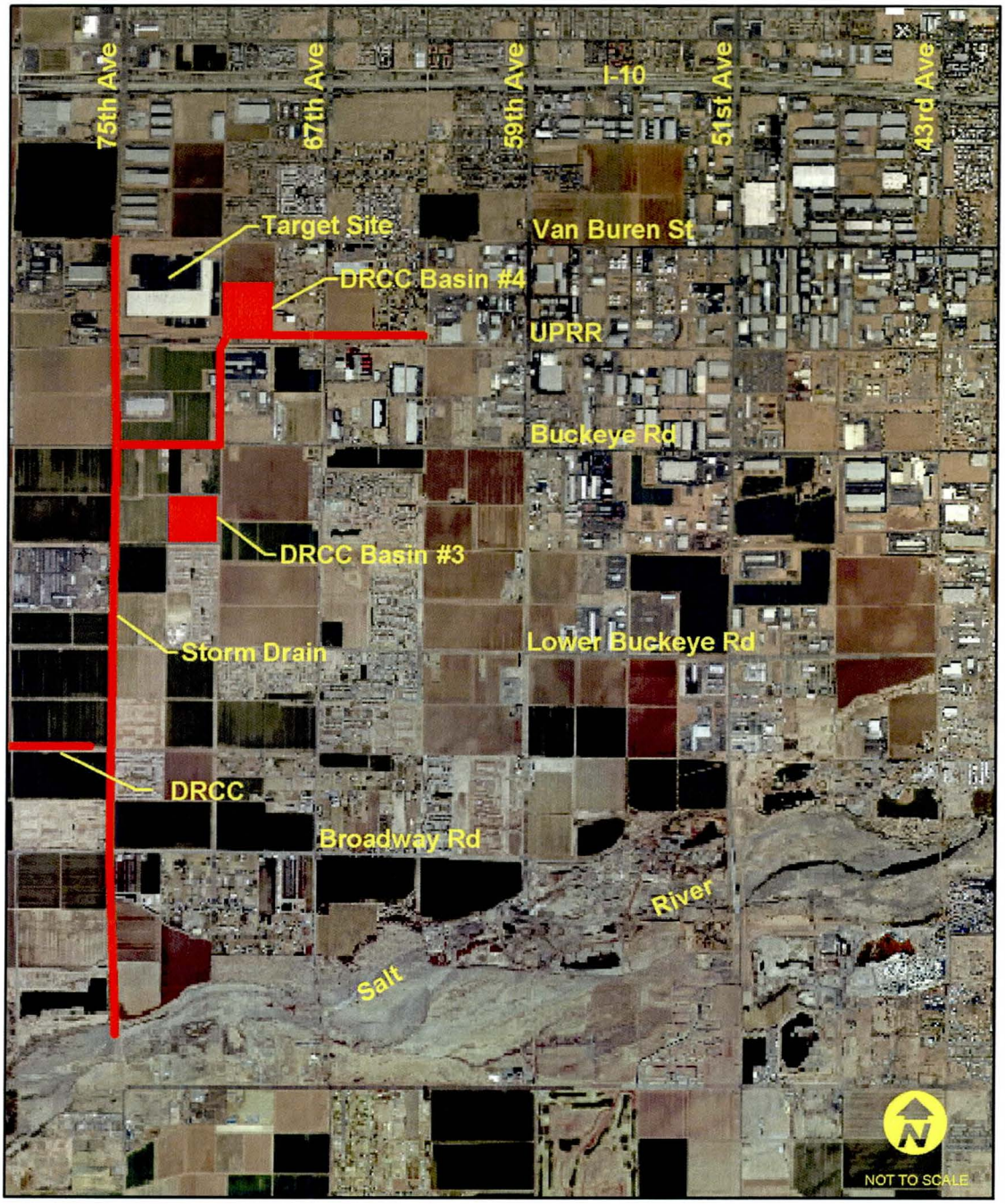


Figure 6. Location and Alignment of Alternative 4 Drainage Facilities

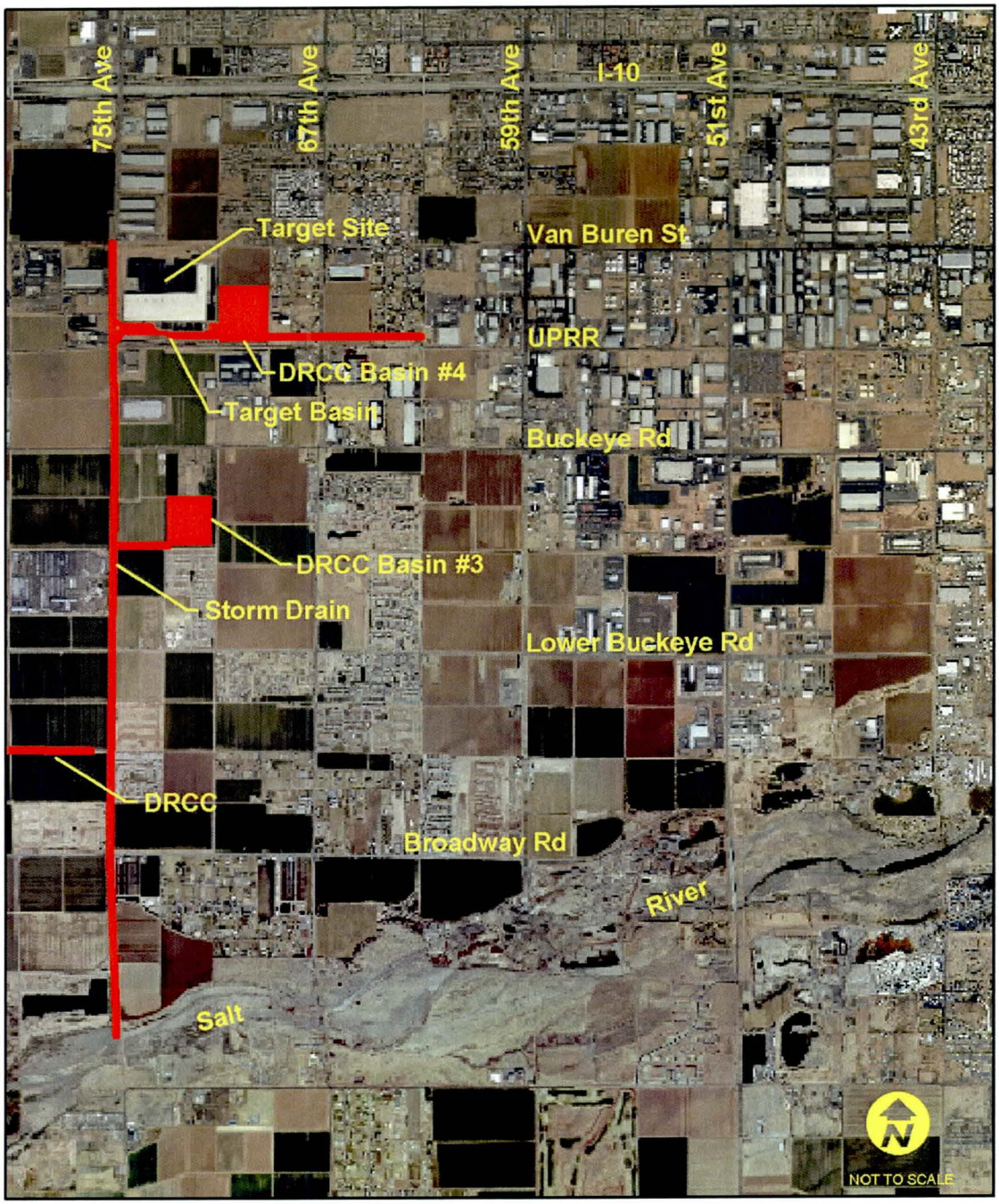


Figure 7. Location and Alignment of Alternative 5 Drainage Facilities

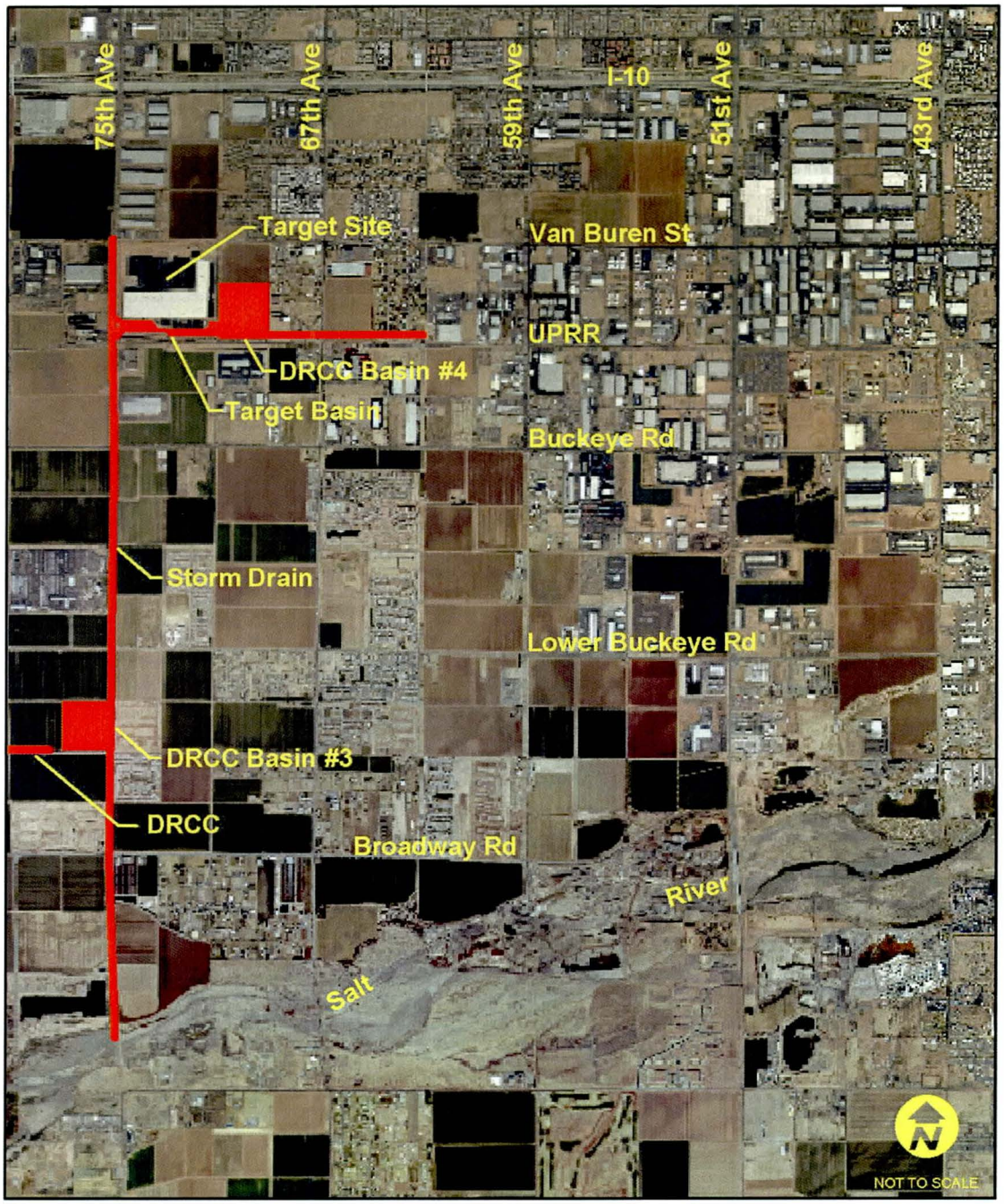
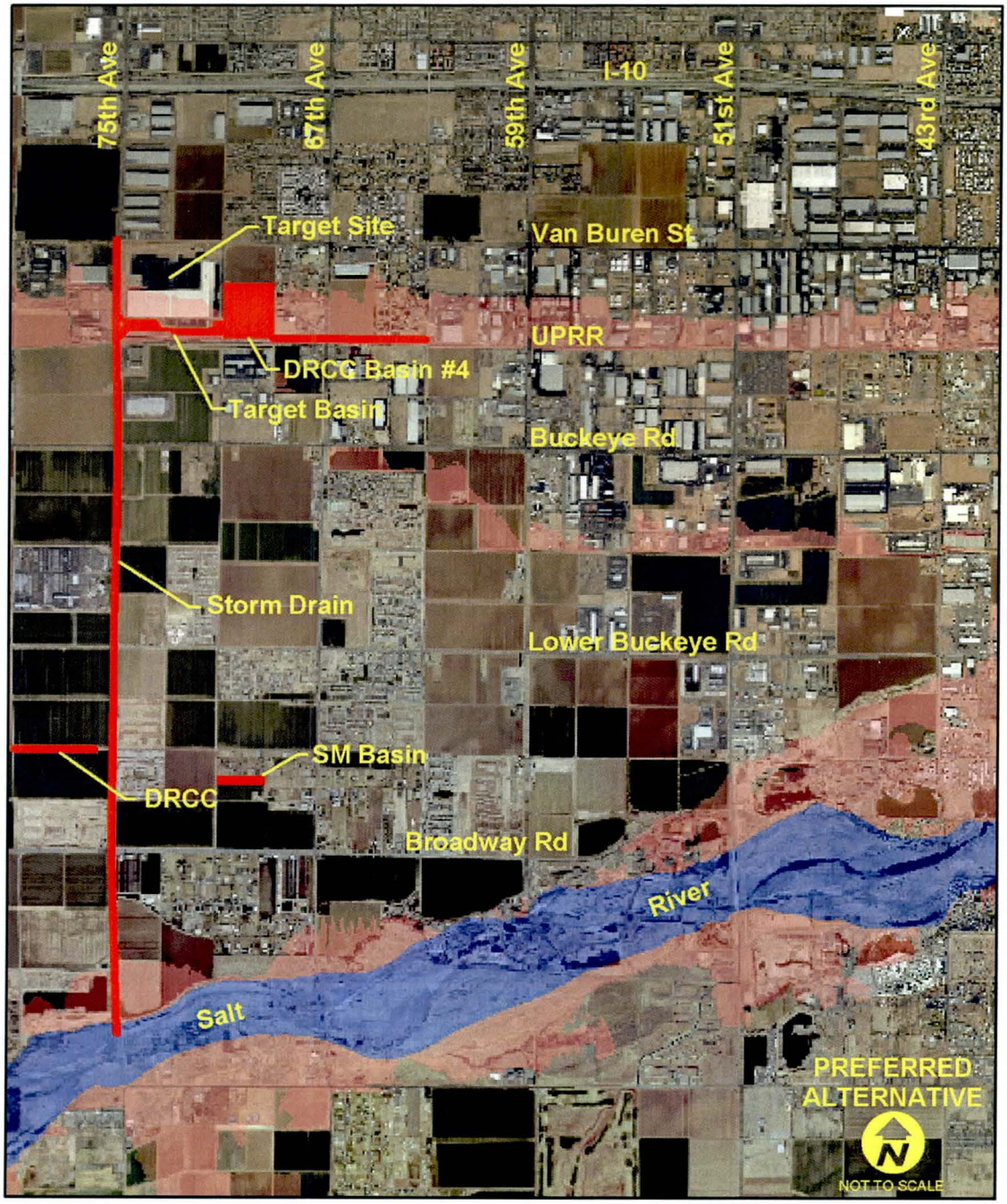


Figure 8. Location and Alignment of Alternative 6 Drainage Facilities



ALTERNATIVES CONSTRUCTION COST ESTIMATES

Hydrologic and hydraulic analyses conducted for the basin alternatives and for the trunk line determined the size and operation conditions of the facilities under design conditions. Based on the hydrologic evaluation (discussed in the next section), Alternatives 4 and 5 are eliminated because the peak discharge controlling the design of the storm drain trunk line downstream of DRCC Basin #3 is generated in Sub-basin JC2. This hydraulic condition led to the development of the Santa Maria Basin alternative located downstream and in lieu of DRCC Basin #3. Hydraulic analysis drives the size of system, which in turn provides the bases for the cost estimates. Once design discharges are estimated the configuration and size of storm drain are dimensioned, quantities taken, and cost estimates completed. Tables 1, 2, 3, and 4 list the total project cost (regional detention facilities and 75th Avenue Storm Drain system) for Alternatives 1, 2, 3, and 6 (the Santa Maria Basin alternative). Because Alternatives 4 and 5 were eliminated from further consideration, no cost analyses were performed for these alternatives.

Construction cost estimates are calculated based on estimated unit costs. Unit costs are obtained from contractors, bid tabulations, and manufacturers. A major cost is the jack and boring of pipe and shoring for the jack and bore pits. Jack and bore costs are based on a unit cost of 12 dollars per diameter-inch per foot of pipe (diameter = steel casing diameter that the Rubber Gasket Reinforced Concrete Pipe (RGRCP) is inserted into) which includes the pipe casing but not the cost of the pipe itself. Shoring cost is based on shoring the wall surface area of the jack and bore pits, and is based on 45 dollars per square foot. Pipe costs include an estimated cost for trenching; therefore, depending on trench depths, the actual cost would vary. A unit cost for 108" storm drain pipe was determined based on the unit cost for the 96" storm drain pipe, which was estimated per bid tabulations.

It is anticipated that the pits and shoring required to jack and bore the 8'x4' box culvert at the Broadway Road intersection would be incorporated into the design and construction of Manholes 7 and 8. Therefore, the pit cost associated with the jack and boring is

incorporated into the cost of the manholes. Until specific designs are developed for Manholes 7 and 8, the cost for each is estimated to be the same.

It is difficult to estimate the cost of utility relocation and protection during construction, even with the mapping of utilities for the ADMP. The only way to accurately predict utility conflicts is through potholing and good survey of existing lines. This will not be accomplished until later in the design phase. Possible utility conflicts include water, power, sanitary sewer, phone, cable, gas, fiber optic, and irrigation. Due to the potential conflicts at this level of design, a unit cost of $200,000 per mile of roadway disturbed is used. This estimate does not include relocation of Salt River Project irrigation infrastructure.

Cost estimates for each alternative reflect proposed improvements developed from generalized topographic information and preliminary hydrology and hydraulics; therefore, the estimates are considered approximate. Given the conceptual level of design of the proposed alternatives, a cost contingency is added to account for the design details that are not undertaken at this stage. This contingency is usually estimated at 20 percent of the total construction cost of the proposed improvements. Additional costs for construction management (12 percent) commonly added to a design cost estimate were not added to the cost estimates at this time. Construction cost estimates presented in this section also do not include landscaping or multi-use elements for detention basins. These costs are similar per alternative and thus would not change the relative ranking of the alternatives. Construction cost estimates presented in this report are for the selection of alternatives only and do not reflect final design construction cost estimates.

Table 1. Alternative 1 Construction Cost Estimates

Storm Drain Pipe Cost Summary

Reach	Pipe Size	Length (ft)	Linear Cost/Foot ($/ft)	Cost ($)
Salt River to Broadway	108"	4410	$ 395.00	$ 1,741,950
Broadway Intersection	3-48" HOBAS (1)	130	Lump Sum	$ 500,000
Broadway To 300' North	96"	300	$ 350.00	$ 105,000
300 feet north of Broadway to Lower Buckeye	78"	4935	$ 200.00	$ 987,000
Lower Buckeye to Buckeye	66"	5165	$ 215.00	$ 1,110,475
Buckeye to Basin DRCC Basin #4	60"	5275	$ 160.00	$ 844,000
DRCC Basin #4 Outflow Pipe	36"	200	$ 95.00	$ 19,000
UPRR to Van Buren	30"	2640	$ 90.00	$ 237,600
Catch Basin Connector Pipe	15"	1300	$ 65.00	$ 84,500
			Total Cost	$ 5,629,525

(1) Estimate does not include formed structures at the inlet and outlet of the pipes.

Bore and Jack Storm Drain Cost Summary

Location	Pipe Size	Length (ft)	Linear Cost/Foot ($)	Cost ($)
RID Canal	36"	200	$ 669.00	$ 133,800
UPRR Crossing	60"	100	$ 957.00	$ 95,700
Broadway Intersection	4'x 8' CBC	130	$ 1,300.00	$ 169,000
			Total Cost	$ 398,500

Catch Basin and Manhole Cost Summary

Item	Quantity	Unit	Unit Cost ($)	Cost ($)
Manhole	35	Each	$ 3,000.00	$ 105,000
Catch Basin	67	Each	$ 2,500.00	$ 167,500
Manhole #7	1	Each	$148,000.00	$ 148,000
Manhole #8	1	Each	$148,000.00	$ 148,000
			Total Cost	$ 568,500

Table 1. Alternative 1 Construction Cost Estimates (continued)

DRCC Basin #4 Cost Summary

Item	Quantity	Unit	Unit Cost ($)	Cost ($)
DRCC Basin #4 R/W	43	Acre	$ 74,000.00	$ 3,182,000
DRCC Basin #4 Excavation	746,360	cy	$ 4.00	$ 2,985,440
Target R/W	1	Acre	$ 87,000.00	$ 87,000
Outlet Works	1	Each	$ 8,000.00	$ 8,000
DRCC Basin #4 Spillway	430	cy	$ 300.00	$ 129,000
DRCC Basin #4 Spillway 2	430	cy	$ 300.00	$ 129,000
			Total Cost	$ 6,520,440

Detour (Traffic Control) Cost Summary

Item	Quantity	Unit	Unit Cost ($)	Cost ($)
Traffic Control	4	Mile	$ 70,000.00	$ 280,000
			Total Cost	$ 280,000

Pavement Cost Summary

Item	Quantity	Unit	Unit Cost ($)	Cost ($)
Asphalt	55,742	sy	$ 20.00	$ 1,114,844
			Total Cost	$ 1,114,844

Utility Relocation Cost Summary

Item	Quantity	Unit	Unit Cost ($)	Cost ($)
	4	Mile	$ 200,000.00	$ 800,000
			Total Cost	$ 800,000

Storm Drain Right-of-Way South of Broadway

Item	Quantity	Unit	Unit Cost ($)	Cost ($)
	5	Acre	$ 65,000.00	$ 325,000
			Total Cost	$ 325,000

Subtotal Project Cost Estimate	$	14,367,809
20% Contingency	$	2,873,562
Total Project Cost Estimate	**$**	**17,241,371**

Table 2. Alternative 2 Construction Cost Estimates

Storm Drain Pipe Cost Summary

Reach	Pipe Size	Length (ft)	Linear Cost/Foot ($/ft)	Cost ($)
Salt River to Broadway	108"	4410	$ 395.00	$ 1,741,950
Broadway Intersection	3-48" HOBAS [1]	130	Lump Sum	$ 500,000
Broadway To 300' North	96"	300	$ 350.00	$ 105,000
300 feet north of Broadway to Lower Buckeye	78"	4935	$ 200.00	$ 987,000
Lower Buckeye to Buckeye	66"	5165	$ 215.00	$ 1,110,475
Buckeye to DRCC Basin #4	60"	2775	$ 160.00	$ 444,000
DRCC Basin #4 Outflow Pipe	36"	200	$ 95.00	$ 19,000
Catch Basin Connector Pipe	15"	1280	$ 65.00	$ 83,200
			Total Cost	$ 4,990,625

(1) Estimate does not include formed structures at the inlet and outlet of the pipes.

Bore and Jack Storm Drain Cost Summary

Location	Pipe Size	Length (ft)	Linear Cost/Foot ($)	Cost ($)
RID Canal	36"	200	$ 669.00	$ 133,800
UPRR Crossing	60"	100	$ 957.00	$ 95,700
Broadway Intersection	4'x 8' CBC	130	$ 1,300.00	$ 169,000
			Total Cost	$ 398,500

Catch Basin and Manhole Cost Summary

Item	Quantity	Unit	Unit Cost ($)	Cost ($)
Manhole	27	Each	$ 3,000.00	$ 81,000
Catch Basin	64	Each	$ 2,500.00	$ 160,000
Manhole #7	1	Each	$148,000.00	$ 148,000
Manhole #8	1	Each	$148,000.00	$ 148,000
			Total Cost	$ 537,000

Table 2. Alternative 2 Construction Cost Estimates (continued)

DRCC Basin #4 Cost Summary

Item	Quantity	Unit	Unit Cost ($)	Cost ($)
DRCC Basin #4 R/W	43	Acre	$ 74,000.00	$ 3,182,000
DRCC Basin #4 Excavation	621,117	cy	$ 4.00	$ 2,484,468
Target R/W	15	Acre	$ 87,000.00	$ 1,305,000
Target Excavation	53,240	cy	$ 4.00	$ 212,960
Outlet Works	1	Each	$ 8,000.00	$ 8,000
DRCC Basin #4 Spillway	430	cy	$ 300.00	$ 129,000
			Total Cost	$ 7,321,428

Detour (Traffic Control) Cost Summary

Item	Quantity	Unit	Unit Cost ($)	Cost ($)
Traffic Control	4	Mile	$ 70,000.00	$ 280,000
			Total Cost	$ 280,000

Pavement Cost Summary

Item	Quantity	Unit	Unit Cost ($)	Cost ($)
Asphalt	46,844	sy	$ 20.00	$ 936,889
			Total Cost	$ 936,889

Utility Relocation Cost Summary

Item	Quantity	Unit	Unit Cost ($)	Cost ($)
	3.5	Mile	$ 200,000.00	$ 700,000
			Total Cost	$ 700,000

Storm Drain Right-of-Way South of Broadway

Item	Quantity	Unit	Unit Cost ($)	Cost ($)
	5	Acre	$ 65,000.00	$ 325,000
			Total Cost	$ 325,000

Subtotal Project Cost Estimate	$	13,002,442
20% Contingency	$	2,600,488
Total Project Cost Estimate	**$**	**15,602,930**

Table 3. Alternative 3 Construction Cost Estimates

Storm Drain Pipe Cost Summary

Reach	Pipe Size	Length (ft)	Linear Cost/Foot ($/ft)	Cost ($)
Salt River to Broadway	108"	4410	$ 395.00	$ 1,741,950
Broadway Intersection	3-48" HOBAS [1]	130	Lump Sum	$ 500,000
Broadway To 300' North	96"	300	$ 350.00	$ 105,000
300 feet north of Broadway to Lower Buckeye	78"	4935	$ 200.00	$ 987,000
Lower Buckeye to Buckeye	66"	5165	$ 215.00	$ 1,110,475
Buckeye to 71st Ave.	66"	2640	$ 215.00	$ 567,600
71st Ave. to DRCC Basin #4	60"	2335	$ 160.00	$ 373,600
DRCC Basin #4 Outflow Pipe	36"	300	$ 95.00	$ 28,500
Buckeye to UPRR	36"	3200	$ 95.00	$ 304,000
UPRR to Van Buren	30"	2080	$ 90.00	$ 187,200
Catch Basin Connector Pipe	15"	1460	$ 65.00	$ 94,900
			Total Cost	$ 6,000,225

(1) Estimate does not include formed structures at the inlet and outlet of the pipes.

Bore and Jack Storm Drain Cost Summary

Location	Pipe Size	Length (ft)	Linear Cost/Foot ($)	Cost ($)
RID Canal	36"	150	$ 669.00	$ 100,350
UPRR Crossing	36"	150	$ 669.00	$ 100,350
Broadway Intersection	4'x 8' CBC	130	$ 1,300.00	$ 169,000
			Total Cost	$ 369,700

Catch Basin and Manhole Cost Summary

Item	Quantity	Unit	Unit Cost ($)	Cost ($)
Manhole	43	Each	$ 3,000.00	$ 129,000
Catch Basin	75	Each	$ 2,500.00	$ 187,500
Manhole #7	1	Each	$148,000.00	$ 148,000
Manhole #8	1	Each	$148,000.00	$ 148,000
			Total Cost	$ 612,500

Table 3. Alternative 3 Construction Cost Estimates (continued)

DRCC Basin #4 Cost Summary

Item	Quantity	Unit	Unit Cost ($)	Cost ($)
DRCC Basin #4 R/W	43	Acre	$ 74,000.00	$ 3,182,000
DRCC Basin #4 Excavation	746,360	cy	$ 4.00	$ 2,985,440
Target R/W		Acre	$ 87,000.00	$ -
Target Excavation		cy	$ 4.00	$ -
Outlet Works	1	Each	$ 8,000.00	$ 8,000
DRCC Basin #4 Spillway	430	cy	$ 300.00	$ 129,000
DRCC Basin #4 Spillway 2	430	cy	$ 300.00	$ 129,000
			Total Cost	$ 6,433,440

Detour (Traffic Control) Cost Summary

Item	Quantity	Unit	Unit Cost ($)	Cost ($)
Traffic Control	4	Mile	$ 70,000.00	$ 280,000
			Total Cost	$ 280,000

Pavement Cost Summary

Item	Quantity	Unit	Unit Cost ($)	Cost ($)
Asphalt	70,898	sy	$ 20.00	$ 1,417,956
			Total Cost	$ 1,417,956

Utility Relocation Cost Summary

Item	Quantity	Unit	Unit Cost ($)	Cost ($)
	5	Mile	$ 200,000.00	$ 1,000,000
			Total Cost	$ 1,000,000

Storm Drain Right-of-Way

Item	Quantity	Unit	Unit Cost ($)	Cost ($)
R/W south of Broadway	5	Acre	$ 65,000.00	$ 325,000
71st Ave. R/W	0.3	Acre	$ 65,000.00	$ 19,500
			Total Cost	$ 344,500

Subtotal Project Cost Estimate	$	15,276,321
20% Contingency	$	3,055,264
Total Project Cost Estimate	**$**	**18,331,585**

Table 4. Alternative 6 Construction Cost Estimates

Storm Drain Pipe Cost Summary

Reach	Pipe Size	Length (ft)	Linear Cost/Foot ($/ft)	Cost ($)
Salt River to Broadway	96"	4410	$ 350.00	$ 1,543,500
Broadway Intersection	3-48" HOBAS [1]	130	Lump Sum	$ 500,000
Broadway To 300' North	96"	300	$ 350.00	$ 105,000
300 feet north of Broadway to Lower Buckeye	78"	4935	$ 200.00	$ 987,000
Lower Buckeye to Buckeye	66"	5165	$ 215.00	$ 1,110,475
Buckeye to Basin DRCC Basin #4	60"	2775	$ 160.00	$ 444,000
DRCC Basin #4 Outflow Pipe	36"	200	$ 95.00	$ 19,000
Catch Basin Connector Pipe	15"	1280	$ 65.00	$ 83,200
			Total Cost	$ 4,792,175

(1) Estimate does not include formed structures at the inlet and outlet of the pipes.

