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EVALUATION OF PRESENT CONDITIONS IN A WATER RESOURCE PROJECT

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SUMMARY: A section about 1,800 m wide and 4,000 m along Mitchell Creek in Edgecombe and Pitt Counties, North Carolina was studied over a 3-year period. The first two years, 1980-81, the area was studied as a drainage system. In 1982 a Fabridam was built to control the water level in the 2-3 m deep channels. Yield, water table elevations, stress day indices, and economical analysis are covered in this report.

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ABSTRACT

A section about 1800 m wide and 4000 m up Mitchell Creek in Edgecombe and Pitt Counties, North Carolina, was studied over a 3-year period. For the first two years , 1980-81, the deep channels in these sandy soils showed a water table drawdown of about 3 m near the stream which affected the water table 884 m away. Corn yields near the creek were half those at 800 m from the creek. Stress day indices varied inversely to the yield. In 1982 a Fabridam, a fabric dam filled with water that automatically controls water levels in the creek and allows floods to pass, was installed on Mitchell Creek. After the Fabridam was installed, the water table in the fields above the dam rose significantly. Corn yields were increased by 25% within 488 m of Mitchell Creek where the water level in the stream was controlled. This increase in yield would pay for the structure over a period of 15 years.

INTRODUCTION

There are about 15-25 million hectares of drained farm land in the humid region of the U.S. About 3.4 million hectares of sandy, sandy loam, and organic soils are found in the South Atlantic Coastal Plain of North Carolina, South Carolina, Georgia, Florida, and Alabama (Wenberg and Gerald, 1982). It is estimated from discussions with Soil Conservation Service personnel that there are another 1.5 million hectares of these soils in Virginia, Maryland, Delaware, and New Jersey.

When the water table is greater than 1.5 m from the surface, the water-holding capacities of these sandy soils is about 3 cm/30cm of soil or less; enough to supply crop water needs for 4 to 7 days. The low water-holding capacity of these sandy soils makes them susceptible to becoming droughty when the water table is drained too far below the soil surface. However, artifical drainage is necessary for trafficability in the spring and fall and to protect crops from excessive soil water conditions during wet periods. Improved drainage channels are also needed for flood protection.

Controlling the stream water levels is considered to be a system of control drainage, subirrigation or total water management system. French scientists, Bordas and Mathieu (1931) reported higher yields from a controlled water table than from other irrigation systems. Some practical aspects of controlled subsurface drainage were considered by Morris (1949) who concluded that in the future all artificial drainage may be controlled drainage.

Kalisvaart (1958) reported on controlling stream water levels for subirrigation in the Zuiderzee Poldus in the Netherlands where only agricultural land with low water-holding capacities needed irrigation. In portions of this land, water can be supplied by subirrigation which might be termed "drainage in reverse". He pointed out that in fields where the subsoil consisted of deep and very permeable low terrace sands, "as a rule subirrigation (reversible drainage) will be the most suitable method" for irrigation.

In the United States, most data on control drainage and subirrigation must be gleaned from drainage research. For example, we find in Table 2.2, pages 34 and 35 of Wessling (1974) that in 21 of the 35 cases reported, yields decreased when the water table was maintained below certain levels from the surface. Water table depth for maximum yields varied with crops and soil classifications. However, for all soils classified as loams, sandy loam, and loamy fine sands, he showed that there was a minimum water table depth that produced maximum yields, but for any greater depth to the water tables, yields were reduced.

When the water table in sands, sandy loams, and silty clay loam soils rose from 80 to 15 cm below the surface, corn yields decreased from 100 to 45% of maximum yield, respectively. Likewise, when the water table fell from 80 to 100 cm below the surface, corn yields decreased from 100 to 45% of maximum, respectively. Soybean growing on sandy loam soils were similarly affected. Yields for wheat, oats, and barley growing on clay soil were somewhat similar for a rise in water table, but 100% of maximum yield was reached at a water table depth of 150 cm. Vegetable crop yields followed about the same trends (Wesseling 1974). The fact that there were no yield decreases as the water table receded in clay soils indicated that water-holding capacities of the clay soils (6.4 cm/30 cm of soil) are higher than in sandy soils (1.5 to 5 cm/30 cm of soil) (Turner et al., 1971).

In the Mid-Atlantic Coastal Plain, soils that are too dry during one period may be excessively wet during another as a result of erratic rainfall distribution and soil conditions. Drainage is needed during periods of excessive rainfall, but when sandy soils are drained too rapidly or deeply, drought stress will occur if it doesn't rain again in 4 to 7 days (Doty, 1975b; Reicosky et al., 1976). An example of this condition is the Conetoe Drainage District in North Carolina where 26,000 hectares of land are drained in Public Law 566 drainage project constructed in 1967. Several thousand hectares of cropland that once were flooded several times a year are now protected. However, to drain parts of the district, channels over 2 m deep were necessary. Although flooding is no longer a problem, overdrainage near the channels is believed to increase drought stresses and reduce yields. Farmers are investing in irrigation systems, and domestic use well points are being lowered to compensate for the lowered water table. Problems are developing because of a lack of water to supply the ever growing number of irrigation systems along the streams.

Control of the variation in the stream water level during non-flood stages and the fast removal of flood flows are being studied. This project, located in Pitt and Edgecombe Counties, North Carolina, is the composite cooperative effort of agencies from the U.S. Department of Agriculture, the Agricultural Research Service and the Soil Conservation Service; the North Carolina Agricultural Research Service, Departments of Biological and Agricultural Engineering and Soil Science, N. C. State University; the drainage industry, Advance Drainage Systems, Inc., and Hancor, Inc.; the Edgecome County Drainage District #2; and local farmers and landowners.

The general objective of this research is to evaluate present methods for design and operation of water table management systems and to develop field-derived criteria to modify these systems for economic efficiencies for water resource projects. This paper will (1) evaluate the effects of deep ditches on field water table levels in sandy soil and (2) give preliminary results on controlling the stream water levels with a "Fabridam" on field water table levels and corn yields.

PROJECT DESCRIPTION AND PROCEDURE

The water management study is located on a 2-mile section of Mitchell Creek (Fig. 2). The area, about 800 hectares, is flat to gently rolling with no more than a 1.5-m difference in elevation. The soil series Altavista, Augusta, Cape Fear, Conetoe, Portsmouth, Roanoke, State, Tarboro, and Wahee were mapped and rechecked for each yield sample site by the Soil Conservation Service. The soils are poorly to somewhat excessively drained, formed in sandy fluvial and marine sediments. They are underlain by a coarse sandy aquifer at about 1.5-m depth. The coarse sand is underlain by a layer of blue consistent clay ranging in depth from 4 to 8 m below the surface. This clay layer was found to be impermeable at points where it was measured, but fissures may occur in the layer.

Six lines of water table observation wells were installed to transect the area on each side of the creek. Well locations ranged from 10 to 970 m from the channel in lines perpendicular to the creek (Fig. 2). Forty wells were equipped with stage recorders and 22 were read manually each week. There were 12 stream gaging sites equipped with stage recorders, 7 on Mitchell Creek, 3 on intersecting channels, and 2 on channels paralleling Mitchell Creek. Manual flow measurements were made at 5 of these sites about twice weekly. Other sites were measured about once a month. Hydaulic conductivity was measured with a drill rig at random over the area.

A Fabridam-type structure (2.7 m high) (Fig. 3) was installed and put into operation on 2 April 1982 across Mitchell Creek about midway in the 3.5-km study area. The water inflatable fabric dam is about 6 m wide at the bottom of the creek bed and 13 m wide at bank height, and is used to automatically control the water level in the creek upstream. The Fabridam is capable of collapsing during flooding which allows the channel to return to normal size. It can control the water level in the channel to a depth of 2.45 m. For example, if the control level is set at 11.45 m above MSL and a flood raises the upstream level to 11.60 (0.15 m rise), the Fabridam begins to deflate, but will remain controlled between 11.45 and 11.60 m. If the flood level still rises to 11.62 m (0.17 m rise) another valve opens and the Fabridam deflates faster, but automatic controls keep it between 11.45 and 11.60 m. If the flood continues to exist and the upstream water level reaches 11.65 m (0.2 m rise), a 20.3-cm syphon will deflate the Fabridam at a rate of about 0.06 m/min until there is no restriction in the channel. As soon as the flood passes and the syphon breaks, the Fabridam will be inflated to the original setting of 11.45 m.

Corn yields were sampled by hand from two replications near the water table observation wells (Fig. 2). For this report the yields are reported in two ways: (a) The distance from the channel to the sample site was divided into seven sections, 0-50 m, 51-100 m, 101-200 m, 201-400 m, 401-600 m, 601-800 m, and greater than 800 m for the data before the Fabridam (1980 and 1981). (b) After the fabridam was installed in 1982, the yields were separated into treatments (1) no water level control with and without irrigation and (2) water table control by the Fabridam with and without irrigation. For the 1982 corn yield data, the nonirrigated data was divided into seven sections, 0-50 m, 51-100 m, 101-200 m, 201-300 m, 301-400 m, 401-500 m and greater than 500 m the distance the channel to the sample site. Average yields were regressed against distance from the channel for before and after Fabridam installation. The 95% confidence limits on all data was based on all sample sites, not just on the averaged data (Eq.9.13, Steel and Torrie, 1960).

The stress-day index (SDI) were determined for each site where corn yields were measured. The stress-day index is defined by:

$$SDI = \sum_{i=1}^{n} \left(1 - \frac{ET_i}{(SPE_i)(Kc_i)}\right) \qquad [1]$$

where:

ET_i = calculated evapotranspiration for day i

SPE_i = screen pan evaporation for day i

Kc_i = crop factor Kc (Soil Conservation Service 1967)

The daily evapotranspiration (ET_i), which depends on the soil moisture conditions, is calculated by:

$$ETi = \begin{cases} (SPE_i)(Kc_i) & ,AW_{i-1}+F_i \geq (SPE_i)(Kc_i) \\ AW_{i-1} + F_i & ,AW_{i-1}+F_i < (SPE_i)(Kc_i) \end{cases} \qquad [2]$$

The potential available water in the root zone (AWP_i) is calculated from the water balance equations.

$$AWP_i = AW_{i-1} + R_i + F_i - Et_i \qquad [3]$$

where

AWP_i = potential available water in the root zone for day i

AW_{i-1} = available water in the root zone for day i-1

R_i = rainfall for day i

F_i = upward flux of water into the root zone calculated from the soil water characteristic curve assuming steady state flux (Skaggs, 1981). In some cases, it was necessary to extrapolate F_i past the depth for which samples for soil water characteristics were taken. For example, near the channel, the water table position was greater than 2.0 m from the surface.

