WIND SET-UP ON LAKE MANITOBA

A THESIS

Presented to

The Faculty of Engineering

The University of Manitoba

In Partial Fulfillment

of the Requirements for the Degree

Master of Science in Engineering

By

F. G. Alden Burrows

October, 1969

SYNOPSIS

An investigation was undertaken of the factors involved in determining the wind set-up and the amount of the resulting flow of water through the Lake Manitoba Narrows.

The study was carried out using Department of Transport weather records at several stations in the vicinity of the lake, Highway Department and Water Resource automatic water level records, and measured current data at the Narrows. The records and measurements were for the period September and October, 1966.

On the basis of the empirical relationships and theoretical analysis of the phenomena, a method of predicting the rise in water level and amount of flow through the Narrows, for different wind velocities is proposed.

ACKNOWLEDGEMENTS

The author wishes to acknowledge the active participation and financial support of the Manitoba Highways Department,without which the project could not have been carried out.

The work done on wind records by the Meteorolgical Branch of The Department of Transport, is also gratefully acknowledged.

The author desires to express his sincere gratitude to Professors E. Kuiper and R. Newbury for their valuable suggestions and advice.

A fellowship, received from the Canadian Good Roads Association, which was sponsored by Allied Chemical Canada, Ltd., was sincerely appreciated, and helped to make this study possible.

TABLE OF CONTENTS

LIST OF GRAPHS

LIST OF TABLES

LIST OF PLATES

LIST OF FIGURES

LIST OF SYMBOLS

A - the angle between the wind direction and tidal axis ($A = 0$ for the Lake Manitoba study).

F - the fetch in miles the distance from the windward still-water shore line to the point the set-up was measured.

H - wave height in feet.

MWL - the mean water level.

N - the planform factor which takes the converging or diverging planform of the body of water into consideration.

S - the difference in windward and leeward water-surface elevations in feet, when the bottom at the windward end is not exposed.

S' - the elevation of the MWL at the leeward shore above the horizontal bottom when the bottom at the windward end is exposed.

S_1 - set-up (difference in windward and leeward water surface elevations) due to the skin friction between wind and water surface.

S_2 - set-up (difference in windward and leeward water surface elevations) due to the form resistance of the waves.

U - the wind velocity in ft/sec.

U_o - the "formula characteristic velocity" in ft/sec. It is about 1.3 times the wind velocity necessary to start waves and was introduced by Keulegan.[6]

SWL - the still-water level

d - still-water depth in feet.

g - the acceleration of gravity ($32.17\ ft/sec^2$).

h - the wind set-up above SWL in ft. (the bottom at the windward shore not exposed).

h' - the wind set-up above SWLin ft. (the bottom at the windward shore is exposed).

u - wind velocity component in x-direction.

u_1 - velocity at the boundary in Boussinesq's equation.

u_s - the velocity at the water surface.

v - wind velocity component in y-direction.

w - wind velocity component in z-direction.

x - distance along x-axis.

y - distance along y-axis.

z - distance along z-axis.

z_s - distance from the bottom to MWL.

γ -- unit weight of water

λ - a coefficient depending upon the turbulence in flow.

μ - coefficient of dynamic viscosity.

ρ - density;of the fluid.

τ_b - shear stress on the bottom.

τ_s - shear stress on the water surface.

I. INTRODUCTION

GENERAL

This study was carried out to determine wind tide effects on Lake Manitoba, to be more specific, wind tide effects at Lake Manitoba Narrows.

DESCRIPTION OF LAKE MANITOBA

Lake Manitoba is a vast shallow lake and is one of the remnants of glacial Lake Agassiz, which at one time covered practically all of the Province of Manitoba. (Figure 1)

The lake is approximately 110 miles long and is effectively divided into two drainage basins by "The Narrows". The North basin is approximately forty-seven miles long and the south, sixty-three miles long. The width of the lake varies from about one-half mile wide at the Narrows to about twenty-eight miles wide at its widest point. The lake is relatively shallow, being an average of fifteen feet deep in the North Basin and eighteen feet deep in the South.

The Narrows itself is approximately twenty miles long and varies from one-half mile to approximately five miles wide..

Lake Manitoba, with a surface area of 1817 sq. miles is the twelfth largest lake in North America and the twenty-fifth largest fresh water lake in the world, in terms of surface area. For comparison, it should be noted that Lake Superior is the largest fresh water lake in the world, with a surface area of 31,820 sq. miles.[1/]