Bore and Jack Storm Drain Cost Summary

Location	Pipe Size	Length (ft)	Linear Cost/Foot ($)	Cost ($)
RID Canal	36"	200	$ 669.00	$ 133,800
UPRR Crossing	60"	100	$ 957.00	$ 95,700
Broadway Intersection	4'x 8' CBC	130	$ 1,300.00	$ 169,000
			Total Cost	$ 398,500

Catch Basin and Manhole Cost Summary

Item	Quantity	Unit	Unit Cost ($)	Cost ($)
Manhole	27	Each	$ 3,000.00	$ 81,000
Catch Basin	64	Each	$ 2,500.00	$ 160,000
Manhole #7	1	Each	$148,000.00	$ 148,000
Manhole #8	1	Each	$148,000.00	$ 148,000
			Total Cost	$ 537,000

Table 4. Alternative 6 Construction Cost Estimates (continued)

DRCC Basin #4 Cost Summary with DRCC #3 R/W Cost

Item	Quantity	Unit	Unit Cost ($)	Cost ($)
DRCC Basin #4 R/W	43	Acre	$ 74,000.00	$ 3,182,000
DRCC Basin #4 Excavation	621,117	cy	$ 4.00	$ 2,484,468
Santa Maria Basin R/W	8	Acre	$ 65,000.00	$ 520,000
Santa Maria Basin Excavation	39,000	cy	$ 4.00	$ 156,000
Target R/W	15	Acre	$ 87,000.00	$ 1,305,000
Target Excavation	53,240	cy	$ 4.00	$ 212,960
Outlet Works	1	Each	$ 8,000.00	$ 8,000
DRCC Basin #4 Spillway	430	cy	$ 300.00	$ 129,000
			Total Cost	$ 7,997,428

Detour (Traffic Control) Cost Summary

Item	Quantity	Unit	Unit Cost ($)	Cost ($)
Traffic Control	4	Mile	$ 70,000.00	$ 280,000
			Total Cost	$ 280,000

Pavement Cost Summary

Item	Quantity	Unit	Unit Cost ($)	Cost ($)
Asphalt	46,844	sy	$ 20.00	$ 936,889
			Total Cost	$ 936,889

Utility Relocation Cost Summary

Item	Quantity	Unit	Unit Cost ($)	Cost ($)
	3.5	Mile	$ 200,000.00	$ 700,000
			Total Cost	$ 700,000

Storm Drain Right-of-Way South of Broadway

Item	Quantity	Unit	Unit Cost ($)	Cost ($)
	5	Acre	$ 65,000.00	$ 325,000
			Total Cost	$ 325,000

Subtotal Project Cost Estimate	$	13,259,992
20% Contingency	$	2,651,998
Total Project Cost Estimate	**$**	**15,911,990**

Table 5 lists a summary of total project construction costs (rounded up to the nearest thousand) for each alternative evaluated. The following conclusions are drawn from the comparison of total project cost for each scenario:

- The least expensive alternative is Alternative 2.
- The values for right-of-way were developed for estimating purposes by the City of Phoenix, from information on recent sales of property in the project area. The right-of-way cost assigned to the Target Basin is presumed to be high because the existing condition land use (retention basin) limits the use of the property. Should the right-of-way cost for the Target Basin in Alternative 2 be less than $87,000 per acre, the overall project cost for Alternative 2 would be less. Right-of-way for a portion of DRCC Basin #4 may also be high because a portion of the site is in a regulatory floodplain.
- The Santa Maria Basin Alternative (Alternative 6) reduces the 75th Avenue Storm Drain trunk line pipe size, which results in an overall cost benefit. The Santa Maria Basin alternative decreases the 10-year peak design discharge for a lateral storm drain in Broadway Road from 345 cfs to 42 cfs, ultimately reducing the lateral storm drain size (to be evaluated and designed in a future project).

Table 5. Total Project Cost Summary

Alternative	Total Project Cost Estimate
1	$ 17,241,371
2	$ 15,602,930
3	$ 18,331,585
6	$ 15,911,990

Sixty percent design plans of the preferred 75th Avenue Storm Drain alignment (Alternative 2) are being submitted separately. With this report are conceptual plans of Alternative 1, 2, 3, and 6 in Plate 1, pages 27, 28, 29, and 30. Details specific to the storm drain construction, such as utility conflicts, are presented in the design submittal (not on the conceptual plans).

ALTERNATIVE SELECTION

The recommended and selected alternative is Alternative 6. Alternative 6 is a combination of Alternative 2 and the Santa Maria Basin. Construction of the Santa Maria Basin element of Alternative 6 reduces the flow rates in the 75th Avenue Storm Drain trunk line below Broadway Road by retaining the flow generated in a watershed located between 71st and 67th Avenues upstream of Broadway. The study shows that the Santa Maria Basin decreases the 10-year peak design discharge for a future lateral storm drain in Broadway Road from 345 cfs to 42 cfs, ultimately reducing the lateral storm drain pipe size and the amount of flooding along Broadway Road. The reduction in lateral pipe size is very important because of the utility constraints within Broadway Road, especially at the intersection of Broadway and 75th Avenue. The reduction in lateral pipe size (108" (345 cfs) to 36" (42cfs)) over a half mile (estimated need) of storm drain equates to a potential future savings of approximately 800,000 dollars. The lateral storm drain is to be evaluated and designed in a future project. Construction of the Santa Maria Basin also reduces the design peak discharge for the 75th Avenue Storm Drain trunk line from Broadway Road to the Salt River from 345 cfs to 256 cfs, allowing reduction of the trunk line pipe size from 108" to 96".

HYDROLOGIC EVALUATION

The project watershed is characterized by a mix of industrial, residential, and agricultural land uses, boundaries defined by transportation and irrigation delivery infrastructure, and drainage flow conveyance that is both concentrated (within and adjacent to roadways) and overland (over agricultural terrain with gentle (5 feet per mile) to flat slopes).

INTRODUCTION

The basis of the hydrologic analysis for the 75th Avenue Storm Drain Project is the hydrologic model developed as part of the Durango ADMP. Revisions made to the model reflect changes in sub-basin boundaries, land use, and routing reaches that have occurred since the completion of the Durango ADMP. In addition to revising the model due to physical changes in the watershed, a 10-year runoff event model is developed. Regional detention basins that are impacted by the project area are sized and analyzed to optimize storage function in order to reduce outfall storm drain and potential DRCC size.

The base hydrologic model used for this study is the model developed for the Durango ADMP recommended design with the exception that the 47th Avenue Basin and associated drainage facilities are considered not to have been constructed. Elements of the recommended design are regional detention facilities and channels. Within the project watershed, two regional detention basins and a flood conveyance channel are proposed. Proposed ADMP drainage facilities are depicted in Figure 2 (page 4).

Hydrologic analysis conducted for the Durango ADMP and this study are facilitated utilizing the US Army Corps of Engineers (COE) HEC-1 computer program. Watershed modeling is conducted in accordance with the methodologies set forth in the District's Drainage Design Manual for Maricopa County, Volume I Hydrology (1995), herein referred to as the Hydrology Manual. The 6-hour duration storm is modeled for the 10- and 100-year frequencies, and the 24-hour duration storm is modeled for the 100-year frequency.

PARAMETER ESTIMATION

Drainage Area Boundaries

Sub-basin boundaries developed as part of the Durango ADMP are revised to be consistent with current and proposed conditions. The following revisions are made:

- The area defined by the panhandle of Sub-basin TB is revised to drain to concentration point CPUA.
- Sub-basin SF is re-delineated to be consistent with drainage improvements constructed as part of the Target Southwest Distribution Center.
- The 75th Avenue Storm Drain is evaluated to drain proposed Durango ADMP regional detention facilities, thus eliminating the conveyance channel between DRCC Basin #4 and DRCC Basin #3 and downstream of DRCC Basin #3. The evaluation of this proposal results in the re-delineation of Sub-basins PB and NA to pre-proposed channel conditions.
- Street drainage that would be directly intercepted by the 75th Avenue Storm Drain and laterals to the storm drain was modeled by developing street drainage sub-basins. Sub-basins as wide as an arterial roadway were delineated for the roadway drainage areas contributing to the storm drain system. These roadway drainage areas are located along 75th Avenue, Buckeye Road, Lower Buckeye Road, and Broadway Road. The contributing drainage area to the storm drain system from Sub-basin FB is limited to roadway drainage within 75th Avenue.
- Sub-basin JC1 was subdivided into two Sub-basins: JC1 and JC2.
- Watershed area includes the drainage area draining to Durango ADMP proposed 47th Avenue Basin upstream of the Union Pacific Railroad (UPRR).

Watershed Work Map

The location of the 75th Avenue Storm Drain Project / DRCC watershed and associated sub-basins are displayed on Figure 9 (pages 29 & 30). Inflow points from adjacent watersheds due to split flow are also indicated on Figure 9.

Precipitation

Point precipitation values used for this study are taken from the hydrology report developed for the Durango ADMP (September 2001). Point precipitation values are presented in Table 6.

Table 6. Point Precipitation Values

Primary Zone:	7	Latitude:	33.40	Elevation:	990
Short Duration Zone:	8	Longitude:	112.20		

	Point Values (in)					
Duration	2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr
5 MIN	0.33	0.43	0.49	0.59	0.67	0.74
10 MIN	0.49	0.64	0.75	0.90	1.02	1.14
15 MIN	0.59	0.80	0.95	1.15	1.30	1.46
30 MIN	0.78	1.08	1.28	1.55	1.76	1.97
1 HOUR	0.96	1.33	1.58	1.93	2.20	2.47
2 HOUR	1.05	1.46	1.74	2.13	2.43	2.73
3 HOUR	1.11	1.55	1.85	2.27	2.58	2.90
6 HOUR	1.22	1.72	2.06	2.52	2.88	3.23
12 HOUR	1.34	1.90	2.28	2.81	3.21	3.61
24 HOUR	1.45	2.09	2.51	3.09	3.54	3.99

Data from Dibble and Associates (2002).

Depth-area reduction of point precipitation values is conducted utilizing procedures cited in the Hydrology Manual.

Physical Parameters

Physically based hydrologic parameters for the watershed and associated sub-basins developed as part of the Durango ADMP are revised as necessary due to changes in the watershed. Parameters are revised or estimated utilizing procedures cited in the Hydrology Manual. Land use and rainfall loss parameters are the two main parameters revised for the hydrologic models developed for the 75th Avenue Storm Drain Project.

Land Use

Existing Land Use

Land uses within the watershed consist of industrial, commercial, residential and agricultural types. The predominate land use types are commercial/industrial and agricultural; however, agricultural land use is rapidly giving way to residential. The predominate land use type utilized for the 75th Avenue Storm Drain Project watershed in the Durango ADMP study is agricultural. Land use is updated for the 75th Avenue Storm Drain Project area for the existing condition hydrologic model to be consistent with current conditions.

Future Land Use

Land uses within the 75th Avenue Storm Drain Project watershed have changed significantly since the completion of the Durango ADMP and are projected to change rapidly in the near future. Figure 10 (page 32) depicts areas within the watershed that are developed or in the development process or zoning process. Approximately 75% of the watershed is developed or in some stage of the development process.

A future condition hydrologic model is developed for the 75th Avenue Storm Drain Project based on the watershed being completely developed. Land use for the future condition model is based on the City of Phoenix General Plan. Portions of the general plan depicting land use in the watershed area are presented in Figure 11 (page 33). Hydrologic models developed to estimate design peak discharges and volumes for the sizing of the regional detention facilities and the 75th Avenue Storm Drain are based on the future condition model.

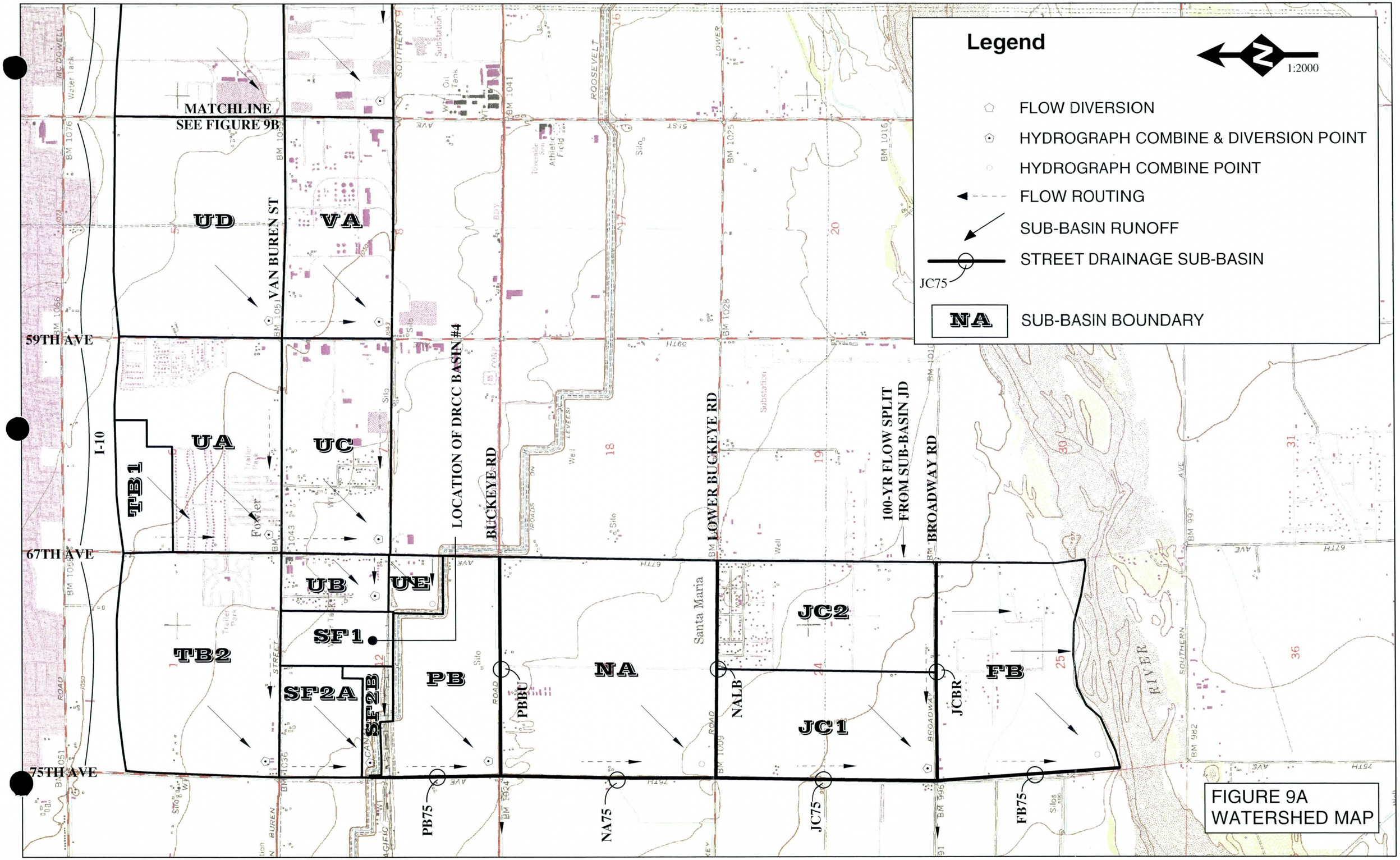


FIGURE 9A
WATERSHED MAP

EASTERN LIMIT OF AREA DRAINING TO DRCC BASIN #4

I-17

27TH AVE

35TH AVE

43RD AVE

51ST AVE

I-10

VAN BUREN ST

WD

XA

WB

WC

VD

WA

VB

VC

MATCHLINE SEE FIGURE 9A

Legend

1:2000

- FLOW DIVERSION
- HYDROGRAPH COMBINE & DIVERSION POINT
- HYDROGRAPH COMBINE POINT
- FLOW ROUTING
- SUB-BASIN RUNOFF
- STREET DRAINAGE SUB-BASIN (JC75)
- NA — SUB-BASIN BOUNDARY

FIGURE 9B
WATERSHED MAP

I-10

VAN BUREN ST

BUCKEYE RD

LOWER BUCKEYE RD

BROADWAY RD

SALT RIVER

67TH AVENUE

67TH AVE

75TH AVENUE

75TH AVE

Legend

- DEVELOPED AREAS
- AREAS UNDER DEVELOPMENT
- AREAS IN REZONING PROCESS

0 1,000 2,000 4,000
Feet

FIGURE 10
DEVELOPMENT STATUS
WITHIN PROJECT WATERSHED

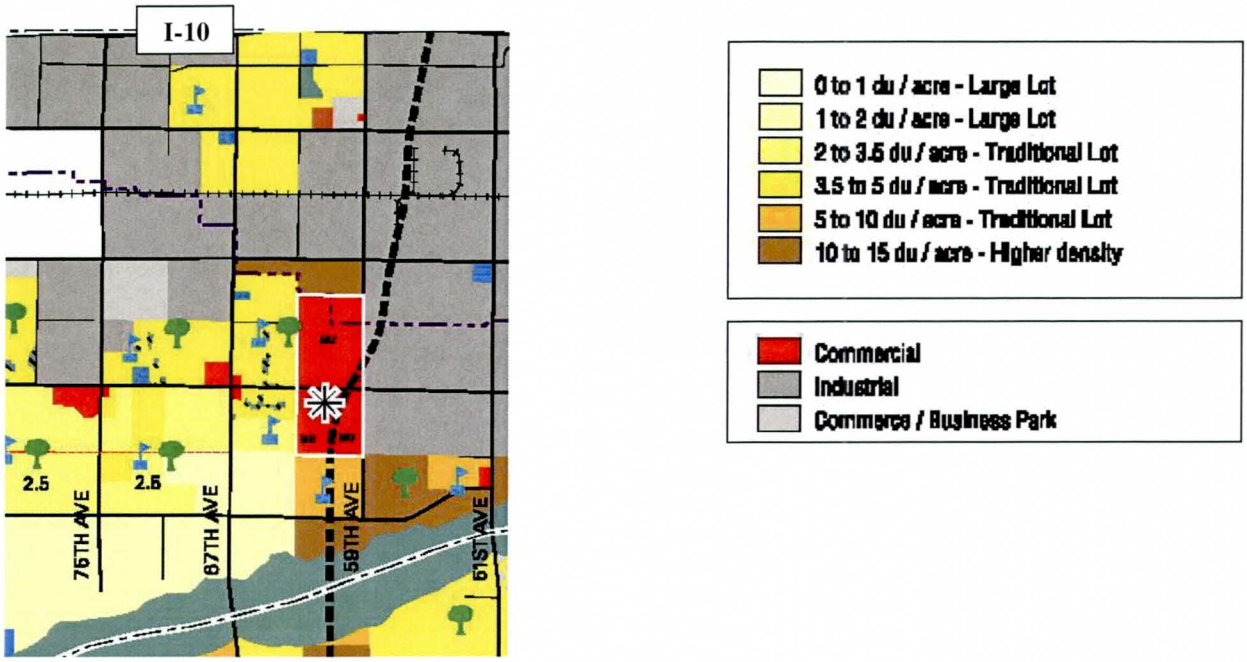


Figure 11. Land Use Within Project Watershed
(after City of Phoenix General Plan revised, 2001)

Rainfall Losses

Rainfall losses for the Durango ADMP and the 75th Avenue Storm Drain Project watershed are estimated using the Green and Ampt infiltration equation as implemented in the HEC-1 computer program. In areas where adjustments to the Durango ADMP watershed boundaries or land use were made for the storm drain project rainfall losses were estimated utilizing guidance provided in the Hydrology Manual. Soil data needed to estimate Green and Ampt infiltration parameters was obtained from the hydrology report prepared for the Durango ADMP (September 2001). Rainfall loss parameters for sub-basins that were revised for the 75th Avenue Storm Drain Project are presented in Appendix A.

Unit Hydrograph

The Agricultural and Phoenix Valley S-Graphs were utilized to develop unit hydrographs for the watersheds in the Durango ADMP study area. The existing and future condition models developed for the 75th Avenue Storm Drain project involved revising Agricultural S-Graph to the Phoenix Valley S-Graph to reflect developed conditions.

Lag Time

The District's S-Graph procedure requires the estimation of basin lag. The estimation of basin lag for the 75th Avenue Storm Drain Project was facilitated with the use of the District's MCUHP2.exe computer program. The program requires the following input information, basin flow path length (L), the length along the flow path to the basin centroid (Lca), slope and basin resistant coefficient (K_n).

ROUTING REACHES

The hydrologic analysis for the Durango ADMP utilized normal depth and reservoir HEC-1 routing routines. Normal depth routing is utilized to route flow between sub-basins and storage routing is used to model retention and detention facilities. Input parameters for the normal depth and storage routines are revised for the 75th Avenue Storm Drain Project hydrologic model to be consistent with either existing or proposed drainage improvements. In addition to the routing revisions a Straddle/Stagger routing was used to simulate the routing of storm drain flow. The following revisions or routines were made/utilized in the 75th Avenue Storm Drain Project hydrologic model.

- The HEC-1 computer program RT (Straddle/Stagger) record is utilized to lag the routing of storm drain flow from one concentration point to another. The routed hydrograph lag time is estimated to be the travel time between two points determined by the storm drain flow velocity for the peak discharge. The RT record was used for storm drain routing for Sub-basins PB, NA, JC, and FB.

- Input normal depth routing parameters for the routing reach between Sub-basins TB2 and SF2B were revised to be consistent with the drainage channel constructed as part of the Target Southwest Distribution Center.

- Stage-storage routing relationships are developed for the retention facilities provided at the Target Southwest Distribution Center and the Durango ADMP proposed DRCC Basin #4.

- Routing reaches for the 100-year storm event, future condition model follow the assumption that flow would be contained in the roadway right-of-way widths. A right-of-way width of 110 feet is utilized.

SPLIT FLOW

Split flow was estimated for hydrologic models developed as part of the Durango ADMP. The split flow analysis assumed that flow in excess of a roadway conveyance capacity would drain to the adjacent watershed. Flow split ratios where developed to estimate the percentage of flow that would leave one watershed and drain to another. Flow splits were applied at concentration points.

Due to recent development and construction of retention basins within Sub-basin NB the flow split used in the ADMP models at that sub-basin concentration point is assumed to be no longer valid.

Under the assumption that existing storm drains, future retention basins and development will minimize or eliminate flow splits from the east to the project watershed, flow splits for the 10-year models for the 75th Avenue Storm Drain hydrologic modeling efforts are assumed not to occur.

STORM DRAIN DIVERSIONS

Existing storm drains within the project watershed that impact hydrologic modeling are located within 67th and 59th Avenues. The capacity of these storm drains at key points were estimated utilizing either drainage design reports or design drawings. Drainage reports reviewed are: Drainage Report, Paving (P-876052), Storm Drain, 67th Avenue, Van Buren Street to I-10 for the City of Phoenix (1990, ST-882316) and Drainage Report, Paving (P-876045), Storm Drain, 67th Avenue, Van Buren Street to I-10 for the City of Phoenix (1990, ST-882332). Drainage design drawings reviewed are: Storm Sewer, 59th Avenue, Van Buren Street to Interstate 10 (ST-823815), Storm Sewer, 59th Avenue, Buckeye Road to Van Buren Street (ST-823807), Storm Sewer, 67th Avenue, Salt River to Buckeye Road (ST-750869). Storm drain capacities were estimated either from values presented in drainage reports or estimated by utilizing Manning's Equation, a

Manning's "n" value of 0.013 and pipe size and slopes determined from design drawings. The capacity at a given location was determined by estimating the pipe capacity at that location then subtracting the capacity of the storm drain determined from the upstream storm drain diversion to obtain the amount of inflow between the two computation points. Storm drain capacities were diverted at specific concentration points utilizing the HEC-1 diversion routine. Location of storm drain diversions and diversion amounts are listed in Table 7. The storm drains commence downstream of Interstate 10 and extend to the Salt River. Storm drain diversions are only estimated at locations where upstream collection systems (catch basins) exist.

Table 7. Storm Drain Diversions

Storm Drain Location	Size (in)	Slope (ft/ft)	Estimated Conveyance Q^1 (cfs)	Design Capacity Q^2 (cfs)	Amount to Divert in Hydrologic Model (cfs)	Location of Diversion
67th Avenue and Roosevelt	36	0.001100		17	17	SUBTB1
67th Avenue and Van Buren	54	0.004485		120	96	SUBUA
59th Avenue and Van Buren	60	0.00155	102		102	SUBUD
59th Avenue and Union Pacific RR	60	0.00386	161		59	SUBVA

1) Estimated using Manning Equation
2) From Reports

STORM WATER STORAGE FACILITIES

Retention

Required storm water retention (retention of the volume of flow from the 100-year, 2-hour storm event) due to development is modeled for both existing and future conditions. Under existing conditions, only the developments that have provided retention are modeled. Under future conditions all undeveloped areas are considered developed and retention is assumed. Eighty percent of the estimated required retention storage volume is modeled in the hydrologic analysis. The following procedures were utilized in estimating retention volumes for each sub-basin:

- Recent aerial photography (provided by Engineering Map Solutions circa February 2002) was utilized to identify developed areas.

- Field reconnaissance was conducted to identify developed areas in areas developed more recent than the date of aerial photography and to identify the presence of retention basins.

- Required retention volumes were calculated for the developed areas (existing and future conditions) containing retention basins utilizing procedures listed in the Hydrology Manual. Retention volumes from developed areas within a given watershed were added to obtain a total volume to be modeled for the specific watershed.

- A HEC-1 diversion routine was utilized to model 80% of the total amount of retention required by development.

- Retention volumes for the future condition model were estimated by taking into consideration existing retention basins in the watershed and future retention that would be provided by development of areas with a current agricultural land use. Retention volumes were not calculated for the existing developed areas that do not have retention facilities. The total watershed area of a subject watershed was utilized in the estimation of retention volume.

Detention

Detention basins proposed in the Durango ADMP are modeled utilizing the reservoir routing routine. Regional detention basins are sized and analyzed to optimize storage function in order to reduce outfall storm drain and potential channel size.

DETENTION BASIN ALTERNATIVE ANALYSES

Alternative analyses evaluating the feasibility and benefits for connection of the 75th Avenue Storm Drain to regional detention facilities proposed as part of the Durango ADMP were conducted. All alternatives are modeled for the 10- and 100-year events.

The proposed 75th Avenue Storm Drain is evaluated for the 10-year event, whereas the regional detention basins are evaluated for the 100-year event. Hydrologic alternative analyses consisted of evaluating the function of proposed detention facilities. DRCC Basin #4 (see Plate 1, pages 27, 28, and 29 for basin location) drains to the proposed 75th Avenue Storm Drain.

Hydraulic modeling of the detention facilities is facilitated by the development of stage-storage rating curves that are ultimately coded into the HEC-1 model. StormCAD is utilized to develop the stage-storage rating curves to realize the backwater effect of the storm drain system on the outlet works of the basin.

MODELING CONSIDERATIONS

The 100-year model for the basin and storm drain took into consideration 10-year storm flows that would be collected by the trunk line and associated laterals. This was accomplished by diverting the 10-year amount from surface runoff (sub-basin runoff) then combining that runoff with flow from DRCC Basin #4.

HEC-1 HYDROLOGIC ANALYSIS RESULTS

Hydrologic analysis results are presented for the 10-year and 100-year events utilizing the 6-hour storm duration for existing and future conditions for each detention basin alternative. Results from utilizing a 24-hour duration storm for the 100-year, event in the hydrologic analyses for DRCC Basin #4 in Alternatives 1, 2 and 3 are also presented. Existing and future conditions analyses results are compared to determine what the difference in peak discharge would be due to urbanization. Under both existing and future conditions, proposed detention basins are modeled. The 100-year hydrologic analysis is conducted to evaluate storm water runoff conditions that may occur with the storm drain in place when a 100-year event occurred. Results from the 24-hour duration model are compared with the 6-hour model to determine which duration produces the greatest peak discharge and highest pool elevation in DRCC Basin #4.

Results from the future condition hydrologic models of the 6- hour and 24 hour duration storms for DRCC Basin #4 in Alternatives 1, 2 and 3 are presented in Tables 8, 9 and 10.

Table 8. DRCC Basin #4 Hydrology & Hydraulics Summary (10-year, 6-hour)

Alternative	DRCC Basin #4 Inflow Volume	DRCC Basin #4 Storage at Maximum Stage	Maximum Stage	Peak Inflow Q	Peak Out Flow Q	HEC-1 Identifier
	(acre-feet)	(acre-feet)	(ft)	(cfs)	(cfs)	
Alternative 1	382.13	83.5	1021.4	848	81	BSN71
Alternative 2	382.13	106.5	1022.4	848	85	BSN71
Alternative 3	382.13	84.6	1021.4	848	78	BSN71

Table 9. DRCC Basin #4 Hydrology & Hydraulics Summary (100-year, 6-hour)

Alternative	DRCC Basin #4 Inflow Volume	DRCC Basin #4 Storage at Maximum Stage	Maximum Stage	Peak Inflow Q	Peak Out Flow Q	HEC-1 Identifier
	(acre-feet)	(acre-feet)	(ft)	(cfs)	(cfs)	
Alternative 1	644.5	229.0	1026.1	1478	93	BSN71
Alternative 2	668.2	252.8	1025.9	1732	93	BSN71
Alternative 3	644.5	230.0	1026.1	1478	93	BSN71

Table 10. DRCC Basin #4 Hydrology & Hydraulics Summary (100-year, 24-hour)

Alternative	DRCC Basin #4 Inflow Volume	DRCC Basin #4 Storage at Maximum Stage	Maximum Stage	Peak Inflow Q	Peak Out Flow Q	HEC-1 Identifier
	(acre-feet)	(acre-feet)	(ft)	(cfs)	(cfs)	
Alternative 1	666.7	206.6	1025.4	1084.5	92	BSN71
Alternative 2	669.2	228.6	1025.4	1496	92	BSN71
Alternative 3	666.7	207.6	1025.4	1084.5	92	BSN71

Results from the future condition hydrologic models 6-hour duration storm for the 10-year and 100-year events for key points of concentration are listed in Tables 11, 12, and 13. Also include in the table are the HEC-1 computation print identifiers and StormCAD inlet identifiers. StormCAD results are discussed in the next section (Hydraulic Evaluation).

Table 11. Summary of 10-year, 6-hour Peak Discharges for Alternatives 1, 2, & 3

HEC-1 Identifier	StormCAD Inlet Identifier	Alternative 1 (cfs)	Alternative 2 (cfs)	Alternative 3 (cfs)	Remarks
RETJC2	I1	345	345	345	Flow in 75th Avenue Storm from Broadway to Salt River controlled by Sub-basin JC2
CJSSD1	I2	131	136	130	Lower Buckeye Road to Broadway Road
CNASD	I3	95	100	93	Buckeye Road to Lower Buckeye Road
BSN71	I4	81	85	78	DRCC Basin #4 to Buckeye Road

Table 12. Summary of 10-year, 6-hour Peak Discharges for Alternative 6

HEC-1 Identifier	StormCAD Inlet Identifier	Alternative 6 (cfs)	Remarks
CPFB	I1	164	Broadway Road to Salt River
CJSSD1	I2	136	Lower Buckeye Road to Broadway Road
CNASD	I3	100	Buckeye Road to Lower Buckeye Road
BSN71	I4	85	DRCC Basin #4 to Buckeye Road

Table 13. Summary of 100-year, 6-hour Peak Discharges for Specific Alternatives

Summary of 100-year Peak Discharge (6-hour)

HEC-1 Identifier	StormCAD Inlet Identifier	Alternative 1 (cfs)	Alternative 2 (cfs)	Alternative 3 (cfs)	Alternative 6 (cfs)	Remarks
CPFB	I1	347	345	342	256	Flow in 75th Avenue Storm from Broadway to Salt River Controlled by Sub-basin JC2 with the Exception of Alternative 6
CPJCS1	I2	211	211	206	211	Lower Buckeye Road to Broadway Road
CPNAS1	I3	146	143	136	143	Buckeye Road to Lower Buckeye Road
DRB71	I4	93	93	93	93	DRCC Basin #4 to Buckeye Road

Results of the existing and future condition hydrologic analyses for the 10-year, 6-hour duration storm for the preferred alternative (Alternative 2) are presented in Table 14.

Table 14. 10-year Peak Discharge for Existing and Future Condition (Alternative 2)

10-yr Existing Condition (cfs)	10-yr Future Condition (cfs)	Remarks
858	345	Flow in 75th Avenue Storm from Broadway to Salt River Controlled by Sub-basin JC2
532	136	Lower Buckeye Road to Broadway Road
316	100	Buckeye Road to Lower Buckeye Road
78	85	DRCC Basin #4 to Buckeye Road

The following conclusions are drawn from the results of the hydrologic analysis:

- Retention (future condition model) that would be provided by new development eliminates off-site drainage to the proposed storm drain for the 10-year event and

reduces the volume of flow that would be experienced in a 100-year event. Given that the watershed contributing to the proposed 75th Avenue Storm Drain is approximately 75 percent developed or in some stage of the development process it is recommended that the future condition model be utilized for design purposes.