ET_i = evapotranspiration for day i from equation 2

The surplus water, (S_i), (runoff, lateral loss, and deep seepage) for day i is then defined by

$$S_i = \begin{cases} 0 & , AWP_i \leq MAW_i \\ AWP_i - MAW_i & , AWP_i > MAW_i \end{cases} \quad [4]$$

MAW_i = Maximum available water in the root zone based on the soil water characteristic which is a function of the soil type, the water table position and the rooting depth. Since the rooting depth and the water table position changes throughout the growing season, the amount of MAW_i is changing daily.

Therefore, the available water in the root zone (AW_i) for day i is then calculated as $AWP_i - S_i$ and

$$AW_i = AW_{i-1} + R_i + F_i - S_i - ET_i \quad [5]$$

The available water in the root zone (AW_{i-1}) where i is the planting day is assumed to be MAW_i; which is obtained from the soil water characteristics curve.

RESULTS AND DISCUSSION

Effect of Deep Ditches

Data were collected in 1980 and 1981 without water level controls to determine the effect of deep ditch drainage on the water table and crop yield. The 2-4 m deep channels are excellent for drainage and flood control, but frequently cause overdrainage in these deep sandy soils after the flood passes. Figure 4a shows the maximum and minimum water table elevations on each side of Mitchell Creek for well line

No. 5. The gradient towards the channel on the water table surface extends to the measured distance of 884 m on the right side looking downstream and to 696 m on the left side. The water table slope towards the channel is greater for the first 400 m. Similar slopes of the water table occur about 1200 m upstream at well line No. 3 (Fig. 4b) where the soil surface is relatively flat. This indicates that water is being drained from the water table by Mitchell Creek at a distance of at least 884 m. Assume that a maximum water table elevation of about 12 m, (1 to 1.5 m below the surface) is the water table depth at which corn can be grown without aeration problems (Wessling 1974, See Fig. 1, and Benz et al. 1981). Then in these fields, the difference from 12.0 m above MSL to the lowest water table elevations on 17 December 1981 is the amount of drop in the water table and overdrainage near the channel caused by dry weather conditions and deep channels in sandy soils along Mitchell Creek in 1980-81 (Fig. 4a, 4b).

The drop in the water table due to weather conditions and over-drainage near the channel are shown with time for well line No. 5 (Fig. 5). At the beginning of data collection in 1980, the water table elevation was about 11.5 m at 594 m from the creek, which is lower than the elevation at which the water table should be maintained without reducing yield (1.5 m below the surface). The water table continued to drop through the remainder of 1980 and 1981, the minimum elevation being about 10.7 m (1.3 m below the desired 12 m). A well 18 m from Mitchell Creek was at least 2.4 m below the desired water level of about 1 m below the surface throughout 1980 and 1981.
The elevation of the water level in the creek was less than 9.6 m at least 2.4 m below the desired 12-m elevation throughout 1980 and 1981.

Similar results were shown at well line No. 3 about 1200 m upstream. The hydraulic conductivity of the surface 0-1.2 m ranged from 0.07 to 9.5 m/day, from 1.2 to 2.1 m from the surface ranged from 0.11 to 42.7 m/day, and 2.1 to 7.5 m from the surface ranged from 0.0 to 58.0 m/day according to the depths of the blue clay layer. This indicates that without water level control in the stream, these sandy soils with high hydraulic conductivity are overdrained.

Stress Day Index and Corn Yield

The average stress day indices for the corn growing season for each sample site where corn yield samples were taken in 1980 and 1981 was plotted against the average distance from Mitchell Creek (Fig. 6a). Stress, as indicated by stress day index, is related to the distance from Mitchell Creek. Near the creek there were about 70 days during the growing season when full ET for the corn crop was not available, but at 700 m from Mitchell Creek there was less than 20 days that full ET was not supplied. This was because the water table near the creek was drawn down to low by the deep drainage channel. At 700 m from the creek the water table was not so far from the surface (Fig. 4a, 4b).

The relationship of corn yield to the distance the sample site was away from Mitchell Creek shows that corn yields increased with distance from the creek (Fig. 6b). Corn yields of 4.8 t/ha were measured at 25 m from Mitchell Creek and increased at a rate of 0.1 t/ha for each 18.7 m (1 bu/38 ft) farther away from the creek to 9.0 t/ha at a distance of 810 m from Mitchell Creek. The yield-distance relationship is the inverse to the SDI-distance relationship showing that the corn crop for 1980 and 1981 growing seasons had more drought stress (SDI = 70) and lower yields (4.8 t/ha) where the water table was farther from the surface near Mitchell Creek (Fig. 4a, 4b). There was considerably less drought stress (SDI = 11) and higher yields (8.6 t/ha) at 800 m from Mitchell Creek where the water table was closer to the soil surface and water could reach the root system of the corn plants. This shows the effects of overdrainage in these sandy soils by the deep ditch systems required for flood control.

The data for the 1980 and 1981 corn-growing seasons show an excellent linear relation (R^2-.99) between the measured yields and the calculated stress-day index based on screened-pan evaporation, soil water characteristics, and water table depth (Fig. 7). With a SDI of 11, the average corn grain yield was only 4.8 t/ha. This is a 79% increase in grain yield for an 84% decrease in SDI. Water table levels varied over the two-year period, but the maximum and minimum water table depth for a SID of 11, 8.6 t/ha corn yield, was between 1.4 and 0.8 m. (Fig. 4). This is in the range of the water table depth that produced the best corn yield, 6.6 t/ha, as reported by Benz et al., 1978. The maximum and minimum water table depth for a SDI of 70, 4.8 t/ha corn yield, was between 2.8 and 2.5 m from the surface (Fig. 4). This corresponds to Benz et al., (1978) deep water table data which produced 3.0 t/ha of corn grain. Doty et al. (1975a) showed that corn silage yields increased by 1.1 t/ha for each additional day the water table was 1.07 m or less from the surface. The water table is being lowered to a point where the root system cannot extract any water from the capillary zone above the water table. Overdrainage occurring in these low water-holding capacity sandy soils with deep channelization can be corrected by controlling water tables at less than a 1.5-m depth. Two possible alternatives are: (1) drainage channels should be less than 1.5 m deep, which can fill with debris and cause flooding, and (2) automatic control structures must be provided to control the water table level on channels large and deep enough to handle flood flows. In either case, the drains would not drain the land far away from the channel, and additional field drains would be required to provide good water management.

Effects of Deep Channels with Water Level Controls

The Fabridam installation (Fig. 3) was completed on 2 April 1982 with the water level in the stream controlled at 10.67 m above MSL until June 18 when the level was raised to 11.28 m. The control level was raised to 11.55 m on July 6 and remained there for the rest of the season. Several large rainfall events caused fluctuation in the dam, but the floods passed easily. One 80 mm rain on August 11-12, 1982, caused the Fabridam to operate seven times.

Corn requires the greatest amount of water from silking to ear fill stages. The last of June (June 30) is considered to be a high water use period for corn for both 1981 and 1982 at the research site. The water table elvations for 30 June 1981 without water level control and 30 June 1982 with Fabridam water level control are shown in Fig. 8a for well line 5, about 90 m upstream from the Fabridam. Near the stream the water table was about 1.5 m closer to the surface in 1982 than in 1981. At about 200 m on either side of the channel the water table was about 0.5 m closer to the surface in 1982 than in 1981. The water table would have been slightly higher in 1982 than in 1981 without the Fabridam due to rainfall. Essentially, controlling the water level in Mitchell Creek produced an almost flat water table with variations in depth to the water table being the change in soil surface elevation (Fig. 8a). Similar results were found about 1200 m upstream from the Fabridam. Doty (1980) showed that corn received ample water for good production with the water table less than 1.4 m from the surface in a Goldsboro sandy clay loam soil in South Carolina.

Below the Fabridam, the stream remained at about its normal level since there was no water table control (Fig. 8b). The general water table was higher in 1982 than in 1981 due to rainfall. The water table for 30 June 1982 paralled that for 30 June 1981. Nearer the stream, the water table was from about 2.4 to 3.7 m from the surface while at distances between 500 and 700 m from Mitchell Creek, the water table was from about 1.5 to 2.5 m from the surface. The water table being closer to the surface at 500 to 700 m from Mitchell Creek than near the Creek would suggest that crop yields should increase in proportion to distance away from Mitchell Creek in the area without water level control by the Fabridam (Fig. 8b). While in the area where the water level in Mitchell Creek was controlled by the Fabridam, the water table was essentailly flat (Fig. 8a).

Corn Yield vs. Distance From Channel

The data for 1982 was the first yield results with water level control in the channel. Data was collected from above the Fabridam where the water level was controlled and below the structure without water level control. The average corn yields from the four water management systems are compared in Table 1. Without irrigation, the system with water level control produced 16% more corn than the check without control. With irrigation, 6.3 cm, the system with the water level control produced 25% more corn than the check. Irrigation applied to the system without water level control (check) produced 16% more yield. However, the farmers in the area were applying the water, and the application times were not the same. The water table was about 1.5 m to 2.2 m from the surface on the water level control system. Benz et al. (1978) showed an increase in yield from irrigation when the water table was greater than 1.8 m from the surface.

Without water level control in the channel, yields increased with distance away from Mtichell Creek (Fig. 9a). The linear regression line had a slope of 0.007. This compares to a slope of 0.005 for the 1980-81 data (Fig. 6b). Even though 1982 was an excellent corn producing year without water level control, about 5 t/ha (80 bu/A) of grain was produced near the channel with the water table about 2.7 m from the surface. At 550 m from the Mitchell Creek, 8.4 t/ha (134 bu/A) of corn was produced with a water table 1.7 m from the surface. On a Hecla sandy loam soil in North Dakota, Follett et al. (1974) reported average corn yields of 4.5 t/ha where the water table was from 1.9 m to 2.9 m and 8.4 t/ha where the water table ranged from 0.7 m to 1.9 m for the two-year period of study. This shows the need for water level control in the channel on these sandy soils.

Above the Fabridam where the water level was controlled, the story was different. There was no increase in yield due to distance from Mitchell Creek (Fig. 9b). The mean yield from 0 to 330 m from Mitchell Creek was 8.3 t/ha (134 bu/A), almost the same as without water level control at 550 m from the Creek. This shows that water level control by the Fabridam increased yields near the deep channels. In addition, flooding was controlled with up to 80 mm of rainfall.

There was some evidence of wet soils in the watershed caused by controlling the water table. Two well sites in low elevations showed that water table less than 0.7 m from the surface for 2- to 3-day periods, and yields may have been reduced due to too wet conditions. The only complaint about surface water was related to a clogged surface outlet into a drainage ditch. After the outlet was cleared, the ponded water drained. The water table was greater than 1 m below the soil surface.