SITE PLAN

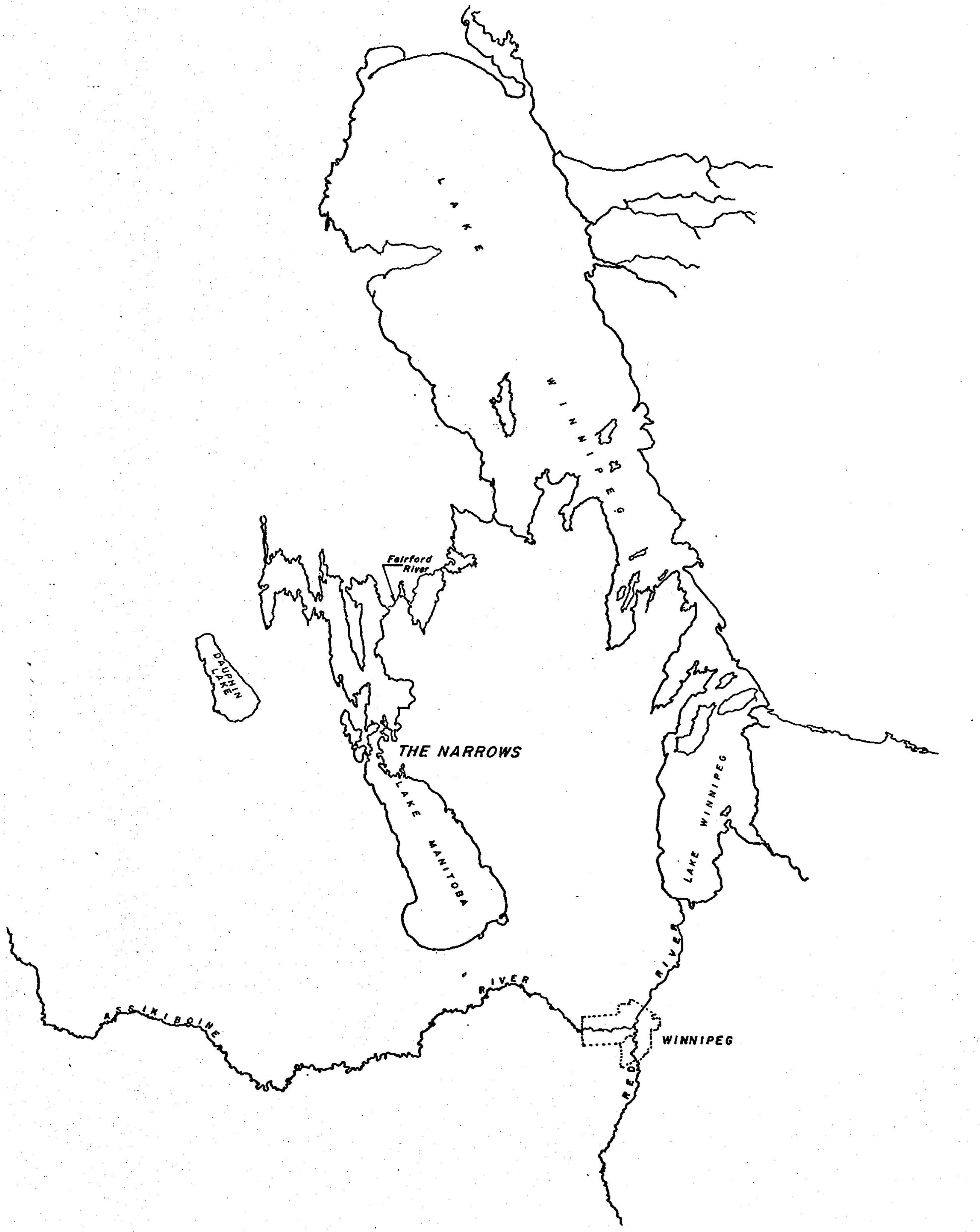


FIG. 1

Lake Manitoba receives the waters from Lake Winnipegosis and a few minor tributaries, and has a total drainage area of 31,000 sq. miles. The outflow river from Lake Manitoba to Lake Winnipeg is called the Fairford River, which has a mean flow of about 2,000 cfs. 2/

The land adjacent to Lake Manitoba is very flat, and to the west and east, is underlain by limestone and has a relatively thin coverage of glacial till. Although the large part of this area is covered by forest and swamp, the greater part is now being used for grazing and mixed farming, supporting a rather sparse population of only a few persons per square mile.

The area south of Lake Winnipeg is covered with rich lacustrine and alluvial depositions and is being used extensively for grain farming.

The lake area comprises cosmopolitan settlements of many ethnic groups. Most of the population is now engaged in farming, fishing or supporting trades.

WATER LEVELS

The fluctuations of levels on Lake Manitoba consists of three types. The first is a long term fluctuation caused by alternate wet and dry periods extending over several years time. The second type is seasonal, caused by spring runoff from the tributary streams, followed by the low runoff during summer and winter. These first two types of fluctuations are now controlled between elev. 811.5-813.5 by river control works on the Fairford River, (completed 1963). The third type of fluctuation is caused by wind setup. This type may attain a height of several feet and extend over five to ten days. The highest recorded wind set-up on Lake Manitoba (at Delta) was 3.4 feet above mean lake level.

Before control of the Lake Level, during periods of extremely high lake levels, thousands of acres of agricultural lands were flooded, sometimes for years at a time. The high lake levels were aggravated further for short periods by wind set-ups. Estimated flooded areas and agricultural losses 1954-56 were 155,000 acres - $1,600,000. 2 /

LAKE MANITOBA NARROWS

In 1963, the Manitoba Hydro built a rock causeway partially across the Narrows, adjacent to the existing Ferry crossing. The causeway was built out from both the west and east shores, leaving a central 1600 ft. long opening, and is used to support Hydro towers for the Grand Rapids Hydro Development.

The Highways Department plans to replace the ferry with a roadway, at the ferry location. This roadway could consist of a 1600 ft. long bridge, thus equalling the existing waterway opening or it could consist of a rock fill completely blocking the Narrows, or it could be a partial rock fill in combination with a bridge. The highway would be located between gauges 2 and 7, see figure 2.

PURPOSE OF STUDY

The purpose of the investigation was to determine a wind set-up equation for each end of the Narrows and an equation for water flow through the Narrows, as a result of the set-up. This information is needed for backwater calculations through the Narrows to ascertain the local effects resulting from further reducing the waterway area at the proposed bridge site.

The fundamental problem deals with the wind set-up on two bodies of water (the north and south basins), connected by essentually an open channel (the Narrows).

Set-up occurs in one basin, while simultaneously set-down occurs at the adjacent end of the next basin and at the same time, both basins are altered by the resulting water flow from one basin into the other, through the Narrows.

The accumulation of field data was analyzed to determine the main governing factors in the phenomena. Incidental information had to be neglected, or eliminated, in order to arrive at basic conclusions. Only certain water level gauges were used in the analysis in order to simplify the study. These gauges were numbers 1,3,4,8, & 10, see figure 2. Other gauges were affected by small bays and inlets.

PREVIOUS INVESTIGATORS

Wind set-up effects have been noted for some time. An interesting historical note of set-up on Lake Geneva is pointed out by Picot 3 /. The event occurred in 1495 and is described in the following words:

" Le 9 janvier, disent-ils, it y eut un vent tel que le Rhone remonta dans le lac jusqu'a un quart de lieue au-dessus de Geneve, et il semgloit etre une montagne d'eau, ce qui dura l'espace d'une heure que l'eau ne put descendre. (On January 9th, 1495, such a strong wind blew that the Rhone withdrew into the lake as far as a quarter of a league above Geneva, and there seemed to be a mountain of water for a whole hour during which the water could not descend)."

Wind tide studies have been treated by many investigators, some of whom are listed below:

Hellstrom (1941)

Langhaar (1951)

Keulegan (1952)

U. S. Corps of Engineers (1955)

Sibul (1957)

Einarsson and Lowe (1966)

In all cases however, the studies dealt with flumes, lakes or bodies of water vastly different to the problem dealt with in this study.