- The 6-hour event results in higher stage elevations in DRCC Basin #4 than the 24-hour event. It is recommended that the 6-hour duration be utilized as the design storm duration.

- Alternatives 1, 2 and 3 will function to reduce peak discharges to the storm drain system. The significance that one alternative has over another is the location of the outlet works to the storm drain. The cost of the over all system is reduced when the outlet works is closer to 75th Avenue.

- Under the future conditions model there is no need for DRCC Basin #3. At the location of DRCC Basin #3 (approximately 75th Avenue and Lower Buckeye Road) the 100-year flow under Alternative 2 (the preferred alternative) that drains to the DRCC proposed as part of the Durango ADMP is approximately 711 cfs. Under the Durango ADMP, the DRCC at this location would need a capacity of 1,043 cfs.

- Under the Santa Maria Basin alternative (Alternative 6) the design peak discharge for the storm drain trunk line from Broadway Road to the Salt River is reduced from 345 cfs to 256 cfs.

- 100-year runoff in the streets with the storm drain in place may exceed the carrying capacity in the right-of-way; however, the amount of runoff in the right-of-way is less than it would be without the storm drain under future conditions.

HEC-1 model output files in PDF format for each alternative are provided on a CD located in Appendix B. Also included on the CD are HEC-1 input and output files. The file names for each hydrologic model developed are presented in Table 15.

Table 15. List of HEC-1 Files

Alternative	HEC-1 File Name		
	10-year, 6-hour	100-year, 6-hour	100-year, 24-hour
1	75TH10YRA1	75THA16	75THA124
2	75TH10YRA2	75THA26	75THA224
3	75TH10YRA3	75THA36	75THA324
6	75TH10YRA2SM	75THAWSM	

RATIONAL METHOD

The Rational Method as presented in the Hydrology Manual was utilized to estimate roadway peak discharges for the 75th Avenue roadway segment between Buckeye Road and Interstate 10. The roadway segment is subdivided into three reaches for the purpose of estimating peak discharges at points of concern. The reaches analyzed are:

- Reach 1. Van Buren Street to I-10. Resultant peak discharge is used to evaluate existing 24" RGRCP within 75th Avenue for approximately 300 feet upstream of Van Buren Street.

- Reach 2. Van Buren Street to Union Pacific Railroad. Resultant peak discharge is used to size a storm drain trunk line in 75th Avenue under Alternatives 1 and 3.

- Reach 3 Union Pacific Railroad to Buckeye Road. Resultant peak discharge is used to size a storm drain trunk line in 75th Avenue under Alternative 3.

The Rational Method along with a runoff coefficient of 0.73 (76% for pavement, 24% for landscape within a 110-foot right-of-way width), and rainfall intensity based on time of concentration are utilized to estimate peak discharge. Time of concentration for the upstream portion of the watershed (the length of Roosevelt Street from 75th Avenue to 71st Avenue) is estimated utilizing the District's Rational.exe computer program. From this point downstream, time of concentration is estimated by adding the appropriate storm drain travel time to the travel time estimated by the Rational.exe program. Estimated peak discharges are listed in Table 16.

Table 16. Summary of Rational Method Peak Discharges

Reach ID	Reach Length (ft)	Area (acres)	Runoff Coefficient	Travel Time (min)	Rainfall Intensity (I_{10}) (inch/hr)	Q_{10} (cfs)
Reach 1	3700	21	0.73	41.4	2.1	32.2
Reach 2	1800	27.7	0.73	45.7	1.8	36
Reach 3	2641	34.4	0.73	56.2	1.55	39

HYDRAULIC EVALUATION

BACKWATER ANALYSIS

Introduction

A backwater analysis is conducted for the proposed 75th Avenue Storm Drain to evaluate the hydraulic performance of the storm drain. The 75th Avenue Storm Drain commences at the Salt River and extends to the north to DRCC Basin #4. From Buckeye Road to DRCC Basin #4, three alternative alignments are evaluated. Alternative 1 (depicted on Plate 1, page 27) extends from the intersection of Buckeye Road and 75th Avenue to the north to the Union Pacific Railroad and crosses the railroad and the Roosevelt Irrigation District Canal then extends to DRCC Basin #4. Alternative 2 (depicted on Plate 1, page 28) extends from the intersection of Buckeye Road and 75th Avenue north to the Union Pacific Railroad and then to DRCC Basin #4. Alternative 3 (depicted on Plate 1, page 29) extends from the intersection of Buckeye Road and 75th Avenue east to 71st Avenue and then north along the 71st Avenue alignment to DRCC Basin #4. Alternative 4 and 5 are not included. Alternative 6 is Alternative 2 with the Santa Maria Basin (depicted on Plate 1, page 30). The storm drain alignment from the Salt River to Buckeye Road is depicted on Pages 1 through 25 of Plate 1. These drawings are conceptual and were used for the alignment study only (refer to the construction drawings for detailed plan and profile). The segment of the storm drain system draining DRCC Basin #4 is evaluated for the 10-year design and 100-year peak discharge.

Methodology

Initial hydraulic analyses, and the final hydraulic analyses of the preferred alternative, conducted for the 75th Avenue Storm Drain are facilitated utilizing StormCAD (version 1.5) by Haestad Methods. Hydraulic modeling is conducted in accordance with the methodologies set forth in the Maricopa County Drainage Design Manual, Volume 2 Hydraulics (DRAFT), herein referred to as the Hydraulic Manual. Final hydraulic analyses will be conducted at the 90% design level utilizing the standard City of Phoenix spreadsheet.

Parameter Estimation

Tailwater Conditions

Tailwater conditions for the 75th Avenue Storm Drain are a function of the water surface elevation within the Salt River for the design event and storm drain exit head loss. The water surface elevation in the Salt River for the 10-year event is estimated by utilizing the HEC-RAS model for the Salt River obtained from the District. The Salt-Gila Reach 3-Floodway model along with an estimated 10-year peak discharge of 51,000 cfs was utilized to estimate a water surface elevation on the Salt River at 75th Avenue. The 10-year peak discharge of 51,000 cfs was obtained from Section 7 Study for Modified Roosevelt Dam, Arizona - Hydrologic Evaluation of Water Control Plans Salt River Project to Gila River at Gillespie Dam. The report lists a 10-year with project peak discharge of 51,000 cfs at 67th Avenue and 49,000 cfs at the confluence with the Gila River. The HEC-RAS model evaluation yielded a 10-year water surface elevation of 980.35 and a 100-year water surface elevation of 986.7 at 75th Avenue. An exit loss is then added to the Salt River water surface elevations to obtain a tailwater elevation for the StormCAD model.

Manning's Coefficient

RGRCP is proposed for all storm drainpipes. A Manning's coefficient ("n"-value) of 0.013 is utilized in the hydraulic evaluation.

Head Losses

Head losses estimated for the storm drain hydraulic evaluation include manhole losses, junction losses, transition losses, exit losses, friction losses, and bend losses. Procedures listed in the Hydraulic Manual are utilized in the estimation of head losses. Head loss estimates for the initial storm drain evaluation utilizing StormCAD for a given reach are summed and accounted for at a single computation point at the upstream end of a reach.

Special Problems

Sanitary sewer utilities within the intersection of Broadway Road and 75th Avenue and within 75th Avenue south of the intersection with Broadway Road present significant

constraints such that a positive grade for the 75th Avenue Storm Drain through the intersection and to the Salt River is not obtainable. At the intersection, it is proposed that the 75th Avenue Storm Drain be siphoned under the sanitary sewer utilities.

Design Procedures

The initial storm drain evaluation involved sizing the storm drain trunk line for the 10-year event so that the hydraulic grade line (HGL) was near or at the crown of pipe. The 100-year peak discharges are a combination of DRCC Basin #4 outflow plus flow from the laterals to the storm drain trunk line (set at the 10-year design capacity) and are evaluated in the system. Pipe sizes are then increased so that maximum water surface elevation within DRCC Basin #4 is within 1 foot of overtopping.

Final Results

Results for the 10-year peak discharges evaluation indicate that the HGL for the storm drain segment below Broadway Road is at the crown of pipe, while the HGL for the storm drain segment upstream of Broadway Road is within the storm drainpipe. For the 100-year event, the system is in pressure flow. Digital StormCAD files are provided on the CD located in Appendix B. StormCAD output summary files for each alternative are provided in Appendix C. The final StormCAD output for the preferred 75th Avenue Storm Drain trunk line alternative (Santa Maria Basin Alternative), which is shown on the 60 percent drawings, is also included in Appendix C. Conceptual plan and profile sheets for the proposed 75th Avenue Storm Drain from the Salt River to DRCC Basin #4 (Alternative 2) are displayed on Pages 3 through 25 of Plate 1 (refer to the construction drawings for detailed plan and profile).

MANNING'S EQUATION

Manning's Equation was utilized to estimate storm drain capacity for the 75th Avenue Storm Drain segment between Buckeye Road and Interstate 10. The storm drain segment was subdivided into three reaches for the purpose of estimating pipe sizes. The reaches are:

- Reach 1. Van Buren Street to Interstate10. Evaluate existing 24" RGRCP within 75th Avenue upstream of Van Buren Street.

- Reach 2. Van Buren Street to Union Pacific Railroad. Size storm drain segment based on full-flow conditions.

- Reach 3 Union Pacific Railroad to Buckeye Road. Size storm drain segment based on full-flow conditions.

The design storm for this storm drain segment is the 10-year event, per District standards. Results of the analysis are listed in Table 17. Manning's calculation sheets are provided in Appendix D.

Table 17. Manning's Rating for Full-Flow Capacity

Reach	Estimated Q_{10} (cfs)	Manning's Roughness Coefficient ("n")	Existing Pipe Slope (in)	Estimated Pipe Slope (ft/ft)	Existing Pipe Size (in)	Estimated Pipe Size (in)	Pipe Full Flow Capacity (cfs)
Reach 1	32	0.013	0.003		24		32
Reach 2	36	0.013		0.008		30	36
Reach 3	39	0.013		0.004		36	39

Under full-flow conditions, the existing 24" RGRCP storm drain within 75th Avenue does not have the capacity to convey a 10-year discharge of 32 cfs without being surcharged.

PLATE

F.H.W.A. REGION	STATE	PROJ. NO.	NO.	TOTAL	AS BUILT
9	ARIZ	ST83110051			

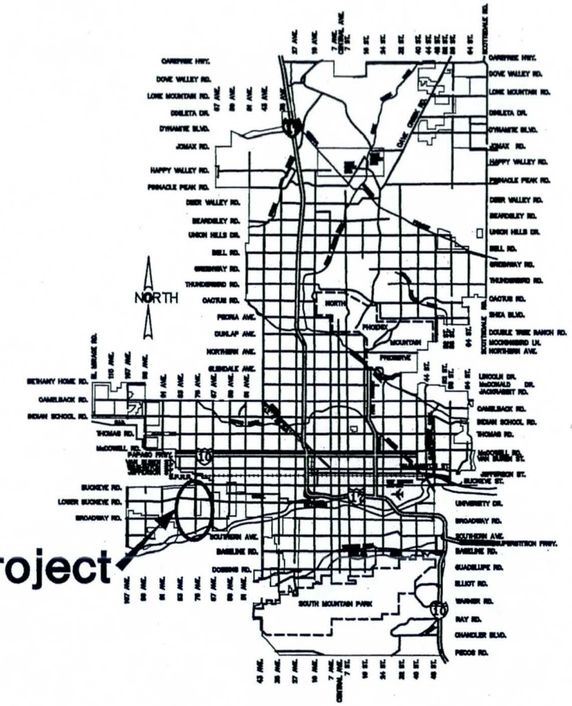
CONSULTING ENGINEER

DES: PJE | DR: DES | CK: PJE | DATE: 05/03

PRELIMINARY "NOT FOR CONSTRUCTION" 15% SUBMITTAL

Stantec

STANTEC CONSULTING INC.
3221 South 48th Street
PHOENIX, AZ. 85044
Tel. 602.438.2200



VICINITY MAP

CITY OF PHOENIX

2003

ST83110051

75th AVENUE STORM DRAIN
SALT RIVER TO VAN BUREN STREET
CONCEPTUAL PLAN
PLATE 1

MAYOR
SKIP RIMSZA

CITY MANAGER
FRANK FAIRBANKS

CITY COUNCIL

DISTRICT NO. 1	DAVE SIEBERT
DISTRICT NO. 2	PEGGY NEELY
DISTRICT NO. 3	PEGGY BILSTEN
DISTRICT NO. 4	JESSICA FLOREZ
DISTRICT NO. 5	CLAUDE MATTOX
DISTRICT NO. 6	GREG STANTON
DISTRICT NO. 7	DOUG LINGNER
DISTRICT NO. 8	MICHAEL JOHNSON

SHEET INDEX

APPROVALS

APPROVED _____ _____
ASSISTANT STREET TRANSPORTATION DIRECTOR — DATE

APPROVED _____ _____
DEPUTY STREET TRANSPORTATION DIRECTOR — DATE

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Two working days before you dig CALL FOR THE BLUE STAKES 602-263-1100 Blue Stake Center CALL COLLECT

CITY OF PHOENIX, ARIZONA
STREET TRANSPORTATION DEPARTMENT
IMPROVEMENT DISTRICT SECTION

STORM DRAIN PLAN AND PROFILE

CITY INDEX NO. ST83110051

75th AVENUE STORM DRAIN
SALT RIVER TO BUCKEYE ROAD

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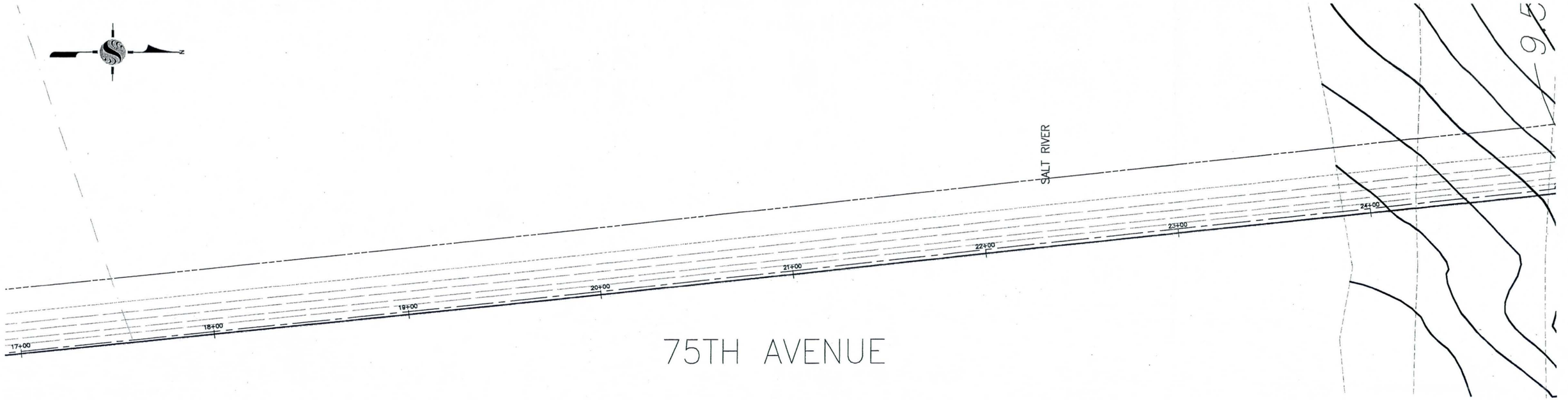
DES: PJE DATE: 05/03	1"=NONE HORIZ.	82000265	1 OF 25
CHK: PJE DATE: 05/03	1"=NONE VERT.		

75th AVENUE STORM DRAIN
PROJ ST83110051



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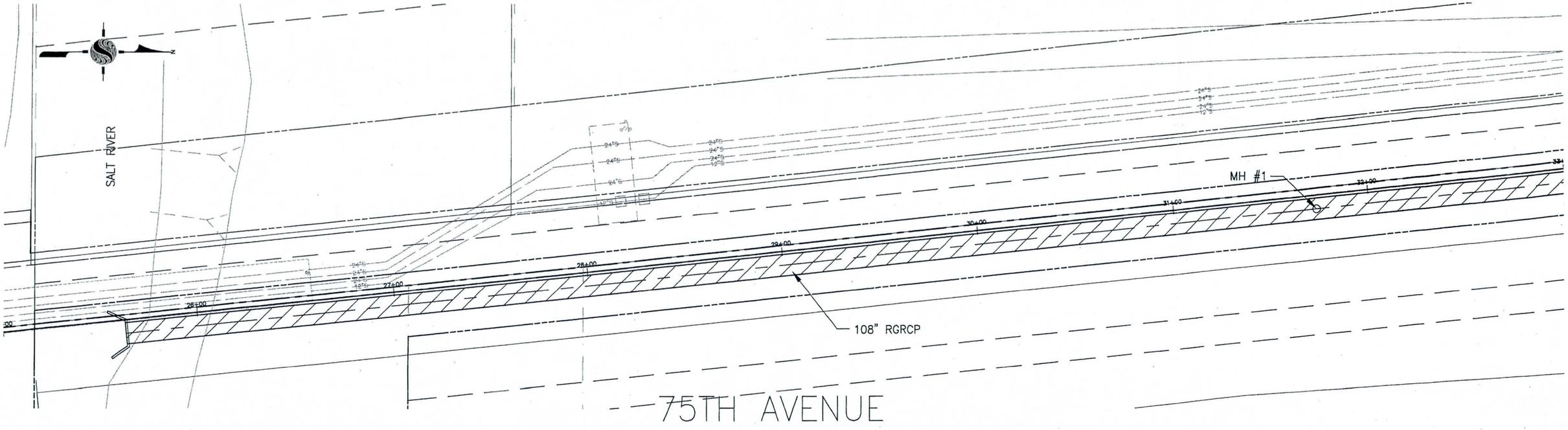
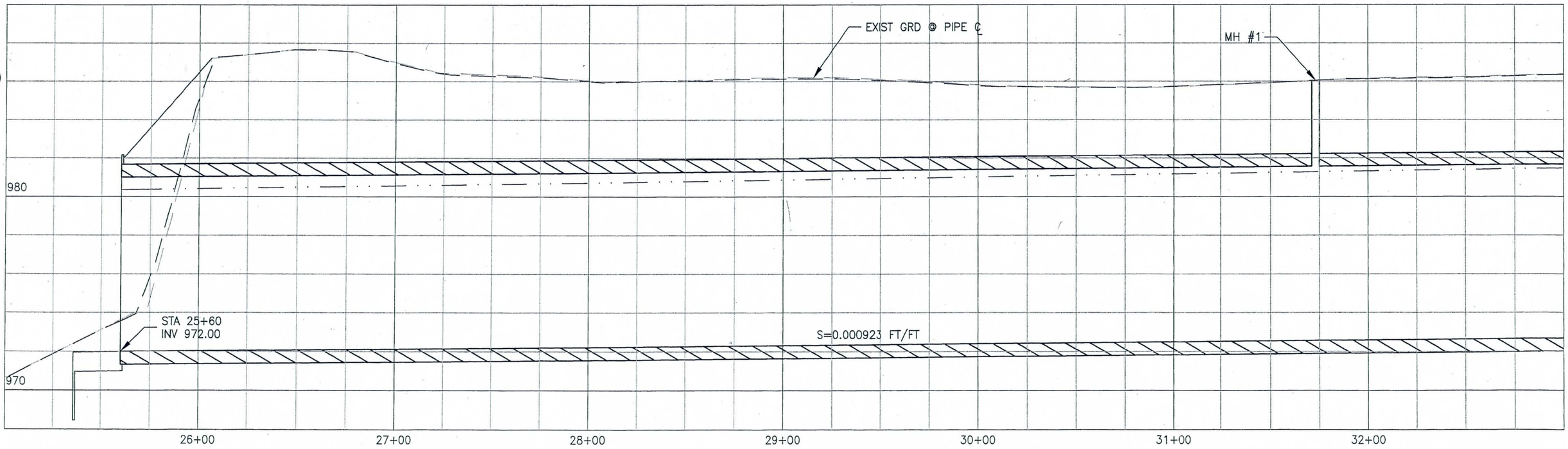
	Project No. 82000265





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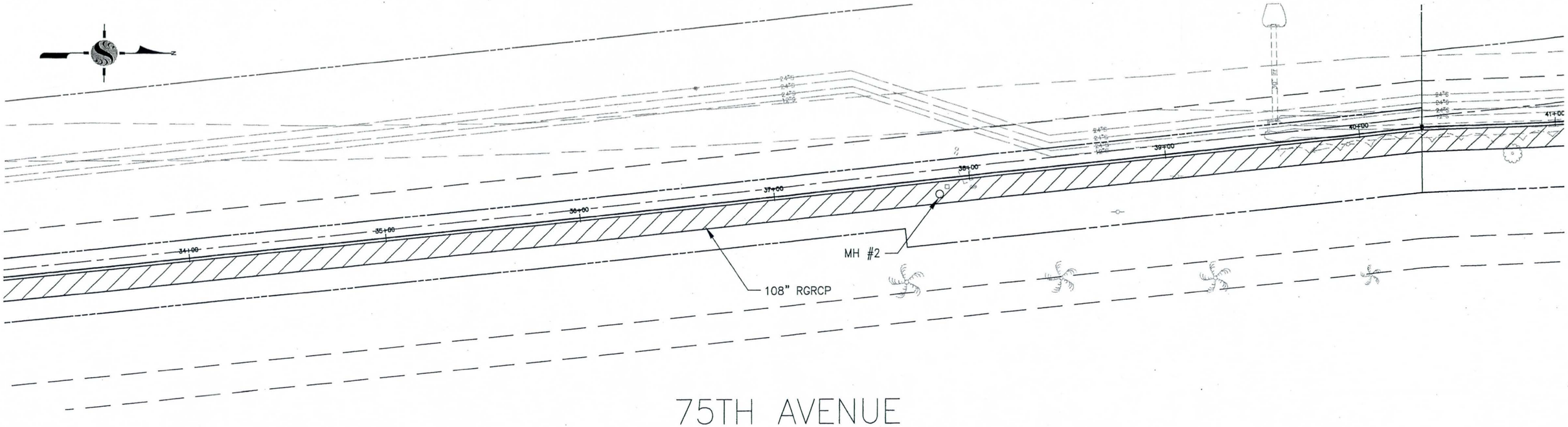

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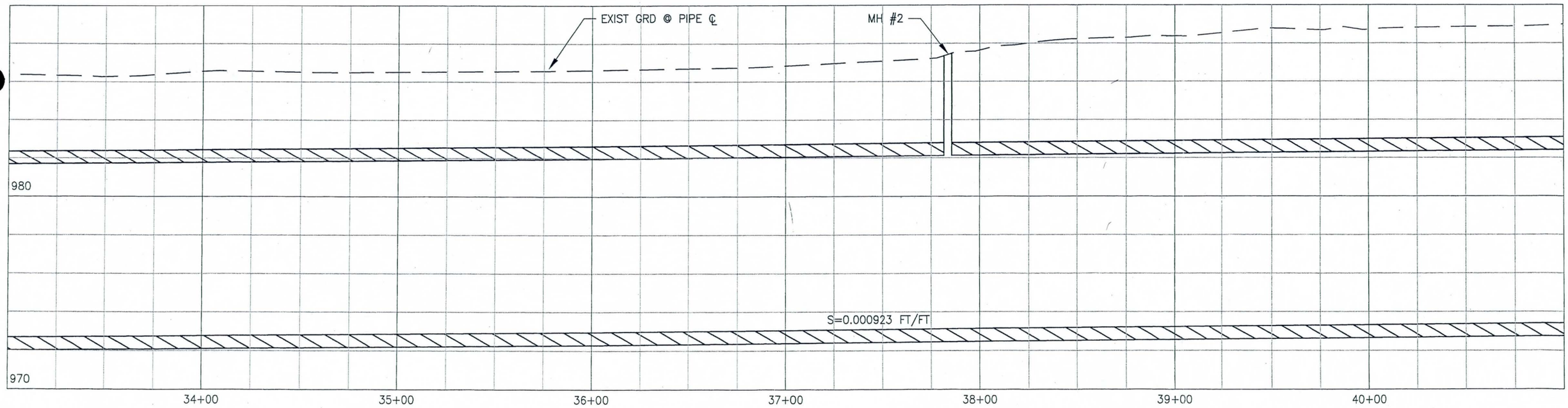

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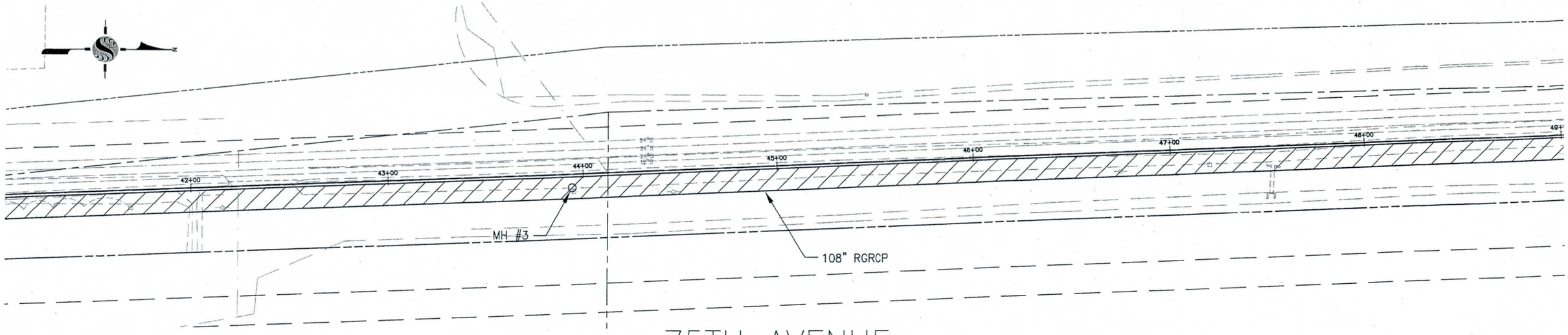

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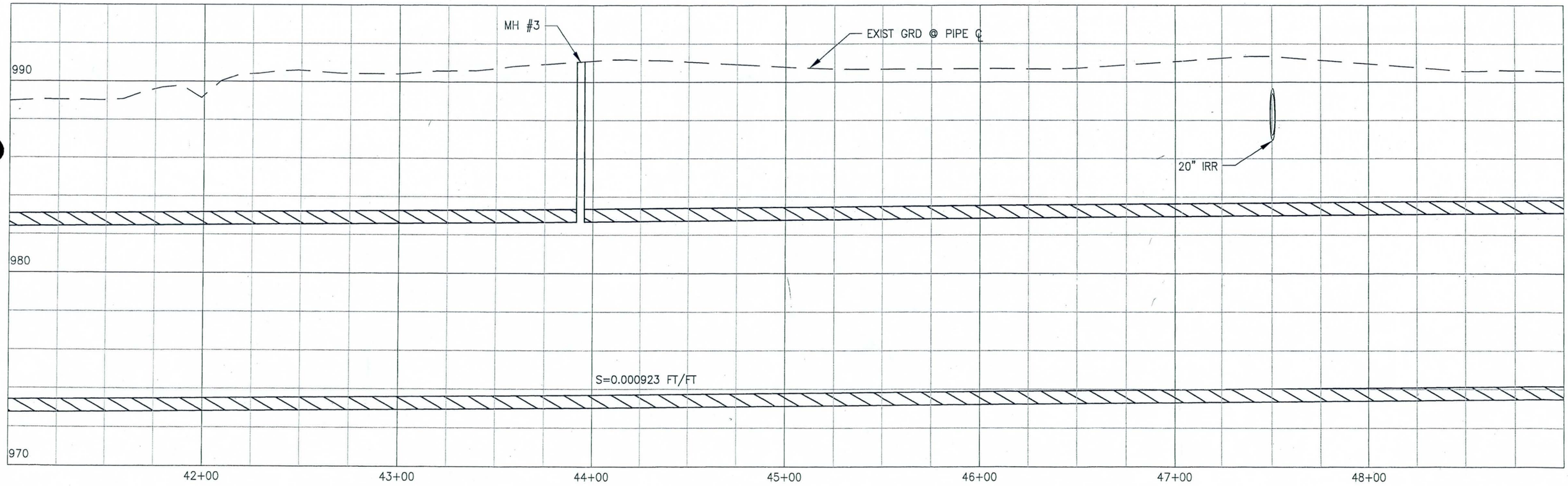

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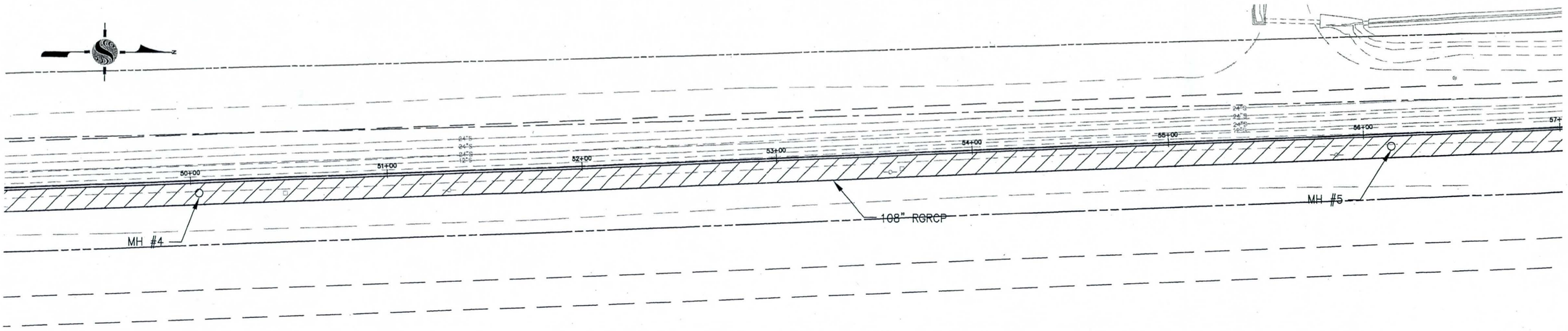

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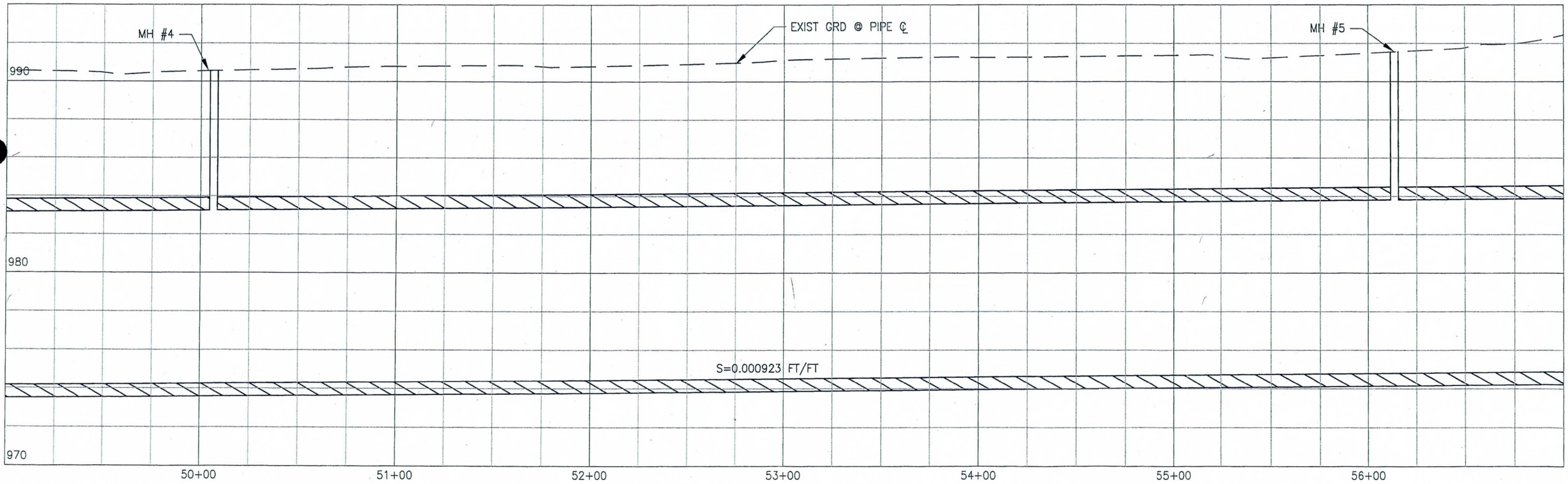