Stress Day Index After Fabridam

The SDI for the 1982 corn yield sample sites below the Fabridam, without water level control, were regressed against distance from Mitchell Creek (Fig. 10a). Although the regression coefficient (R^2 = 0.30) was low, the 1982 SDI-distance relationship was inverse to the 1982 yield-distance relationship (Fig. 9a). This inverse relationship was similar to the one shown for the 1980-81 data (Fig. 6a,b). For the 1982 corn yield sample sites above the Fabridam where the water level in the stream was controlled, the SDI decreased also with distance from the creek (Fig. 10b). However, the point at 330 m from the creek is questionable. The soil series in the general area is mapped Cape Fear and the closest point where the soil series had been determined previously was the Portsmouth silt loam. The Portsmouth silt loam soil water characteristic was used to determine SDI. The SDI for the point at 330 m from the creek was also calculated with the soil water characteristic of a Portsmouth coarse loamy variant soil which gave an SDI of 32.08. With the Portsmouth coarse loamy variant series, there would be no relationship between SDI and distance from the creek for the yield plots above the Fabridam.

Stress Day Index Vs. Yield

All data points for 1980 through 1982 were used to give a relationship between SDI and measured yield (Fig. 11). The maximum single well site yield measured in the area was 10.52 t/ha for nonirrigated soils and 12.221 irrigated soils in 1982; 10.025 nonirrigated and 11.869 irrigated in 1980 and 1981. The maximum projected yield from the regression line (Fig. 10) shows that with a SDI of 0.0, the yield should be 10.554 t/ha, $\pm$ 2.00 t/ha (168 bu/A) or from 8.5 to 12.5 t/ha for the 95% conficence limits. This compares favorably with the highest observed yield of 10.700 t/ha (170 bu/A) or the projected potential yield of 11.1 t/ha (177 bu/A) for the Tidewater Research Station, near Plymouth, North Carolina, about 100 miles east of this site (Hardjoamidjojo and Skaggs, 1982). However, our data show that plant populations are in the range of 37,000 to 57,000 plants/ha for nonirrigated fields and 49,000 to 72,000 plants/ha in the irrigated fields. North Carolina State University recommends 54,000 to 69,000 plants/ha for nonirrigated corn. Rhoads (1982) showed yields of 14.5 t/ha (230 bu/A) under irrigation at 90,000 plants/ha on a sandy soil in Florida. Therefore, when farmers use higher plant populations, yields should increase.

The low R^2 value indicating a wide scatter of points between corn yield and stress day index (Fig. 10) shows that some improvement is needed in obtaining stress day index. We plan to include some work by Hardjoamidjojo and Skaggs (1982) and include crop susceptibility factors, planting delay, and wet soil conditions for future studies on these data.

Economical Analysis of Water Table Control

The farmers and action agency scientists want to know how water table control will affect the pocket book. A present value analysis of the 1982 data is shown in Table 2. This data shows that although the Fabridam costs $248,700 to install, it will more than pay for itself in a 15-year period. Based upon the 1982 data only, with irrigation on only 142 hectares of the 202-ha area which the Fabridam affects, the Fabridam will pay for itself and leave $214,700 ($14,300/yr) for maintenance and management (Table 2). This may not be true when the long-term results are collected, but these results are very encouraging.

SUMMARY AND CONCLUSIONS

The data collected in this study show that in sandy soils when the water table falls too far below the surface, yields are reduced below the maximum. This study confirms on a field basis what other studies have shown from small plots (Benz et al., 1978, 1981; Wesseling, 1974; Williamson and Kriz, 1970).

A section about 1800 m wide and 4000 m long on Mitchell Creek was studied over a 3-year period. The first two years, 1980-81, the area was studied as a drainage system. In 1982 a Fabridam was built in the creek to control the water level in the 2-3 m deep channels.

In the area of Mitchell Creek, the 1980-81 data showed the effect of deep ditch overdrainage. The 3-m deep channels in Mitchell Creek affected the water table 884 m from the creek. Overdrainage was also shown by the drought stress of the crops occurring near the creek and affected corn yields under irrigated and nonirrigated conditions. These observed effects were studied on all soil series where corn yields were measured.

Data collected for 1982 were the first results using the Fabridam to control the water table levels. The water level in the stream at an elevation of 11.25 m, about 1 to 2 m from the soil surface was relatively flat with the variation in depth of the water table similar to the variation in soil surface elevation. On the average, the water table in the area was about 0.65 m higher after the stream water level was raised about 1.25 m.

Measurement of water table levels below the Fabridam showed the water table elevations to be about 0.2 m higher than they were in 1981 due to rainfall, but were drawn down sharply near the channel.

Corn yields were affected by the stream water level control and the higher water tables. Nonirrigated corn yields above the Fabridam were 16% greater than those from below the Fabridam. Irrigated yields were 25% higher than those from below the Fabridam.

The method of calculating SDI can use some improvement. This is indicated by the fact that SDI was more closely related to yield in the drier years of 1980 and 1981 (Fig. 7) when the rainfall was more scattered than in 1982, a year of more abundant rainfall (Fig. 10a, b). However, the SDI did a good job in projecting the maximum yield of 10.554 t/ha (168 bu/A).

Farmers and action agency personnel are very interested in the economical analysis of this project. Based on 1982 data only, the use of the Fabridam, without additional irrigation equipment, should pay for itself in 15 years at 10% interest. This would leave $5,300 per year for maintenance and management. However, with irrigation, the Fabridam will pay for itself in 15 years and leave $214,700 ($14,300/yr) additional for maintenance and management.

Overdrainage is occurring in the low water-holding capacity sandy soils with high hydraulic conductivities and deep channelization throughout the Southeast. Shallow channels would probably decrease overdrainage, but maintenance, flood control, and proper drainage during wet periods are problems that would still exist. Engineering design criteria must be established for future planning of water resource projects that will provide proper drainage and flood control during wet periods and still provide soil water storage in the soil profile and in the stream channels for supplying water for crop needs either by capillary rise in the soil or by being available for irrigation pumping.

Design of water level control structures can be critical in streams subject to flooding. These structures must be automatic in order to pass flood water. We have shown the possible economic effects of the better and more expensive water level control structure, the Fabridam, but our limited data show it to be worthwhile. Why take the chance of designing a water level control structure that man has to operate and risk loss of property and possibly life. Design all water level control structures to operate automatically.

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LIST OF TABLES

Table 1. Corn yield data for the four water management systems on Mitchell Creek for 1982.

Water Management System	Mean Corn Yield Nonirrigated	Mean Corn Yield Irrigated
	-------------t/ha-------------	
No Water Level Control	7.157 b*	8.289 b
Control by Fabridam	8.321 b	10.326 a

* Yield followed by the same letter are not significantly different by DMRT at 5%.

Table 2. Present value of the 1982 corn crop at $98.40/ton ($2.50/bu) projected for 15 years at 10% interest (PWF = 7.606). The estimated life of the fabridam is 50 years.

Treatment	Yield[1/] (t/ha)	Area involved (ha)	Present value of crop	Increase value due to treatment	Present cost of treatment (Fabridam)	Returns for maintenance-management
			-----------------------	dollars	---	
No controls	6.68	202	1,009,900	-		1,009,900
Fabridam control	8.36	202	1,263,900	254,000	248,700	1,015,200
Fabridam plus irrigation[2/]	10.33	142	1,473,300	463,400	248,700	1,224,600

1/ Average yields for 0 to 488 m from Mitchell Creek (Fig. 9a,b)

2/ This 142-ha area had a yield increase of 1.97 t/ha because irrigation water could be supplied. Therefore, the present value also includes the present value of the 202 ha with water level control by the Fabridam. It was also assummed that the farmer owned the irrigation system.

LIST OF FIGURES

Creek for the 1982 growing season. (a) with no water level control and (b) with water level control in Mitchell Creek by a Fabridam.

Fig. 10. Relation of average stress-day index to distance from Mitchell Creek (a) with no water level control and (b) with water level control by the Fabridam.

Fig. 11. Stress-day index vs. corn yield for three growing seasons, 1980, 1981, and 1982.

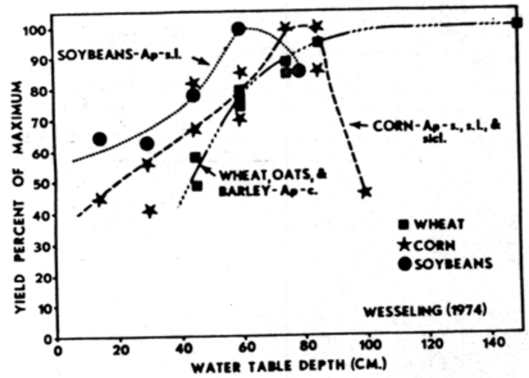


Fig. 1. Water table depth vs. percent of maximum yield for major field crops (after Wesseling 1974).