LAKE MANITOBA

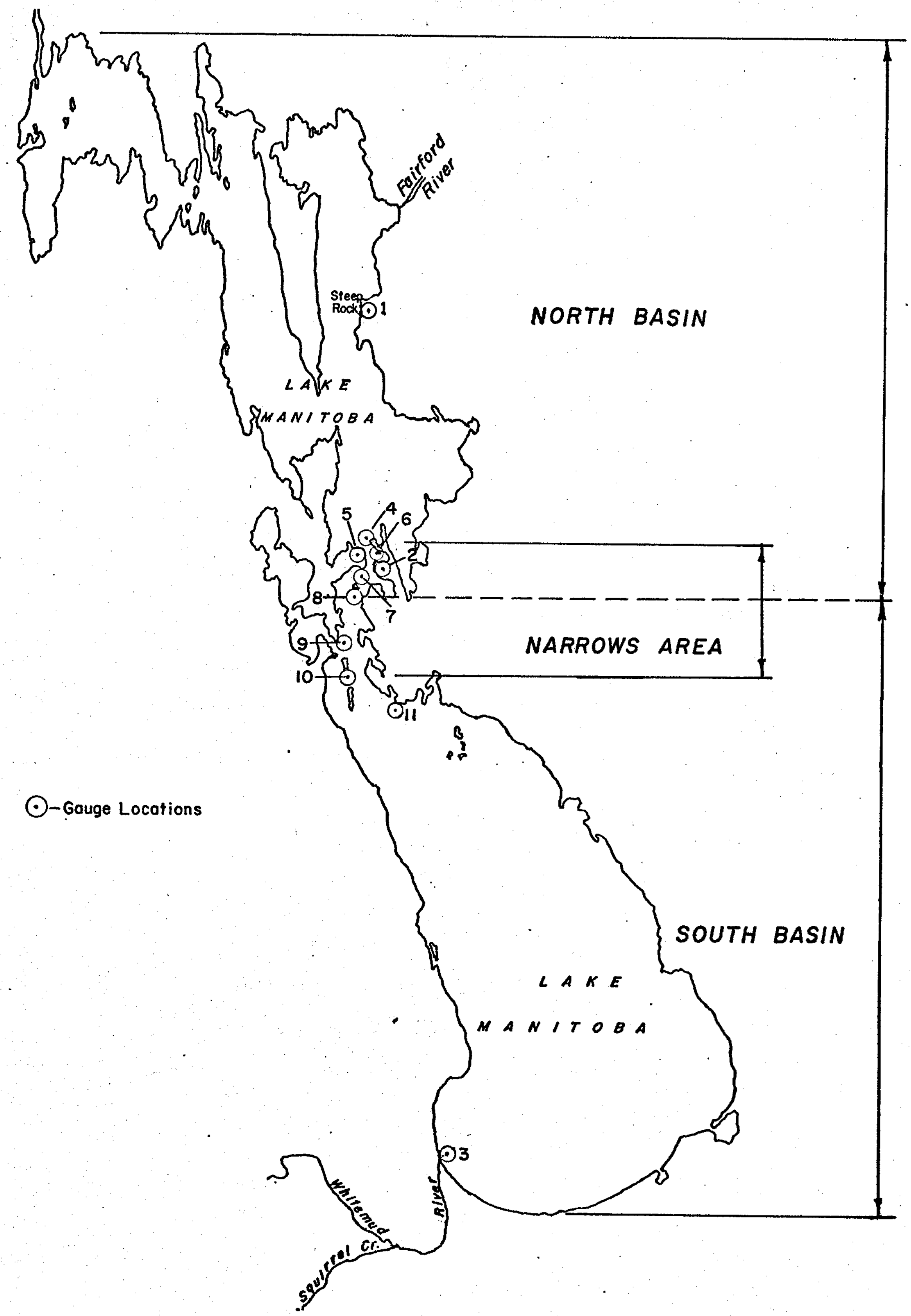


FIG. 2

II. THORETICAL WIND SETUP ANALYSIS

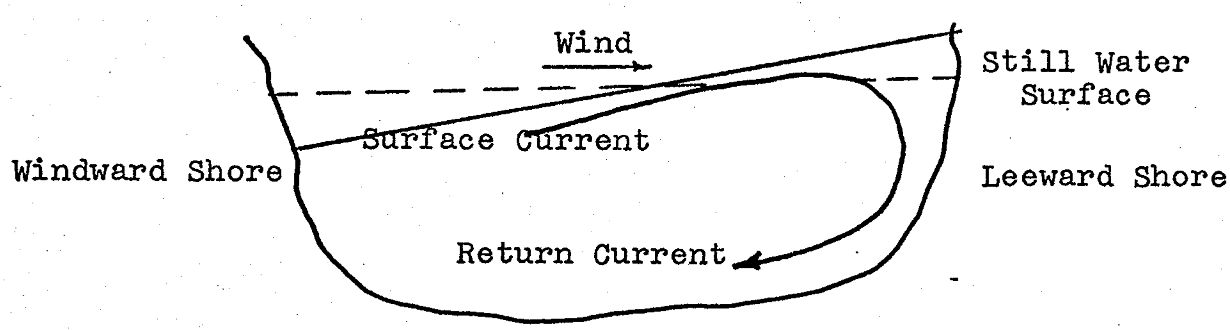
GENERAL

When the wind blows over a water surface it exerts a horizontal stress on the water, creating a surface current, driving it in the direction of the wind. This wind effect results in a "piling up" of the water at the leeward end of an enclosed body of water, and lowering of the water level at the windward end. This effect is called wind tide, which is the cumulative effect of wind force and water reaction throughout the entire body of water.

The result of raising the water level at one end and lowering at the other creates a pressure head which generates and sustains a return current in the opposite direction to that occuring due to the wind stress, see Figure 3.

In deep lakes and reservoirs, this current usually returns along the bottom, however internal currents can occur due to thermal stratification in the lake.

Return currents in shallow bodies of water may be different again, in that return currents may occur as surface currents along the edge of the lake or in the lee of islands or be otherwise altered by physical obstructions.



WIND SET-UP
Figure 3

CLASSIFICATION OF WIND TIDES

Wind tides may be classified into (1) static and (2) dynamic tides. The total height of the static tide is the sum of the set-up and set-down at opposite ends of the lake, although some literature treats it as the difference in elevation between still water level and that of the water level at the ends of the lake.

Dynamic tides, or seiches, occur when the momentum of the water carries it beyond the position of static equilibrium, and tidal oscillations result. The occurence of seiches appears to be a function of depth, length of the body of water and bottom characteristics. The hydrodynamics of seiches have been investigated theoretically by Hellstrom 4 /, Langhaar 5 /, and others.

Owing to the slight friction losses of oscillatory motion in deep water, seiches generally become well developed in deep lakes. On the other hand, the static effect becomes more pronounced or dominant in shallow lakes where the cross-section of the current is small, and the flow consequently encounters great resistance which can only be overcome by a comparatively large difference in water surface elevation.

Seiches in a lake can generally be recognized by an examination of water level recordings at the ends of the lake. The seiche is characterized by rises in water level at constant time periods. For Lake Okeechobee, the complete period of the fundamental seiche has been found to be 6 hours or longer 6 /

For the Lake Manitoba study, seiches were not considered to be worth while evaluating because of the extreme shallow depth and length of the lake. Analyses of wind tide presented in this report pertains solely to static tides. Although the measured and projected set-ups include both statical and dynamic tides, the dynamic effect is assumed to be practically zero. Einarsson and Lowe [7] showed that, for Lake Winnipeg, longer and deeper than Lake Manitoba, the effect of seiches on wind tide, was negligible.