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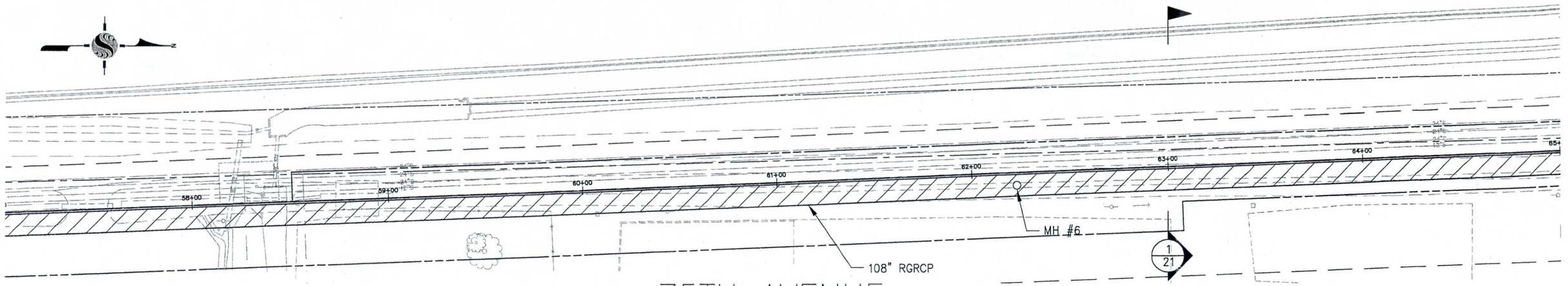

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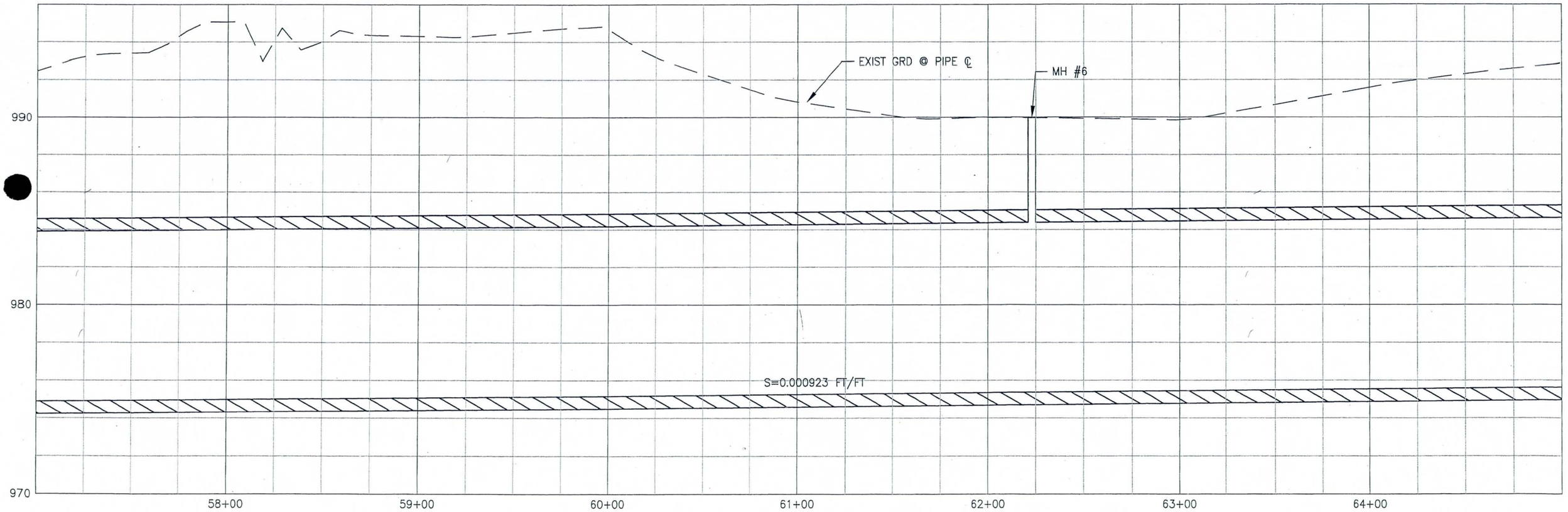

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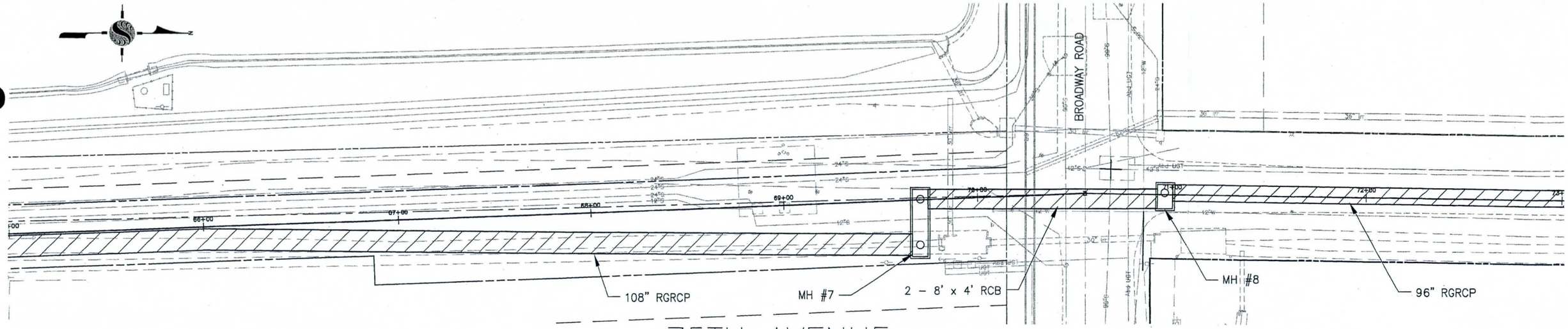

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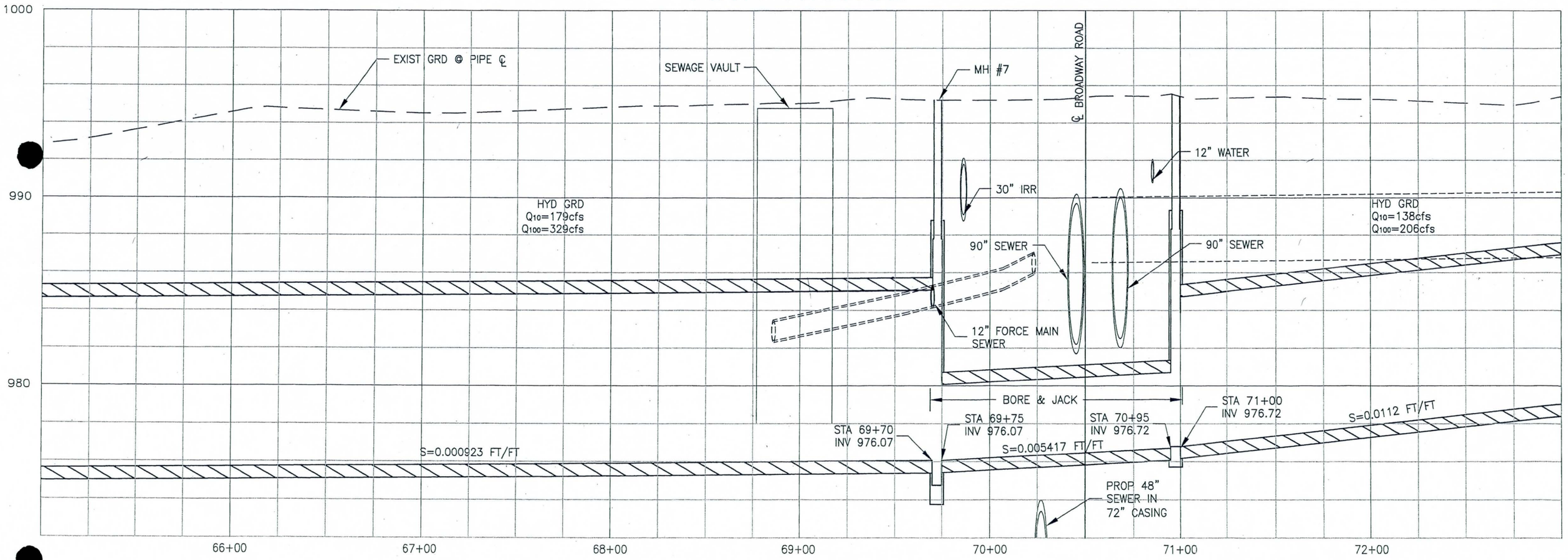

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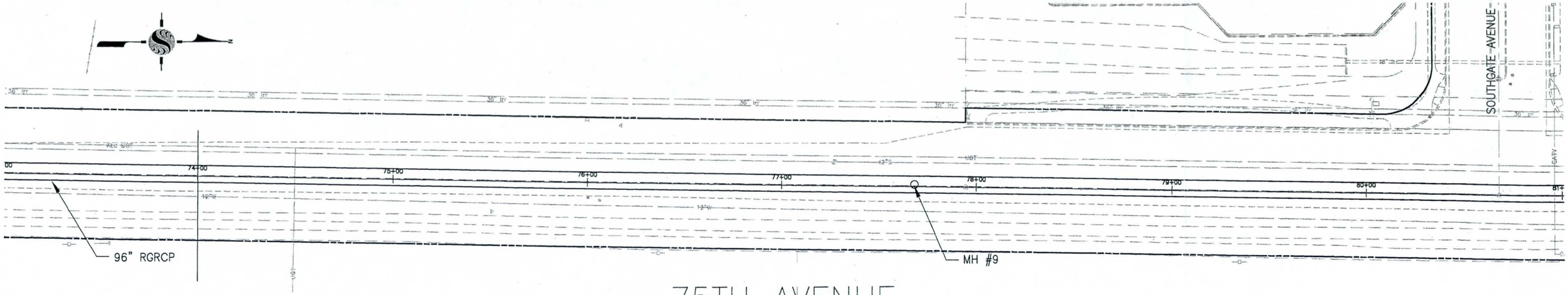

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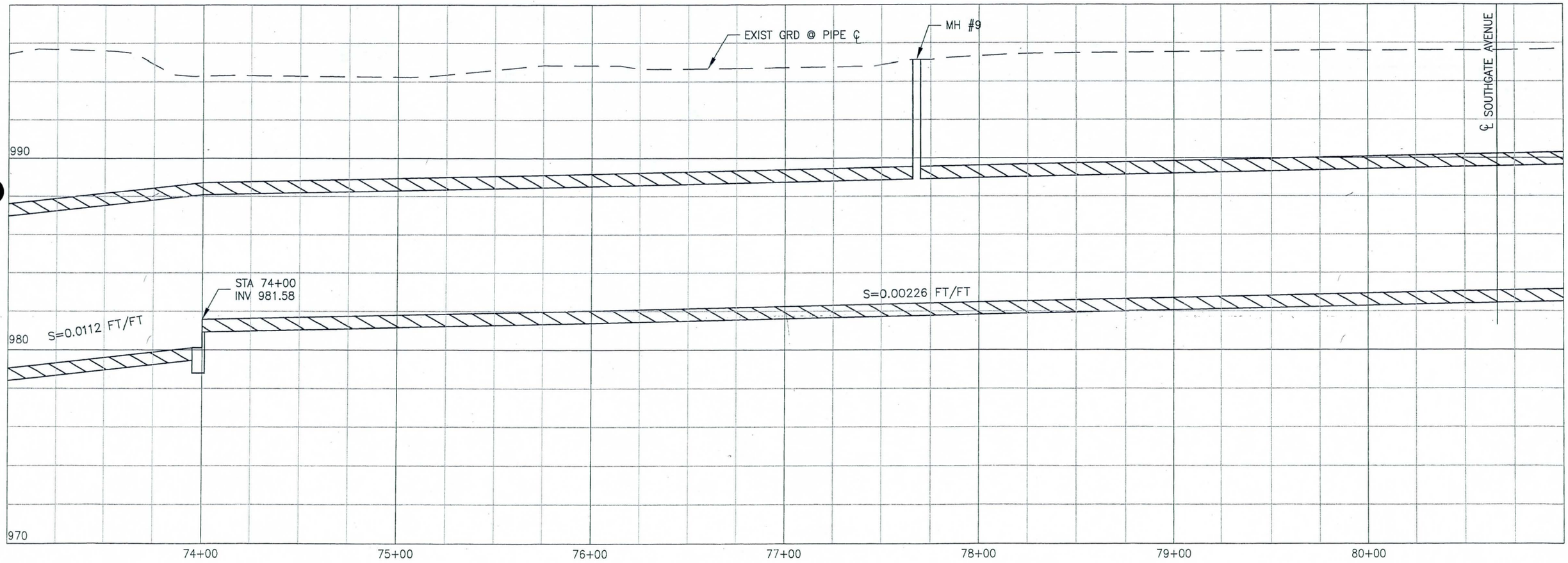

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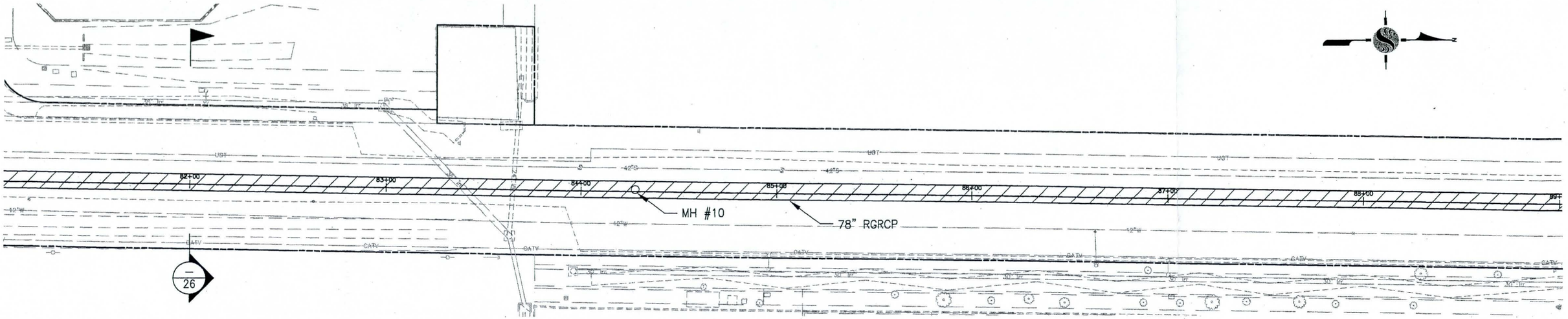

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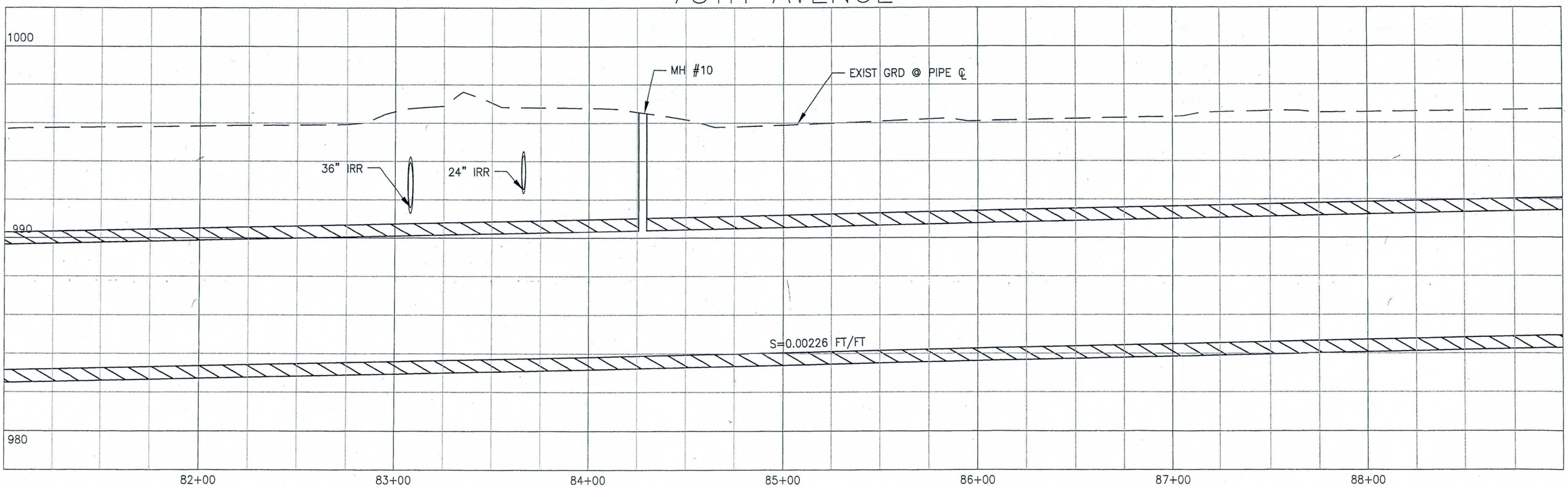

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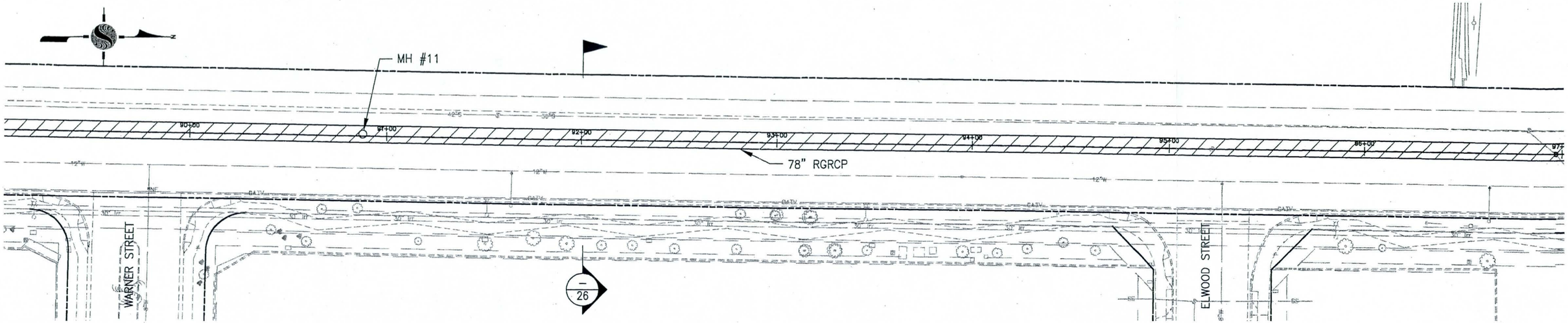

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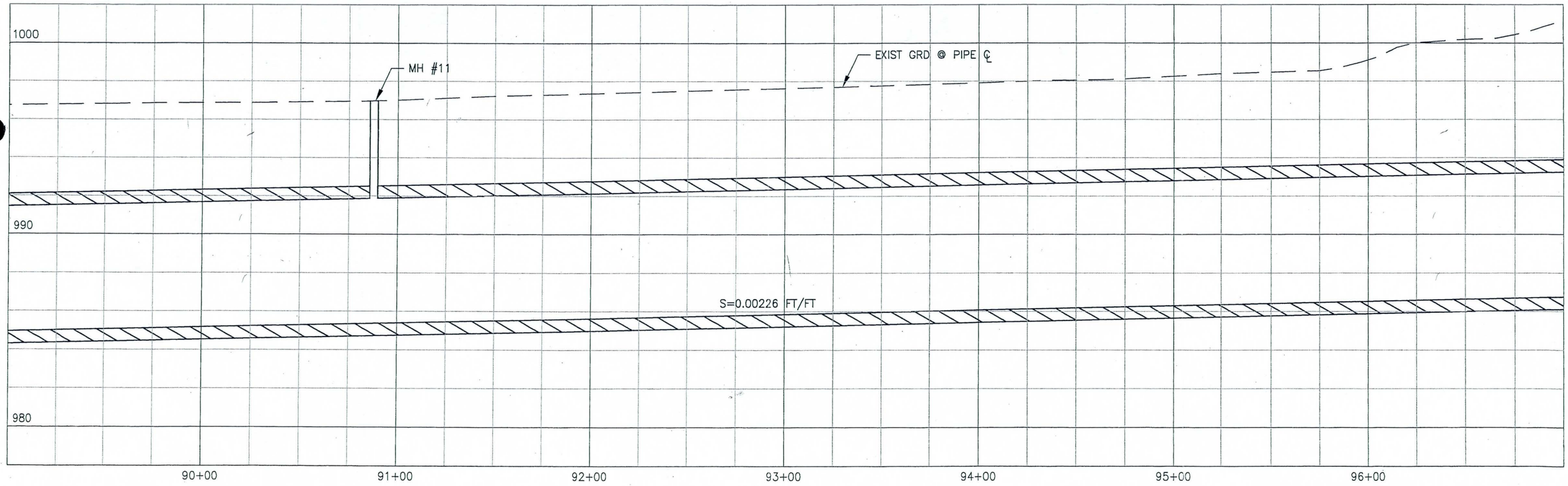

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	Date 10-13-03
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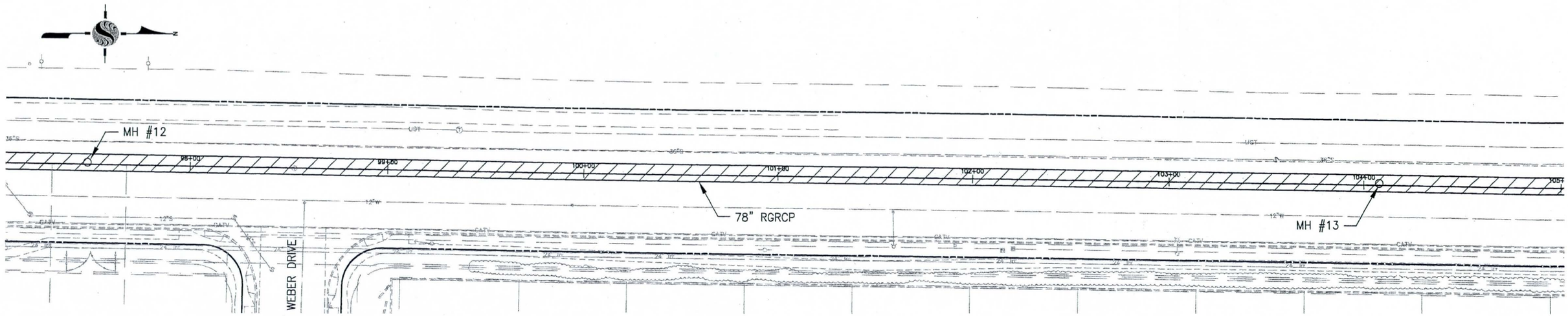

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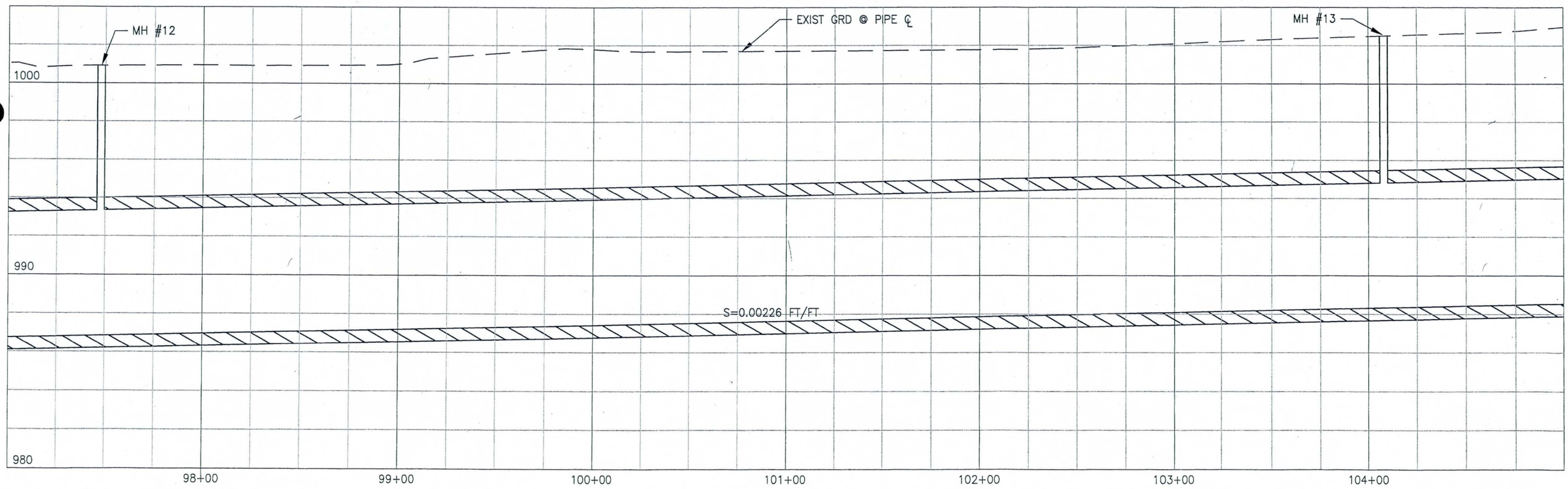

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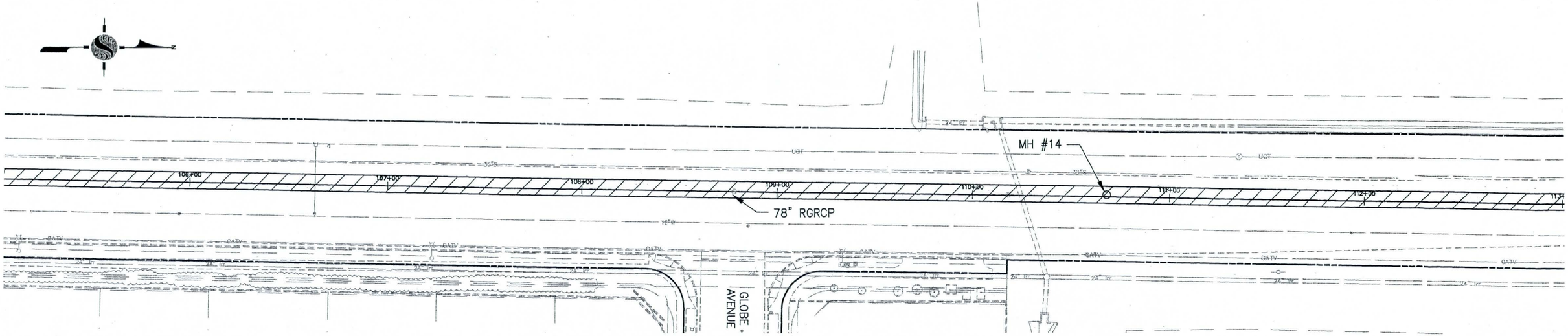
Client/Project CITY OF PHOENIX 75TH AVE STORM DRAIN	Title CONCEPTUAL PLAN AND PROFILE
	Date 10-13-03
Page No. 12 of ~~29~~ 30	Project No. 82000265



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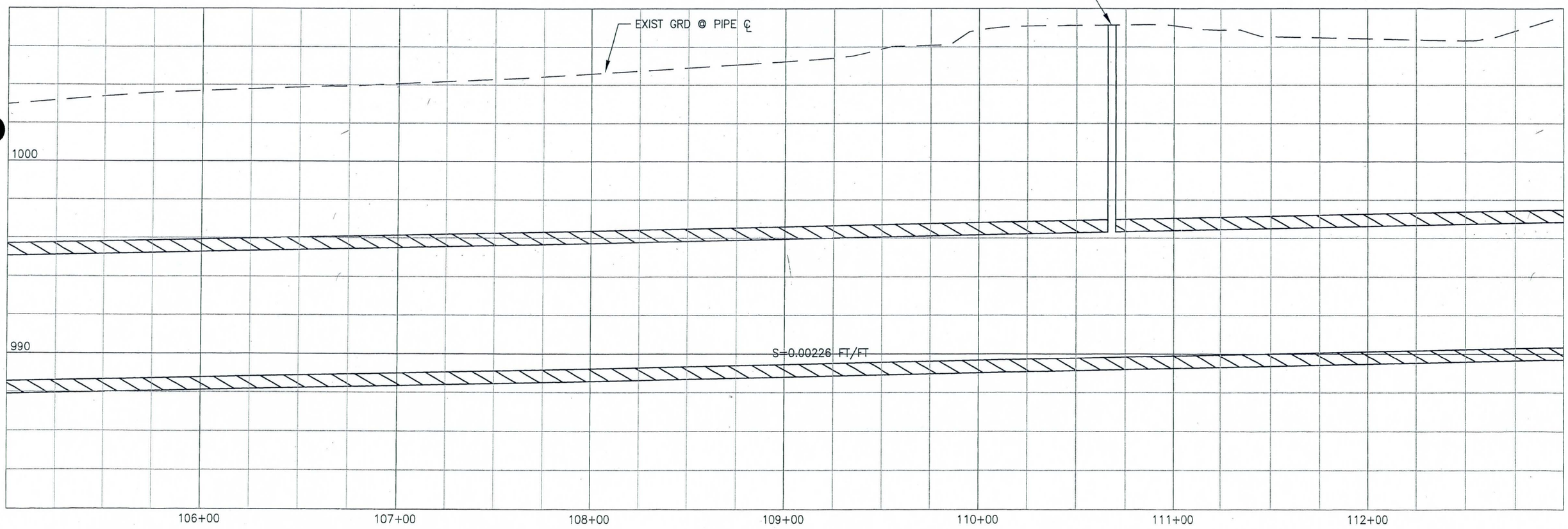

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Client/Project CITY OF PHOENIX 75TH AVE STORM DRAIN	Title CONCEPTUAL PLAN AND PROFILE
	Date 10-13-03
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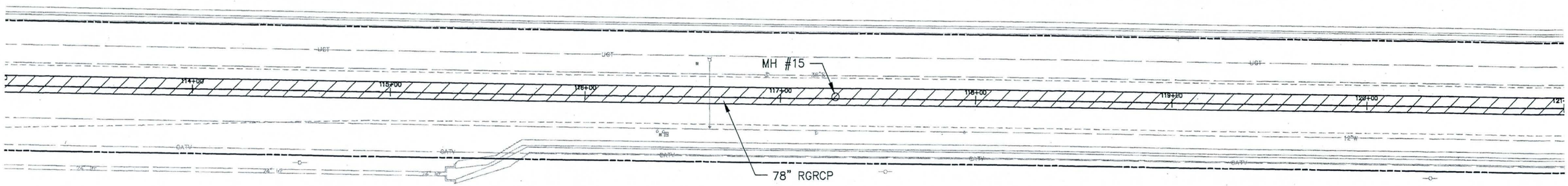

