FIRST ANNUAL REPORT

SOUTH PLATTE DITCH RECHARGE DEMONSTRATION

A COOPERATIVE VENTURE BY:

SOUTH PLATTE DITCH COMPANY

COLORADO DIVISION OF WATER RESOURCES

COLORADO STATE UNIVERSITY

GROUNDWATER APPROPRIATORS OF THE SOUTH PLATTE

SEPTEMBER 1975

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This cooperative venture has included direct financial support by each of the agencies. The Colorado Division of Water Resources contributed toward construction and maintenance costs and also provided staff time and expense money for collection of data. Colorado State University through the "Groundwater Management" Experiment Station Project provided much of the instrumentation on a loan basis and has paid the salaries and travel expenses for those CSU personnel who participated. The South Platte Ditch Company covered the cost of operating the canal system and also paid for some of the construction and maintenance costs. The Groundwater Appropriators of the South Platte provided an annual payment which was used to defray part of the construction and maintenance costs.

The large number of individuals who have contributed either directly or indirectly to this project prohibits acknowledgement of each one separately. Certainly the splendid cooperation provided by all landowners in the study area has been greatly appreciated. The effort required by the officials from the South Platte Ditch Company and the Groundwater Appropriators of the South Platte is gratefully acknowledged.

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SOUTH PLATTE DITCH RECHARGE DEMONSTRATION

The ever increasing demand for water to meet domestic, municipal, agricultural and industrial needs makes it imperative that the available supplies be put to maximum beneficial use. This includes developing measures to conserve and use excess or surplus water such as the surface flows of the South Platte River that leave Colorado during the non-irrigation season. Storing these surplus surface flows in the underlying alluvial aquifer by means of artificial recharge is one practical and relatively inexpensive way of achieving greater utilization of the State's water resources. The water stored underground through artificial recharge would help to maintain adequate water table levels and would contribute to the base flow of the river during the critical summer months.

In addition to the above mentioned benefits, the underground storage of excess surface water could be incorporated into a plan of augmentation for wells as specified in the Water Right Determination and Administration Act of 1969 (Colorado Revised Statutes 1973, 37-92-307). This act places groundwater diversions in the same priority system as surface water rights, resulting in most cases in the curtailment of pumping unless the well owner develops an acceptable plan of augmentation.

A cooperative venture including the South Platte Ditch Company (SPD Co.), the Colorado Division of Water Resources (DWR), Colorado State University (CSU), and the Groundwater Appropriators of the South Platte (GASP) was initiated on March 19, 1974, to demonstrate the feasibility of artificially recharging surplus flows. This report briefly summarizes the project activities since March 1974. It is anticipated that the three-year demonstration period will continue through the spring of 1977.

OBJECTIVES

The purpose of this project was to explore the feasibility of artificially recharging the surplus stream flows. The technique of artificially recharging water into underlying alluvial aquifers has been successfully employed in Colorado on the Arickaree River near Cope and in Prospect Valley as well as in other states. It is hoped that this demonstration project will encourage local groundwater users to develop their own recharge plan.

The project will also provide experience on the types and amounts of data which must be collected to evaluate project benefits. It will be necessary to evaluate the flow direction, rate of movement, removal by wells and return flow to the river. Both ground and surface water measurements will be needed to make these estimates.

It will also be necessary to demonstrate the types of data which must be collected to assure that individual farms are not damaged by rising water tables which could create drainage problems. Operating experience gained throughout the winter months may suggest methods to minimize the damage resulting from icing problems.

DESCRIPTION OF STUDY AREA

The service area of the South Platte Ditch Company, which is located on the south side of the South Platte River near Merino, Colorado, was selected for the demonstration project. The Ditch Company's desire to participate in the project, their headgate location below the diversion points for Prewitt and Sterling Reservoirs, and the fact that this reach of the river often has surplus water were important considerations in site selection. The key factor in site selection, however, was the availability of the abandoned Sand Hill Lateral of the South Platte Ditch. This lateral had been used very little in recent times because of its high seepage rate. The high seepage rate made it a prime candidate for the recharge structure. Near the downstream end of the Sand Hill Lateral, there were also deflation basins in the sand hills which could be used as terminal recharge basins, thus increasing the recharge capacity.

The entire project area, as shown in Figure 1, is located within the boundaries of the South Platte aquifer. The alluvium in the valley consists mainly of heterogeneous mixtures of clay, sand and gravel or lenses of these materials. The aquifer is underlain by the impermeable Pierre Shale. Much of the surface soil through which the lateral flows consists of aeolian sand deposits. A more detailed description of the project area geology can be found in Bjourkland and Brown (1954).

The existing conveyance facilities of the SPD Co. were used for the recharge project. The company obtains its water from a diversion structure on the South Platte River located in the SW¼, Section 8, T5N, R54W. The total length of the South Platte Ditch is approximately 14 miles. However, the Sand Hill Lateral takes water through a headgate located about 5.4 miles below the river diversion point. The first 4.7 miles of the abandoned lateral were rehabilitated for this project and provisions were made to dump the flow remaining at the downstream end into nearby natural depressions. The period of flow and flow rates were controlled to prevent overflow of water from the natural depressions which would have damaged crop land.

Rehabilitation of the Sand Hill Lateral in April 1974, included an initial cleaning of the entire 4.7 miles to remove trash, weeds and sand deposits. This initial cleaning also removed some of the Bijou Clay which had accumulated earlier when the ditch was used for irrigation. Complete removal of the clay was desired in the lower reaches to increase seepage rates. Some low spots on the canal banks were filled and realignment of a short reach was necessary. Four pipe culverts were installed for road and cattle crossings. Repair of the control structures at the upper end of the lateral was necessary.

Prior to recharge in September of 1974, the lateral was again cleaned and an effort made to further enlarge the upstream portion. A third rehabilitation effort was completed in May 1975, when extensive earthmoving was undertaken to raise the canal banks in the upper 1/3 reach of the canal and much of the Bijou Clay was removed from the bottom of the canal in the middle reach of the lateral. The carrying capacity of the lateral was increased to approximately 20 cubic feet per second. In addition, a 160 foot section of 12-inch