Origional Picture will be used for this figure

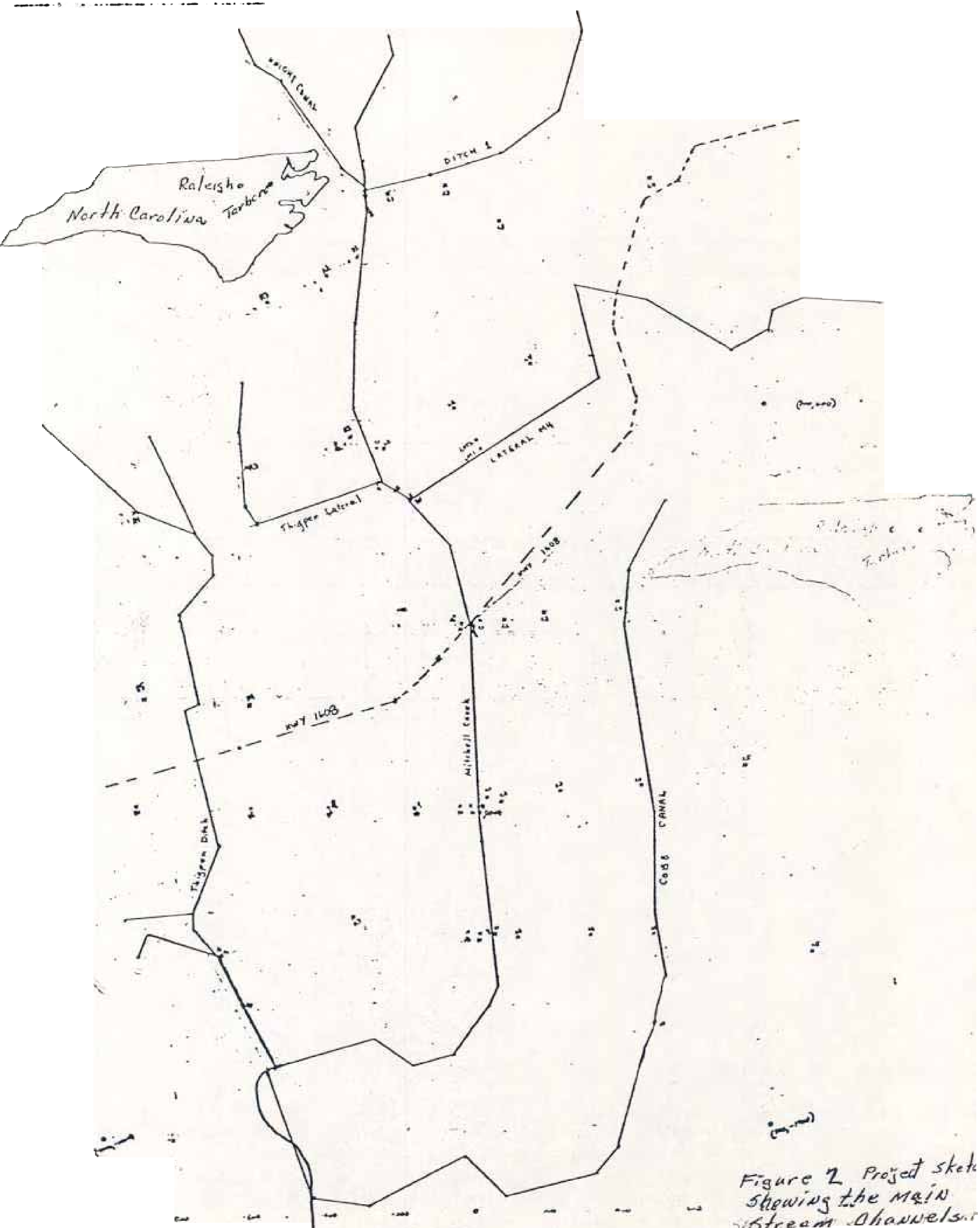


Figure 2 Project sketch showing the main stream channels.

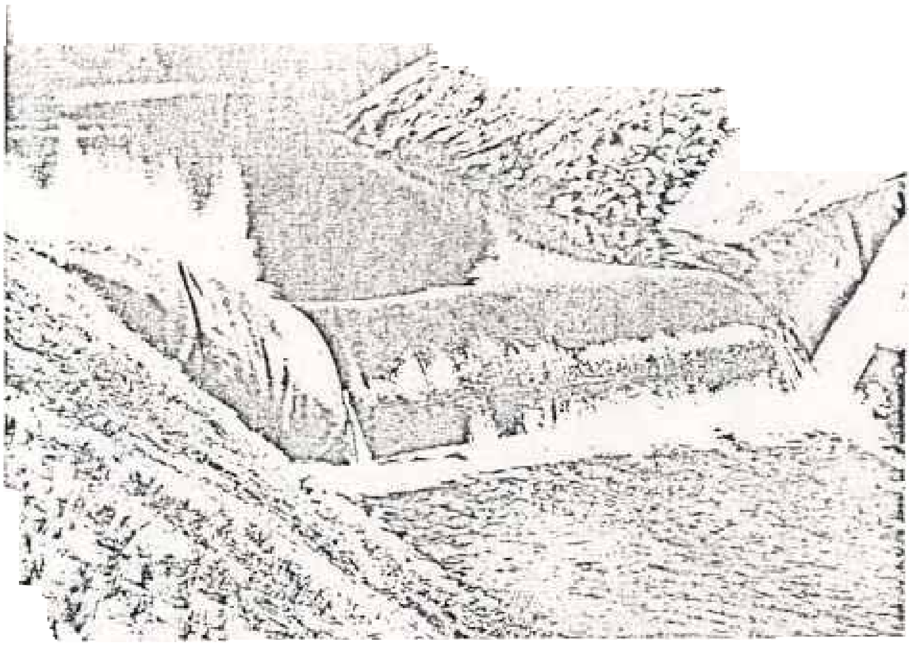
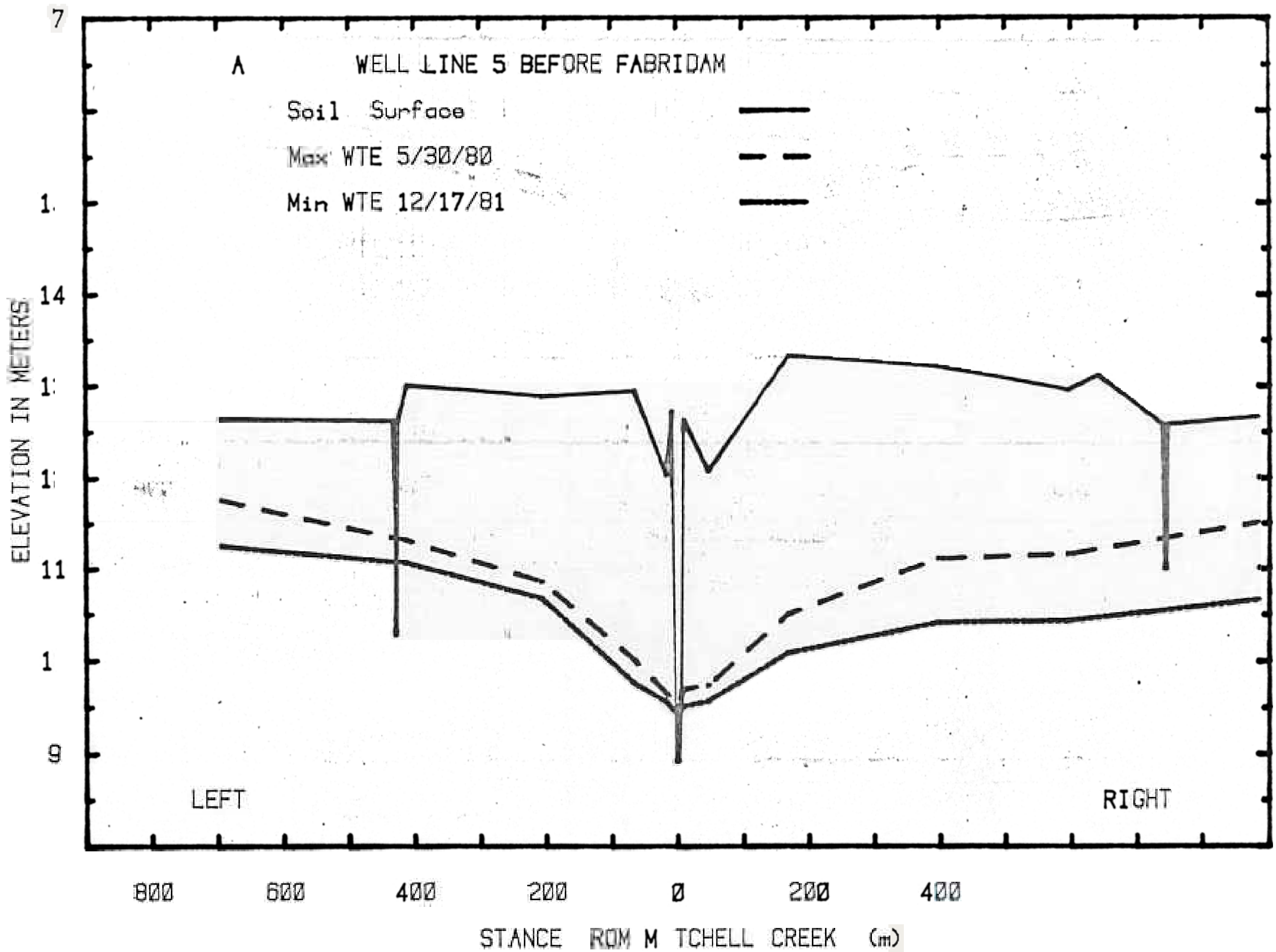


Fig 3 The Fabr dam n Mitchell Cr ek
looking up str.

a better Picture is being Prepared



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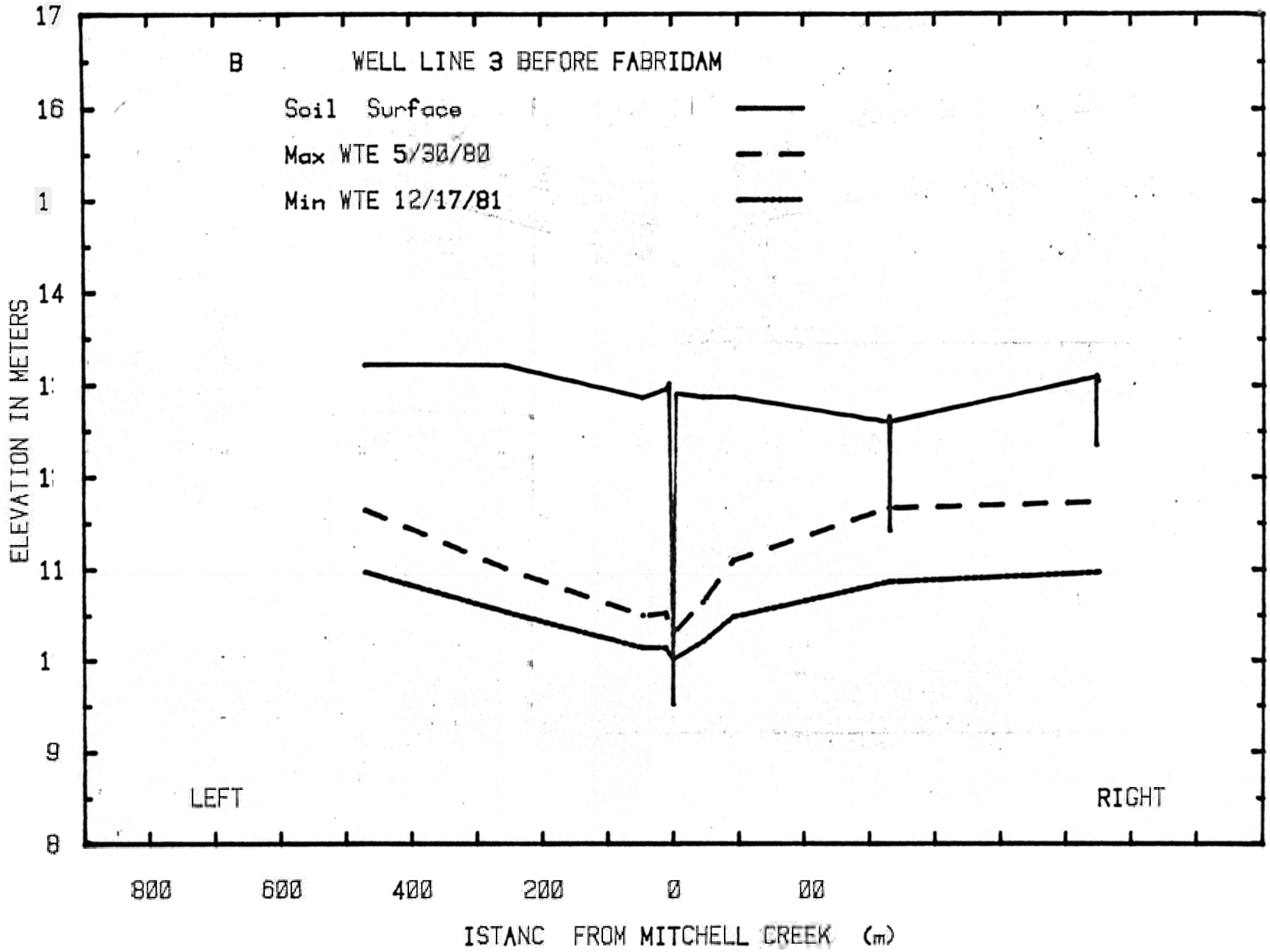