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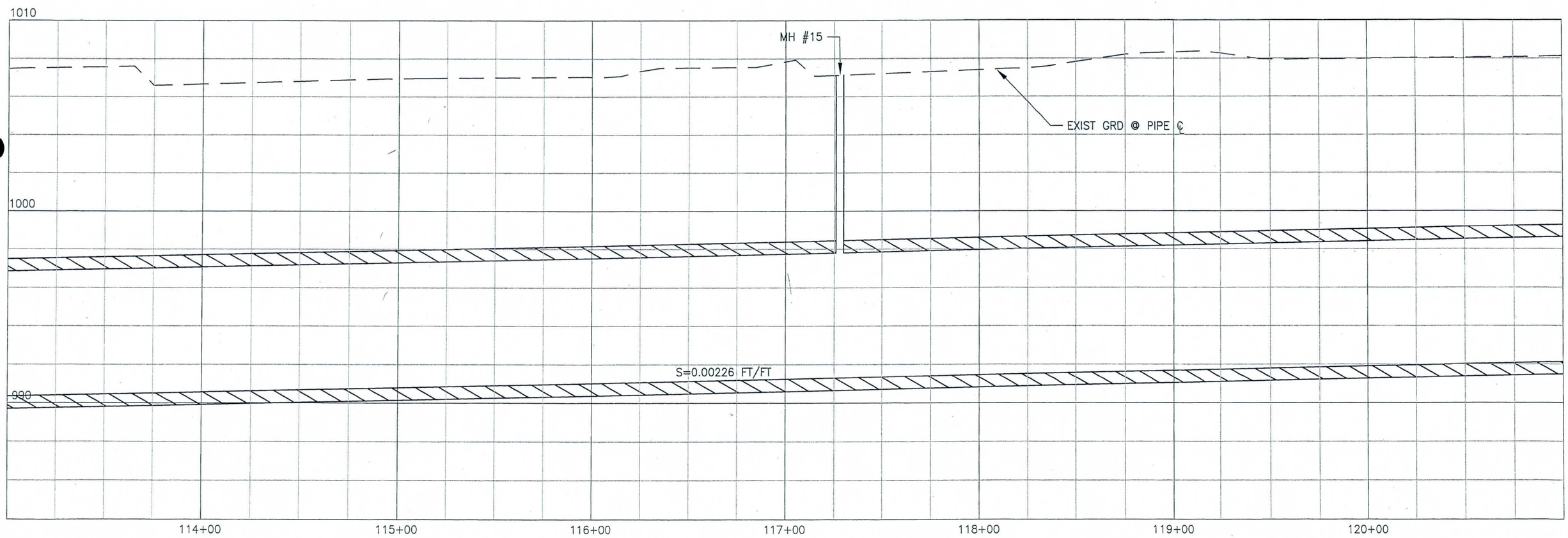

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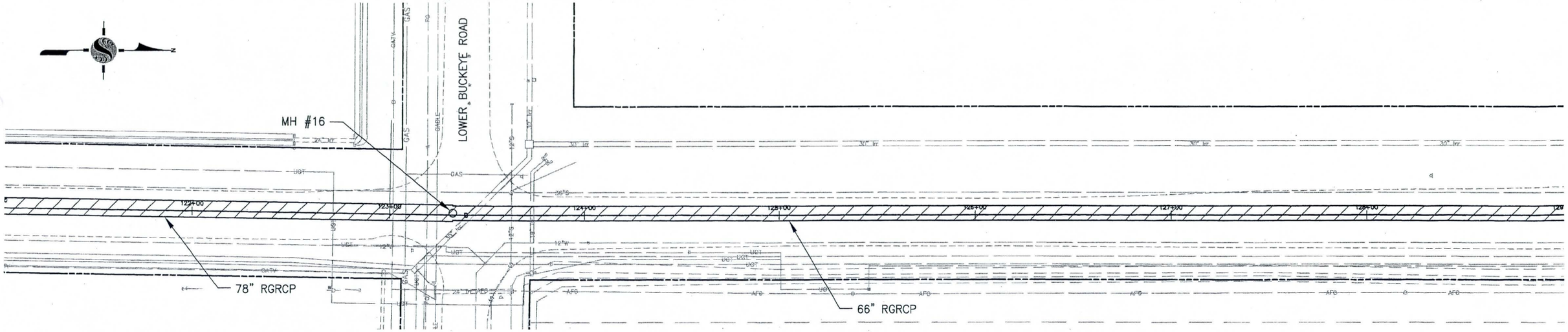
Client/Project CITY OF PHOENIX 75TH AVE STORM DRAIN	Title CONCEPTUAL PLAN AND PROFILE
Page No. 14 of ~~29~~ 30	Date 10-13-03
	Project No. 82000265



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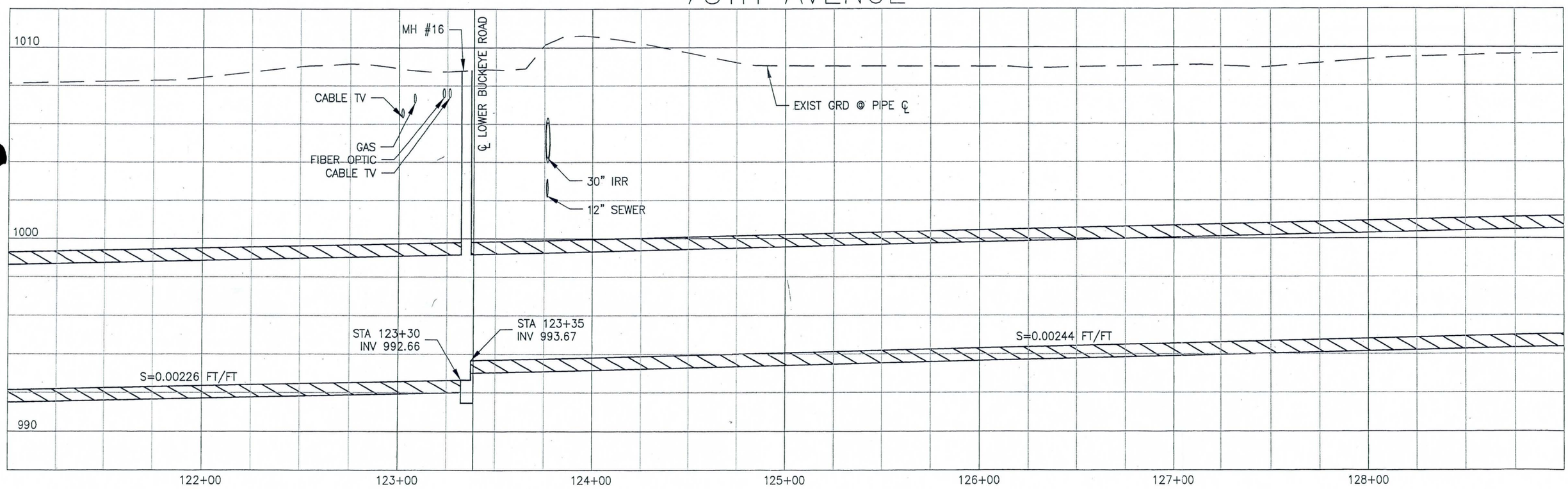

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Client/Project CITY OF PHOENIX 75TH AVE STORM DRAIN	Title CONCEPTUAL PLAN AND PROFILE
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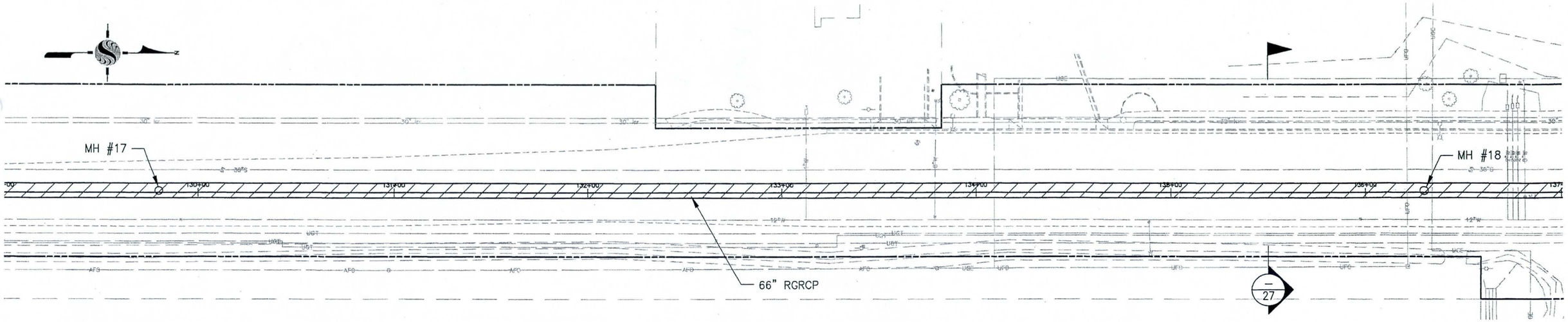

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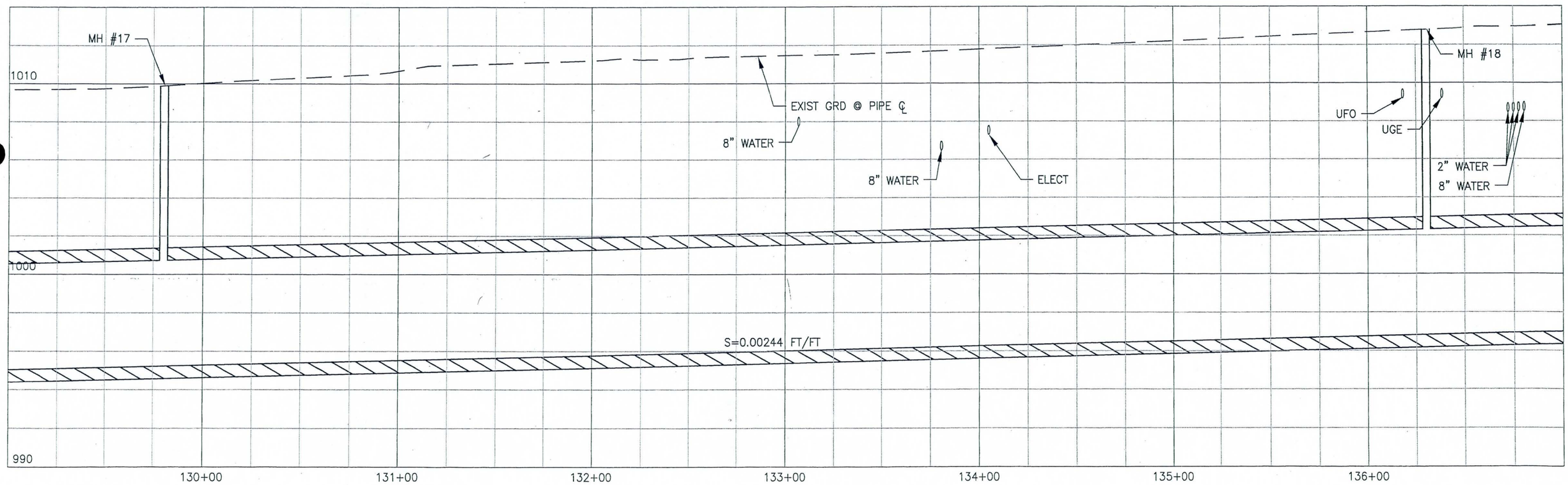

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Client/Project CITY OF PHOENIX 75TH AVE STORM DRAIN	Title CONCEPTUAL PLAN AND PROFILE
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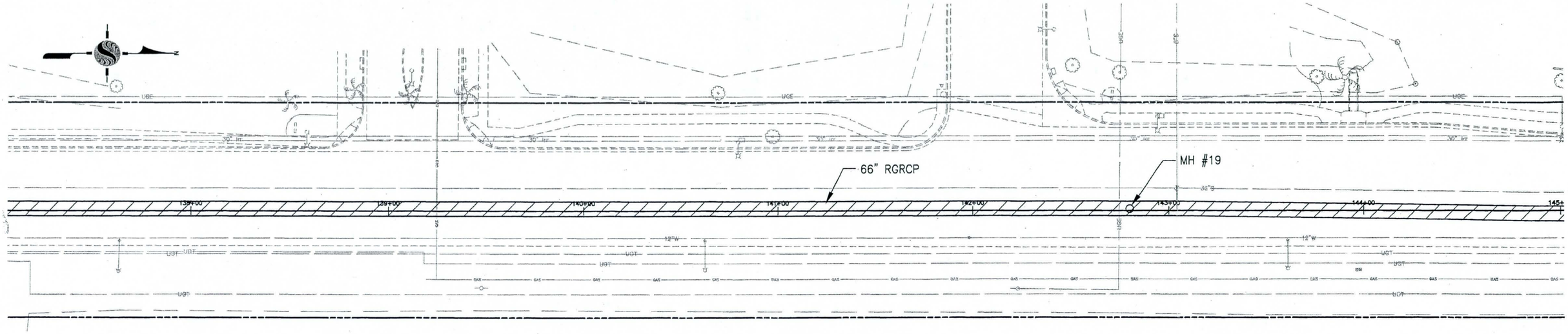

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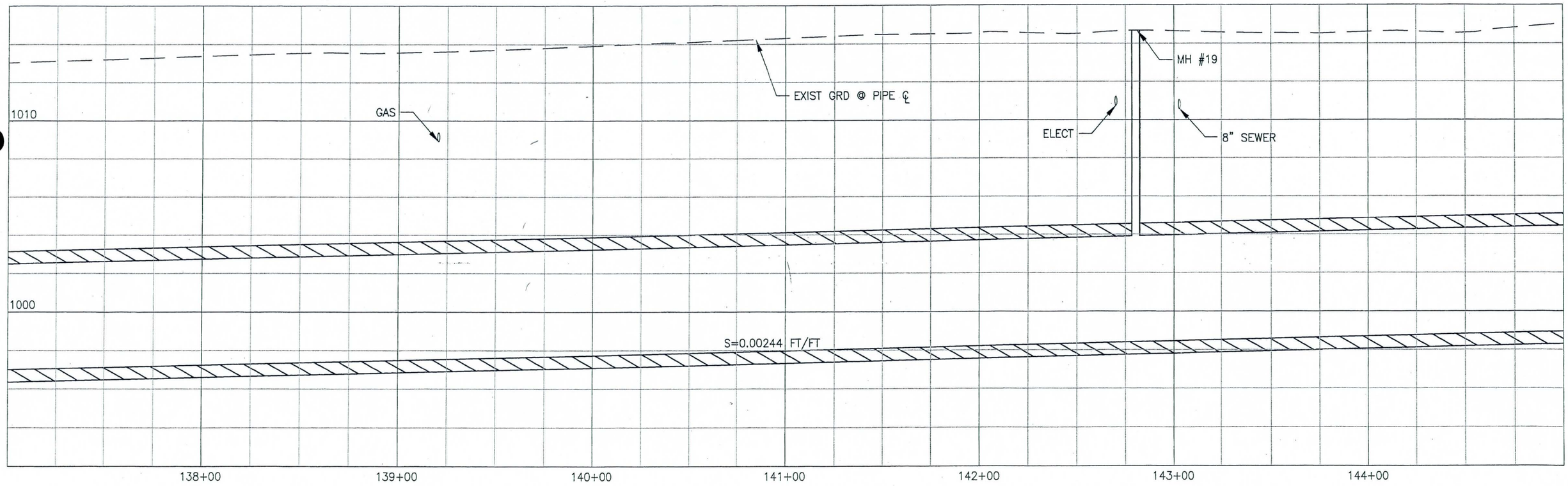

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Client/Project CITY OF PHOENIX 75TH AVE STORM DRAIN	Title CONCEPTUAL PLAN AND PROFILE
	Date 10-13-03
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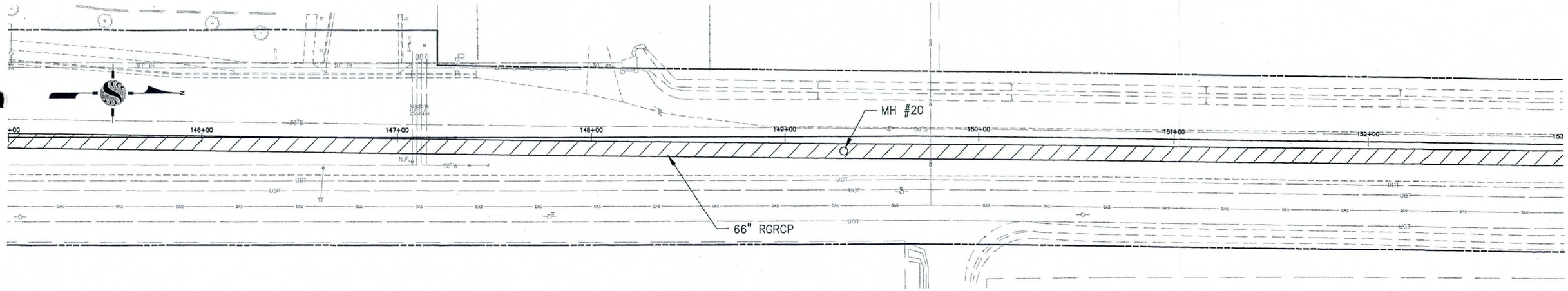

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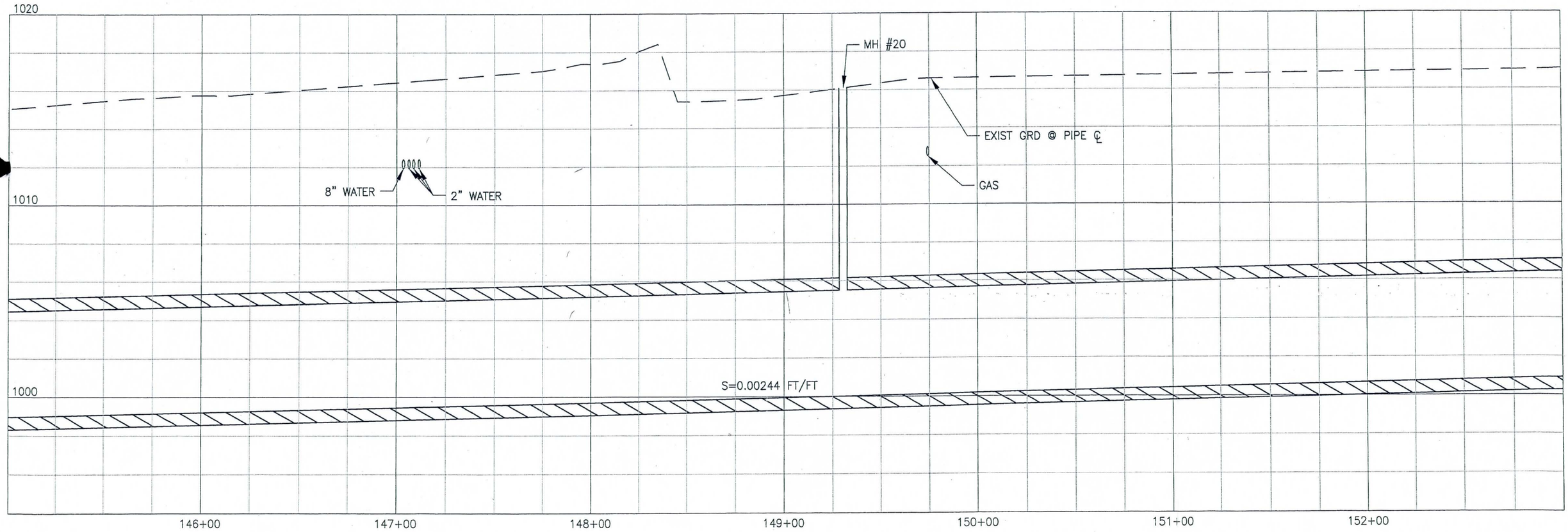

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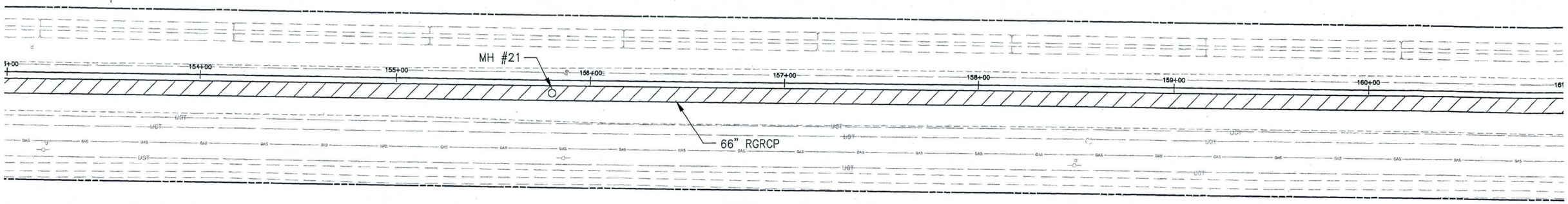

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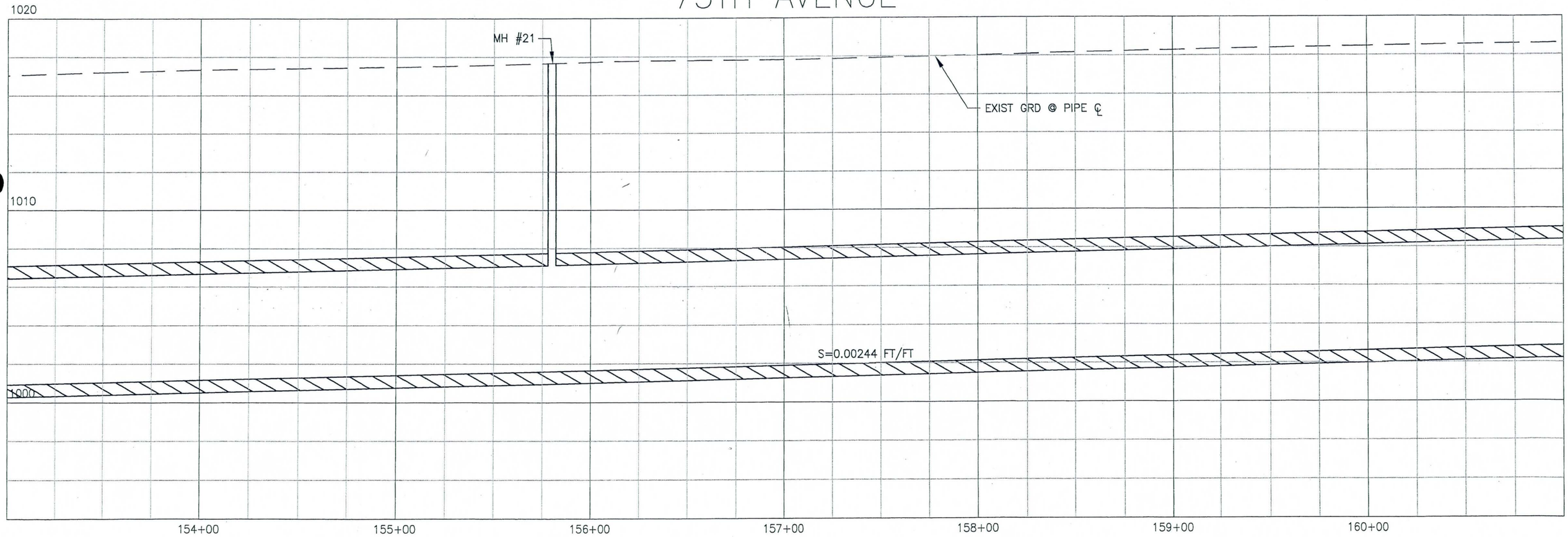

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Client/Project CITY OF PHOENIX 75TH AVE STORM DRAIN	Title CONCEPTUAL PLAN AND PROFILE
Page No. 19 of ~~29~~ 30	Date 10-13-03
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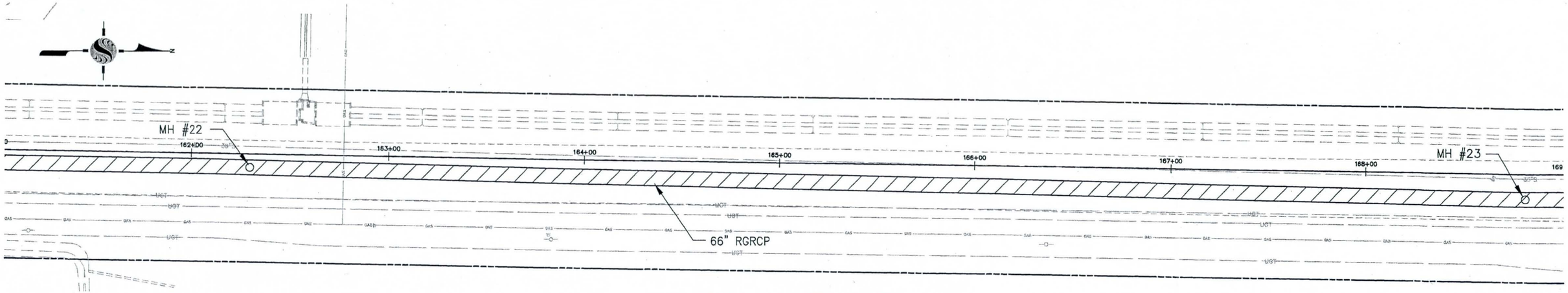

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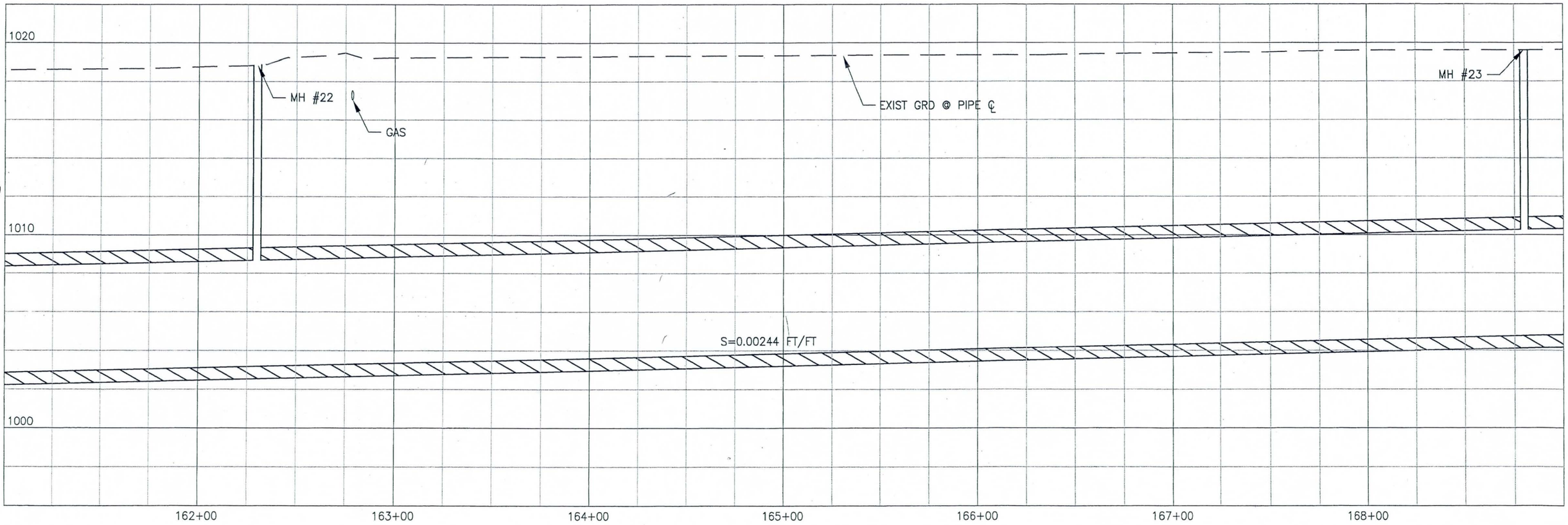

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VERTICAL SCALE: 1"=5'

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	Date 10-13-03
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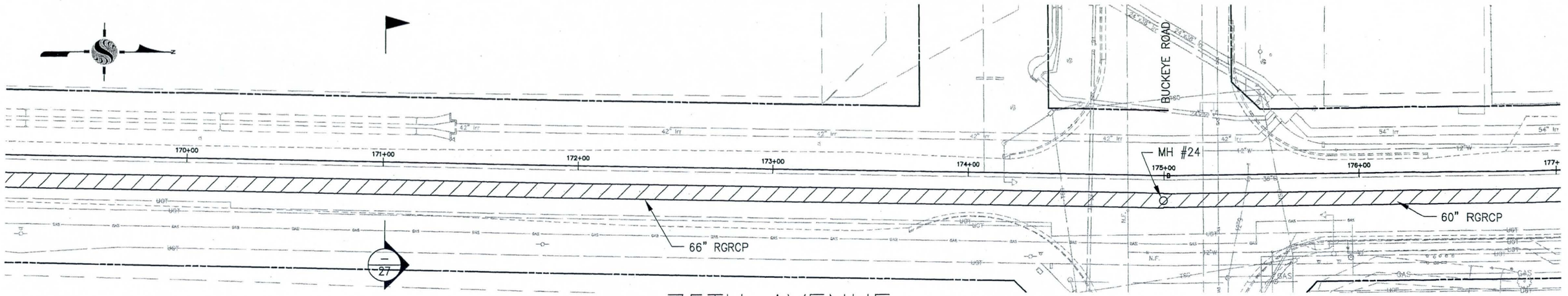

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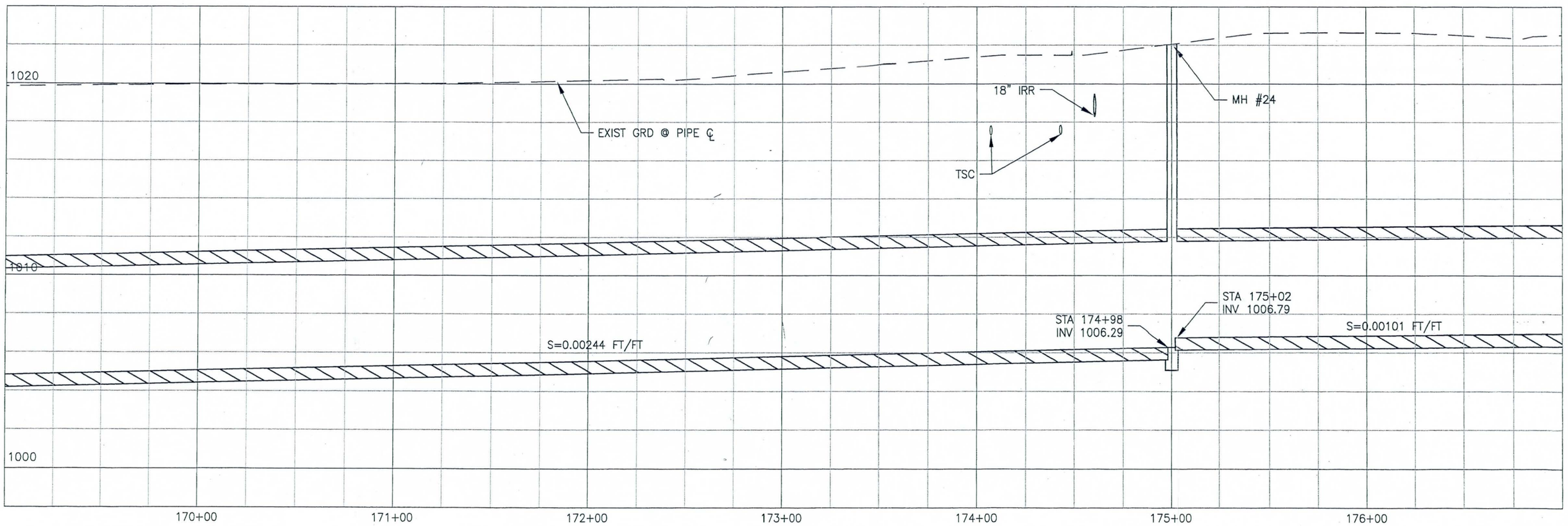