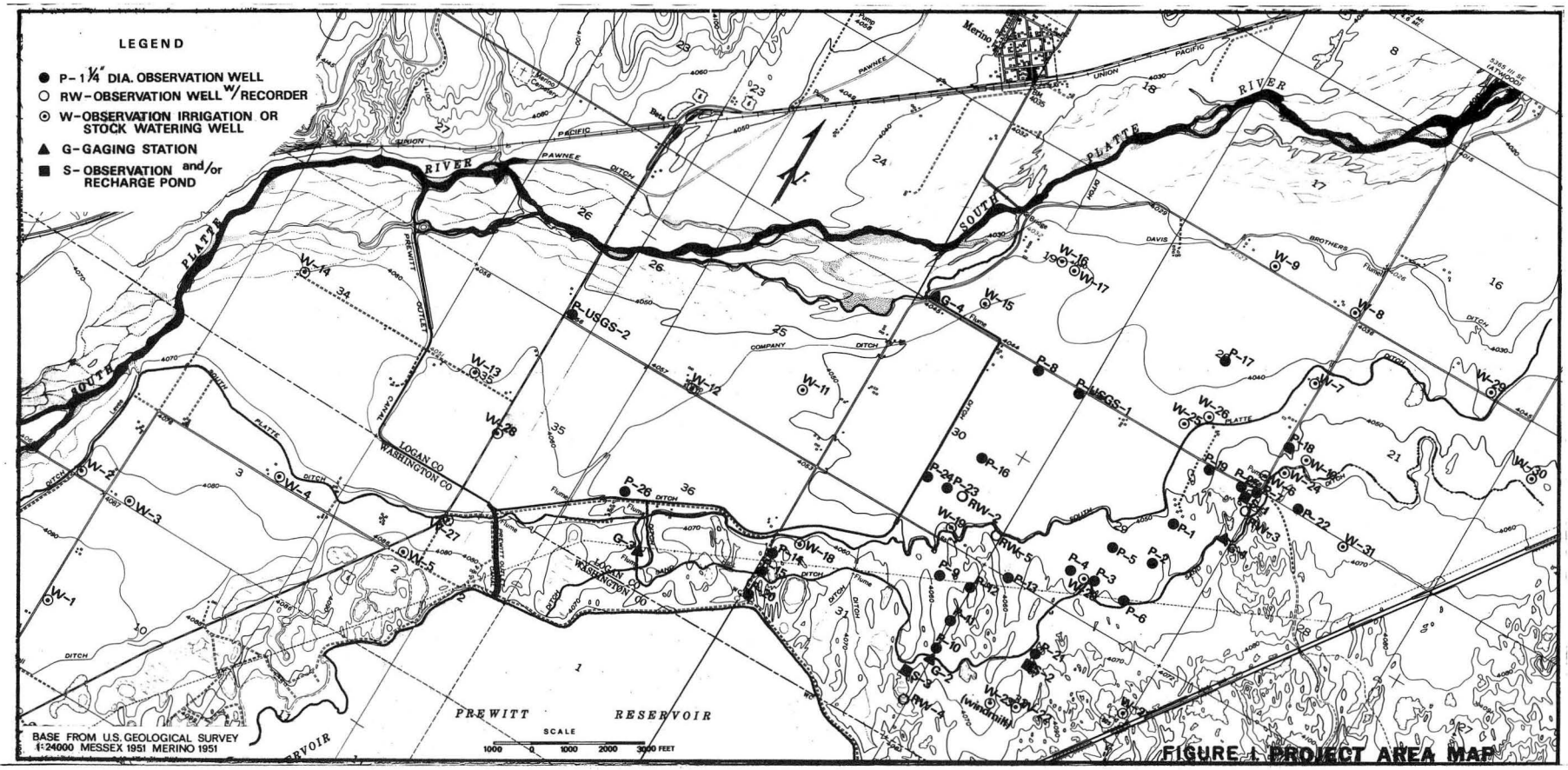

FIGURE 1. PROJECT AREA MAP

Photo 1. Cleaning of canal by South Platte Ditch Co..

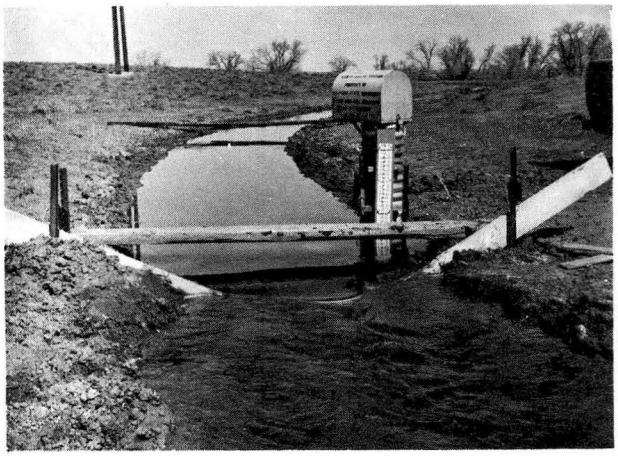

Photo 2. Upstream gaging station with triangular weir and recorder.

PVC pipe was installed 0.6 miles downstream of the gaging station G-2 for the purpose of diverting water from the Sand Hill Lateral to a natural depression (G-2 in Figure 1) in Section 32, T6N, R53W. This modification provided additional storage volume for the recharge system.

A washout of the ditch bank occurred when water was turned into the Sand Hill Lateral following the May 1975 rehabilitation and earthwork. The washout took place in Section 31, T6N, R53W approximately 0.8 miles upstream from the gaging station G-2 where a Prewitt Reservoir drain crosses under the recharge ditch. This washout necessitated replacement of 70 feet of lateral with a 48-inch diameter corrugated pipe.

Within the South Platte Ditch Company service area, there are approximately 4400 irrigated acres consisting of corn, alfalfa, sugar beets, and beans. Thirty-two (32) privately owned, large capacity irrigation wells tap the alluvial aquifer underlying the service area. The majority of these wells are used in conjunction with surface water as a supplemental source of irrigation water. Eight of the wells are located between the South Platte Ditch and the Sand Hill Lateral.

The proximity of Prewitt Reservoir, located immediately south, upstream and adjacent to the study area, complicates the area's hydrology. Seepage from Prewitt Reservoir occurs and is probably responsible, in part, for some of the high water tables necessitating construction of a drainage ditch several years ago. Only a small amount of Prewitt Reservoir water is used in the SPD Co. system. Some groundwater underflow and occasionally some surface flow comes into the study area from a drainage basin which extends southward from the study area toward Akron, Colorado.

Previous groundwater studies, Bjourkland and Brown (1954), indicated the general direction of groundwater flow was north and west for most of the study area. Water table elevations indicated there would be a return flow from the aquifer to the South Platte River.

RESPONSIBILITIES OF AGENCIES

At the March 19, 1974 organization meeting, Colorado State University and the Division of Water Resources agreed to develop the demonstration project. The South Platte Ditch Company agreed to obtain local easements, if necessary, and to begin rehabilitation of the lateral. The SPD Co. was also to be responsible for actual release and control of water to the lateral, in coordination with the Water Commissioner of DWR.

DWR and CSU personnel determined what instrumentation was necessary and began immediately to select instrumentation sites, arrange for instrumentation and determine what construction was necessary. It was agreed that DWR would be responsible for establishing instrumentation and collecting and analyzing all surface water data. Personnel from CSU were responsible for selecting test drilling sites, installation of observation wells, location of recorder wells and collection of groundwater data. Both DWR and CSU were to cooperate in the analysis and preparation of reports.

Initially GASP was not directly involved in the project. However, because of their strong desire to promote water conservation and develop additional water sources that could be used to augment stream flows depleted by pumping, they joined as active participants during the summer of 1974. Their principal role has been to provide financial support and offer encouragement and suggestions. They have negotiated a contract with the SPD Co. to allow well users beneath the SPD Co. system to obtain credit for the recharge toward their plans of well augmentation. The contract also provides agreements on how the SPD Co. and GASP will share in future benefits.

An extensive survey of the study area was conducted jointly by DWR and CSU to establish the mean sea level elevations of the various data collection points. The survey included a complete traverse of the Sand Hill Lateral which was used to evaluate rehabilitation needs and locate possible gaging station sites.

Photo 3. Drilling rig used to install observation and recorder wells.

INSTRUMENTATION

Three gaging stations, G-1, G-2, and G-3 as shown in Figure 1, were installed on the Sand Hill Lateral for measuring the flow at critical locations. The stations consisted of water level recorders and wooden weirs. An initial shortage of funds precluded the installation of calibrated measuring devices such as trapazoidal or Parshall flumes. Estimates of flow are made knowing the canal's stage and using a rating curve which relates discharge to stage. Development of the rating curves for each of the three gaging station sites required a hydrographer to make current-meter measurements at various flow rates.

Since the start of the recharge program in April 1974, the upstream gage, G-3, has been relocated once and the downstream station, G-1, twice in an effort to improve the quality of the record. In order to eliminate some of the problems associated with the present gaging stations, a galvanized steel trapazoidal flume is being fabricated and will be installed prior to the fall 1975 recharge period. Financial assistance from GASP made the purchase of the trapazoidal flume possible.

During March and April 1974, a total of 17 observation wells were drilled and cased. Twenty-five (25) additional irrigation and stock wells were selected and monitored for water table fluctuations. Two of the wells were equipped with automatic recorders. An additional 12 observation wells were drilled during the fall and winter of 1974-75. A total of four wells are now equipped with automatic recorders and at least 5 more irrigation wells have been added to the observation network. The location of the observation wells and irrigation wells is shown in Figure 1.

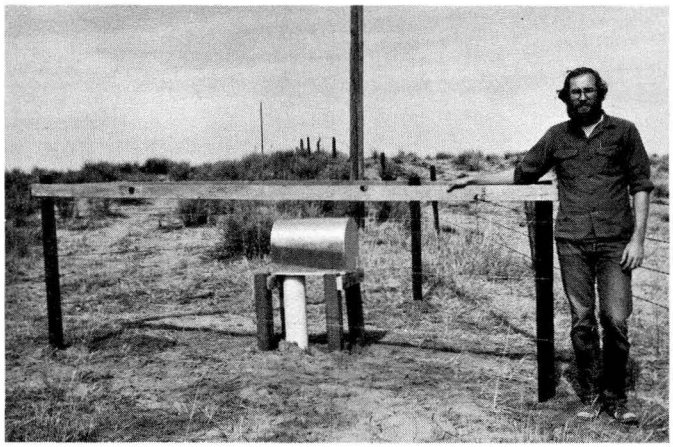

Photo 4. Recorder well with recorder installed in metal house and protected by a fence.