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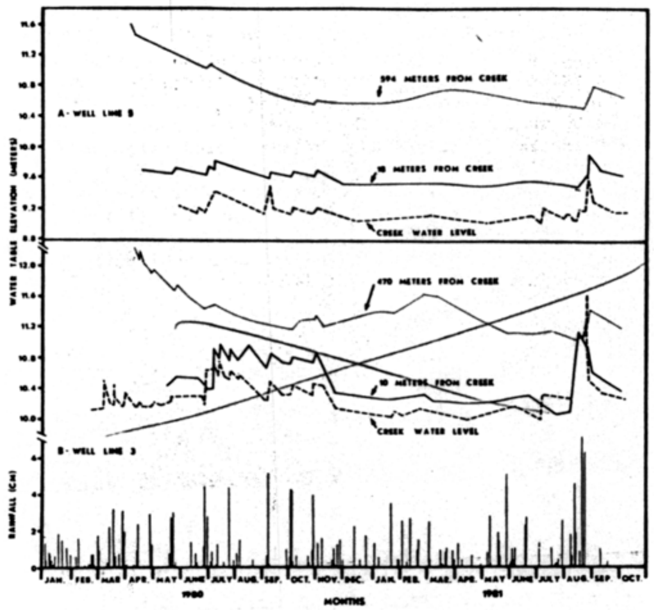

Fig. 5. Relation of stream water elevation fluctuation to water table fluctuation near Mitchell Creek and at a distance away from Mitchell Creek at Well Line #5~~(A), and Well Line #3(B)~~.

This figure will be changed to include the full year data for 1981, but will only include line 5

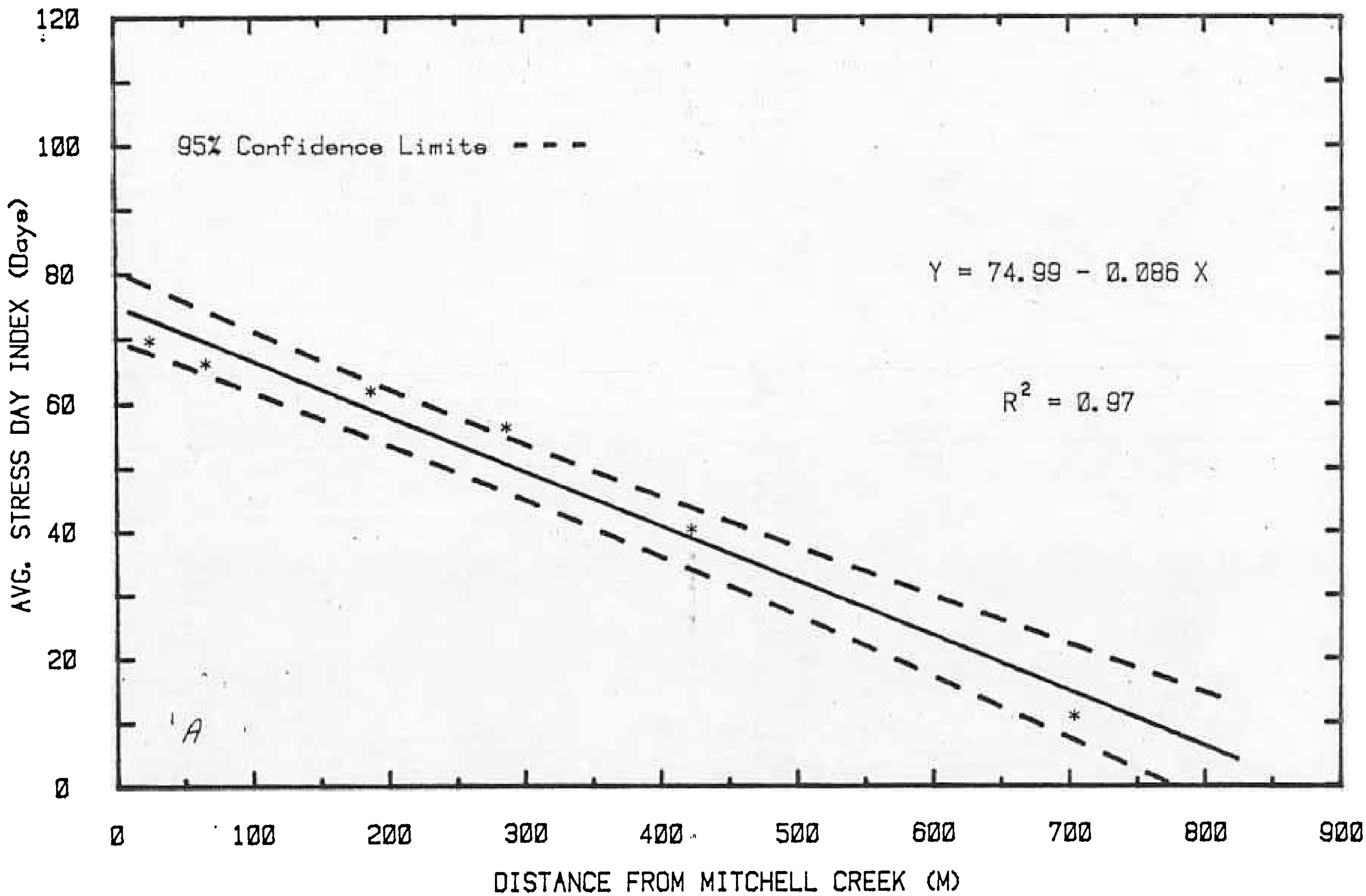

Fig. 6a. Relationship between average stress day index (SDI) and distance from Mitchell Creek for crop years 1980 and 1981.

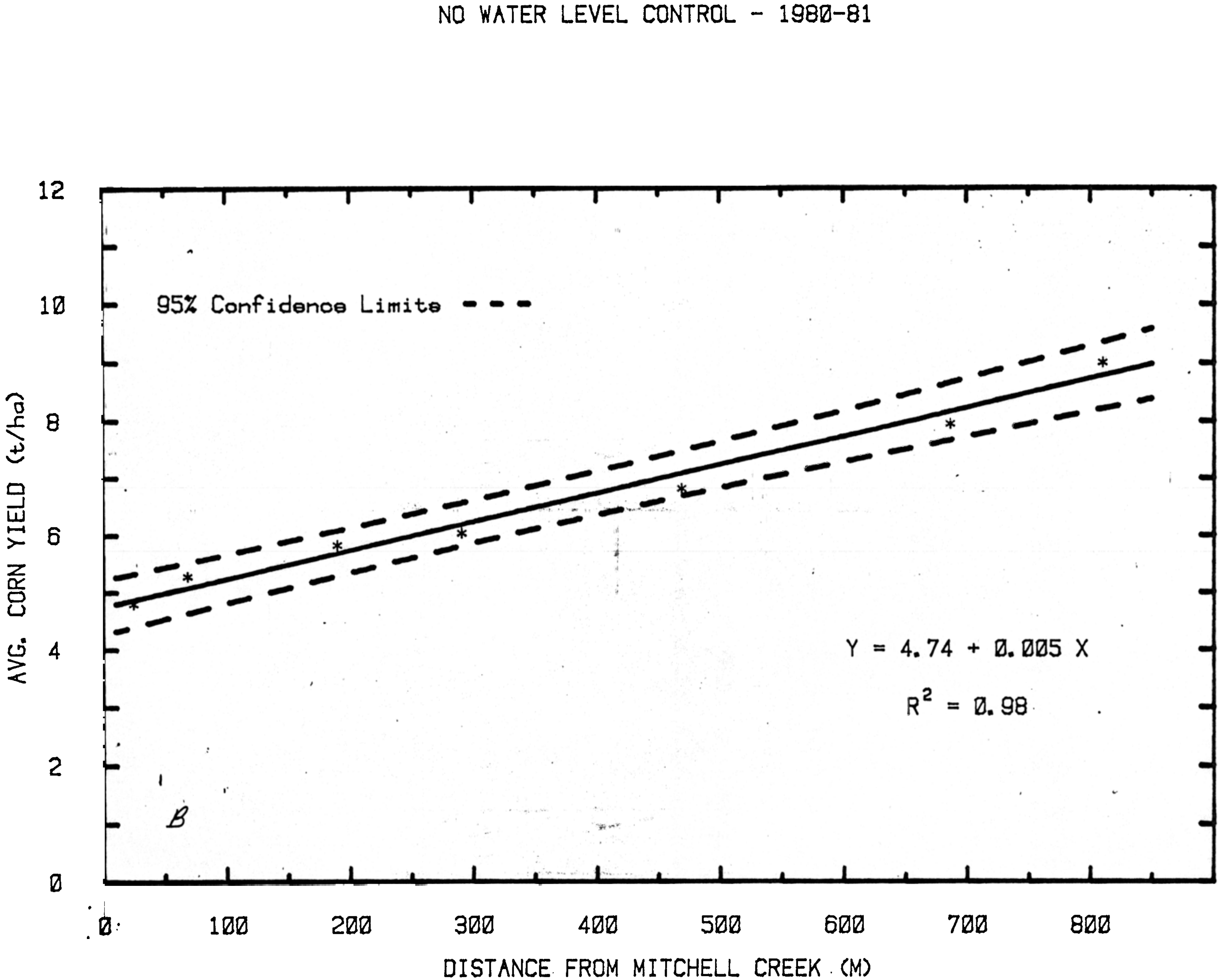

Fig. 6b. Relationship between average corn yield and distance from Mitchell Creek for crop years 1980 and 1981.