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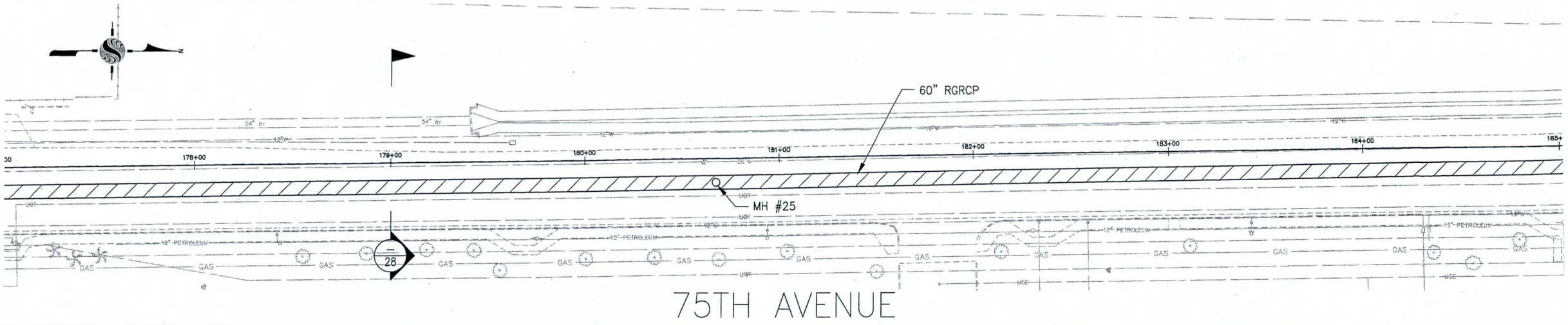

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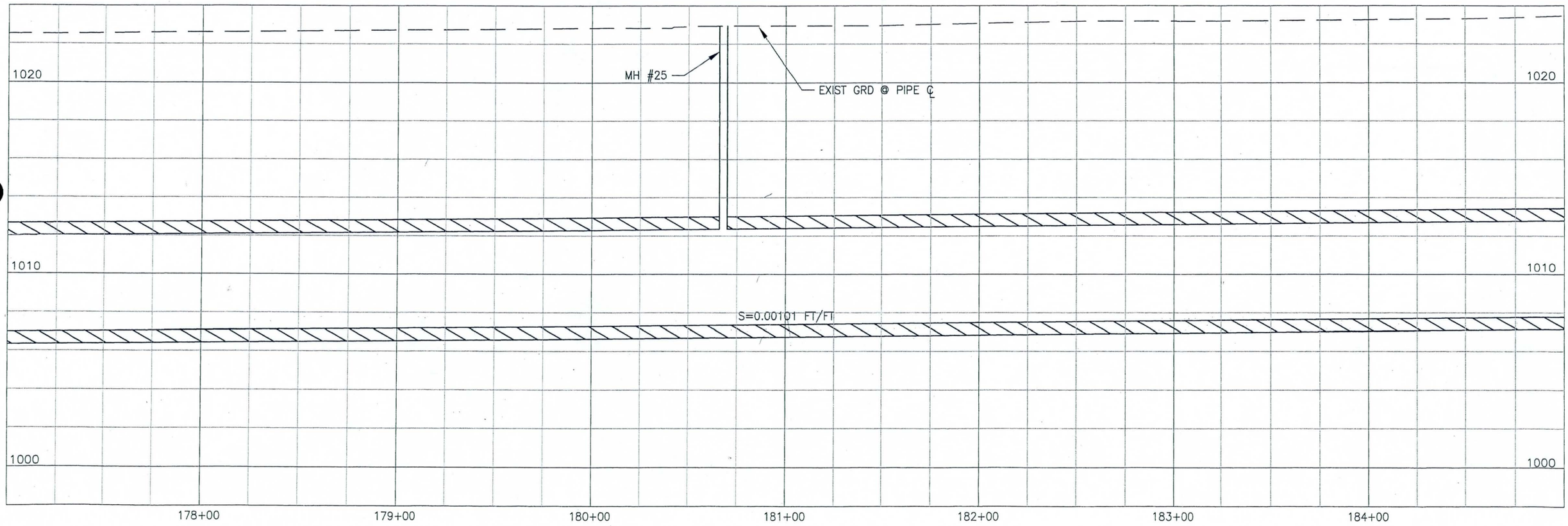

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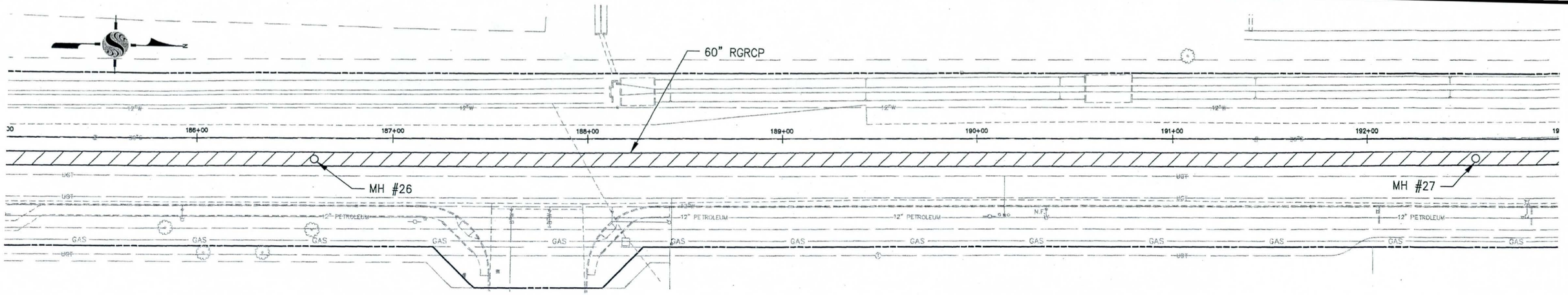

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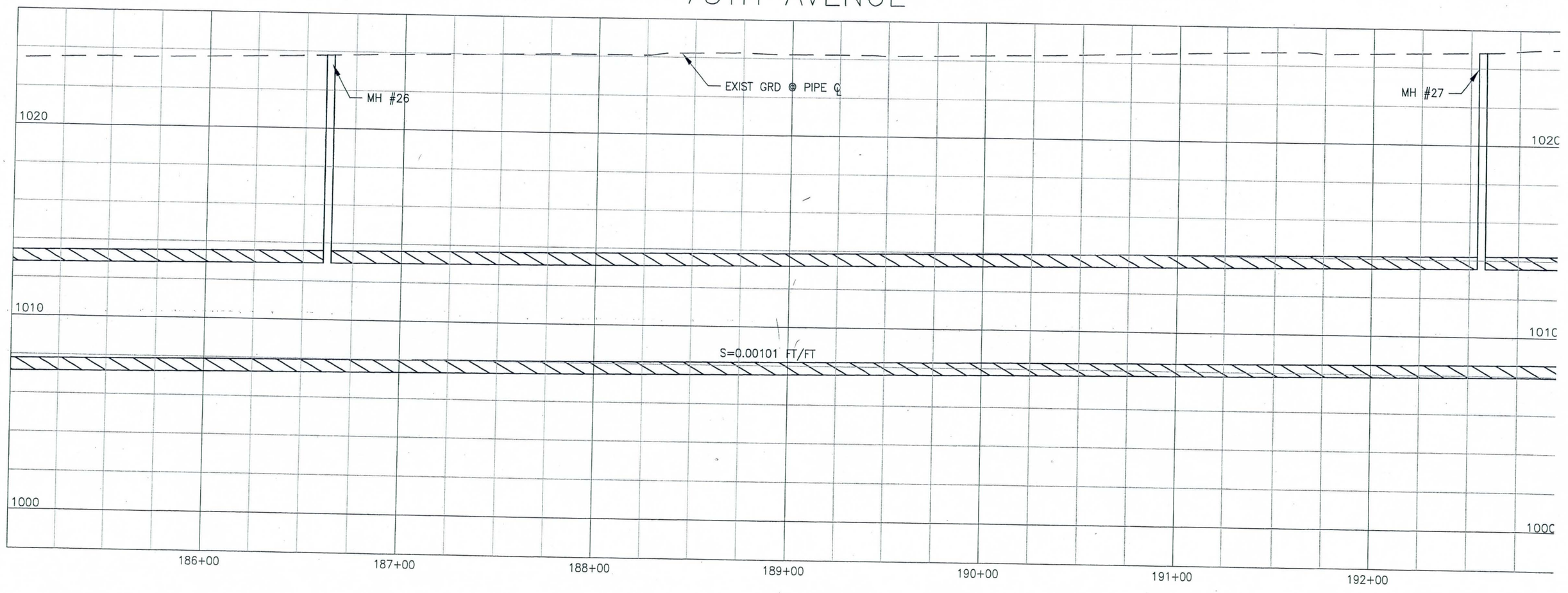

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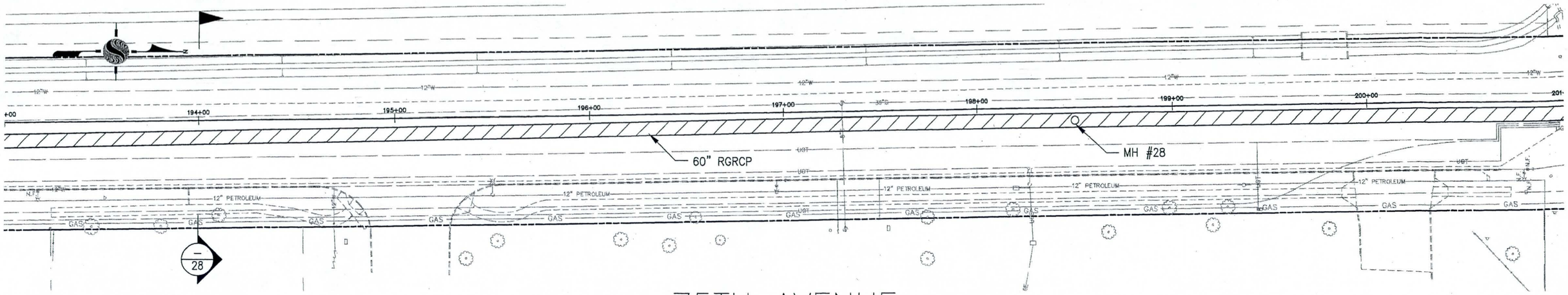

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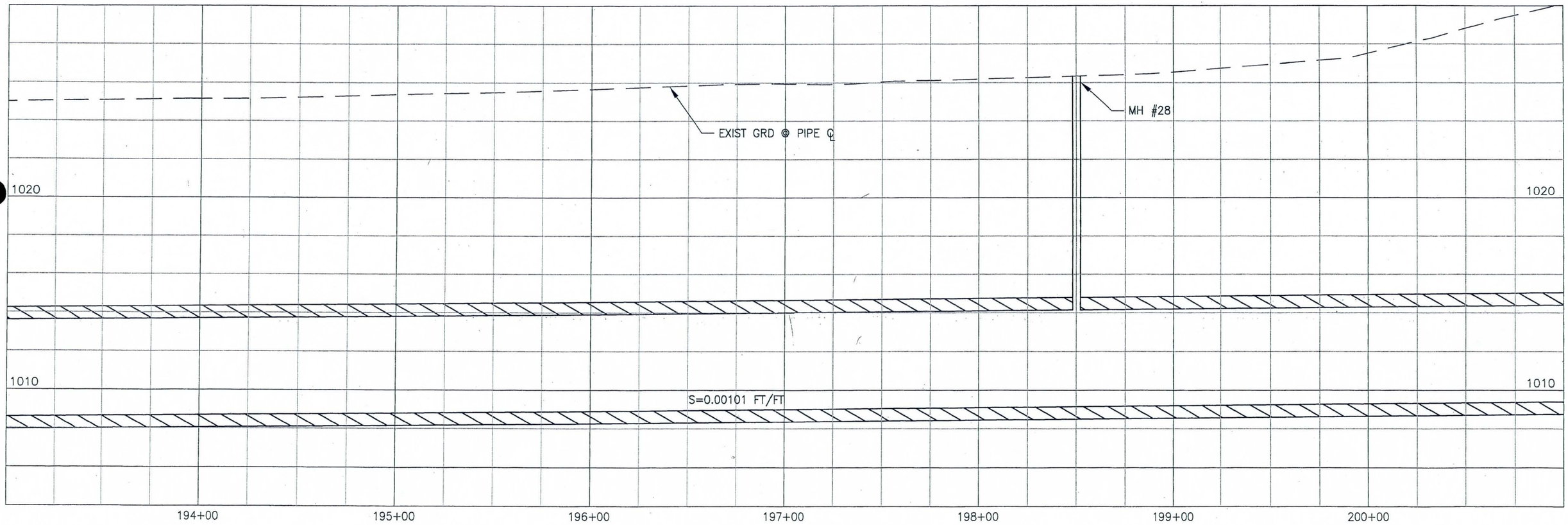

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Client/Project CITY OF PHOENIX 75TH AVE STORM DRAIN	Title CONCEPTUAL PLAN AND PROFILE
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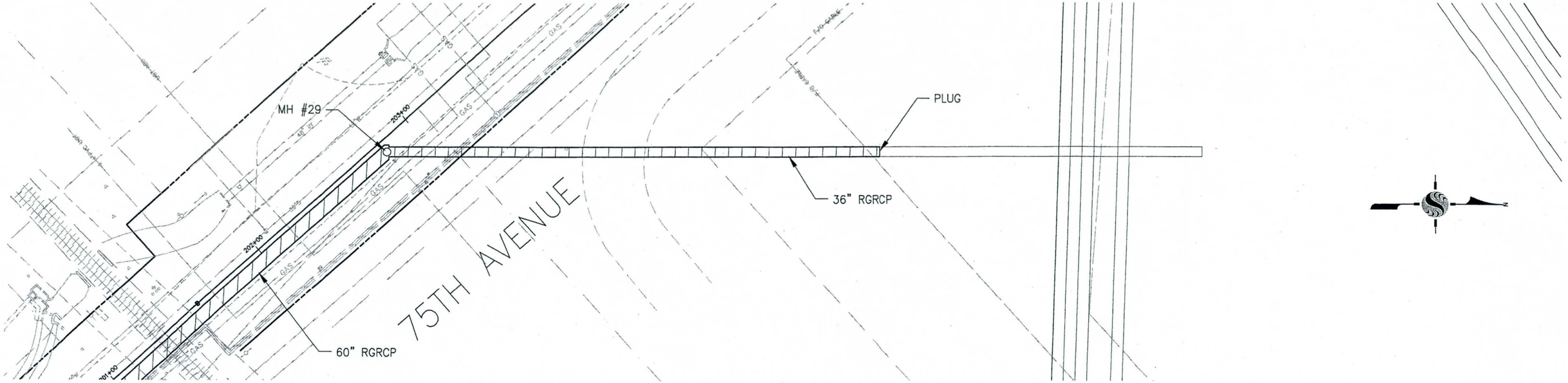

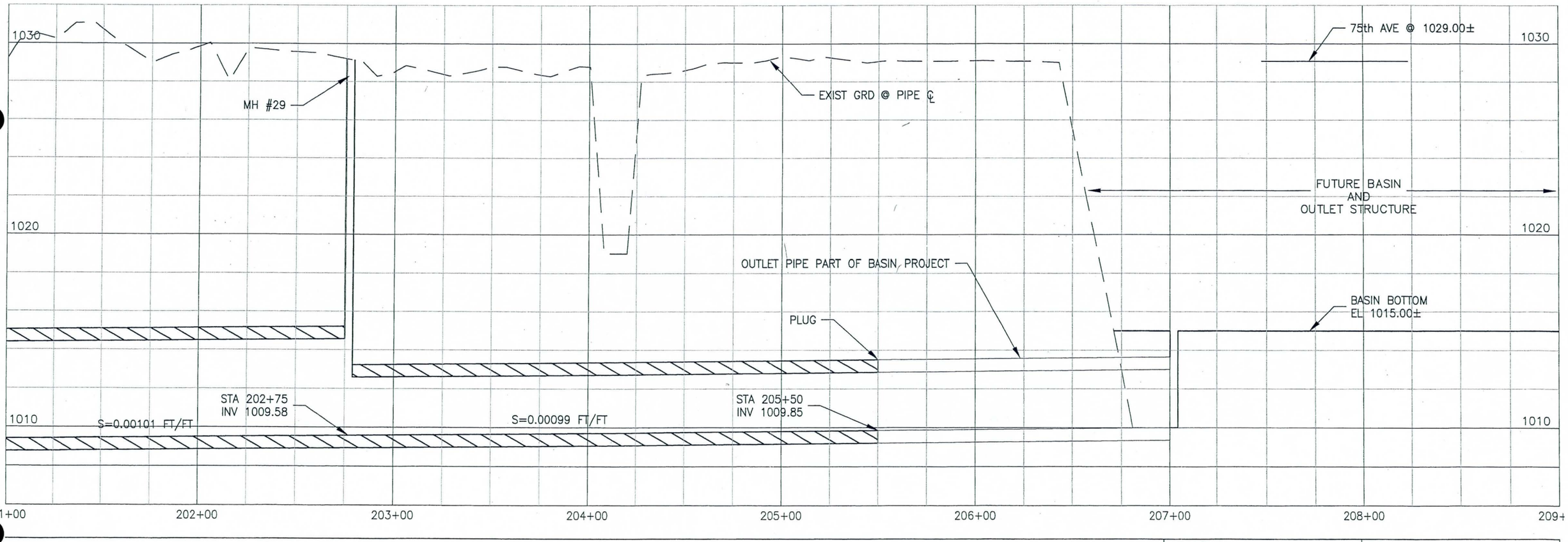

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DRAFT

Client/Project CITY OF PHOENIX 75TH AVE STORM DRAIN	Title CONCEPTUAL PLAN AND PROFILE
	Date 10-13-03
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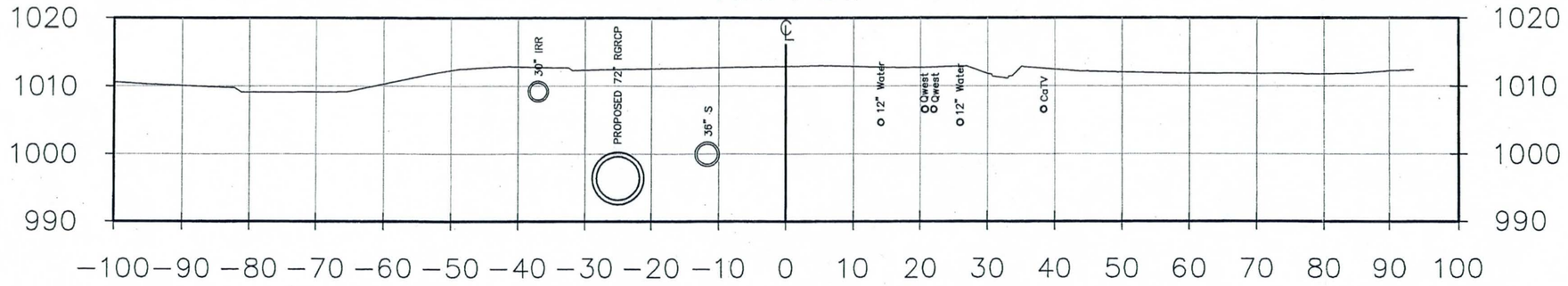

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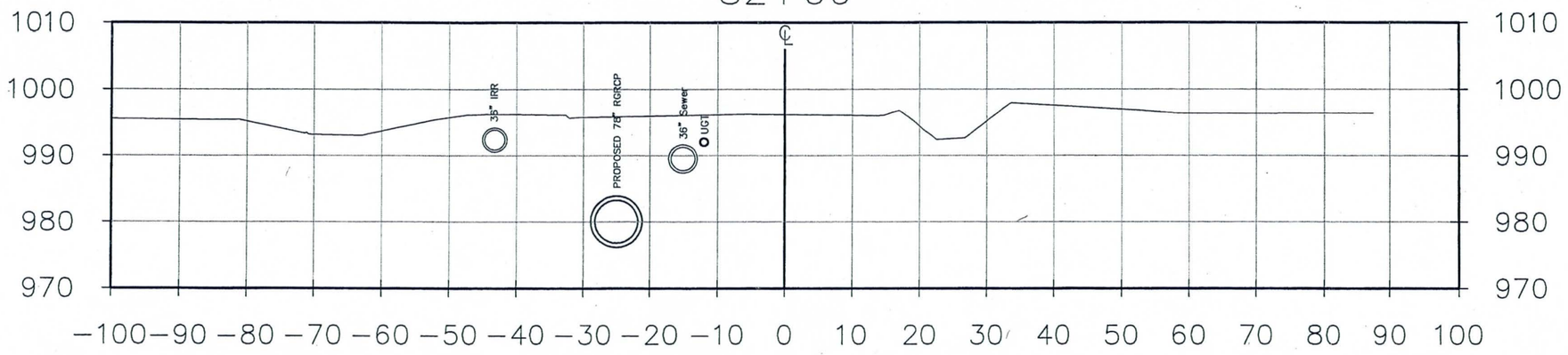

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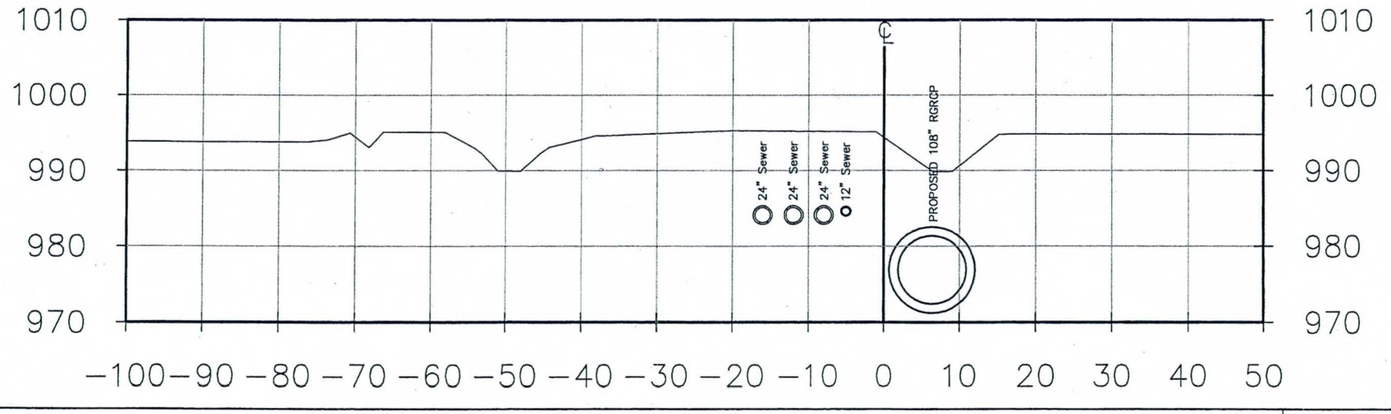

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Client/Project CITY OF PHOENIX 75TH AVE STORM DRAIN	Title CROSS SECTIONS
Page No. 26 of ~~29~~ 30	Date 05-28-03
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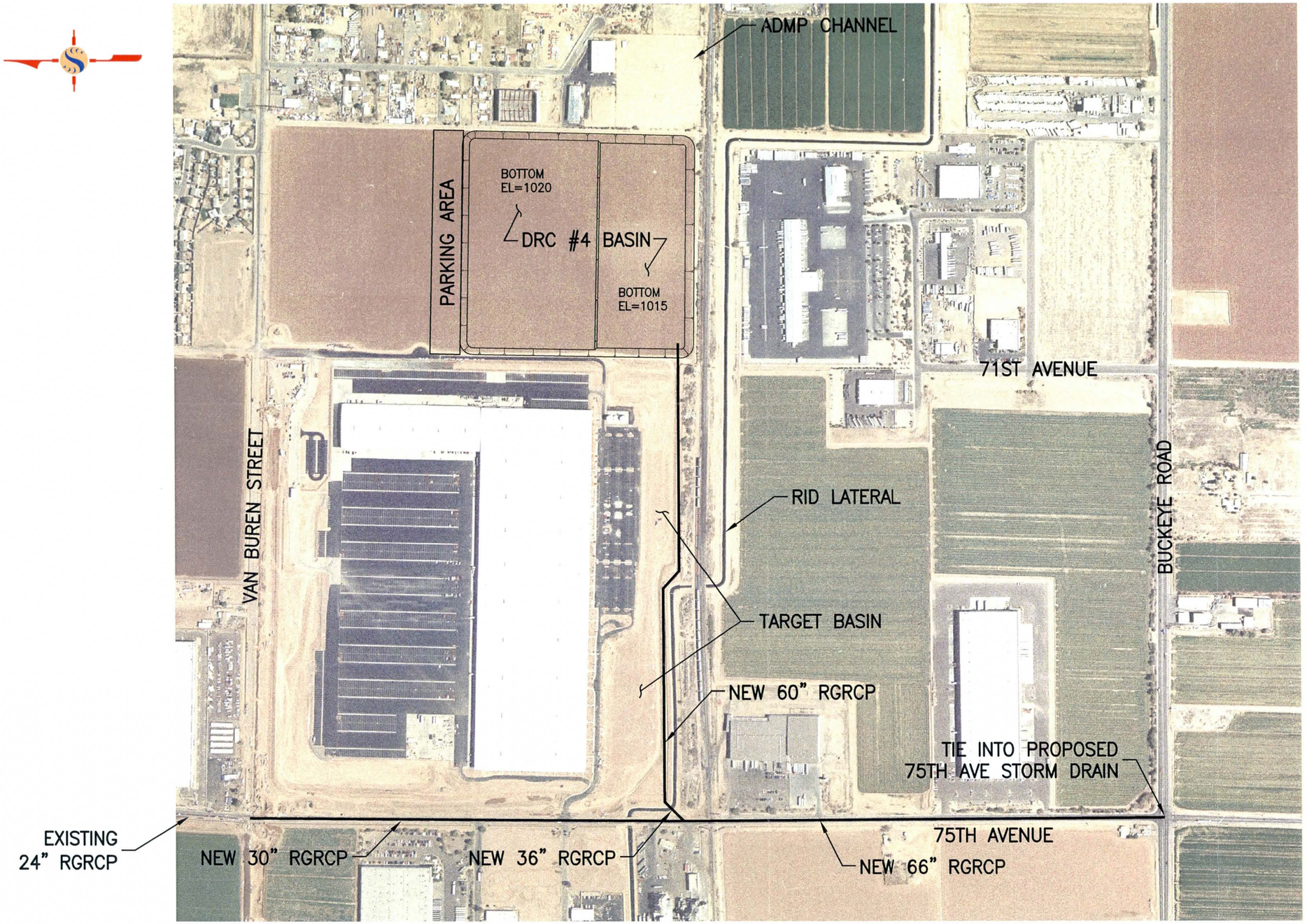
ALTERNATIVE 1
DRC BASIN #4/STORM
DRAIN ALIGNMENT



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(IN FEET)

GRAPHIC SCALE

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Client/Project CITY OF PHOENIX 75TH AVE STORM DRAIN	Title CONCEPTUAL PLAN
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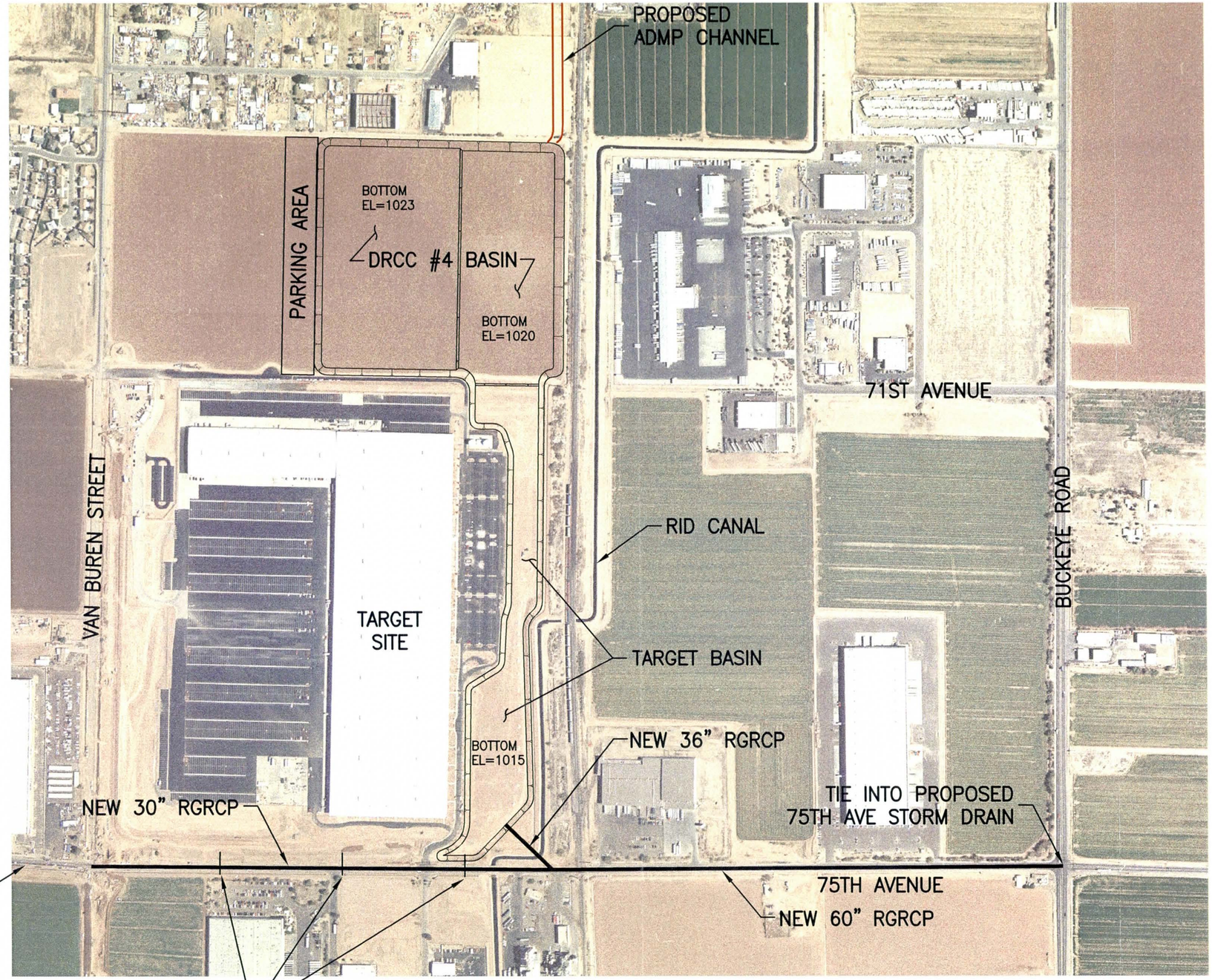
ALTERNATIVE 2
DRCC BASIN #4/STORM
DRAIN ALIGNMENT