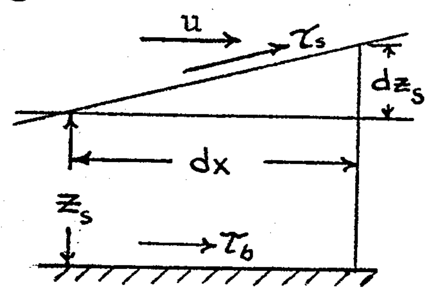
WIND TIDE THEORY

The analysis of wind tide data involves numerous variables which include the wind velocity and the energy transfer between the air and water, which in turn depends on the wave conditions, temperature gradients, stability and other properties of both the air and water. The depth and the geometric shape of the body of water and the roughness and configuration of the bottom are also important. In very large bodies of water the rotation of the earth, and the attraction of the sun and the moon may also be important. However, these forces were neglected in this study.

To solve the problem theoretically, several simplifying assumptions must be made which include the flow conditions and viscosity at or near the air-water boundary, in order to solve the problem.

Several investigators have studied this problem using different approaches and assumptions [4,5,6,8,9].

Consider the simple two-dimensional condition represented in the following sketch.



WIND SET-UP ANALYSIS
Figure 4

For steady conditions, the force equation for unit width perpendicular to the sketch is:

$$\frac{\gamma}{2}\left\{ (z_s + dz_s)^2 - z_s^2 \right\} = (\tau_s + \tau_b)\, dx \qquad (1)$$

Disregarding terms of order higher than the first of dx and dx_s the differential equation of the water surface is

$$\frac{dz_s}{dx} = \frac{(\tau_s + \tau_b)}{\gamma z_s} \qquad (2)$$

Keulegan 9/ has chosen to express the bottom shear τ_b, as a function of the surface shear, τ_s, by the relation

$$\tau_b = \tau_s(\lambda - 1) \qquad (3)$$

Substitution of equation 3 in equation 2 gives

$$\frac{dz_s}{dx} = \lambda \frac{\tau_s}{\gamma z_s} \qquad (4)$$

Equation 4 is the form used by most investigators in studies of wind tides;.The value of λ used in the integration of this equation depends on the particular flow theory that is adopted.

This differential equation was arrived at by Hellstrom 4/ in 1941, in a very comprehensive theoretical treatment whereby he derived the equation using the basic Euler-Navier equation for the three - dimensional motion of a viscous, incompressible fluid,

$$\rho\left(\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}+w\frac{\partial u}{\partial z}\right)=\rho X-\frac{\partial p}{\partial x}+\mu\left(\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 u}{\partial y^2}+\frac{\partial^2 u}{\partial z^2}\right)$$
$$\rho\left(\frac{\partial v}{\partial t}+u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}+w\frac{\partial v}{\partial z}\right)=\rho Y-\frac{\partial p}{\partial y}+\mu\left(\frac{\partial^2 v}{\partial x^2}+\frac{\partial^2 v}{\partial y^2}+\frac{\partial^2 v}{\partial z^2}\right) \quad (5)$$
$$\rho\left(\frac{\partial w}{\partial t}+u\frac{\partial w}{\partial x}+v\frac{\partial w}{\partial y}+w\frac{\partial w}{\partial z}\right)=\rho Z-\frac{\partial p}{\partial z}+\mu\left(\frac{\partial^2 w}{\partial x^2}+\frac{\partial^2 w}{\partial y^2}+\frac{\partial^2 w}{\partial z^2}\right)$$
$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}+\frac{\partial w}{\partial z}=0$$

Here u, v, and w are the velocity components, parallel to the co-ordinate axis x, y, and z at the time t; ρ is the density of fluid; p is the pressure; μ the coefficient of viscosity; and X, Y, and Z are the components of Coriolis forces due to the earths rotation and gravity. Coriolis forces act at right angles to the direction of velocity, toward the right in the Northern and toward the left in the Southern Hemispheres. Hellstrom found $\lambda = 3/2$ for laminar flow and $\lambda = 1$ for turbulent flow conditions.

To solve the equation, Hellstrom made the following assumptions:

(a) the flow is laminar,

(b) the depth is constant and small,

(c) the water surface slope is small,

(d) the pressure distribution is hydrostatic,

(e) the wind velocity and direction is constant,

(f) all motion is steady and equilibrium is established.

Solving this equation; the following expressions for the velocities "u" and "v" were obtained:

$$u=\frac{\gamma}{\mu}\frac{\partial z_s}{\partial x}\left(\frac{z^2}{2}-z_s z\right)+\frac{\tau_s z}{\mu} \quad (6)$$

$$v=\frac{\gamma}{\mu}\frac{\partial z_s}{\partial y}\left(\frac{z^2}{2}-z_s z\right) \quad (7)$$

For incompressible fluids:

$$\int_0^{z_s} u\, dz = 0 \quad \text{and} \quad \int_0^{z_s} v\, dz = 0 \tag{8}$$

hence

$$\frac{\partial z_s}{\partial x} - \frac{3}{2}\frac{\tau_s}{\gamma z_s} = 0 \quad \text{and} \quad \frac{\partial z_s}{\partial y} = 0 \tag{9}$$

or, as z_s is dependent on x only,

$$\frac{\partial z_s}{\partial x} = \lambda \frac{\tau_s}{\gamma z_s} \tag{10}$$

The equation demonstrates that for lakes of shallow depth, the rotation of the earth has an insignificant effect on results. This is also demonstrated by the fact that Keulegan 9/ arrived at the same results, although he neglected the effect of Coriolis force in the original equation. According to Ekman 10/ rotation of the earth will reduce the gradient of water surface in the ratio of 0.98 when the depth is 150 to 300 feet; in the ratio of 0.77 when the depth is 400 to 750 feet; and by 0.66 when the depth is infinite. It can easily be seen that the effect on Lake Manitoba, with an avarage depth of 15-18 feet, would be negligible.

APPLICATIONS OF THE THEORY

The application of the differential equation

$$\frac{dz_s}{dx} = \frac{\lambda \tau_s}{\gamma z_s} \tag{4}$$

has various forms, as is illustrated by a summary of results by the more prominent investigators, in Appendix A.

III. FIELD INVESTIGATION

GENERAL

A series of instruments were set up at Lake Manitoba Narrows in the fall of 1966, to determine the relationship between wind velocity and duration, and wind set-up at the Narrows, and the effect caused bythe resulting flow of water from one basin into the other. The information obtained was used to determine wind set-up relationships for two situations, namely;

(a) to determine the relationship under existing conditions.

(b) to determine what water level changes would occur upon construction of a causeway across the Narrows with various waterway area restrictions.

The measuring apparatus was set up during the fall of 1966, however, accurate measurements were only obtained for the month of October. This information is tabulated in the Appendices. The measuring apparatus is described in this chapter.