Two surface ponds were instrumented with staff gages to record water level fluctuations which were expected to coincide with the groundwater table. In April 1975, a stream gaging station was installed on the Prewitt Drain Ditch where it dumps into the Davis Brothers Ditch. Information obtained from this station will depict the seasonal as well as daily fluctuation of drainage flow. A possible correlation between recharge activities, South Platte Ditch flow, Prewitt Reservoir fillings and precipitation events is expected.

DATA COLLECTION

Surface Water

In order to determine the quantity of South Platte River water diverted into the Sand Hill Lateral and thereby estimate the total amount of infiltration to groundwater storage it was necessary to establish a gaging station at the upstream end of the lateral (station G-3 in Figure 1). Two other gaging stations, G-1 and G-2, were also installed at the downstream end and near the middle of the lateral, respectively. Gaging station G-1 measures the quantity of water reaching the end of the lateral and diverted into the nearby natural depressions. Gaging station G-2, located 2.4 miles downstream of the Sand Hill Lateral headgate, is used to determine the amount of water that recharges the aquifer and is creditable to the South Platte Ditch Company. Water seeping into the ground from the lateral upstream of G-2 is intercepted by the Prewitt Reservoir Drain and is, therefore, not creditable to the SPD company.

Recharge began on April 8, 1974, when water was first diverted from the South Platte River into the Sand Hill Lateral. The dates when water was diverted into the lateral and the amount of water passing the upstream gaging station, G-3, are shown below:

April 8, 1974 through May 13, 1974	273 Ac-Ft
Sept. 20, 1974 through Dec. 5, 1974	781 Ac-Ft
April 9, 1975 through June 29, 1975	871 Ac-Ft

The daily flow volumes recorded at each of the three gaging stations are presented in tabular form in Appendix A.

Photo 5. Sand Hill Lateral full of water from which recharge is occurring.

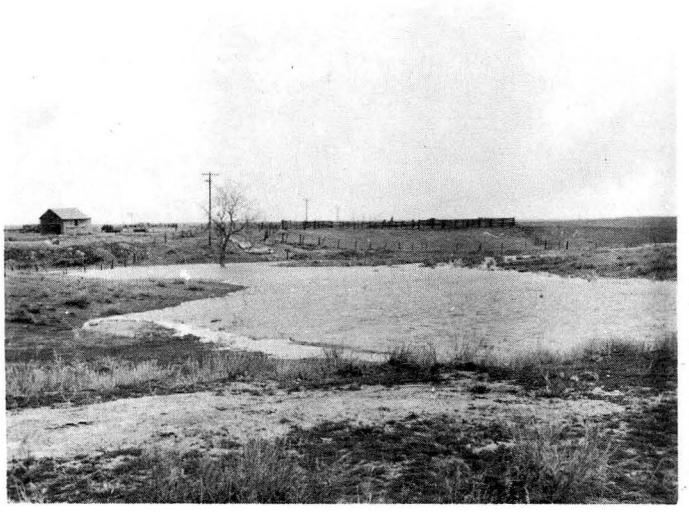

Photo 6. Recharge basin partially filled with water at downstream end of Sand Hill Lateral.

Groundwater

Groundwater table fluctuations have been monitored in the observation wells and selected irrigation wells. Measurements of depth to the water table were made in the observation wells at bi-weekly intervals during the artificial recharge periods and at less frequent intervals the rest of the time. The two continuous water level recorders provided information on the daily fluctuations during 1974 and this number has been expanded to four recorders for 1975. Some instrumentation problems have resulted in missing records for part of 1975 for the continuous recorders. Irrigation wells were monitored only during the non-pumping season.

The daily mean sea level elevations of the water table in each observation well are tabulated in Appendix B.

ANALYSES

Amount Recharged

As mentioned above, the flow at gaging station G-2 is used to estimate the quantity of water recharged to the alluvial aquifer and creditable to the South Platte Ditch Company. A groundwater computer model of the project area is currently being developed to determine how accurate the flow at gaging station G-2 approximates the quantity of recharged surface water that is physically available for withdrawal during the irrigation season.

The amounts of diverted surface water passing gaging station G-2 during the initial start-up period (spring 1974) and during the first full season (1974-75) of operation are as follows:

Spring 1974	185 Ac-Ft
Fall 1974	652 Ac-Ft
Spring 1975	716 Ac-Ft
TOTAL	1553 Ac-Ft

A plot of the amount of water passing each of the three gaging stations as a function of time is presented in Figures 2 and 3.

Groundwater Fluctuations

The observation well data provides the information on how the aquifer responds to recharge. Water level rises are normally associated with recharge while declines can often be explained by nearby pumping or the natural drainage of water to lower elevations.

A water table contour map was prepared from data collected during the Spring of 1974, however, the additional observation wells and the elevation survey completed in 1974 provided even more data to prepare the Water Table Contour Map included as Figure 4. This latter contour map represents the water table elevations as of April 22, 1975. Generally, the direction of groundwater flow is toward the north, however, the mound developed near the recharge ponds at the end of the Sand Hill Lateral has water moving away from it to the west, north and east. The lack of data near and beneath Prewitt Reservoir makes it difficult to evaluate the influence of the reservoir.

Data presented in Appendix B can be plotted to obtain water table hydrographs similar to those presented in Figure 5 . The four hydrographs included on Figure 5 were selected to demonstrate how the aquifer is responding to recharge. The rise in the water table elevations for observation well P-7 are highly correlated with the periods of recharge in the nearby spreading basins. Similarly, the maximum elevation of 4041.77 was observed on June 26, 1975 following the June 1975 recharge period of over 240 acre-feet to the nearby ponds. On June 26 the distance from the land surface to the water table at observation well P-7 was only 16 feet and it continued to rise until recharge was discontinued on June 29.

Observation wells P-10, P-11 and P-12 were selected to demonstrate the recharge associated with the leaky canal. From Figure 1 it is possible to determine that

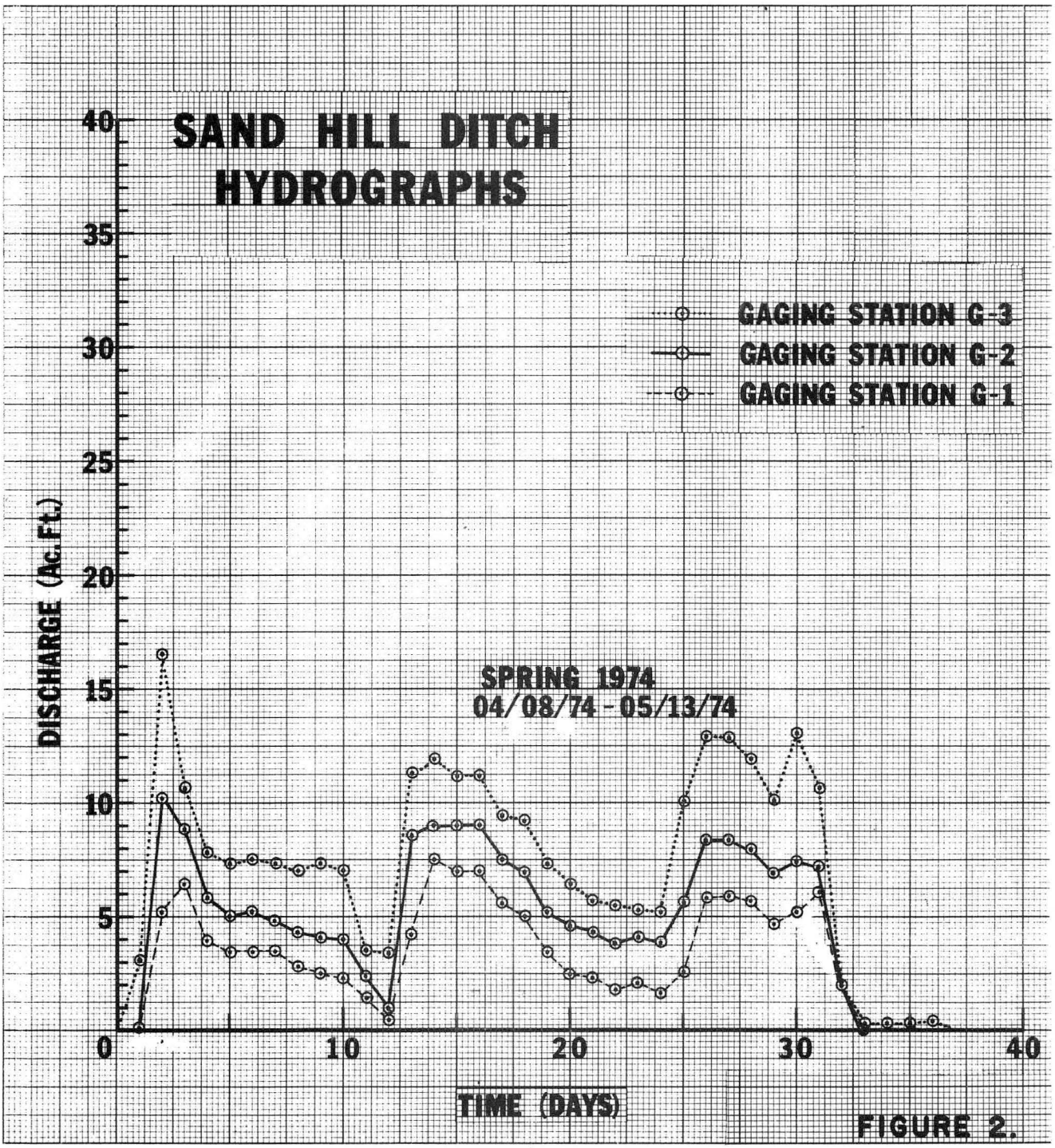
SAND HILL DITCH
HYDROGRAPHS
GAGING STATION G-3
GAGING STATION G-2
GAGING STATION G-1
SPRING 1974
04/08/74 - 05/13/74
DISCHARGE (Ac. Ft.)
TIME (DAYS)
0
5
10
15
20
25
30
35
40
0
10
20
30
40