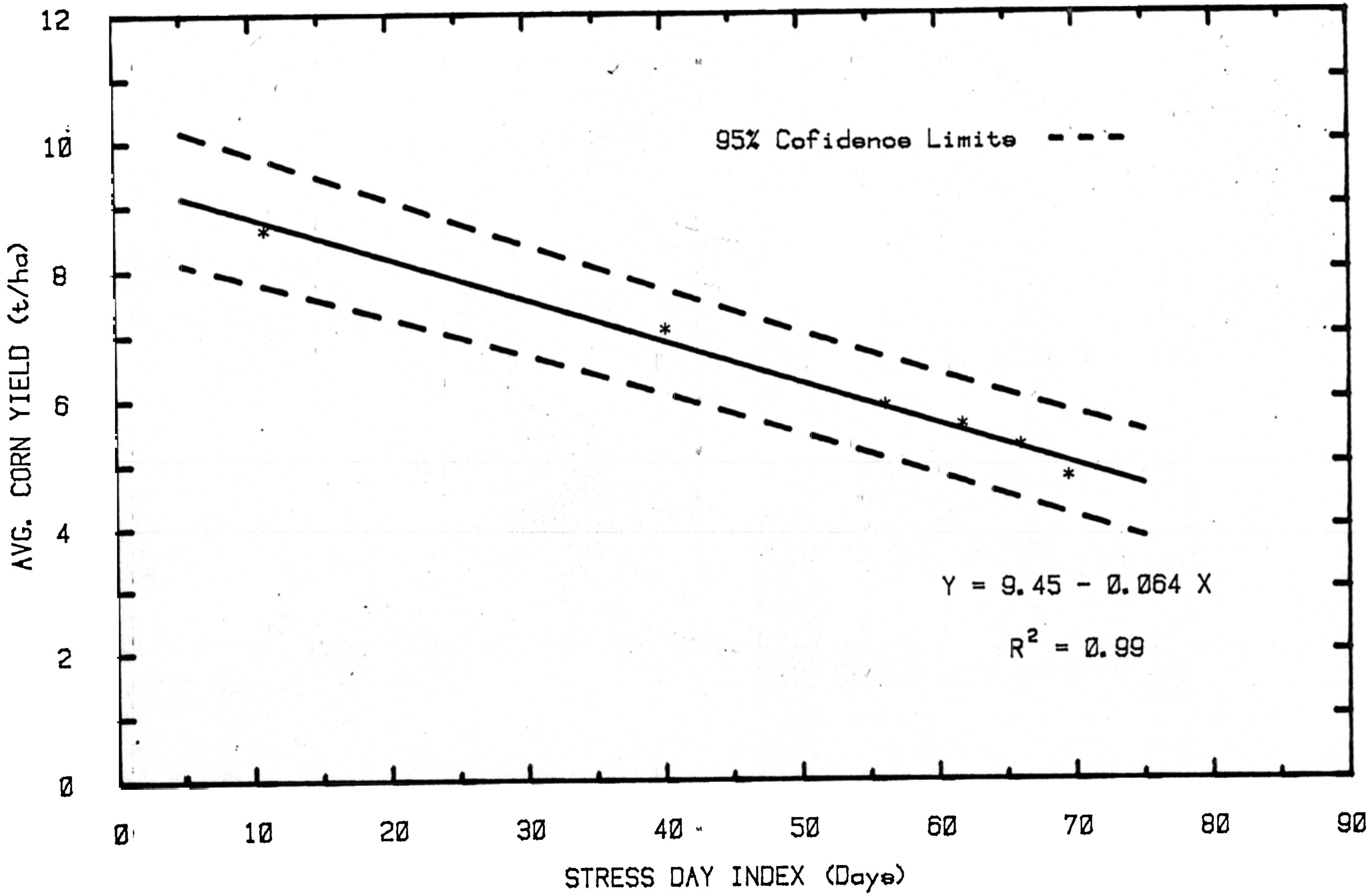

Fig. 7. Relationship of corn yield to stress day index for the 1980-81 growing seasons in sandy soils in the Mitchell Creek Watershed. The confidence limits are based on the full 17 data points, not the average 6 points shown.

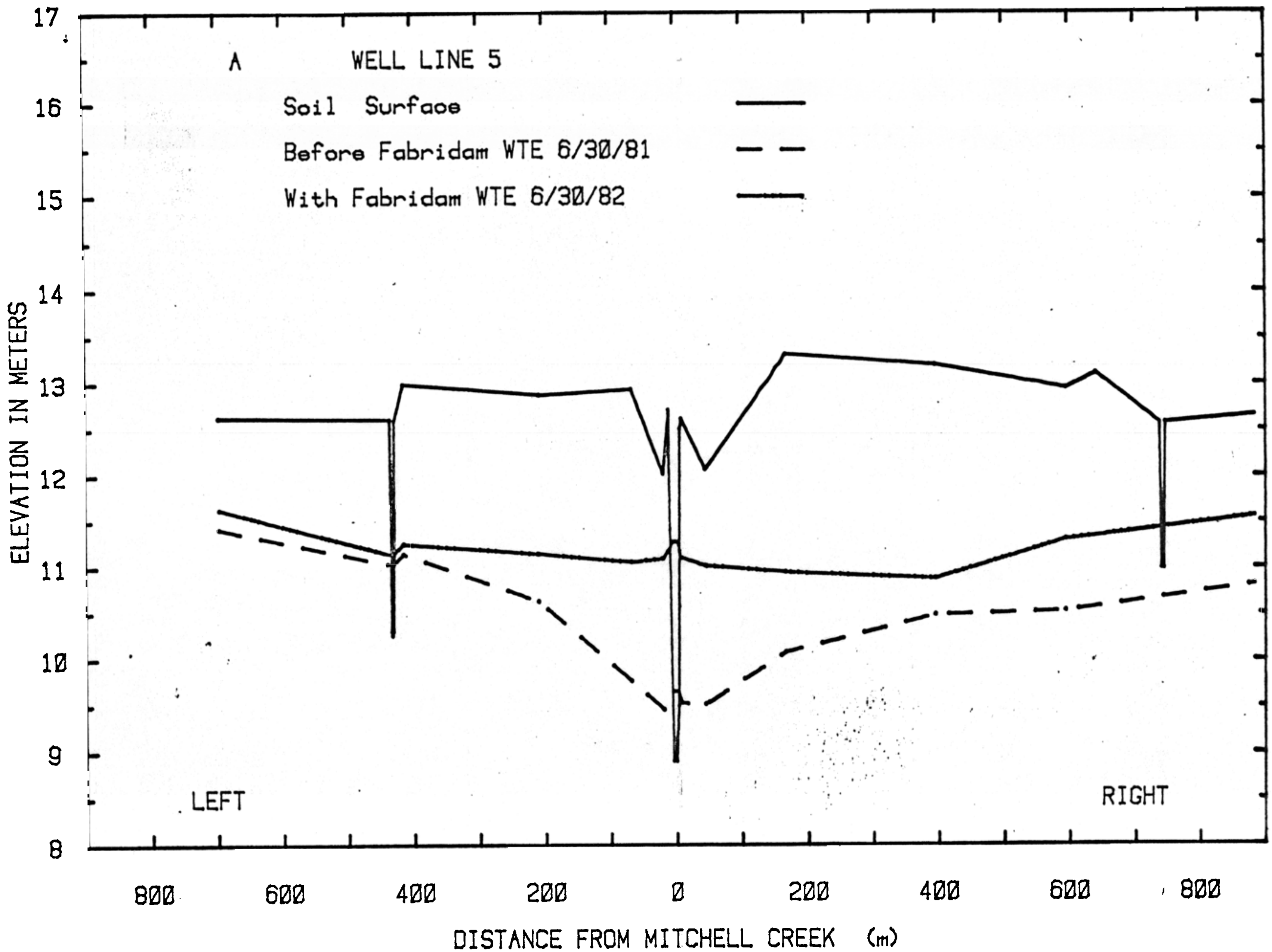

Fig. 8a. Water table above the Fabridam in relation to distance from Mitchell Creek for the high water use period for corn before the Fabridam, June 30, 1981, and after the Fabridam was installed to control the stream water level on June 30, 1982.