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Client/Project CITY OF PHOENIX 75TH AVE STORM DRAIN	Title CONCEPTUAL PLAN
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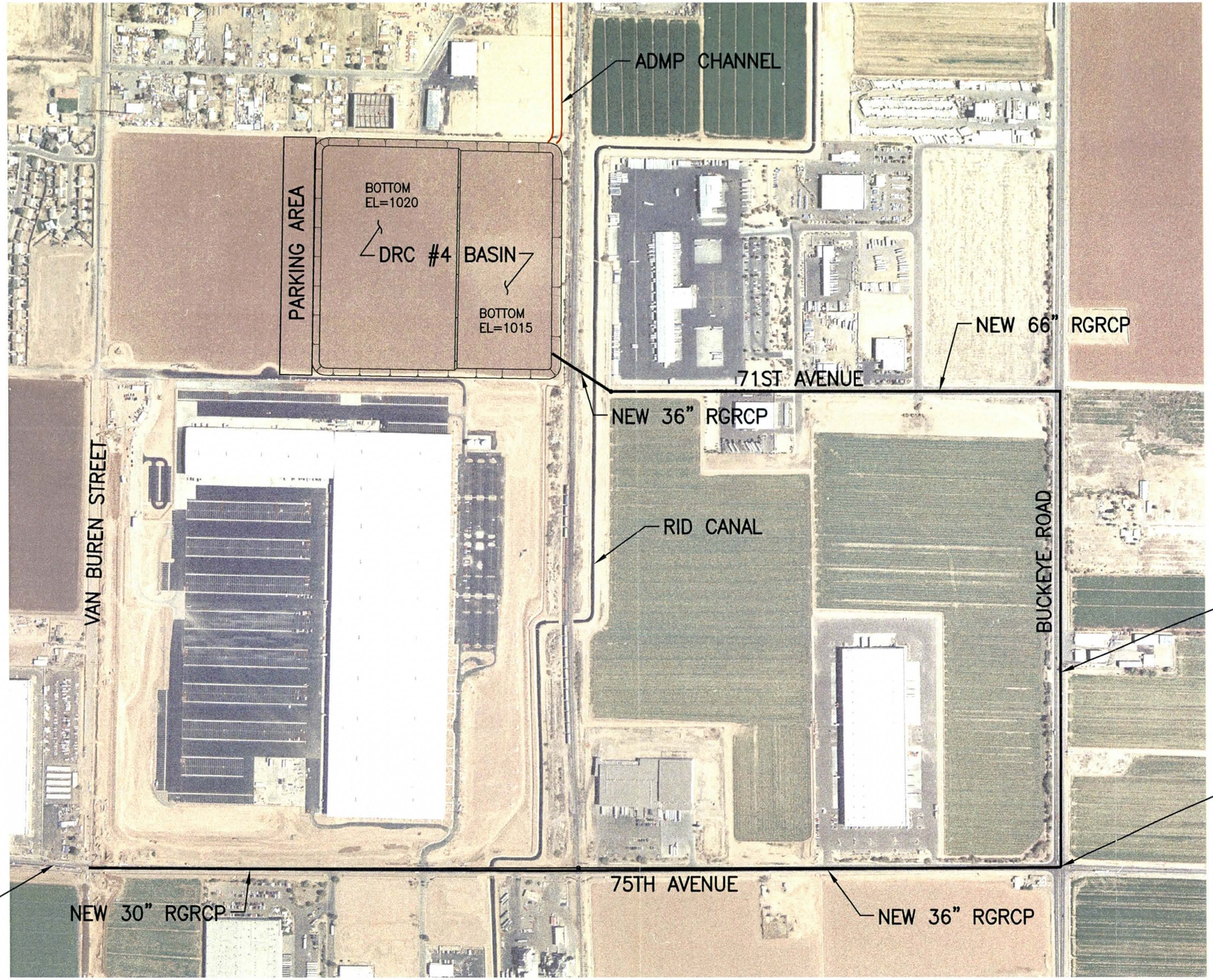
ALTERNATIVE 3
DRC BASIN #4/STORM DRAIN ALIGNMENT



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(IN FEET)

GRAPHIC SCALE

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Client/Project	Title
CITY OF PHOENIX 75TH AVE STORM DRAIN	CONCEPTUAL PLAN
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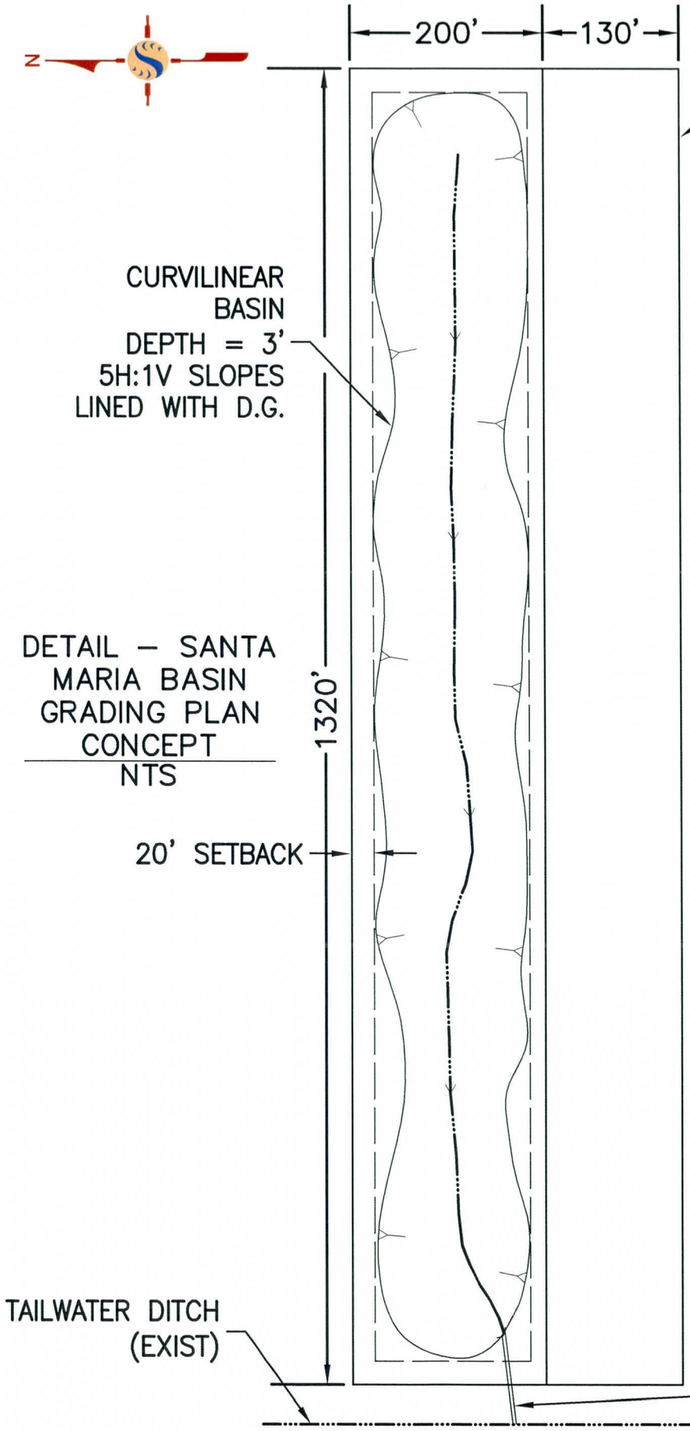
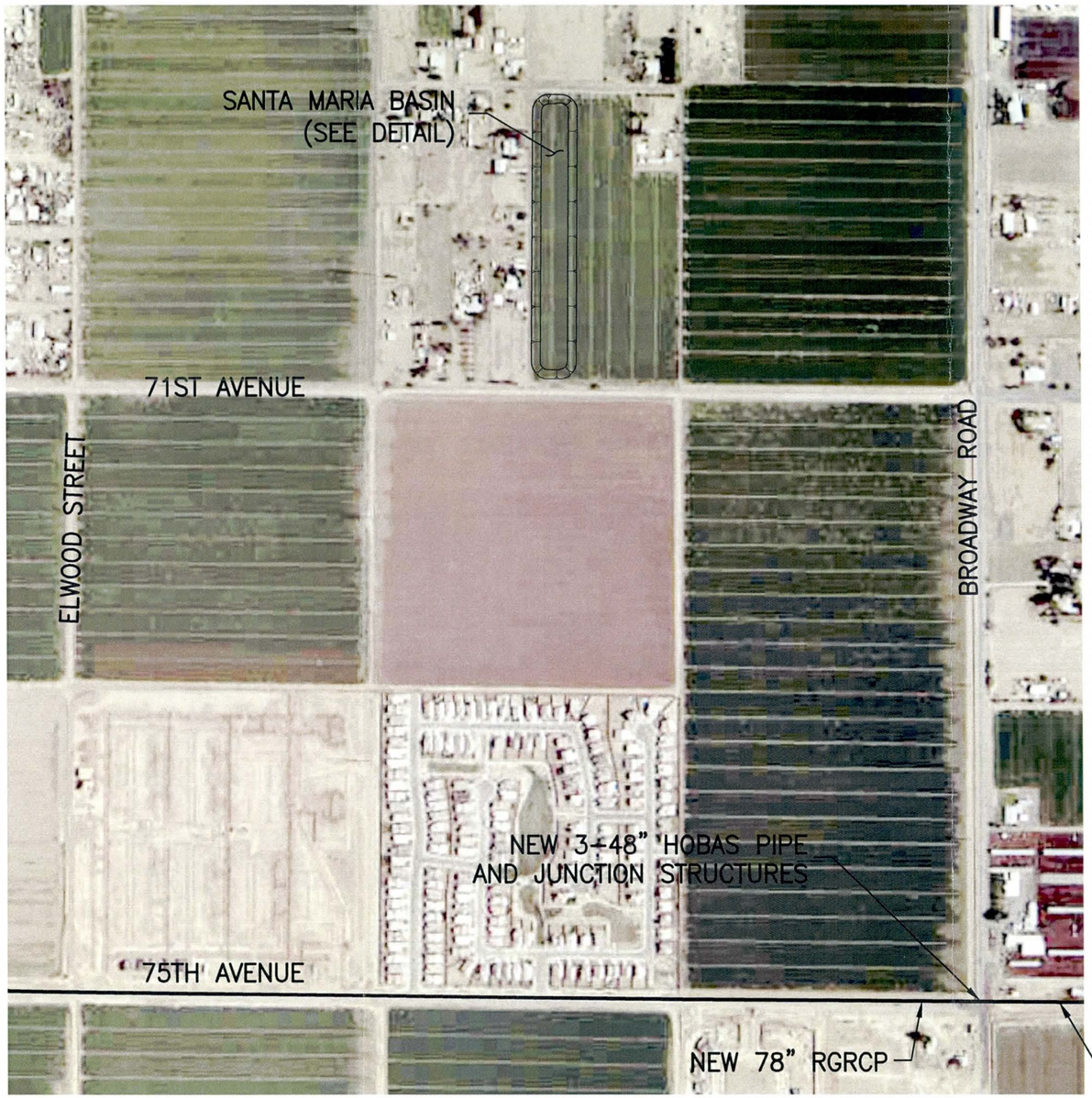
ALTERNATIVE 6
SANTA MARIA BASIN/
STORM DRAIN ALIGNMENT



DETAIL – SANTA MARIA BASIN GRADING PLAN CONCEPT
NTS



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Client/Project CITY OF PHOENIX 75TH AVE STORM DRAIN	Title CONCEPTUAL PLAN
	Date 1-31-05
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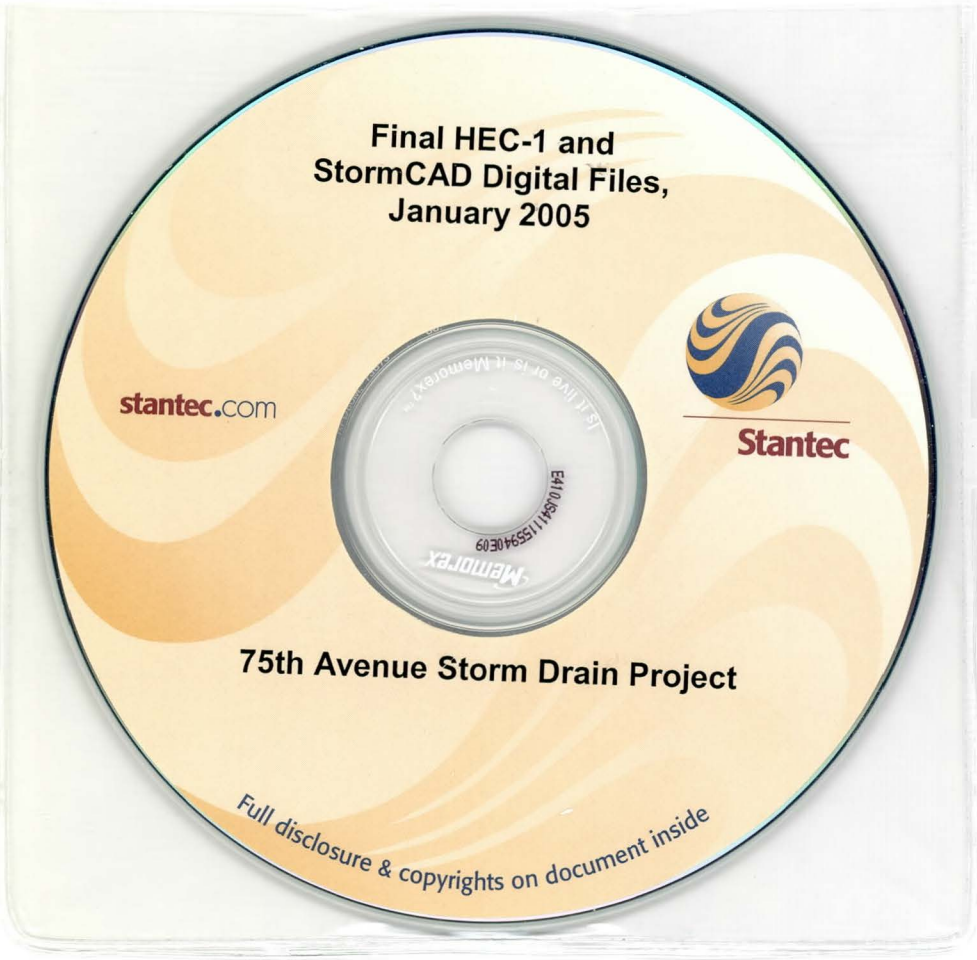
APPENDICES

APPENDIX A: HEC-1 INPUT DATA

Hec-1 Input Parameters Used for Future Conditions

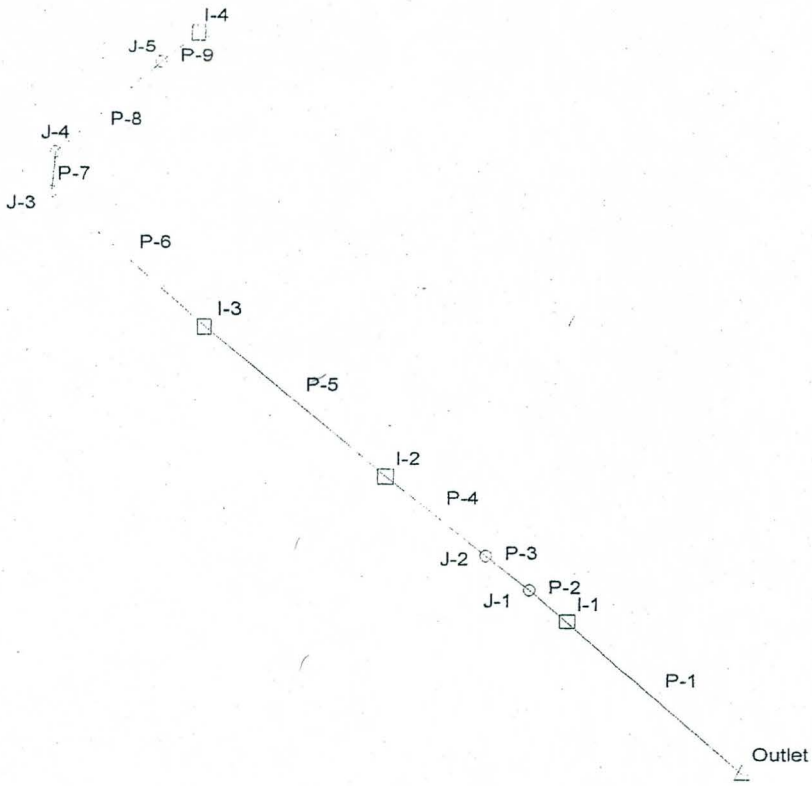
Sub Basin ID	Area ($mile^2$)	L (miles)	Lca (miles)	Slope (ft/ft)	Kn	IA	DTHETA	PSIF	XKSAT	Percent Impervious (%)	Runoff Coefficient Used to Estimate Retention Volume	100-YR Retention Volume Modeled (acre ft)
TB1	0.138	0.85	0.25	9.4	0.02	0.25	0.15	9.7	0.053	30	0.7	11.2
SF1	0.127	0.5	0.3	9.2	0.1	0.5	0.15	9.7	0.07	0	0.90	13.3
TB2	0.75	1.75	0.9	10.3	0.046	0.15	0.15	8.8	0.056	55	0.90	19.6
SF2B	0.11	0.5	0.3	2.9	0.02	0.15	0.15	9.7	0.07	50	0.90	11.5
SF2A	0.14	0.6	0.2	5.9	0.02	0.15	0.15	9.7	0.07	80	0.90	14.6
PB	0.41	1.13	0.5	5.3	0.02	0.25	0.15	8.8	0.056	55	0.90	42.9
NA	0.94	2	1	10.5	0.02	0.25	0.15	8	0.08	51	0.82	89.6
UD	0.76	1.25	0.63	20.0	0.02	0.15	0.15	9.7	0.047	55	0.9	38.7
NB	0.444	1.36	0.68	16.8	0.02	0.25	0.15	6.8	0.156	12	0.65	33.5
JD	0.51	1.1	0.55	12.7	0.02	0.25	0.17	8	0.098	22.5	0.59	35.0
JC1	0.470	1.5	1	10.7	0.02	0.25	0.15	7.15	0.12	30	0.65	35.5
JC2	0.480	1.5	1	11.3	0.02	0.25	0.15	7	0.13	24	0.65	19.7
	Road Way Drainage											
PB75	0.01	0.5	0.25	12.0	0.02	0.15	0.15	9.7	0.041	80	NA	NA
PBBU	0.021	1	0.5	6.0	0.02	0.15	0.15	8	0.071	80	NA	NA
NA75	0.02	0.985	0.4925	15.2	0.02	0.15	0.15	7.6	0.081	80	NA	NA
NALB	0.021	1	0.5	6.0	0.02	0.15	0.19	6.6	0.119	80	NA	NA
JC75	0.021	1	0.5	13.0	0.02	0.15	0.15	7	0.098	80	NA	NA
JCBR	0.021	1	0.5	11.0	0.02	0.15	0.169	6.9	0.111	80	NA	NA
FB75	0.018	0.84	0.42	10.7	0.02	0.15	0.25	4.7	0.25	80	NA	NA



APPENDIX B: HEC-1 / STORMCAD INPUT / OUTPUT DIGITAL FILES

APPENDIX C: STORMCAD OUTPUT FILES

ALTERNATIVE 1, 100-YEAR MODEL


I-4
J-5
P-9
P-8
J-4
P-7
J-3
P-6
I-3
P-5
I-2
P-4
J-2
P-3
P-2
J-1
I-1
P-1
Outlet

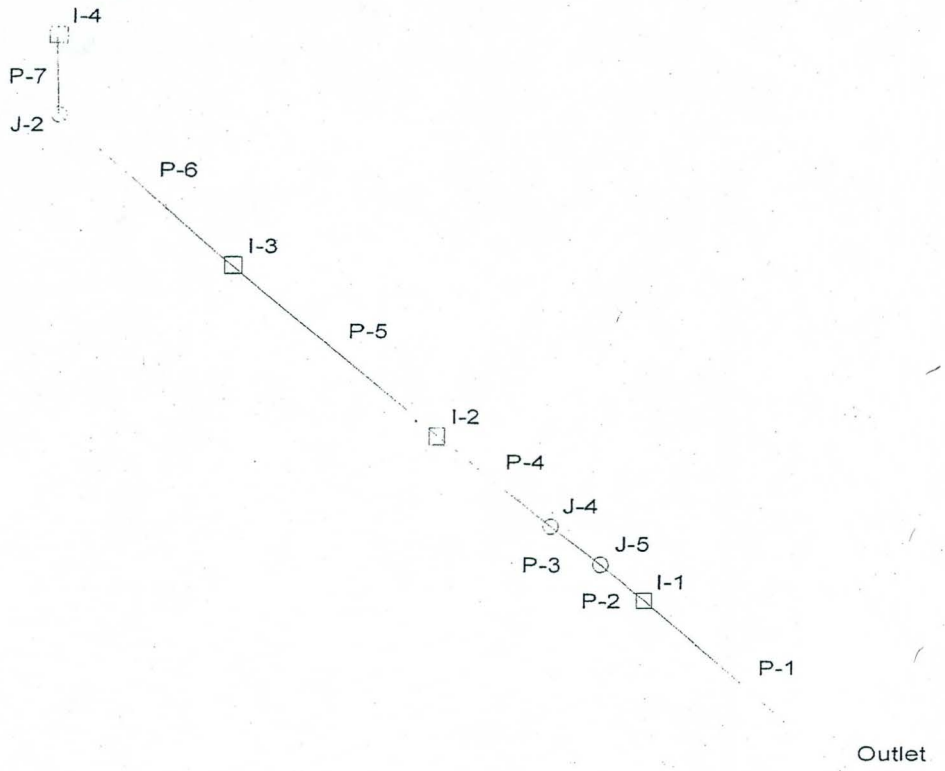
```
------------------ Beginning Calculation Cycle ------------------
Discharge: 93.00 cfs  at node I-4
Discharge: 93.00 cfs  at node J-5
Discharge: 93.00 cfs  at node J-4
Discharge: 93.00 cfs  at node J-3
Discharge: 140.00 cfs  at node I-3
Discharge: 211.00 cfs  at node I-2
Discharge: 211.00 cfs  at node J-2
Discharge: 211.00 cfs  at node J-1
Discharge: 347.00 cfs  at node I-1
Discharge: 347.00 cfs  at node Outlet
Beginning iteration 1
Discharge: 93.00 cfs  at node I-4
Discharge: 93.00 cfs  at node J-5
Discharge: 93.00 cfs  at node J-4
Discharge: 93.00 cfs  at node J-3
Discharge: 140.00 cfs  at node I-3
Discharge: 211.00 cfs  at node I-2
Discharge: 211.00 cfs  at node J-2
Discharge: 211.00 cfs  at node J-1
Discharge: 347.00 cfs  at node I-1
Discharge: 347.00 cfs  at node Outlet
Discharge Convergence Achieved in 1 iterations: relative error:  0.0
** Warning: Design constraints not met.
Warning: No Duration data exists in IDF Table
Information: Outlet Known flow propagated from upstream junctions.
Information: P-1 Surcharged condition
Violation: P-1 does not meet minimum slope constraint.
Information: P-2 Surcharged condition
Information: J-1 Known flow propagated from upstream junctions.
Information: P-3 Surcharged condition
Violation: P-3 does not meet minimum velocity constraint.
Information: J-2 Known flow propagated from upstream junctions.
Information: P-4 Surcharged condition
Violation: P-6 does not meet minimum slope constraint.
Information: J-3 Known flow propagated from upstream junctions.
Information: P-7 Surcharged condition
Violation: P-7 does not meet minimum slope constraint.
Information: J-4 Known flow propagated from upstream junctions.
Information: P-8 Surcharged condition
Violation: P-8 does not meet minimum slope constraint.
Information: J-5 Known flow propagated from upstream junctions.
Information: P-9 Surcharged condition
Violation: P-9 does not meet minimum slope constraint.
---------------------- Calculations Complete ----------------------

** Analysis Options **
Friction method:  Manning's Formula
Hydraulic Grade Convergence Test:  0.001000
Maximum Network Traversals:  5
Number of Flow Profile Steps:  5
Discharge Convergence Test:  0.001000
Maximum Design Passes:  3
```

---------- Network Quick View ----------

Label	Length	Size	Discharge	Hydraulic Grade Upstream	Hydraulic Grade Downstream
P-1	4,403.00	108 inch	347.00	990.57	987.17
P-2	130.00	8 x 4 ft	211.00	991.74	991.45
P-5	5,163.00	66 inch	140.00	1,011.48	1,002.58
P-4	4,935.00	78 inch	211.00	1,002.09	994.10
P-3	300.00	96 inch	211.00	994.10	993.94
P-6	2,773.00	60 inch	93.00	1,015.27	1,011.75
P-7	280.00	36 inch	93.00	1,020.93	1,015.48
P-9	30.00	60 inch	93.00	1,025.25	1,025.21
P-8	2,470.00	60 inch	93.00	1,025.21	1,022.06

		Elevations	
Label	Discharge	Ground	Upstream HGL	Downstream HGL
Outlet	347.00	986.00	987.17	987.17
I-1	347.00	994.91	991.45	990.57
J-1	211.00	995.29	993.94	991.74
I-2	211.00	1,008.80	1,002.58	1,002.09
I-3	140.00	1,021.66	1,011.75	1,011.48
J-3	93.00	1,024.00	1,015.48	1,015.27
I-4	93.00	1,030.00	1,025.66	1,025.25
J-2	211.00	994.60	994.10	994.10
J-4	93.00	1,029.00	1,022.06	1,020.93
J-5	93.00	1,030.00	1,025.21	1,025.21

Elapsed: 0 minute(s) 1 second(s)


I-4
P-7
J-2
P-6
I-3
P-5
I-2
P-4
J-4
J-5
P-3
I-1
P-2
P-1
Outlet

```
------------------ Beginning Calculation Cycle ------------------
Discharge: 93.00 cfs  at node I-4
Discharge: 93.00 cfs  at node J-2
Discharge: 143.00 cfs  at node I-3
Discharge: 211.00 cfs  at node I-2
Discharge: 211.00 cfs  at node J-4
Discharge: 211.00 cfs  at node J-5
Discharge: 345.00 cfs  at node I-1
Discharge: 345.00 cfs  at node Outlet
Beginning iteration 1
Discharge: 93.00 cfs  at node I-4
Discharge: 93.00 cfs  at node J-2
Discharge: 143.00 cfs  at node I-3
Discharge: 211.00 cfs  at node I-2
Discharge: 211.00 cfs  at node J-4
Discharge: 211.00 cfs  at node J-5
Discharge: 345.00 cfs  at node I-1
Discharge: 345.00 cfs  at node Outlet
Discharge Convergence Achieved in 1 iterations: relative error:  0.0
** Warning: Design constraints not met.
Warning: No Duration data exists in IDF Table
Information: Outlet Known flow propagated from upstream junctions.
Information: P-1 Surcharged condition
Violation: P-1 does not meet minimum slope constraint.
Information: P-2 Surcharged condition
Information: J-5 Known flow propagated from upstream junctions.
Information: P-3 Surcharged condition
Violation: P-3 does not meet minimum velocity constraint.
Information: J-4 Known flow propagated from upstream junctions.
Information: P-4 Surcharged condition
Information: P-5 Surcharged condition
Information: P-6 Surcharged condition
Violation: P-6 does not meet minimum slope constraint.
Information: J-2 Known flow propagated from upstream junctions.
Information: P-7 Surcharged condition
Violation: P-7 does not meet minimum slope constraint.
--------------------- Calculations Complete ---------------------

** Analysis Options **
Friction method:  Manning's Formula
Hydraulic Grade Convergence Test:  0.001000
Maximum Network Traversals:  5
Number of Flow Profile Steps:  5
Discharge Convergence Test:  0.001000
Maximum Design Passes:  3


----------------- Network Quick View ------------------------
```

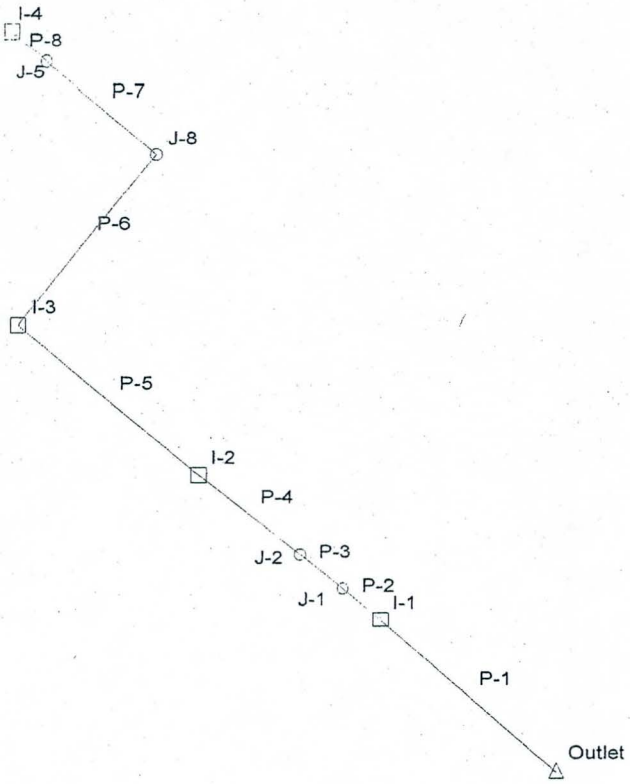
				Hydraulic Grade	
Label	Length	Size	Discharge	Upstream	Downstream
P-1	4,403.00	108 inch	345.00	990.53	987.17
P-2	130.00	8 x 4 ft	211.00	991.69	991.40
P-5	5,163.00	66 inch	143.00	1,011.90	1,002.54
P-7	350.00	36 inch	93.00	1,022.87	1,016.06
P-4	4,935.00	78 inch	211.00	1,002.05	994.05
P-3	300.00	96 inch	211.00	994.05	993.89
P-6	2,773.00	60 inch	93.00	1,015.70	1,012.16

		Elevations		
Label	Discharge	Ground	Upstream HGL	Downstream HGL
Outlet	345.00	986.00	987.17	987.17
I-1	345.00	994.91	991.40	990.53
J-5	211.00	995.29	993.89	991.69
I-2	211.00	1,008.80	1,002.54	1,002.05
I-3	143.00	1,021.66	1,012.16	1,011.90
J-2	93.00	1,024.00	1,016.06	1,015.70
I-4	93.00	1,030.00	1,026.10	1,022.87

J-4	211.00	994.60	994.05	994.05

Elapsed: 0 minute(s) 1 second(s)

ALTERNATIVE 3, 100-YEAR MODEL


I-4
P-8
J-5
P-7
J-8
P-6
I-3
P-5
I-2
P-4
J-2
P-3
J-1
P-2
I-1
P-1
Outlet

```
------------------ Beginning Calculation Cycle ------------------
Discharge: 93.00 cfs  at node I-4
Discharge: 93.00 cfs  at node J-5
Discharge: 93.00 cfs  at node J-8
Discharge: 136.00 cfs  at node I-3
Discharge: 206.00 cfs  at node I-2
Discharge: 206.00 cfs  at node J-2
Discharge: 206.00 cfs  at node J-1
Discharge: 342.00 cfs  at node I-1
Discharge: 342.00 cfs  at node Outlet
Beginning iteration 1
Discharge: 93.00 cfs  at node I-4
Discharge: 93.00 cfs  at node J-5
Discharge: 93.00 cfs  at node J-8
Discharge: 136.00 cfs  at node I-3
Discharge: 206.00 cfs  at node I-2
Discharge: 206.00 cfs  at node J-2
Discharge: 206.00 cfs  at node J-1
Discharge: 342.00 cfs  at node I-1
Discharge: 342.00 cfs  at node Outlet
Discharge Convergence Achieved in 1 iterations: relative error:  0.0
** Warning: Design constraints not met.
Warning: No Duration data exists in IDF Table
Information: Outlet Known flow propagated from upstream junctions.
Information: P-1 Surcharged condition
Violation: P-1 does not meet minimum slope constraint.
Information: P-2 Surcharged condition
Information: J-1 Known flow propagated from upstream junctions.
Information: P-3 Surcharged condition
Violation: P-3 does not meet minimum velocity constraint.
Information: J-2 Known flow propagated from upstream junctions.
Information: P-4 Surcharged condition
Violation: P-6 does not meet minimum slope constraint.
Information: J-8 Known flow propagated from upstream junctions.
Information: P-7 Surcharged condition
Violation: P-7 does not meet minimum slope constraint.
Information: J-5 Known flow propagated from upstream junctions.
Information: P-8 Surcharged condition
Violation: P-8 does not meet minimum slope constraint.
---------------------- Calculations Complete ----------------------

** Analysis Options **
Friction method:  Manning's Formula
Hydraulic Grade Convergence Test:  0.001000
Maximum Network Traversals:  5
Number of Flow Profile Steps:  5
Discharge Convergence Test:  0.001000
Maximum Design Passes:  3
```