FIGURE 2.

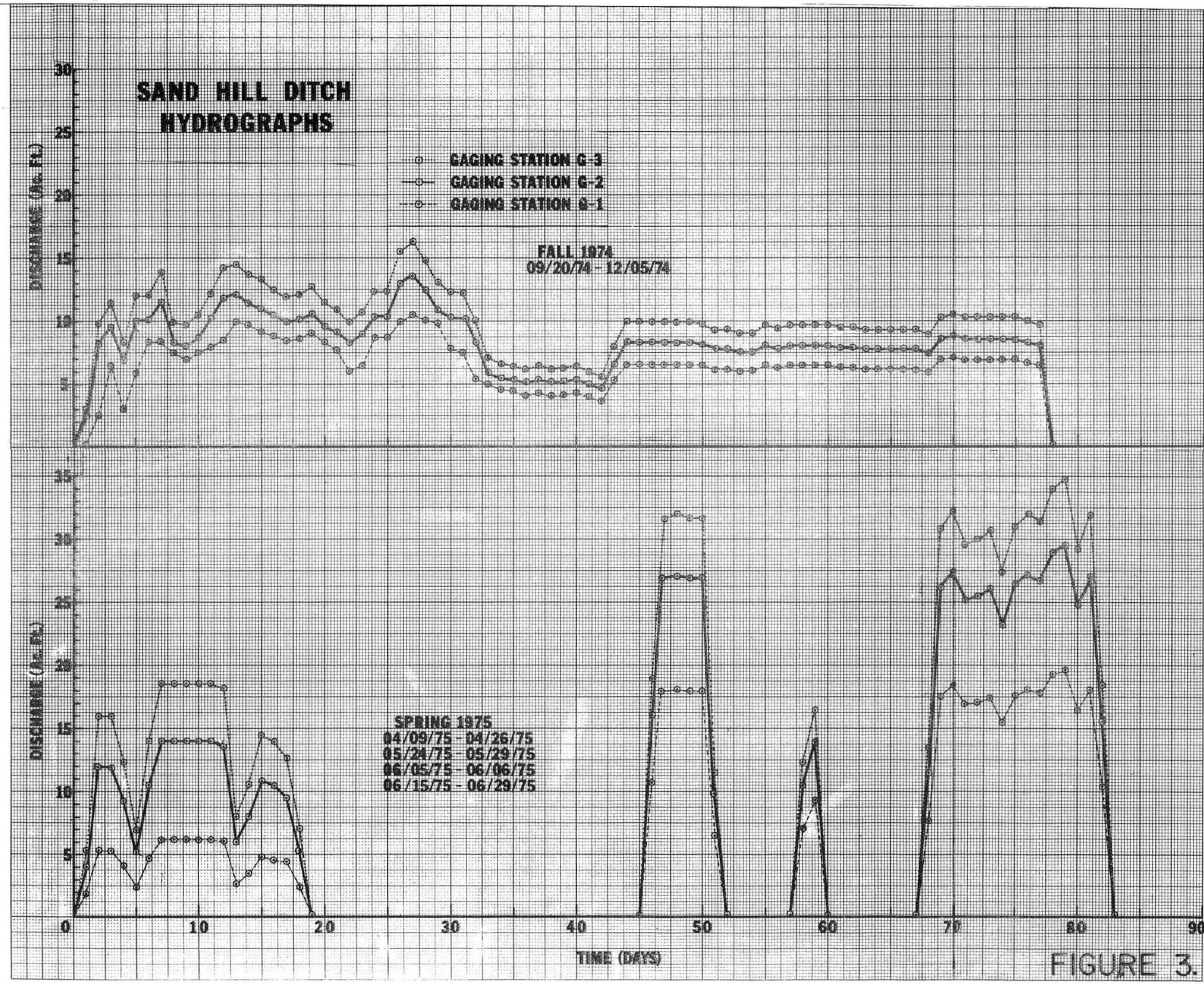
SAND HILL DITCH
HYDROGRAPHS
GAGING STATION G-3
GAGING STATION G-2
GAGING STATION G-1
FALL 1974
09/20/74 - 12/05/74
SPRING 1975
04/09/75 - 04/26/75
05/24/75 - 05/29/75
06/05/75 - 06/06/75
06/15/75 - 06/29/75
DISCHARGE (Ac. Ft.)
TIME (DAYS)
0
10
20
30
40
50
60
70
80
90
5
10
15
20
25
30
35

FIGURE 3.

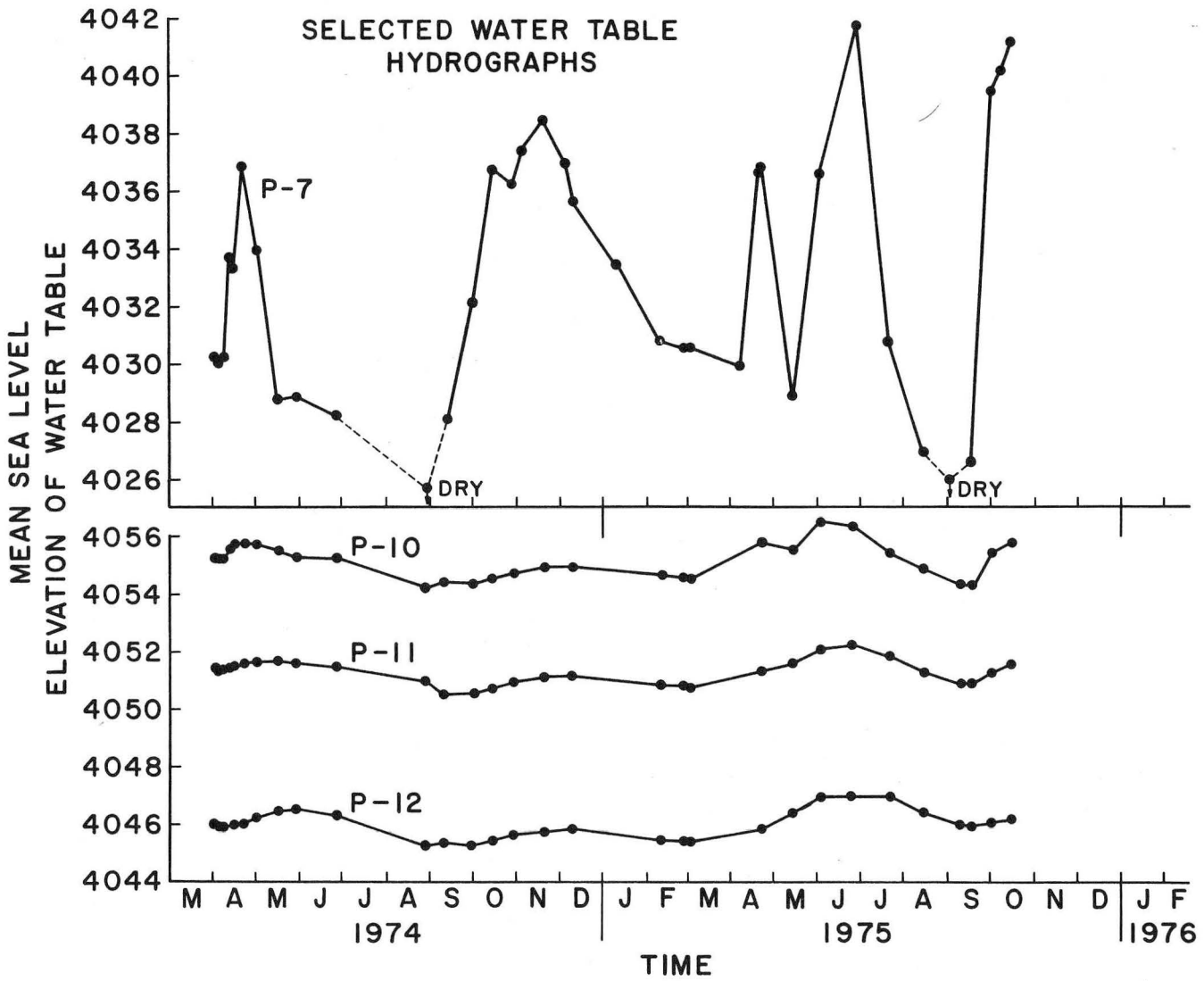
SELECTED WATER TABLE
HYDROGRAPHS
MEAN SEA LEVEL
ELEVATION OF WATER TABLE
4042
4040
4038
4036
4034
4032
4030
4028
4026
P-7
DRY
DRY
4056
4054
4052
4050
4048
4046
4044
P-10
P-11
P-12
M A M J J A S O N D J F M A M J J A S O N D J F
1974
1975
1976
TIME