WIND RECORDS

A wind anenometer was set up adjacent to Gage 2, see Fig. 2, on the East ferry landing, from August to November, 1966. Unfortunately, the instrument was not serviceable for a very long duration and few records were obtained,however these were compared to longer records in the area.

Wind records, from wind measuring stations, were examined at Winnipeg, Gimli and the outlet of the Red River into Lake Winnipeg, as well as Dauphin and Portage la Prairie. It was determined, by comparison with the short record at the Narrows, that generally, Dauphin winds were indicutive of North winds and Portage la Prairie of South winds. These hourly records, then were used to establish all the wind set-up relationships and were assumed to act over the entire lake. Also it was assumed that over water and over land wind velocities, in this case, were similar.

CURRENT MEASUREMENTS

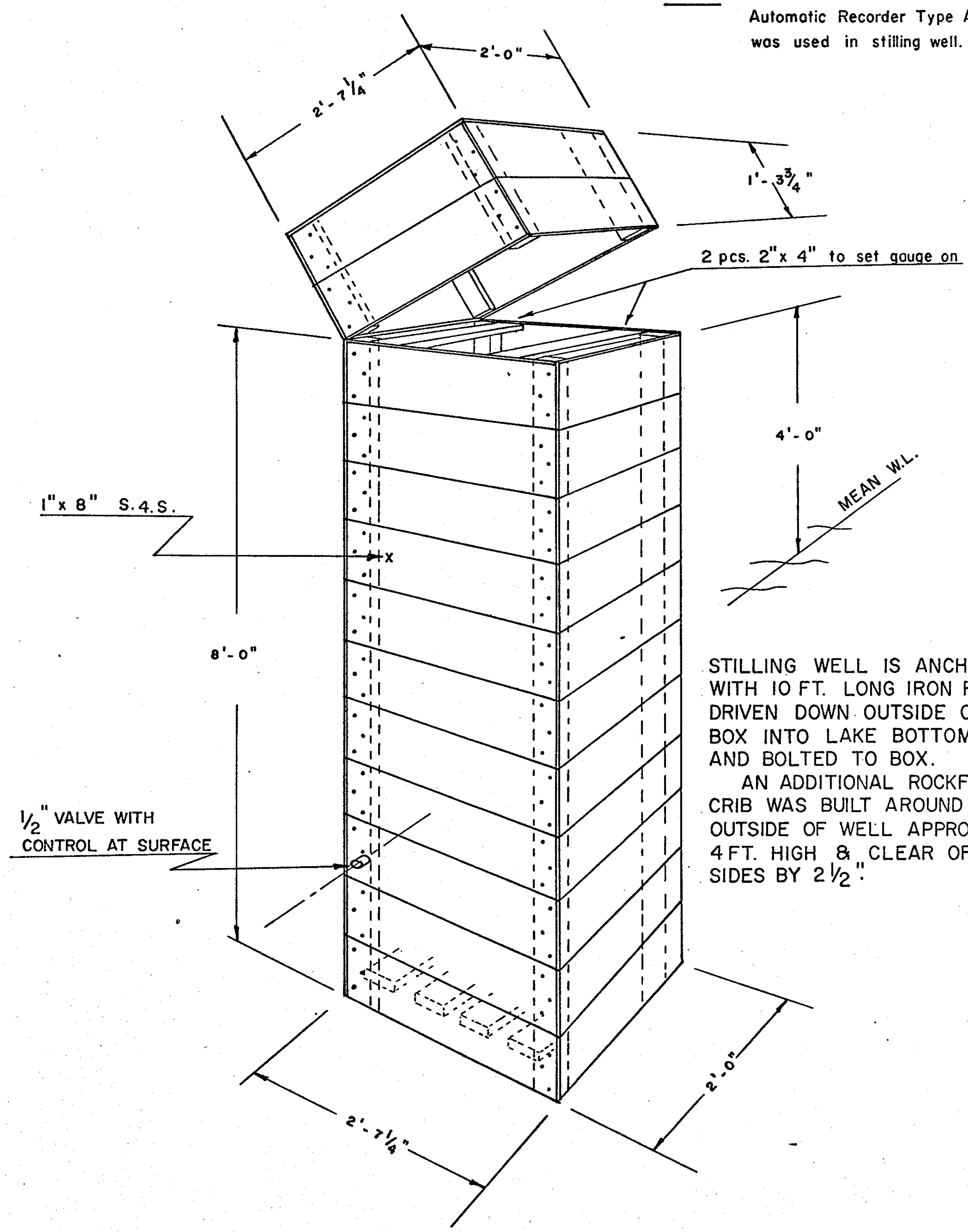
Current measurements were obtained in the area of the Hydro crossing 22 times during September and October 1966 and also 12 times in the months of February and March 1967. The measurements were taken with a Price current meter from a boat anchored on a steel line spanning between the Hydro towers, at specific stations along the line, during September and October, see Plate 3. During February and March, current measurements were taken on the same cross section, through the ice.

WATER LEVEL GAGES

Eight Stevens A-35 automatic water level recorders were installed by the Highways Department, during the fall of 1966, in positions marked 4 to 11 inclusive, see Figure 6 and Plates 5 and 6. Originally they were installed in August, however because of water surging in the boxes, difficulty was experienced with the needle, which tore the chart paper and smeared the ink. Pencil was then used, but had to be sharpened regularly. Additionally, several of the boxes upset during storms on the lake and had to be reset and further stabilized. Consequently, no decent records were obtained until the beginning of October. The records ended on October 30th, with freeze-up. However, good records were obtained in October with some severe winds.

STILLING WELL

NOTE: Stevens Water Level Automatic Recorder Type A 35 was used in stilling well.



STILLING WELL IS ANCHORED WITH 10 FT. LONG IRON RODS DRIVEN DOWN OUTSIDE OF BOX INTO LAKE BOTTOM AND BOLTED TO BOX.

AN ADDITIONAL ROCKFILL CRIB WAS BUILT AROUND OUTSIDE OF WELL APPROX. 4 FT. HIGH & CLEAR OF ALL SIDES BY 2½".

FIG. 5

The records from three permenent Stevens A-35 instruments belonging to the Federal Water Resources, at locations 1,2 and 3, see Figure 2, were also used to establish the wind set-up relationships.

CROSS-SECTIONS

Approximately 18 cross-sections, over the length of the Narrows, a distance of approximately 20 miles, were taken by Highways Department crews during the winter of 1967. The work was done by means of survey crews working with snow vehicles on the ice, see Plates 7 and 8. The cross-sections were taken to see if any waterway area restrictions, besides that of the Hydro causeway, affects the flow through the Narrows, and were used for the backwater calculations through the Narrows. It was found that the Hydro causeway was by far the largest restriction in the Narrows area. These cross-sections are on file with the Manitoba Highways Department.