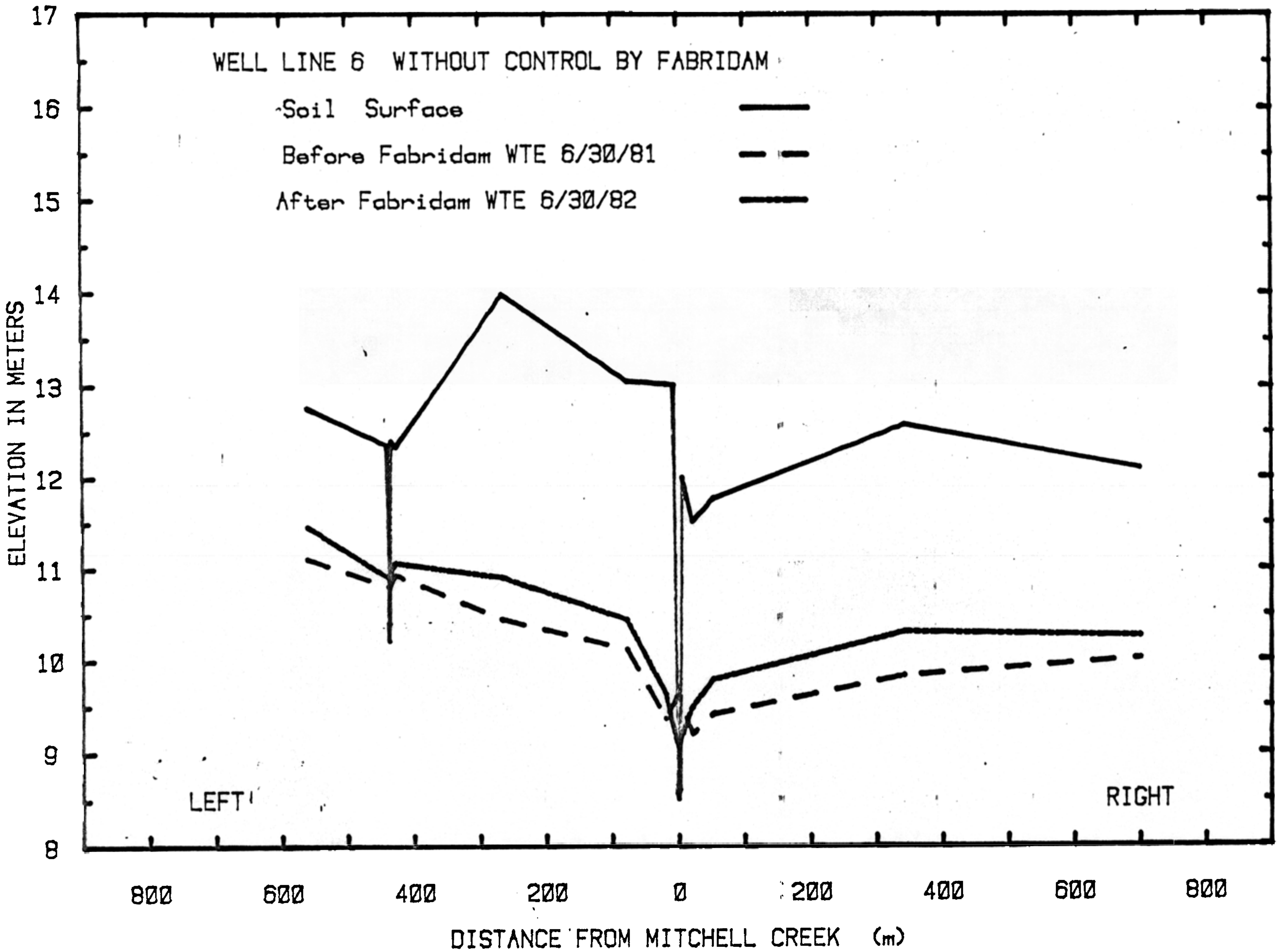

Fig. 8b. Water table below the Fabridam in relation to distance from Mitchell Creek for the high water use period for corn, June 30, 1981 and June 30, 1982.

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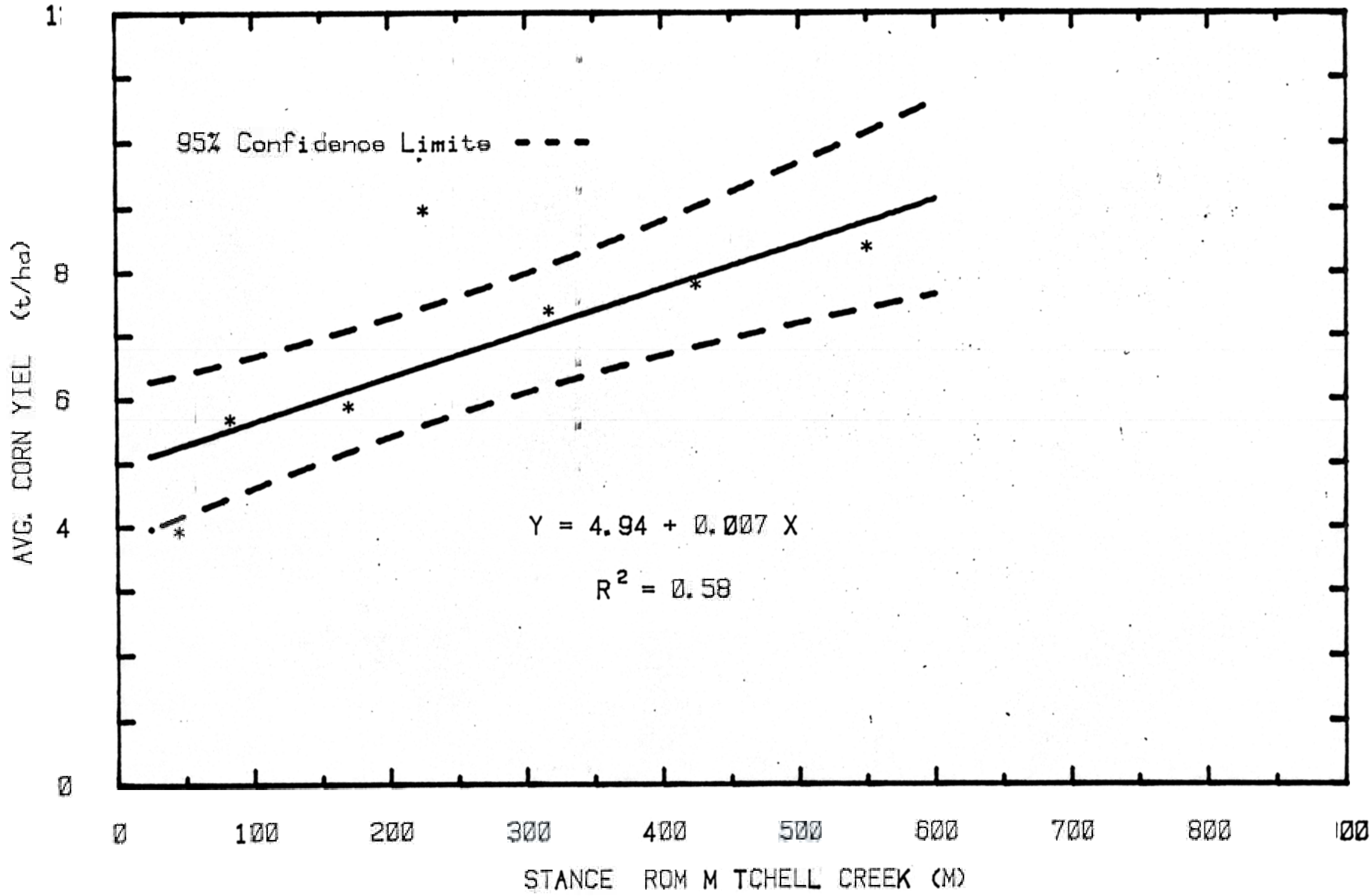

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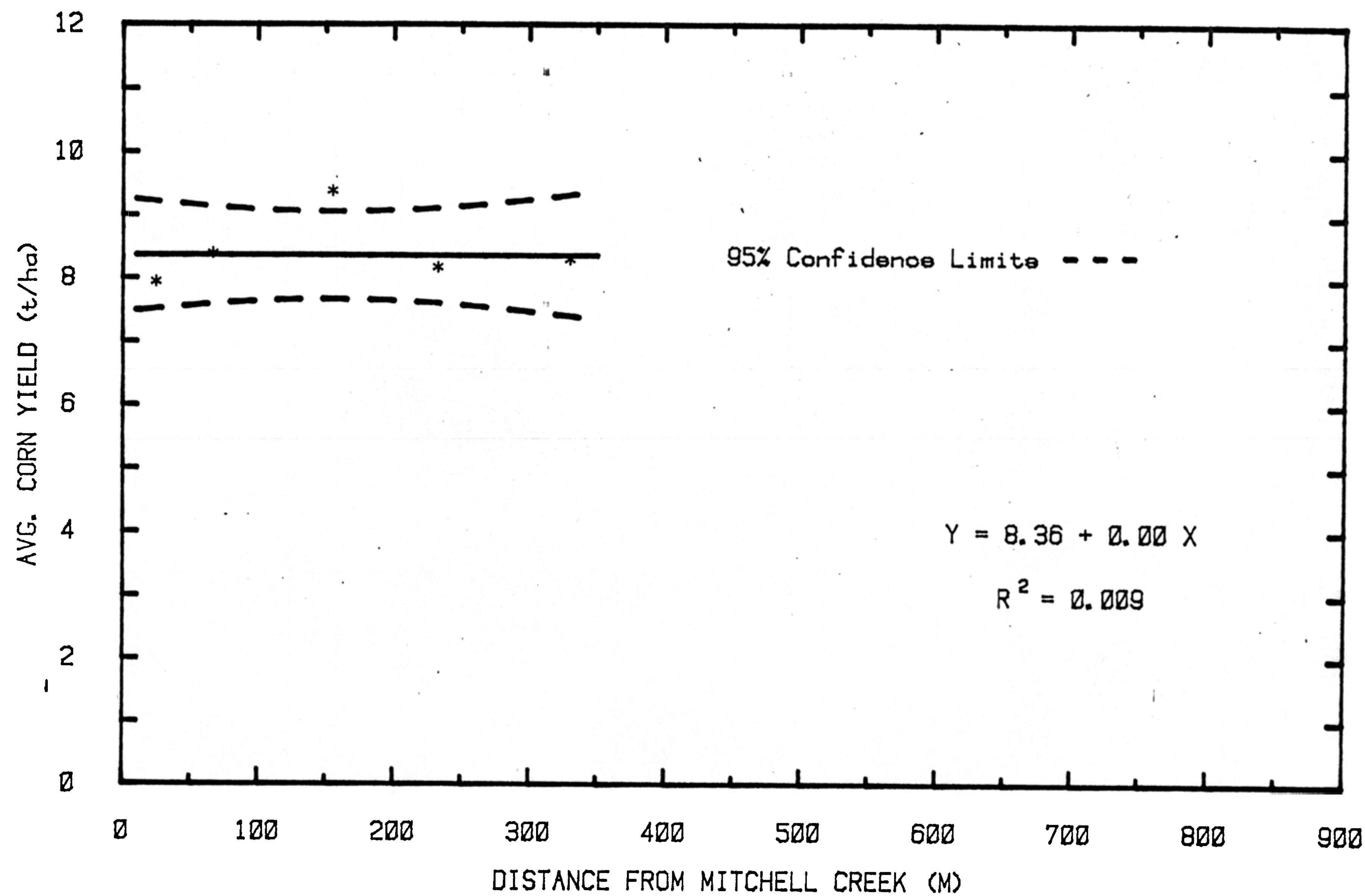

Fig. 9b. Relationship of average corn yield to distance from Mitchell Creek for the 1982 growing season, with water level control in the stream by the Fabridam.