FIGURE 5.

P-10 is located about 150 feet from the canal, P-11 about 1200 feet and P-12 about 2400 feet. Note that the maximum rise occurs in P-10 with successively smaller rises as you move further and further away. The lag time for recharge to move away from the canal is also visible in the successive longer and longer periods of time required to reach the peak elevations as you move away from the canals. Fluctuations in P-10 exceeded 2 feet while rises for the Spring 1975 rise in wells P-11 and P-12 were respectively 1.2 and 1.0 feet.

For RW-2 and RW-4, see Figure 1, shallow depths to the water table on the recorders show a distinct diurnal fluctuation which is attributed to evapotranspiration from the water table. The magnitude of this fluctuation is near zero in early spring and increases to about 0.15 feet per day during July and August for RW-2 before decreasing to a near zero value in the fall. RW-2 also indicates that there is a high correlation with groundwater table rise to the flow period of the South Platte Canal. Records for May 1-10 of 1974 indicate nearly a one foot rise in the water table which corresponds with the first flow period in the nearby South Platte Ditch. Detailed records which indicate what portion of the South Platte Ditch receives water on any one day are not available for further correlation. It is also suspected that the irrigation well W-19, located about 1000 feet south of RW-2, has an effect on the water table at RW-2 but sufficient records are not yet available to prove this.

Water table fluctuations also seem to strongly suggest that for the area beneath the South Platte Canal one would expect a rising or nearly steady water table which could be attributed to deep percolation and recharge from surface irrigation. In the area above the South Platte Canal there seems to be a decline in the water tables during the summer months with the exception of brief periods when significant rainfall occurs. Near pumped wells that are located south of the South Platte Canal, the declines were most noticeable and exceeded 10 to 15 feet depending on the particular location; P-7, P-25, W-6 and W-10.

Although it is difficult to evaluate the exact benefits of recharge to specific wells, it is felt that the recharge from the Sand Hill Lateral and recharge ponds certainly raised the water table in Sections 20, 21 and 29. This recharge should have allowed the nearby wells to pump larger volumes of water at a lower energy cost.

FUTURE DATA NEEDS AND ANALYSES

Additional data is needed to determine the aquifer characteristics and response function to recharge. Tests should be made to determine the aquifer permeability and storage coefficient. Aquifer tests at wells W-6 and W-20 are recommended.

The need to collect additional information on water table fluctuations resulting from reasonable levels of recharge are needed to determine the aquifer response to recharge and suggest possible recharge rates which would allow maximum storage and still prevent damages from water-logging. It appears that the amount that can be recharged without damage will be a function of the starting water table elevations, rate of recharge and time period over which recharge occurs.

The use of mathematical models to study the integrated effect of recharge, pumping, return flows to the river, and other parameters is highly recommended. Good hydrologic data including records on the time and space distribution of both pumping and recharge is essential. The additional data on the aquifer properties would be useful. Better records on where water is used beneath the South Platte Canal would be useful.

APPENDIX A

Flow Volumes Recorded at the Sand Hill
Lateral Gaging Stations

Spring 1974

Date	G-3 Upstream Station (Ac-Ft)		G-2 Middle Station (Ac-Ft)		G-1 Downstream Station (Ac-Ft)	
	Daily	Cumulative	Daily	Cumulative	Daily	Cumulative
04/08/74	3.1	3.1	0	0	0	0
04/09/74	16.5	19.6	10.2	10.2	5.2	5.2
04/10/74	10.6	30.2	8.8	19.0	6.4	11.6
04/11/74	7.8	38.0	5.8	24.8	3.9	15.5
04/12/74	7.3	45.3	5.0	29.8	3.4	18.9
04/13/74	7.5	52.8	5.2	35.0	3.4	22.3
04/14/74	7.3	60.1	4.8	39.8	3.5	25.8
04/15/74	7.0	67.1	4.3	44.1	2.8	28.6
04/16/74	7.3	74.4	4.1	48.2	2.5	31.1
04/17/74	7.0	81.4	4.0	52.2	2.3	33.4
04/18/74	3.6	85.0	2.4	54.6	1.4	34.8
04/19/74	3.4	88.4	1.0	55.6	0.5	35.3
04/20/74	11.3	99.7	8.6	64.2	4.2	39.5
04/21/74	11.9	111.6	9.0	73.2	7.5	47.0
04/22/74	11.2	122.8	9.0	82.2	7.0	54.0
04/23/74	11.2	134.0	9.0	91.2	7.0	61.0
04/24/74	9.4	143.4	7.5	98.7	5.6	66.6
04/25/74	9.2	152.6	6.9	105.6	5.0	71.6
04/26/74	7.3	159.9	5.2	110.8	3.4	75.0
04/27/74	6.4	166.3	4.6	115.4	2.5	77.5
04/28/74	5.7	172.0	4.3	119.7	2.3	79.8
04/29/74	5.5	177.5	3.8	123.5	1.8	81.6
04/30/74	5.3	182.8	4.1	127.6	2.1	83.7
* * * *						
05/01/74	5.2	188.0	3.8	131.4	1.7	85.4
05/02/74	10.1	198.1	5.6	137.0	2.6	88.0
05/03/74	12.9	211.0	8.3	145.3	5.8	93.8
05/04/74	12.8	223.8	8.3	153.6	5.9	99.7
05/05/74	11.9	235.7	7.9	161.5	5.7	105.4
05/06/74	10.1	245.8	6.9	168.4	4.7	110.1
05/07/74	13.1	258.9	7.4	175.8	5.2	115.3
05/08/74	10.7	269.6	7.2	183.0	6.1	121.4
05/09/74	2.0	271.6	2.2	185.2	2.1	123.5
05/10/74	0.3	271.9	0.0	185.2	0.1	123.6
05/11/74	0.3	272.2	0.0	185.2	0.0	123.6
05/12/74	0.3	272.5	0.0	185.2	0.0	123.6
05/13/74	0.4	272.9	0.0	185.2	0.0	123.6