Additionally, the survey crews established the datum elevations for all the Highway Department water level gagges.

HORIZONTAL CONTROL

Aerial photos of the Narrows area were taken by a commercial firm hired by the Highways Department, in October 1966. These photos were used to establish the location of all the Highway Department water level gauges. They will also be used as reference should any claims be filed for flood damages caused by construction of the Highway causeway.

The aerial photos and mosaic are on file with the Manitoba Highways Department.

IV. DISCUSSION OF RESULTS

GENERAL

The period of record for the instruments described in Chapter III was fairly short, however, the author was able to establish certain wind velocity and resulting wind set-up relationships as described in this Chapter.

WIND

Weather stations, located at Department of Transport Airports, at Dauphin and at Portage la Prairie, were used for North and South Winds respectively, as was mentioned in the previous chapter.

Graphs I to 18 show the hourly wind velocities for days in October, when there were significant winds and also include the water levels for Gauges 4, 8, and 10, (see Figure 2.). These particular graphs are representative and show the wind effects on the main recorders used in this study.

Graphs 32 to 43 show how the hourly winds affect wind set-up, basin storage and outflow through the Narrows. These relationships will be described in later sections of this chapter.

It should be noted that the wind velocities shown are the components in the direction of the longest fetch, namely 157° for southwinds and 0° for north winds.

McKay's [15], "Design Winds for Reservoirs in Southern Manitoba"was used to calculate wind velocity return periods and to determine the reduction factor for 6 hours duration winds, as shown in Table I which was 0.9 times the one hour wind velocity.

The maximum set-up generally occured in 12 to 14 hours of continuous wind, therefore, the 6 hour duration was considered conservative.

FLOW THROUGH THE NARROWS

During the Fall of 1966 twelve significant current measurements were made at the Hydro Causeway, six being generated by North winds and six by South winds, (see Plate 3).

The water level records were examined to ascertain which basin elevation gauges should be used to correlate to the measured flow through the Narrows. It was found that Δh_1 (Gauge 10 minus Gauge 4) should be used for South winds, see Graph 44, and that Δh_2 (Gauge 4 minus Gauge 10) should be used for North winds, (see Graph 45).

The relationships obtained from these curves and shown on Graphs 46 and 47 are as follows:

South Winds

$$Outflow_1 = 46{,}600 \ \Delta h_1^{\frac{1}{2}} \qquad (29)$$

North Winds

$$Outflow_2 = 40{,}000 \ \Delta h_2^{\frac{1}{2}} \qquad (30)$$

where,

$Outflow_1$ = Flow, from the South basin into the North basin, through the Narrows, caused by a South Wind, in c.f.s.

$Outflow_2$ = Flow, from the North basin into the South basin, through the Narrows, caused by a North Wind, in c.f.s.

WATER LEVEL GAUGES

The hourly water levels for the various gauges are shown in Appendix B. The records missing are due to damaged recorders, as mentioned in Chapter III.

The lake profile for the various time periods are shown on Graphs 19 to 31. The Graphs are shown only when signifigant winds occured and only during the month of October, as certain of the important Gauges were not operative prior to October 3rd.

An examination of all the Gauges indicated that the profile of the lake was very uneven, this being caused by certain physical features, such as the presence of large bays and inlets where water could be stored, and possible discrepancies in Datum elevation. Consequently, the author decided to use Gauges 1, 3, 4, 8, and 10 for the lake profiles, see Figure 2.

No gauges were available for the ends of the lake, consequently, straight line water profiles were assumed and the end of Lake elevations were interpolated as shown on Graphs 19 to 31.

It should be noted that Graphs 19, 21, 23, 25, 26, 28, and 31, exhibit classical water surface profiles showing the set-up in each basin for North winds and similarly Graphs 24, 27, and 30 do so for South Winds.

Graph 48 was prepared showing storage in the North half of the South basin for set-up due to South winds and Graph 49 for storage in the south half of the North basin for set-up due to North winds.These graphs were prepared with the assumption that the Nodal point was located at the center of gavity of each basin and, conservatively, that there was no appreciable gain in surface area with increases in lake level.

An examination of the water level gauges indicated that Gauge 8 should be used as the apex for storage in the south basin, due to South winds, and Guage 4 for storage in the north basin, due to North winds.

Appendix C was prepared from the storage and outflow graphs, 46, 47, 48, and 49. For each of the time periods shown in Appendix C, the wind and water records were examined to determine when set-up and outflow were started by a particular wind. At the time when wind reaction was assumed to have occured, the storage and outflow were assumed to be zero, and all following storage and outflow quantities were calculated on that datum. The reason for this basic assumption was that it was impossible to establish a still water level, even after periods of no wind. Water, from previous wind set-up, in storage in different basins, tended to flow to an equilibrium position after the wind ceased, however, the lake is so large that still water elevation is never reached before another wind begins.

WIND SET-UP

(a) Narrows Blocked Wind set-up is calculated at the Narrows for both a North and South wind, assuming the Narrows blocked, and consequently, no flow from one basin into the other. Normal wind set-up would then occur separately in each basin. This case is examined in order to compare these calculations and their simplifying assumptions previously discussed, with a general wind set-up equation, the revised Zuider Zee, see Appendix A, which Sibul [8], in a comparison of various current formulas, acknowledges as being most accurate for shallow lakes.

The revised Zuider Zee equation, of course, can only be used in a normal basin where there is no appreciable outflow out of the lake caused by wind set-up.

With the Narrows blocked off completely, water would not flow from one basin into the other, but would simply go into storage and consequently would increase the set-up in the particular basin. Hence the storage and outflow curves were added together on Graphs 32 to 43 and the calculated set-up, under the Narrows Blocked condition, was based on this total quantity. The calculated set-up is assumed to be correct up to the point of maximum water reaction, however, at, or near the time of maximum set-up, the return flow in the basin would increase due to the increased pressure head at the leeward end of the lake, thus reducing the set-up and destroying the additive relationship.

It is evident that wind set-ups established in this study, are maximum set-ups and not that occuring after equilibrium is established. This is also evident from a study of Graphs 32 to 43. Maximum set-up is observed to occur only for an hour or two, and then decreases, even under continuing steady wind conditions. This effect, no doubt, is caused by return currents being generated by a pressure head at the leeward end of the basin, which when sufficiently developed, reduces the initial set-up. Newbury [16], noted in his laboratory study of water set-up in a flume, that initial set-up, occuring within a few seconds, could be as much as twice that of set-up reached under final equilibrium conditions. No doubt in a large lake, equilibrium takes much longer to develop.

Based on the calculated set-up, (Narrows blocked), the following equations were established, and Graphs 50 and 51 were prepared. The constant was obtained, first by assuming that the equation should be of the form shown, which has been established as valid for a shallow lake, Sibul 8 /, and then solving for an average value of the constant based on calculated set-ups as previously described, fetches and average lake depths for the wind velocities acting on the lake at the particular time of set-up.