---------- Network Quick View ----------

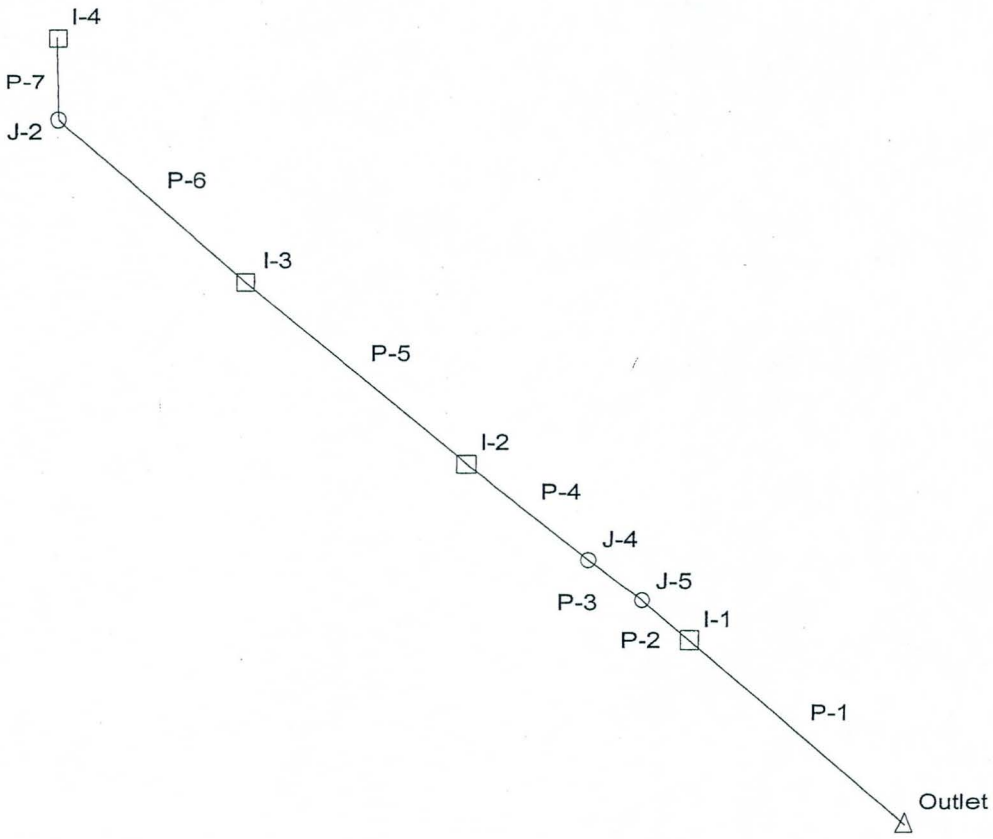
				Hydraulic Grade	
Label	Length	Size	Discharge	Upstream	Downstream
P-1	4,403.00	108 inch	342.00	990.47	987.17
P-2	130.00	8 x 4 ft	206.00	991.61	991.33
P-5	5,163.00	66 inch	136.00	1,010.18	1,001.94
P-4	4,935.00	78 inch	206.00	1,001.47	993.85
P-3	300.00	96 inch	206.00	993.85	993.70
P-8	300.00	36 inch	93.00	1,023.18	1,017.35
P-6	2,540.00	66 inch	93.00	1,013.56	1,011.83
P-7	2,450.00	60 inch	93.00	1,017.13	1,014.00

		Elevations		
Label	Discharge	Ground	Upstream HGL	Downstream HGL
Outlet	342.00	986.00	987.17	987.17
I-1	342.00	994.91	991.33	990.47
J-1	206.00	995.29	993.70	991.61

I-2	206.00	1,008.80	1,001.94	1,001.47
I-3	136.00	1,021.66	1,011.83	1,010.18
I-4	93.00	1,030.00	1,026.41	1,023.18
J-2	206.00	994.60	993.85	993.85
J-5	93.00	1,030.00	1,017.35	1,017.13
J-8	93.00	1,024.00	1,014.00	1,013.56

Elapsed: 0 minute(s) 0 second(s)

SANTA MARIA BASIN (PREFERRED) ALTERNATIVE, 100-YEAR MODEL


I-4
P-7
J-2
P-6
I-3
P-5
I-2
P-4
J-4
J-5
P-3
I-1
P-2
P-1
Outlet

Combined Pipe/Node Report

Pipe	Upstream Node	Upstream Invert Elevation (ft)	Upstream HGL (ft)	Downstream Node	Downstream Invert Elevation (ft)	Downstream HGL (ft)	Section Size	Length (ft)	Constructed Slope (ft/ft)	Discharge (cfs)	Capacity (cfs)
P-7	I-4	1,010.00	1,023.11	J-2	1,009.61	1,015.34	36 inch	400.00	0.000975	93.00	20.83
P-6	J-2	1,009.61	1,014.97	I-3	1,000.16	1,011.43	60 inch	2,782.00	0.003397	93.00	151.78
P-5	I-3	999.66	1,011.16	I-2	989.13	1,002.12	66 inch	4,985.00	0.002112	143.00	154.33
P-4	I-2	988.11	1,001.63	J-4	977.63	993.35	78 inch	5,115.00	0.002049	211.00	237.30
P-3	J-4	976.13	993.35	J-5	975.58	993.20	96 inch	270.00	0.002037	211.00	411.63
P-2	J-5	975.44	991.62	I-1	974.73	991.25	48 inch	153.00	0.004641	211.00	293.54
P-1	I-1	974.70	990.49	Outlet	970.67	987.03	96 inch	4,386.00	0.000919	256.00	276.46

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```
------------------ Beginning Calculation Cycle -------------------
Discharge: 93.00 cfs  at node I-4
Discharge: 93.00 cfs  at node J-2
Discharge: 143.00 cfs  at node I-3
Discharge: 211.00 cfs  at node I-2
Discharge: 211.00 cfs  at node J-4
Discharge: 211.00 cfs  at node J-5
Discharge: 256.00 cfs  at node I-1
Discharge: 256.00 cfs  at node Outlet
Beginning iteration 1
Discharge: 93.00 cfs  at node I-4
Discharge: 93.00 cfs  at node J-2
Discharge: 143.00 cfs  at node I-3
Discharge: 211.00 cfs  at node I-2
Discharge: 211.00 cfs  at node J-4
Discharge: 211.00 cfs  at node J-5
Discharge: 256.00 cfs  at node I-1
Discharge: 256.00 cfs  at node Outlet
Discharge Convergence Achieved in 1 iterations: relative error:  0.0
** Warning: Design constraints not met.
Warning: No Duration data exists in IDF Table
Information: Outlet Known flow propagated from upstream junctions.
Information: P-1 Surcharged condition
Violation: P-1 does not meet minimum slope constraint.
Information: P-2 Surcharged condition
Information: J-5 Known flow propagated from upstream junctions.
Information: P-3 Surcharged condition
Violation: P-3 does not meet minimum velocity constraint.
Information: J-4 Known flow propagated from upstream junctions.
Information: P-4 Surcharged condition
Information: P-5 Surcharged condition
Information: P-6 Surcharged condition
Violation: P-6 does not meet minimum velocity constraint.
Information: J-2 Known flow propagated from upstream junctions.
Information: P-7 Surcharged condition
Violation: P-7 does not meet minimum slope constraint.
--------------------- Calculations Complete ----------------------

** Analysis Options **
Friction method:  Manning's Formula
Hydraulic Grade Convergence Test:  0.001000
Maximum Network Traversals:  5
Number of Flow Profile Steps:  5
Discharge Convergence Test:  0.001000
Maximum Design Passes:  3
```

---------- Network Quick View ----------

				Hydraulic Grade	
Label	Length	Size	Discharge	Upstream	Downstream
P-1	4,386.00	96 inch	256.00	990.49	987.03
P-2	153.00	48 inch	211.00	991.62	991.25
P-5	4,985.00	66 inch	143.00	1,011.16	1,002.12
P-7	400.00	36 inch	93.00	1,023.11	1,015.34
P-4	5,115.00	78 inch	211.00	1,001.63	993.35
P-3	270.00	96 inch	211.00	993.35	993.20
P-6	2,782.00	60 inch	93.00	1,014.97	1,011.43

		Elevations		
Label	Discharge	Ground	Upstream HGL	Downstream HGL
Outlet	256.00	986.00	987.03	987.03
I-1	256.00	995.30	991.25	990.49
J-5	211.00	995.40	993.20	991.62
I-2	211.00	1,009.04	1,002.12	1,001.63

I-3	143.00	1,022.03	1,011.43	1,011.16
J-2	93.00	1,028.54	1,015.34	1,014.97
I-4	93.00	1,030.00	1,026.34	1,023.11
J-4	211.00	994.33	993.35	993.35

Elapsed: 0 minute(s) 0 second(s)

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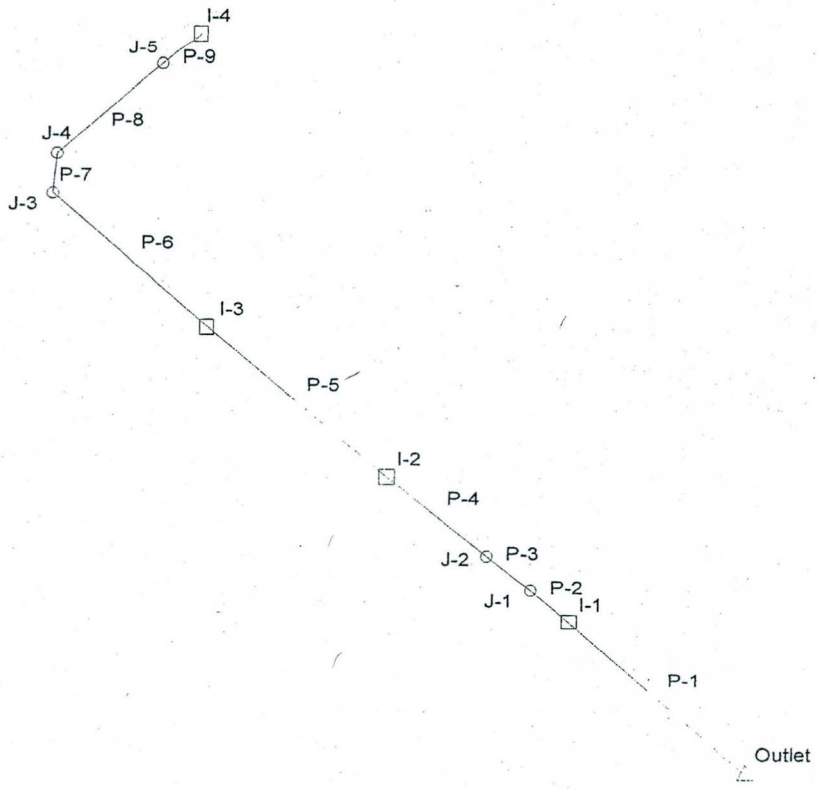

I-4
J-5
P-9
P-8
J-4
P-7
J-3
P-6
I-3
P-5
I-2
P-4
J-2
P-3
P-2
J-1
I-1
P-1
Outlet

```
------------------ Beginning Calculation Cycle -------------------
Discharge: 80.00 cfs  at node I-4
Discharge: 80.00 cfs  at node J-5
Discharge: 80.00 cfs  at node J-4
Discharge: 80.00 cfs  at node J-3
Discharge: 95.00 cfs  at node I-3
Discharge: 131.00 cfs  at node I-2
Discharge: 131.00 cfs  at node J-2
Discharge: 131.00 cfs  at node J-1
Discharge: 345.00 cfs  at node I-1
Discharge: 345.00 cfs  at node Outlet
Beginning iteration 1
Discharge: 80.00 cfs  at node I-4
Discharge: 80.00 cfs  at node J-5
Discharge: 80.00 cfs  at node J-4
Discharge: 80.00 cfs  at node J-3
Discharge: 95.00 cfs  at node I-3
Discharge: 131.00 cfs  at node I-2
Discharge: 131.00 cfs  at node J-2
Discharge: 131.00 cfs  at node J-1
Discharge: 345.00 cfs  at node I-1
Discharge: 345.00 cfs  at node Outlet
Discharge Convergence Achieved in 1 iterations: relative error:  0.0
** Warning: Design constraints not met.
Warning: No Duration data exists in IDF Table
Information: Outlet Known flow propagated from upstream junctions.
Violation: P-1 does not meet minimum slope constraint.
Information: P-2 Surcharged condition
Violation: P-2 does not meet minimum velocity constraint.
Information: J-1 Known flow propagated from upstream junctions.
Violation: P-3 does not meet minimum velocity constraint.
Information: J-2 Known flow propagated from upstream junctions.
Violation: P-6 does not meet minimum slope constraint.
Information: J-3 Known flow propagated from upstream junctions.
Information: P-7 Surcharged condition
Violation: P-7 does not meet minimum slope constraint.
Information: J-4 Known flow propagated from upstream junctions.
Information: P-8 Surcharged condition
Violation: P-8 does not meet minimum slope constraint.
Information: J-5 Known flow propagated from upstream junctions.
Information: P-9 Surcharged condition
Violation: P-9 does not meet minimum slope constraint.
--------------------- Calculations Complete ----------------------

** Analysis Options **
Friction method:  Manning's Formula
Hydraulic Grade Convergence Test:  0.001000
Maximum Network Traversals:  5
Number of Flow Profile Steps:  5
Discharge Convergence Test:  0.001000
Maximum Design Passes:  3
```

---------- Network Quick View ----------

				Hydraulic Grade	
Label	Length	Size	Discharge	Upstream	Downstream
P-1	4,403.00	108 inch	345.00	984.88	981.55
P-2	130.00	8 x 4 ft	131.00	985.87	985.75
P-5	5,163.00	66 inch	95.00	1,009.27	996.71
P-4	4,935.00	78 inch	131.00	996.01	986.75
P-3	300.00	96 inch	131.00	986.75	986.71
P-6	2,773.00	60 inch	80.00	1,013.48	1,009.65
P-7	280.00	36 inch	80.00	1,017.73	1,013.70
P-9	30.00	60 inch	80.00	1,020.93	1,020.90
P-8	2,470.00	60 inch	80.00	1,020.90	1,018.57

| ---------- Elevations ----------

Label	Discharge	Ground	Upstream HGL	Downstream HGL
Outlet	345.00	986.00	981.55	981.55
I-1	345.00	994.91	985.75	984.88
J-1	131.00	995.29	986.71	985.87
I-2	131.00	1,008.80	996.71	996.01
I-3	95.00	1,021.66	1,009.65	1,009.27
J-3	80.00	1,024.00	1,013.70	1,013.48
I-4	80.00	1,030.00	1,021.23	1,020.93
J-2	131.00	994.60	986.75	986.75
J-4	80.00	1,029.00	1,018.57	1,017.73
J-5	80.00	1,030.00	1,020.90	1,020.90

Elapsed: 0 minute(s) 1 second(s)

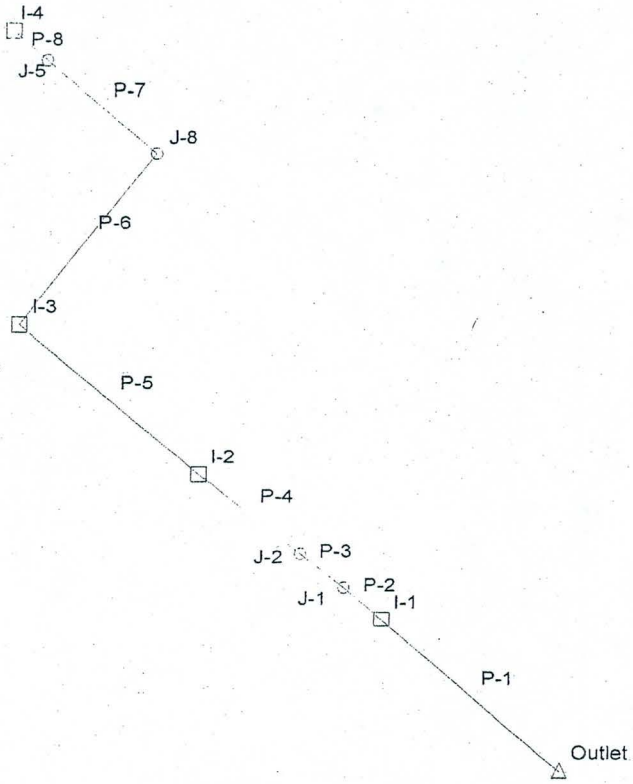

I-4
P-7
J-2
P-6
I-3
P-5
I-2
P-4
J-4
J-5
P-3
I-1
P-2
P-1
Outlet

```
------------------ Beginning Calculation Cycle ------------------
Discharge: 84.00 cfs  at node I-4
Discharge: 84.00 cfs  at node J-2
Discharge: 100.00 cfs  at node I-3
Discharge: 136.00 cfs  at node I-2
Discharge: 136.00 cfs  at node J-4
Discharge: 136.00 cfs  at node J-5
Discharge: 345.00 cfs  at node I-1
Discharge: 345.00 cfs  at node Outlet
Beginning iteration 1
Discharge: 84.00 cfs  at node I-4
Discharge: 84.00 cfs  at node J-2
Discharge: 100.00 cfs  at node I-3
Discharge: 136.00 cfs  at node I-2
Discharge: 136.00 cfs  at node J-4
Discharge: 136.00 cfs  at node J-5
Discharge: 345.00 cfs  at node I-1
Discharge: 345.00 cfs  at node Outlet
Discharge Convergence Achieved in 1 iterations: relative error:  0.0
** Warning: Design constraints not met.
Warning: No Duration data exists in IDF Table
Information: Outlet Known flow propagated from upstream junctions.
Violation: P-1 does not meet minimum slope constraint.
Information: P-2 Surcharged condition
Violation: P-2 does not meet minimum velocity constraint.
Information: J-5 Known flow propagated from upstream junctions.
Violation: P-3 does not meet minimum velocity constraint.
Information: J-4 Sump elevation must be at or below minimum pipe invert elevation (adjusted)
Information: J-4 Known flow propagated from upstream junctions.
Violation: P-6 does not meet minimum slope constraint.
Information: J-2 Known flow propagated from upstream junctions.
Information: P-7 Surcharged condition
Violation: P-7 does not meet minimum slope constraint.
--------------------- Calculations Complete ---------------------

** Analysis Options **
Friction method:  Manning's Formula
Hydraulic Grade Convergence Test:  0.001000
Maximum Network Traversals:  5
Number of Flow Profile Steps:  5
Discharge Convergence Test:  0.001000
Maximum Design Passes:  3


----------------- Network Quick View ------------------------
```

				Hydraulic Grade	
Label	Length	Size	Discharge	Upstream	Downstream
P-1	4,403.00	108 inch	345.00	984.88	981.55
P-2	130.00	8 x 4 ft	136.00	985.88	985.75
P-5	5,163.00	66 inch	100.00	1,009.37	996.80
P-7	350.00	36 inch	84.00	1,019.58	1,014.03
P-4	4,935.00	78 inch	136.00	996.09	986.82
P-3	300.00	96 inch	136.00	986.82	986.79
P-6	2,773.00	60 inch	84.00	1,013.64	1,009.76

		Elevations		
Label	Discharge	Ground	Upstream HGL	Downstream HGL
Outlet	345.00	986.00	981.55	981.55
I-1	345.00	994.91	985.75	984.88
J-5	136.00	995.29	986.79	985.88
I-2	136.00	1,008.80	996.80	996.09
I-3	100.00	1,021.66	1,009.76	1,009.37
J-2	84.00	1,024.00	1,014.03	1,013.64
I-4	84.00	1,030.00	1,022.21	1,019.58
J-4	136.00	994.60	986.82	986.82

```
Elapsed: 0 minute(s) 1 second(s)
```


I-4
P-8
J-5
P-7
J-8
P-6
I-3
P-5
I-2
P-4
J-2
P-3
J-1
P-2
I-1
P-1
Outlet

```
------------------ Beginning Calculation Cycle ------------------
Discharge: 77.00 cfs  at node I-4
Discharge: 77.00 cfs  at node J-5
Discharge: 77.00 cfs  at node J-8
Discharge: 93.00 cfs  at node I-3
Discharge: 130.00 cfs  at node I-2
Discharge: 130.00 cfs  at node J-2
Discharge: 130.00 cfs  at node J-1
Discharge: 345.00 cfs  at node I-1
Discharge: 345.00 cfs  at node Outlet
Beginning iteration 1
Discharge: 77.00 cfs  at node I-4
Discharge: 77.00 cfs  at node J-5
Discharge: 77.00 cfs  at node J-8
Discharge: 93.00 cfs  at node I-3
Discharge: 130.00 cfs  at node I-2
Discharge: 130.00 cfs  at node J-2
Discharge: 130.00 cfs  at node J-1
Discharge: 345.00 cfs  at node I-1
Discharge: 345.00 cfs  at node Outlet
Discharge Convergence Achieved in 1 iterations: relative error:  0.0
** Warning: Design constraints not met.
Warning: No Duration data exists in IDF Table
Information: Outlet Known flow propagated from upstream junctions.
Violation: P-1 does not meet minimum slope constraint.
Information: P-2 Surcharged condition
Violation: P-2 does not meet minimum velocity constraint.
Information: J-1 Known flow propagated from upstream junctions.
Violation: P-3 does not meet minimum velocity constraint.
Information: J-2 Known flow propagated from upstream junctions.
Violation: P-6 does not meet minimum slope constraint.
Information: J-8 Known flow propagated from upstream junctions.
Violation: P-7 does not meet minimum slope constraint.
Information: J-5 Known flow propagated from upstream junctions.
Information: P-8 Surcharged condition
Violation: P-8 does not meet minimum slope constraint.
--------------------- Calculations Complete ---------------------

** Analysis Options **
Friction method:  Manning's Formula
Hydraulic Grade Convergence Test:  0.001000
Maximum Network Traversals:  5
Number of Flow Profile Steps:  5
Discharge Convergence Test:  0.001000
Maximum Design Passes:  3
```

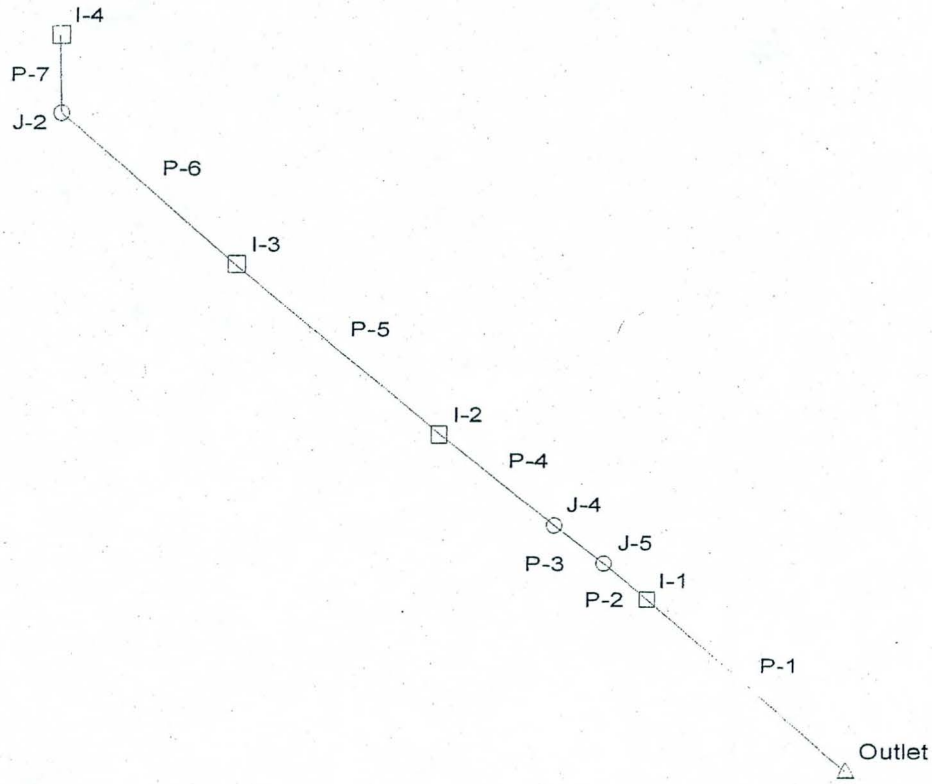
---------- Network Quick View ----------

				Hydraulic Grade	
Label	Length	Size	Discharge	Upstream	Downstream
P-1	4,403.00	108 inch	345.00	984.88	981.55
P-2	130.00	8 x 4 ft	130.00	985.87	985.75
P-5	5,163.00	66 inch	93.00	1,009.23	996.69
P-4	4,935.00	78 inch	130.00	996.00	986.73
P-3	300.00	96 inch	130.00	986.73	986.70
P-8	300.00	36 inch	77.00	1,019.39	1,015.39
P-6	2,540.00	66 inch	77.00	1,012.44	1,010.72
P-7	2,450.00	60 inch	77.00	1,015.18	1,012.96

		Elevations		
Label	Discharge	Ground	Upstream HGL	Downstream HGL
Outlet	345.00	986.00	981.55	981.55
I-1	345.00	994.91	985.75	984.88
J-1	130.00	995.29	986.70	985.87
I-2	130.00	1,008.80	996.69	996.00
I-3	93.00	1,021.66	1,010.72	1,009.23
I-4	77.00	1,030.00	1,021.61	1,019.39

J-2	130.00	994.60	986.73	986.73
J-5	77.00	1,030.00	1,015.39	1,015.18
J-8	77.00	1,024.00	1,012.96	1,012.44

Elapsed: 0 minute(s) 0 second(s)


I-4
P-7
J-2
P-6
I-3
P-5
I-2
P-4
J-4
J-5
P-3
I-1
P-2
P-1
Outlet

```
------------------ Beginning Calculation Cycle ------------------
Discharge: 84.00 cfs  at node I-4
Discharge: 84.00 cfs  at node J-2
Discharge: 100.00 cfs  at node I-3
Discharge: 136.00 cfs  at node I-2
Discharge: 136.00 cfs  at node J-4
Discharge: 136.00 cfs  at node J-5
Discharge: 164.00 cfs  at node I-1
Discharge: 164.00 cfs  at node Outlet
Beginning iteration 1
Discharge: 84.00 cfs  at node I-4
Discharge: 84.00 cfs  at node J-2
Discharge: 100.00 cfs  at node I-3
Discharge: 136.00 cfs  at node I-2
Discharge: 136.00 cfs  at node J-4
Discharge: 136.00 cfs  at node J-5
Discharge: 164.00 cfs  at node I-1
Discharge: 164.00 cfs  at node Outlet
Discharge Convergence Achieved in 1 iterations: relative error:  0.0
** Warning: Design constraints not met.
Warning: No Duration data exists in IDF Table
Information: Outlet Known flow propagated from upstream junctions.
Violation: P-1 does not meet minimum slope constraint.
Information: P-2 Surcharged condition
Violation: P-2 does not meet minimum velocity constraint.
Information: J-5 Known flow propagated from upstream junctions.
Information: J-4 Known flow propagated from upstream junctions.
Violation: P-6 does not meet minimum slope constraint.
Information: J-2 Known flow propagated from upstream junctions.
Information: P-7 Surcharged condition
Violation: P-7 does not meet minimum slope constraint.
--------------------- Calculations Complete ----------------------

** Analysis Options **
Friction method:  Manning's Formula
Hydraulic Grade Convergence Test:  0.001000
Maximum Network Traversals:  5
Number of Flow Profile Steps:  5
Discharge Convergence Test:  0.001000
Maximum Design Passes:  3
```

---------- Network Quick View ----------

				Hydraulic Grade	
Label	Length	Size	Discharge	Upstream	Downstream
P-1	4,403.00	96 inch	164.00	981.88	980.56
P-2	130.00	8 x 4 ft	136.00	982.51	982.39
P-5	5,163.00	66 inch	100.00	1,009.37	996.80
P-7	350.00	36 inch	84.00	1,019.58	1,014.03
P-4	4,935.00	78 inch	136.00	996.09	984.66
P-3	300.00	96 inch	136.00	982.98	983.43
P-6	2,773.00	60 inch	84.00	1,013.64	1,009.76

		Elevations		
Label	Discharge	Ground	Upstream HGL	Downstream HGL
Outlet	164.00	986.00	980.56	980.56
I-1	164.00	994.91	982.39	981.88
J-5	136.00	995.29	983.43	982.51
I-2	136.00	1,008.80	996.80	996.09
I-3	100.00	1,021.66	1,009.76	1,009.37
J-2	84.00	1,024.00	1,014.03	1,013.64
I-4	84.00	1,030.00	1,022.21	1,019.58
J-4	136.00	994.60	982.98	982.98

Elapsed: 0 minute(s) 0 second(s)

APPENDIX D: MANNING'S CALCULATION SHEETS

Strom Drain 75th Ave. I-10 to Van Buren Street
Worksheet for Circular Channel

Project Description	
Worksheet	75th VanBuren- to
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Full Flow Capacity

Input Data		
Mannings Coeffic	0.013	
Slope	003000	ft/ft
Diameter	24	in

Results		
Depth	2.00	ft
Discharge	12.39	cfs
Flow Area	3.1	ft²
Wetted Perime	6.28	ft
Top Width	0.00	ft
Critical Depth	1.27	ft
Percent Full	100.0	%
Critical Slope	005669	ft/ft
Velocity	3.94	ft/s
Velocity Head	0.24	ft
Specific Energ	2.24	ft
Froude Numbe	0.00	
Maximum Disc	13.33	cfs
Discharge Full	12.39	cfs
Slope Full	003000	ft/ft
Flow Type	N/A	

75th Ave.Storm Drain Van Buren Street to Union Pacifc Railroad
Worksheet for Circular Channel

Project Description	
Worksheet	75th Ave Targe
Flow Element	Circular Chann
Method	Manning's For
Solve For	Discharge

Input Data		
Mannings Coeffic	0.013	
Slope	008000	ft/ft
Depth	2.50	ft
Diameter	30	in

Results		
Discharge	36.68	cfs
Flow Area	4.9	ft²
Wetted Perime	7.85	ft
Top Width	6.66e-8	ft
Critical Depth	2.05	ft
Percent Full	100.0	%
Critical Slope	0.007978	ft/ft
Velocity	7.47	ft/s
Velocity Head	0.87	ft
Specific Energ	3.37	ft
Froude Numbe	1.54e-4	
Maximum Disc	39.46	cfs
Discharge Full	36.68	cfs
Slope Full	0.008000	ft/ft
Flow Type	Subcritical	

75th Ave. Storm Drain Union Pacific Railroad to Buckeye Road
Worksheet for Circular Channel

Project Description	
Worksheet	75th Avenue Union Pacific to
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Discharge

Input Data		
Mannings Coeffic	0.013	
Slope	004000	ft/ft
Depth	2.50	ft
Diameter	36	in

Results		
Discharge	42.79	cfs
Flow Area	6.3	ft²
Wetted Perime	6.90	ft
Top Width	2.24	ft
Critical Depth	2.13	ft
Percent Full	83.3	%
Critical Slope	0.005652	ft/ft
Velocity	6.80	ft/s
Velocity Head	0.72	ft
Specific Energ	3.22	ft
Froude Numbe	0.71	
Maximum Disc	45.37	cfs
Discharge Full	42.18	cfs
Slope Full	0.004116	ft/ft
Flow Type	Subcritical	