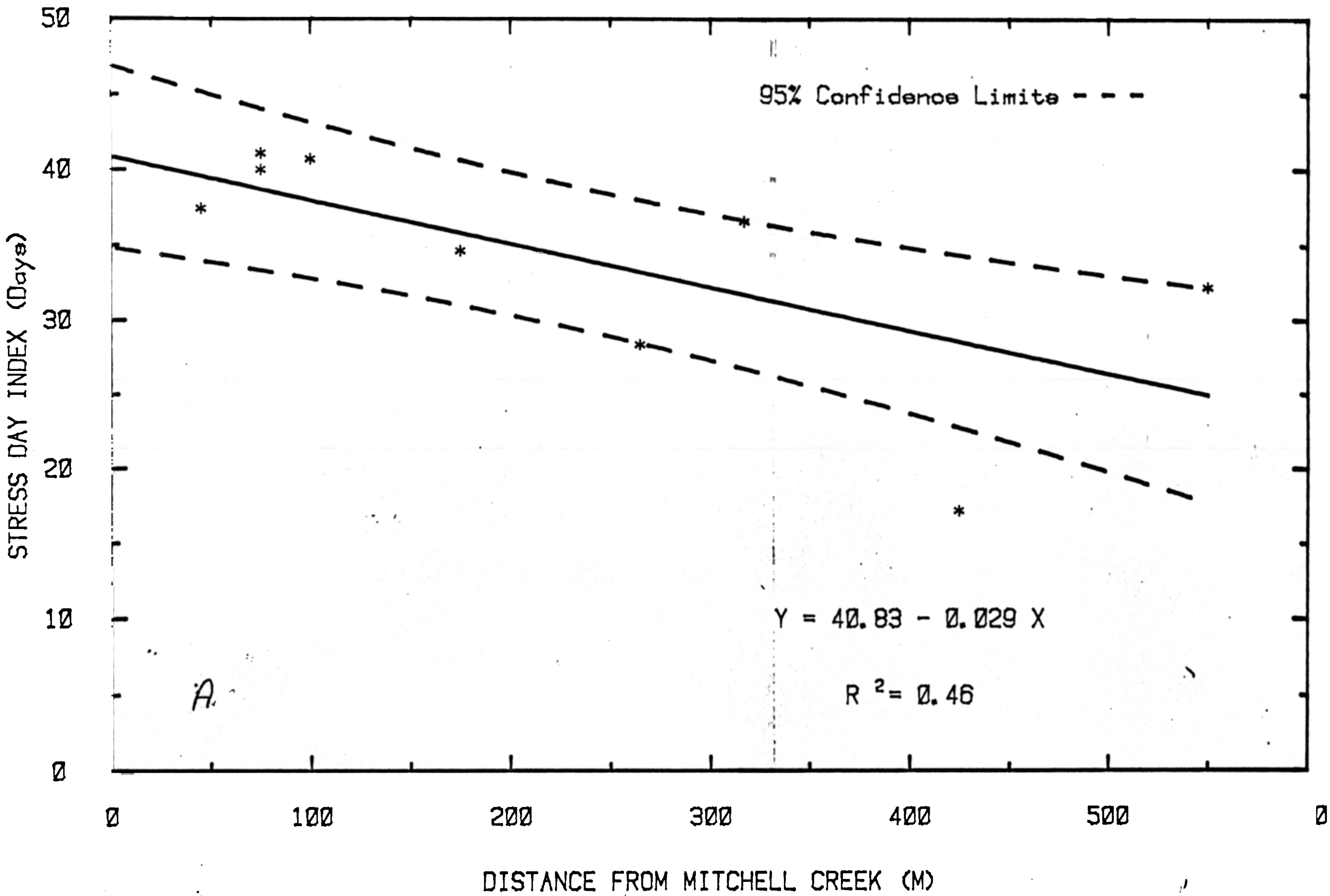

Fig. 10a. Relationship between average stress day index and distance from Mitchell Creek, with no water level control in the stream.

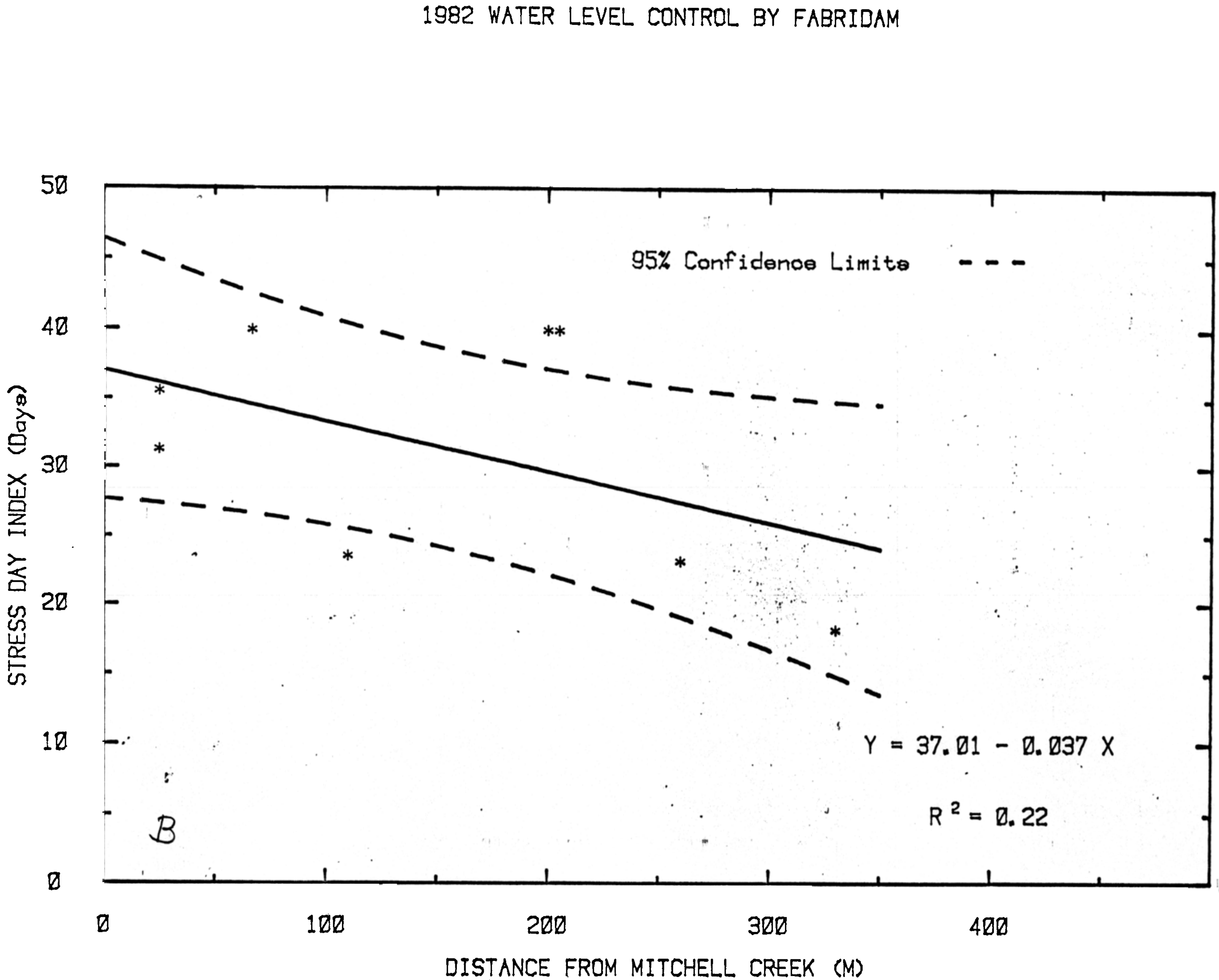

Fig. 10b. Relationship between average stress day index and distance from Mitchell Creek, with water level control in the stream by the Fabridam.

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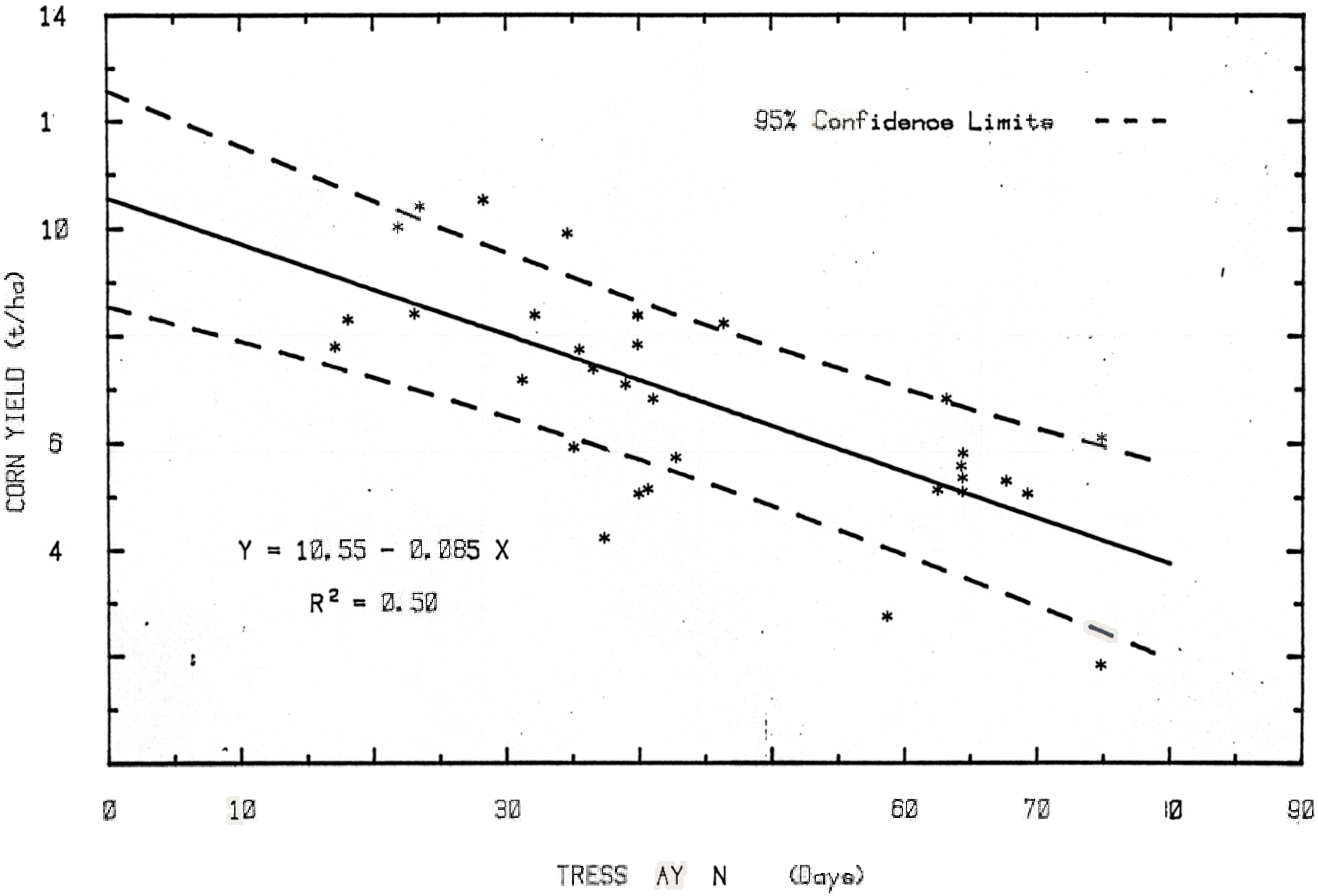

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