Fall 1974

Date	G-3 Upstream Station (Ac-Ft)		G-2 Middle Station (Ac-Ft)		G-1 Downstream Station (Ac-Ft)	
	Daily	Cumulative	Daily	Cumulative	Daily	Cumulative
09/20/74	3.0	3.0	2.5	2.5	0	0
09/21/74	9.8	12.8	8.2	10.7	2.5	2.5
09/22/74	11.4	24.2	9.5	20.2	6.4	8.9
09/23/74	8.3	32.5	6.9	27.1	3.0	11.9
09/24/74	12.0	44.5	10.0	37.1	5.8	17.7
09/25/74	12.1	56.6	10.1	47.2	8.1	25.8
09/26/74	13.8	70.4	11.5	58.7	8.1	33.9
09/27/74	9.9	80.3	8.3	67.0	7.5	41.4
09/28/74	9.7	90.0	8.1	75.1	6.9	48.3
09/29/74	10.4	100.4	8.7	83.8	7.5	55.8
09/30/74	12.2	112.6	10.2	94.0	7.9	63.7
* * * *						
10/01/74	14.2	126.8	11.8	105.8	8.5	72.2
10/02/74	14.5	141.3	12.1	117.9	9.9	82.1
10/03/74	13.7	155.0	11.4	129.3	9.7	91.8
10/04/74	13.3	168.3	11.1	140.4	9.2	101.0
10/05/74	12.4	180.7	10.4	150.8	8.8	109.8
10/06/74	11.9	192.6	9.9	160.7	8.4	118.2
10/07/74	12.1	204.7	10.1	170.8	8.6	126.8
10/08/74	12.7	217.4	10.6	181.4	9.1	135.9
10/09/74	11.5	228.9	9.6	191.0	8.3	144.2
10/10/74	10.9	239.8	9.1	200.1	7.7	151.9
10/11/74	9.9	249.7	8.3	208.4	6.1	158.0
10/12/74	10.7	260.4	8.9	217.3	6.5	164.5
10/13/74	12.3	272.7	10.3	227.6	8.7	173.2
10/14/74	12.3	285.0	10.3	237.9	8.7	181.9
10/15/74	15.5	300.5	12.9	250.8	9.9	191.8
10/16/74	16.3	316.8	13.6	264.4	10.5	202.3
10/17/74	14.8	331.6	12.4	276.8	10.1	212.4
10/18/74	13.1	344.7	10.9	287.7	9.8	222.2
10/19/74	12.3	357.0	10.3	298.0	7.8	230.0
10/20/74	12.2	369.2	10.2	308.2	7.5	237.5
10/21/74	10.0	379.2	8.3	316.5	5.4	242.9
10/22/74	7.1	386.3	5.9	322.4	5.0	247.9
10/23/74	6.6	392.9	5.5	327.9	4.6	252.5
10/24/74	6.4	399.3	5.3	333.2	4.4	256.9
10/25/74	6.2	405.6	5.2	338.4	4.1	261.0
10/26/74	6.4	412.0	5.3	343.7	4.3	265.3
10/27/74	6.2	418.2	5.2	348.9	4.1	269.4
10/28/74	6.3	424.5	5.2	354.1	4.2	273.6
10/29/74	6.4	430.9	5.3	359.4	4.3	277.9
10/30/74	6.0	436.9	5.0	364.4	4.0	281.9
10/31/74	5.6	442.5	4.7	369.1	3.7	285.6
* * * *						
11/01/74	7.9	450.4	6.6	375.7	5.3	290.9
11/02/74	9.9	460.3	8.3	384.0	6.6	297.5

Fall 1974

Date	G-3 Upstream Station (Ac-Ft)		G-2 Middle Station (Ac-Ft)		G-3 Downstream Station (Ac-Ft)	
	Daily	Cumulative	Daily	Cumulative	Daily	Cumulative
11/03/74	9.9	470.2	8.3	392.3	6.6	304.1
11/04/74	9.9	480.1	8.3	400.6	6.6	310.7
11/05/74	9.9	490.0	8.3	408.9	6.6	317.3
11/06/74	9.9	499.9	8.3	417.2	6.6	323.9
11/07/74	9.9	509.8	8.3	425.5	6.6	330.5
11/08/74	9.8	519.6	8.2	433.7	6.5	337.0
11/09/74	9.3	528.9	7.8	441.5	6.2	343.2
11/10/74	9.3	538.2	7.8	449.3	6.2	349.4
11/11/74	9.1	547.3	7.6	456.9	6.1	355.5
11/12/74	9.1	556.4	7.6	464.5	6.1	361.6
11/13/74	9.7	566.1	8.1	472.6	6.5	368.1
11/14/74	9.4	575.5	7.8	480.4	6.3	374.4
11/15/74	9.7	585.2	8.1	488.5	6.5	380.9
11/16/74	9.7	594.9	8.1	496.6	6.5	387.4
11/17/74	9.7	604.6	8.1	504.7	6.5	393.9
11/18/74	9.7	614.3	8.1	512.8	6.5	400.4
11/19/74	9.5	623.8	7.9	520.7	6.3	406.7
11/20/74	9.5	633.3	7.9	528.6	6.3	413.0
11/21/74	9.3	642.6	7.8	536.4	6.2	419.2
11/22/74	9.3	651.9	7.8	544.2	6.2	425.4
11/23/74	9.3	661.2	7.8	552.0	6.2	431.6
11/24/74	9.3	670.5	7.8	559.8	6.2	437.8
11/25/74	9.3	679.8	7.8	567.6	6.2	444.0
11/26/74	8.9	688.7	7.4	575.0	5.9	449.9
11/27/74	10.3	699.0	8.6	583.6	6.9	456.8
11/28/74	10.6	709.6	8.8	592.4	7.1	463.9
11/29/74	10.3	719.9	8.6	601.0	6.9	470.8
11/30/74	10.3	730.2	8.6	609.6	6.9	477.7
* * * *						
12/01/74	10.3	740.5	8.6	618.2	6.9	484.6
12/02/74	10.3	750.8	8.6	626.8	6.9	491.5
12/03/74	10.3	761.1	8.6	635.4	6.9	498.4
12/04/74	10.0	771.1	8.3	643.7	6.7	505.1
12/05/74	9.7	780.8	8.1	651.8	6.5	511.6

Spring 1975

Date	G-3 Upstream Station (Ac-Ft)		G-2 Middle Station (Ac-Ft)		G-1 Downstream Station (Ac-Ft)	
	Daily	Cumulative	Daily	Cumulative	Daily	Cumulative
04/09/75	5.3	5.3	4.0	4.0	1.8	1.8
04/10/75	15.9	21.2	11.9	15.9	5.3	7.1
04/11/75	15.9	37.1	11.9	27.8	5.3	12.4
04/12/75	12.3	49.4	9.2	37.0	4.1	16.5
04/13/75	6.9	56.3	5.2	42.2	2.3	18.8
04/14/75	14.0	70.3	10.5	52.7	4.7	23.5
04/15/75	18.6	88.9	14.0	66.7	6.2	29.7
04/16/75	18.6	107.5	14.0	80.7	6.2	35.9
04/17/75	18.6	126.1	14.0	94.7	6.2	42.1
04/18/75	18.6	144.7	14.0	108.7	6.2	48.3
04/19/75	18.6	163.3	14.0	122.7	6.2	54.5
04/20/75	18.2	181.5	13.6	136.3	6.1	60.6
04/21/75	8.0	189.5	6.0	142.3	2.7	63.3
04/22/75	10.6	200.1	8.0	150.3	3.5	66.8
04/23/75	14.4	214.5	10.8	161.1	4.8	71.6
04/24/75	13.9	228.4	10.4	171.5	4.6	76.2
04/25/75	12.7	241.1	9.5	181.0	4.2	80.4
04/26/75	7.1	248.2	5.3	186.3	2.4	82.8
* * * *						
05/24/75	18.9	267.1	16.1	202.4	10.7	93.5
05/25/75	31.6	298.7	26.9	229.3	17.9	111.4
05/26/75	31.9	330.6	27.1	256.4	18.1	129.5

Date	G-3 Upstream Station (Ac-Ft)		G-2 Middle Station (Ac-Ft)		G-1 Downstream Station (Ac-Ft)	
	Daily	Cumulative	Daily	Cumulative	Daily	Cumulative
05/27/75	31.7	362.3	26.9	283.3	17.9	147.4
05/28/75	31.7	394.0	26.9	310.2	17.9	165.3
05/29/75	11.5	405.5	9.8	320.0	6.5	171.8
* * * *						
06/05/75	12.3	417.8	10.5	330.5	7.0	178.8
06/06/75	16.4	434.2	13.9	344.4	9.3	188.1
* * * *						
06/15/75	13.5	447.7	11.5	355.9	7.7	195.8
06/16/75	30.8	478.5	26.2	382.1	17.6	213.4
06/17/75	32.2	510.7	27.4	409.5	18.4	231.8
06/18/75	29.6	540.3	25.2	434.7	16.9	248.7
06/19/75	30.0	570.3	25.5	460.2	17.1	265.8
06/20/75	30.7	601.0	26.1	486.3	17.4	283.2
06/21/75	27.3	628.3	23.2	509.5	15.5	298.7
06/22/75	31.0	659.3	26.4	535.9	17.6	316.3
06/23/75	32.0	691.3	27.2	563.1	18.1	334.4
06/24/75	31.4	722.7	26.7	589.8	17.8	352.2
06/25/75	34.0	756.7	28.9	618.7	19.3	371.5
06/26/75	34.8	791.5	29.6	648.3	19.7	391.2
06/27/75	29.2	820.7	24.8	673.1	16.5	407.7
06/28/75	31.9	852.6	27.1	700.2	18.1	425.8
06/29/75	18.4	871.0	15.6	715.8	10.4	436.2

APPENDIX B

SOUTH PLATTE DITCH RECHARGE STUDY - 1974 page 1

Key: Observation Well No.
Final Location
Elev. of M.P.(msl)

Date	W-1 B5-54-10-cb 4093.21	W-2 B5-54- 4-dd 4086.07	W-3 B5-54- 3-cc 4087.38	W-4 B5-54- 3-ac 4077.17	W-5 B5-54- 2-bd 4086.00	W-6 B6-53-20-dd 4057.18	W-7 B6-53-20-ad 4048.59	W-8 B6-53-17-dd 4036.08	W-9 B6-53-17-cd 4035.59	W-10 B6-53-21-cb 4058.50	W-11 B6-54-25-db 4056.33	W-12 B6-54-25cd 4065.29
3/13/74						29.64			21.58			
3/26/74	78.39	72.19	15.77	10.70	16.75	29.20	25.64	19.72	21.50	26.72	41.33	52.01
4/ 2/74												
4/ 9/74						29.36						
4/16/74						30.24						
4/23/74						31.04	24.52	20.48	21.93	28.12		
5/ 2/74						30.58						
5/16/74						25.60				24.46		
5/31/74												
6/27/74						26.23						
8/29/74						22.57						
10/ 1/74						ppg						
10/15/74						30.48	22.84			32.54		
10/29/74						32.16	23.93			28.34		
11/ 5/74						32.46						
11/20/74						33.45						
12/11/74												

Date	W-13 B6-54-35-bd 4063.06	W-14 B6-54-34-bdc 4066.75	W-15 B6-53-19-cd 4046.34	W-16 B6-53-19-ac1 4040.52	W-17 B6-53-19-ac2 4040.53	W-18 B6-53-31-bc 4059.39	W-19 B6-53-30-dc 4053.51	W-20 B6-53-29-cd 4059.10	W-21 B6-53-32-ad 4087.27	W-22 B6-53-32-db 4067.50	W-23 B6-53-32-ca 4067.45
3/13/74											
3/26/74		58.97	32.75	28.34	28.17						
4/ 2/74							43.21	42.08			
4/ 9/74						47.23		42.10	55.29	59.42	60.29
4/16/74						47.34	43.19		55.32	59.47	ppg
4/23/74						47.33	43.22	42.67			
5/ 2/74						47.42	43.33	ppg		59.49	60.43
5/16/74						ppg	44.17	ppg	55.38	59.52	ppg
5/31/74								42.28			
6/27/74							ppg	ppg			
8/29/74						ppg	ppg	ppg	55.11	58.68	ppg
10/ 1/74							42.71	41.59		58.52	ppg
10/15/74						47.48	42.83	42.13	55.11	58.85	ppg
10/29/74						47.60	42.96	42.18	55.18	58.67	59.52
11/ 5/74							42.93	42.23			
11/20/74						47.59	43.03	42.43	55.27	58.82	59.65
12/11/74									55.38		

Note: All readings fall within the 4000.00 to 4100.00 msl elevation of M.P.. Add 40 in front of the number for a full reading.

Key: Observation Well No.
Elev. of M.P.(msl)
M.P. to land surface

Date	P-1 4058.53 4.2	P-2 4059.93 1.5	P-3 4059.58 0.5	P-4 4062.50 3.7	P-5 4053.15 3.0	P-6 4062.13 1.2	P-7 4058.75 1.1	P-USGS1 4042.81 2.0	P-8 4043.22 1.8	P-9 4055.84 2.2	P-10 4063.93 2.35	P-11 4064.88 2.0	P-12 4059.77 0.8	P-13 4055.97 1.9	P-14 4060.85 2.5	P-15 4066.29 0.7
4/ 2/74	35.30	38.59	41.80	41.48	37.74	42.04	30.27	32.27	32.67	48.85	55.28	51.45	46.01	44.21	50.37	
4/ 5/74	35.20	38.56				41.99	30.03	32.18	32.60	46.81	55.24	51.36	45.95	44.14	50.34	53.28
4/ 9/74	35.27	38.56	41.82	41.45	37.71	42.19	30.24	32.26	32.70	46.81	55.27	51.41	45.97	44.17	50.42	54.28
4/13/74	35.30	38.78	42.28	41.47	37.74	43.50	33.73	32.28	32.71	46.83	55.58	51.47	45.98	44.17	50.51	54.34
4/16/74	35.35	38.93	42.40	41.52	37.80	43.82	33.35	32.33	32.75	46.87	55.71	51.54	46.01	44.19	50.55	54.14
4/23/74	35.49	39.09	42.66	41.61	37.91	43.69	36.88	32.42	32.84	46.91	55.78	51.62	46.07	44.27	50.55	53.90
5/ 2/74	35.65	39.19	41.80	41.77	38.07	43.62	33.94	32.23	32.69	47.02	55.72	51.66	46.25	44.25	50.30	53.78
5/16/74	36.02	39.18	37.88	41.53	38.79	42.62	28.82	33.51	33.63	47.32	55.53	51.70	46.49	44.76	50.83	53.79
5/31/74	36.13	39.36	41.92	42.18	38.85	42.59	28.90	33.45	33.66	47.25	55.28	51.62	46.51		50.29	53.39
6/27/74	35.93	39.28	36.36	40.95	38.29	42.33	28.21	32.91	33.34	47.02	55.26	51.46	46.30	44.50	50.80	53.82
8/29/74	34.22	37.88	36.99	40.20	37.21	41.37		31.53	32.31	46.07	59.23	51.00	45.28	43.46	49.81	52.59
9/13/74	34.11	37.57	36.69	40.90	36.83	41.22	28.10	31.83		46.30	54.41	50.54	45.40	43.52	50.01	52.57
10/ 1/74	34.53	38.17	41.78	40.65	37.01	42.23	32.16	31.68	32.34	46.21	54.39	51.58	45.27	43.42	50.37	53.20
10/15/74	35.24	38.64	42.20		37.43	42.72	36.74	31.83	32.40	46.39	54.59	50.74	45.47	43.68	50.63	
10/29/74	35.95	39.02	42.12	41.32	37.85	42.69	36.26	31.97	33.33	46.58	54.74	50.98	45.69	43.91	50.83	53.75
11/ 5/74	36.20	39.13	42.20	41.39	38.02	42.74	37.40	31.98	33.33							
11/20/74	36.68	39.42	42.38	41.47	38.13	42.91	38.45	32.02	33.29	46.66	54.94	51.12	45.78	44.03	50.80	53.71
12/ 6/74	37.13	39.74	42.50	41.57	38.36	43.04	36.97									
12/11/74	37.17	39.83	41.31	41.57	38.42	42.94	36.65	32.08	33.33	46.72	54.93	51.18	45.84	44.14	50.51	53.41

Date	P-16 4044.72	P-18 4050.10	P-19 4053.34	P-20 4068.75	P-21 4070.35	RW-1* 40____ 0.5	RW-2 4044.67 0.6	S-1* 40____ -8.0	S-2* 4048.88 -10.0	S-3* 4058.85 -2.0	G-1* 40____	G-2* 40____	G-3* 40____
4/ 2/74						16.69							
4/ 5/74						16.83							
4/ 9/74						16.83		0.45	4.50	0.05	1.40	1.91	2.28
4/13/74						16.79		0.11	4.56	0.33	1.07	1.54	1.84
4/16/74						16.81	40.20	-0.10	4.58	0.46	0.93	1.43	1.82
4/23/74	37.84					16.80	40.18	3.00	4.56	0.55	1.34	1.73	0.98
5/ 2/74	37.85					16.73	40.21	2.40	4.60	0.47	0.86	1.36	1.92
5/16/74	39.11					16.82	41.24	0.26	4.63	0.23		0.75	
5/31/74	39.03						40.87			-0.11	dry	dry	dry
6/27/74	38.74					16.72	40.71			dry	dry	dry	
8/29/74	38.37					dry	40.12	dry	3.60	dry		dry	dry
9/13/74	38.04												
10/ 1/74	37.67												
10/15/74	37.69							4.74	6.3	≈3.5		1.76	
10/29/74	37.62							4.72	≈5.85	≈3.7		1.22	
11/ 5/74	37.59							4.73	top of mark				
11/20/74	37.57							4.75	8.3	4.3est.		1.77	
12/ 6/74		29.34	34.28										
12/11/74	36.93	29.30	34.27	56.66	52.59								

*Conversions not made. Readings - depth to water, feet.

Note: All readings fall within the 4000.00 to 4100.00 msl elevation of M.P.. Add 40 in front of the number for a full reading.

SOUTH PLATTE DITCH RECHARGE STUDY - 1975 page 1

Key: Observation Well No.
Elevation of M.P. (msl)

Date	W-1 4093.21	W-2 4086.07	W-3 4087.38	W-4 4077.17	W-5 4086.00	W-6 4057.18	W-7 4048.59	W-8 4036.08	W-9 4035.59	W-10 4058.50	W-11 4056.33	W-12 4065.33	W-13 4063.06	W-14 4066.75	W-15 4046.34	W-16 4040.52
1/ 9/75																
2/11/75																
2/27/75						29.35	23.95		20.83							
3/ 4/75					70.16	29.18			20.81	27.81	40.87	51.65			31.06	27.64
4/ 8/75						28.54	23.51			27.21					31.44	27.90
4/22/75		72.17	71.71		69.68	30.80	23.10			28.02	ppg	38.43	53.58	58.97	31.48	27.76
5/15/75						26.78	22.49									28.24
6/ 3/75						31.98	25.11			28.58						29.10
6/26/75						34.35	25.71			29.53						29.51
7/22/75						ppg	ppg			ppg						ppg
8/15/75						23.61	20.79			18.87						ppg
9/10/75						22.71	22.41	17.58		20.04						
9/18/75						23.95	22.59	17.94		20.72						28.64

Date	W-17 4040.53	W-18 4059.39	W-19 4053.51	W-20 4059.10	W-21 4087.27	W-22 4067.50	W-23 4067.45	W-24 40____	W-25 40____	W-26 40____	W-27 4071.47	W-28 4064.67	W-29 4041.42	W-30 4058.03	W-31 40____
1/ 9/75															
2/11/75					55.35										
2/27/75			42.50	41.82	55.68										
3/ 4/75		47.14	42.53	41.77	55.35						62.35	54.03	17.72	22.86	
4/ 8/75				41.69									17.28	22.03	
4/22/75		47.79	43.13	43.59	55.34						62.42	55.08	16.88	23.16	
5/15/75				41.94											
6/ 3/75				43.38	55.51										54.66
6/26/75				44.27									18.46	21.21	47.89
7/22/75		ppg		41.95	55.76								16.99	20.56	51.31
8/15/75	ppg			41.56									ppg	17.82	45.85
9/10/75		47.45	43.85										14.86	ppg	44.09
9/18/75		47.74	43.75	ppg	55.43								ppg	17.95	43.31

Key: Observation Well No.
Elevation of M.P. (msl)
M.P. to Land Surface

Date	P-1 4058.53 4.2	P-2 4059.93 1.5	P-3 4059.58 0.5	P-4 4062.50 3.7	P-5 4053.15 3.0	P-6 4062.13 1.2	P-7 4058.75 1.1	P-USGS#1 4042.81 2.0	P-8 4043.22 1.8	P-9 4055.84 2.2	P-10 4063.93 2.35	P-11 4064.88 2.0	P-12 4059.77 0.8	P-13 4055.97 1.9	P-14 4060.85 2.5	P-15 4066.29 0.7	P-16 4044.72 1.3
1/ 9/75							33.45	31.93	33.30								
2/11/75	35.72	39.00	41.94	41.16	37.78	42.37	30.82	31.79	32.19	46.37	54.65	50.86	45.50	43.78	50.32	53.19	37.29
2/27/75	35.52	38.83	41.85	41.02	37.-3	42.23	30.57	31.71	32.19	46.29	54.60	50.87	45.44	43.71	50.26	53.10	37.28
3/ 4/75	35.44	38.75	41.82	40.98	37.55	42.83	30.59	31.65	32.05	46.28	54.58	50.80	45.43	43.68	50.26	53.08	37.24
4/ 8/75	35.11	38.51	41.68	40.96	37.34	42.01	29.98	31.67	32.20								
4/22/75	35.48	39.43	44.34	41.71	37.87	43.76	36.81	31.82	32.18	46.78	55.80	51.34	45.84	44.09	50.95	54.17	37.34
5/15/75	36.23	39.63	41.80	41.99	39.18	42.69	28.88	33.11	33.45	47.24	55.54	51.60	46.42	44.73	50.83	53.77	39.31
6/ 3/75	36.70	39.99	43.62	42.70	39.39	43.42	36.62	33.94	34.10	47.82	56.50	52.14	46.99	45.12	51.18	54.31	40.02
6/26/75	37.65	40.69	45.58	43.06	39.58	44.62	41.77	33.63	33.94	47.79	56.34	52.28	47.00	45.34	51.35	54.94	38.98
7/22/75	38.70	41.15	41.18	42.52	40.65	43.63	30.77	34.60	34.52	47.76	55.46	51.89	47.02	45.29	50.96	53.91	40.45
8/15/75	37.58	40.97	40.90	42.01	40.29	43.25	26.93	33.76	33.67	47.04	54.80	51.36	46.42		50.79	53.53	39.68
9/10/75	36.74	40.18	36.69	41.97	39.71	42.78		33.23	33.62	46.79	54.35	50.93	46.02	44.27	50.47	53.10	39.39
9/18/75	36.43	39.95	38.30	41.54	39.35	42.65	26.61	33.00	33.42	46.74	54.34	50.92	45.99	44.33	50.51	53.09	39.08

Date	P-17 4041.33	P-18 4050.10	P-19 4053.34	P-20 4068.75	P-21 4070.35	P-22 4070.97	P-23 4046.73	P-24 4047.32	P-25 4062.23	P-USGS#2 4057.44	P-26 4061.25	RW-2 4044.67 0.6	RW-3 4066.06	RW-4 4068.25	RW-5 4054.15
1/ 9/75		28.80	32.14			32.27									
2/11/75	25.45	28.22	31.15	56.51	52.21	31.51						39.69	dry		
2/27/75	25.33	27.82	30.91	56.76	51.95	30.87						36.68		63.84	
3/ 4/75	25.24	27.70	30.79	56.37	52.23	30.76				49.00		39.62		62.87	
4/ 8/75	25.02	27.17				30.33									
4/22/75	25.33	27.22	31.83	57.06	52.55	30.97	40.84	40.83	33.50	48.60		40.87	dry	63.08	41.96
5/15/75	25.19	26.68	29.36	57.11	52.55	29.52	41.77	41.77	29.60			40.83	dry	63.44	42.83
6/ 3/75	27.27	28.01	33.86	57.66	55.11	31.12	42.17	42.19	36.32			42.19	38.74	63.98	42.97
6/26/75	27.29	29.30	35.76	57.74	55.18	32.77	41.69	41.74	41.25			41.65	46.50	63.27	42.71
7/22/75	27.01	26.34	33.28	57.27	53.92	31.33	42.31	42.25	31.63			42.47	35.18	62.79	43.38
8/15/75	25.65	22.09	30.01	56.69		28.10	41.71	41.79	28.10			41.81		62.51	42.81
9/10/75	25.74	20.93	29.43	56.15	51.97	28.60	41.70	41.86	26.96	49.33	53.50	41.62	dry	62.01	42.26
9/18/75	25.45	21.38	29.74	55.97	51.77	28.78	41.48	41.50	27.79		53.36	41.50	dry	61.94	42.98