North Wind:

$$h_m = \frac{U^2 F}{2133\ d} \qquad (31)$$

South Wind:

$$h_m = \frac{U^2 F}{991\ d} \qquad (32)$$

Additionally, the modified Zuider Zee formula (25), is also shown on Graphs 50 and 51. (the equation has been modified by the Planform factor, Equation 28).

Modified Zuider Zee:

North Wind: (Planform N = 0.87)

$$h_m = \frac{U^2 F}{1610\ d} \qquad (33)$$

South Wind: (Planform N = 1.25)

$$h_m = \frac{U^2 F}{1120\ d} \qquad (34)$$

where,

h_m = the wind set-up above SWL in ft. at Lake Manitoba Narrows.

U = the wind velocity component in the direction of greatest fetch in m.p.h.

F = the fetch in miles. (the longest fetch for the North Basin, at a bearing of 0^{o}, is 41.6 miles, and for the South Basin, at 157^{o} bearing is 63.7 miles.

d = the average depth of the particular basin in feet. (the North basin is 15 ft. deep and the South basin is 18 ft. deep)

Comparison With The Modified Zuider Zee Equation

North Winds Graph 50 illustrates both equation 31, derived from the empirical data measured on the lake, and the Modified Zuider Zee relationship, equation 33. It can be seen that the two curves are fairly close, with the Zuider Zee equation giving a set-up of 32% greater than that of the Lake Manitoba equation.

South Winds Graph 51 illustrates the empirical relationship derived from Lake Manitoba (equation 32) and the Modified Zuider Zee equation (equation 34). The two curves are closer than for North Winds, the difference being 15%, with the Zuider Zee providing the lower set-up.

Graph 50 and 51 illustrate that the well known and well verified Zuider Zee equation gives set-up values both a little greater and a little lower (depending on the direction of the wind) than the derived relationships.

It seems reasonable to conclude that there is some factor, planform, or depth consideration, that is unique for each basin and which could account for the difference in the curves.

The Zuider Zee equation was corrected for planform, However, the correction was for a trapazoid, which both basins approach, but only approximately, see Figure 1). Additionally, average approximate depths were assumed for each basin, as there was very little data available on the underwater topography of the lake.

An additional factor that could be considered is that the Zuider Zee equation is based on "over water winds". Generally, it can be assumed, that over-water winds are greater by a factor of 1.3 to 1.5 depending on the wind velocity and relative temperatures of the air and water.17,18 / However, Lake Manitoba is relatively narrow compared to its length, and it is therefore assumed that the wind over the lake would be influenced by the land rather than the water. (In any case, the land surrounding the lake, including the wind stations at Dauphin and Portage la Prairie, for the wind directions considered, is quite flat and without obstructions.) It is therefore assumed that over water = over land winds, and that the Zuider Zee equation can be compared to the derived equations without including a wind velocity factor based on the difference in friction between land and water.

(b) Existing Conditions. Graphs 52 and 53 have been prepared for the wind set-up that could be expected, at the Narrows, for various wind velocities, from the North and South.

These graphs are based on the wind set-up actually measured at the Narrows and were derived from the information shown on Graphs 32 to 43. Again the form of equation was postulated as for equations 31 and 32, with the constant calculated from averaging the measured set-ups for various wind velocities.

The equations obtained from the measured set-up are:

North Winds:

$$h_m = \frac{U^2F}{2412\ d} \tag{35}$$

South Winds:

$$h_m = \frac{U^2F}{1026\ d} \tag{36}$$

OUTFLOW THROUGH THE NARROWS

Graphs 54 and 55 show the outflow that could be expected through the Narrows, from one Basin into the other, under existing conditions, as a function of wind velocity. Equation 37 and 38 were established from the wind set-up equations with the constants evaluated by averaging the the constants calculated from measured outflows. The equations thus derived and shown on graphs 54 and 55 are:

North Winds:

$$\text{Outflow} = \frac{913\ UF}{d} \tag{37}$$

South Winds:

$$\text{Outflow} = \frac{815\ UF}{d} \tag{38}$$

The above relationships can be assumed to be reasonably valid, as they are based on the same basic assumptions which were proved valid in the previous section. No doubt, if longer records were available, there would be more assurance that the derived relationships were more accurate, especially for the higher wind velocities.

Table one has been prepared showing wind set-up and flow through the Narrows for various wind velocity return periods.

This table and Graphs 50 to 55 inclusive show values extrapolated far outside the limits of measured data. It should be noted that there is really no justification for this. More measured data is needed, especially for winds in excess of 20 m.p.h. The Curves were extrapolated in order to obtain some indication, at least to a first order, of water reaction to the higher wind velocities. It should be emphasized that additional field measurements should be made in order to justify the derived equations for higher wind velocities.

BACKWATER CALCULATIONS

The wind set-up graphs derived in this section provide the increase in elevation of water level above still water depth at the North and South ends of the lake as a function of wind velocity. The outflow graphs provide the flow through the Narrows, also as a function of wind velocity. The elevation of water through the Narrows itself, has to be obtained through backwater calculations for the alternate waterway area restrictions proposed at the future bridge site, see figure 7 and Chow 19/

The backwater calculations are considered beyond the scope of this study, however, they are not difficult and can easily be solved with the aid of a computer.

The waterway area of the various cross-sections throughout the length of the Narrows, which are on file with the Highways Department, would be required for these calculations.

The procedure for calculating backwater curves through the Narrows would be as follows:

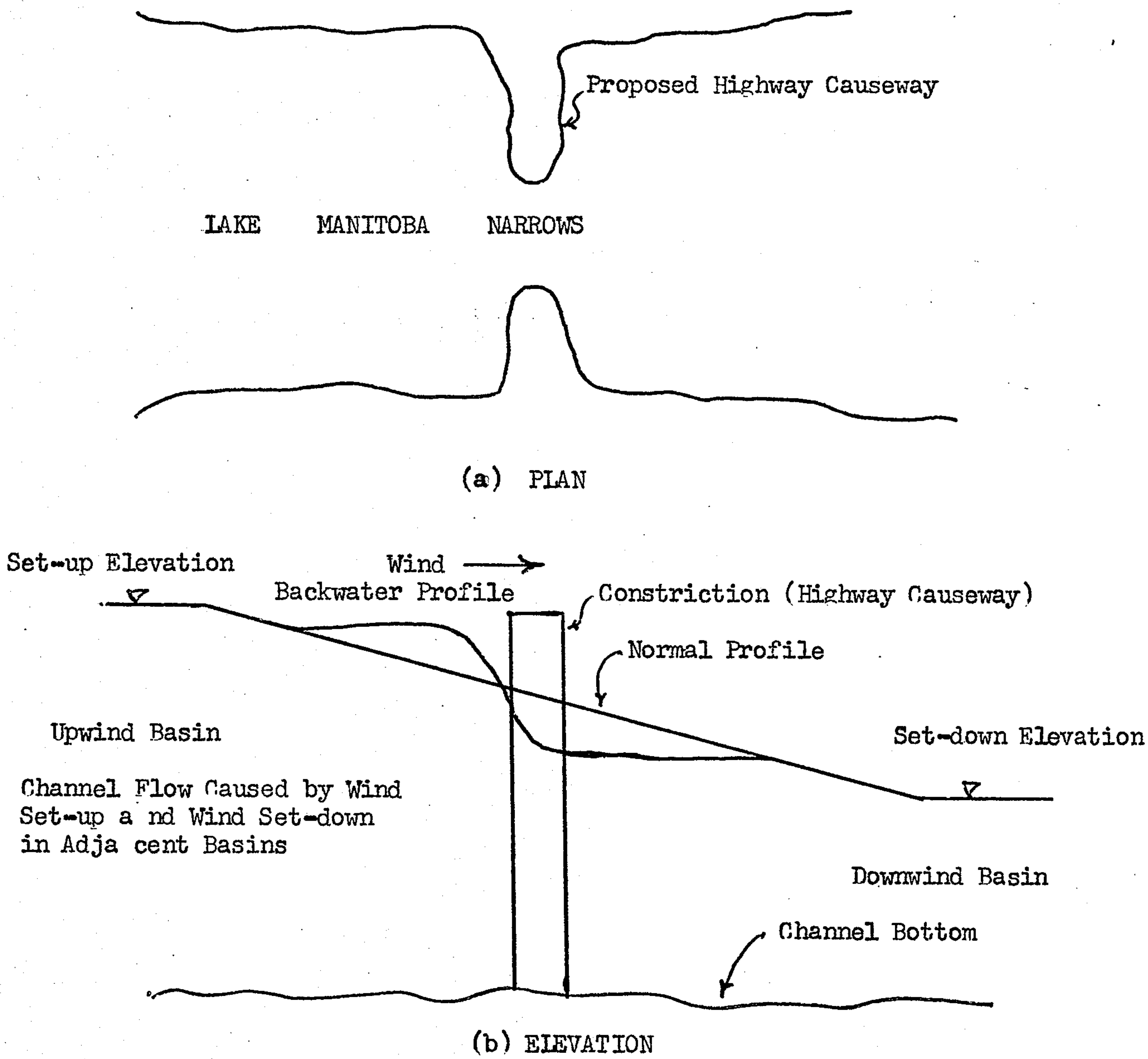
(1) Establish the design wind velocity based on the return period desired. McKay 15 / would be valuable for this step. (Most bridges are designed for a 50 year return period, although this can be altered, depending on the circumstances). It should be realized that the full set-up will not occur unless the wind acts for 10 to 20 hours.

(2) Using the wind velocity found in (1), wind set-up at water level gauge 4 or 10 can be established from graphs 52 or 53.

(3) Graphs 54 and 55 are used to calculate flow through the Narrows for the North or South wind, for the wind velocity established in (1).

(4) Backwater curves are then calculated for the length of the Narrows for the various proposed bridge lengths, as is illustrated in Chow 19 /. A bridge ca

A bridge causes a local constriction which affects the water elevation both up and downstream of the brige site, see figure 7. The alternate backwater curves will enable the designer to ascertain and define the local effects. It is probable that large constrictions will cause local flooding upstream of the bridge. Small constrictions will alleviate the flooding effect but will cost more money because of the increase in bridge length. The designers function is to obtain the optimum bridge length based on possible flood damage and bridge construction cost.



BACKWATER CURVE CAUSED BY CHANNEL RESTRICTION

LAKE MANITOBA NARROWS

Figure 7

TABLE I

WIND SET-UP

LAKE MANITOBA NARROWS

RETURN PERIOD (years)	WIND VELOCITY (m.p.h.) duration 1 hr.	6 hrs.	WIND SET-UP (ft.)	FLOW THROUGH NARROWS (c.f.s.)
			Existing Conditions	
NORTH WIND			NORTH BASIN	
2	28	25.2	0.73	63,500
5	35	31.5	1.14	79,500
10	40	36.0	1.49	91,000
20	44	39.6	1.80	100,000
50	50	45.0	2.33	114,000
100	54	48.6	2.72	123,000
SOUTH WIND			SOUTH BASIN	
2	28	25.2	2.19	73,000
5	32	28.8	2.86	83,000
10	34.5	31.0	3.21	89,500
20	37.5	33.8	3.95	97,500
50	40.0	36.0	4.47	104,000
100	43	38.7	5.17	111,500

Most of the backwater curves, depending on the wind velocity and waterway restriction selected, will not extend to the ends of the Narrows and hence do not affect wind set-up on the basins, or outflow through the Narrows. However with high winds from the north, it may be found, from the backwater curve calculations, that the backwater curve extends into the North basin and hence affects the flow through the Narrows. Should this be the case, then the backwater calculations have to be repeated with various reduced flows, until no discrepancy occurs in water elevation at the lake.

Backwater curves will not extend into the south basin, for south winds, as the distance is 18 miles, which is too long for the effect to be felt.

It should be noted in graphs 32 to 43 that maximum set-up usually occurs for only an hour or two, as was mentioned in a previous section, and then receeds, never reaching an equilibrium position, even after our maximum recorded wind duration of 40 hours, on October 30-31st. Therefore, for more refined design considerations, the time aspect should be considered for backwater calculations. The problem would involve flood routing and channel storage 19 /.

V. CONCLUSIONS AND FUTURE STUDIES

Equations have been derived, and graphs prepared, for wind set-up and basin outflow at Lake Manitoba Narrows, for winds from the North and South.

Additionally, equations and graphs have been prepared for wind set-up which would occur if the Narrows were completely blocked, primarily in order to validate basic assumptions and procedures.

A method for determining backwater curves for water elevation through the length of the Narrows has been outlined.

A satisfactory waterway area for a Highway Causeway design can be obtained from the basic data derived in this study.

Future Studies

The study of water reaction to wind velocity on Lake Manitoba, has revealed that there is room for additional research on the problem. Several possible topics for future study are outlined as follows:

(1) A study of seiches on Lake Manitoba. Graphs 32 to 43 show that wind set-up recedes very rapidly, even under steady wind conditions, after maximum set-up is reached. The water pushed up by the wind at the leeward shore, cannot maintain its position, and quickely recedes, likely causing oscillations in each basin. The phenomena was not pursued in this study, but seems likely to povide interesting research.

(2) Currents due to changes in atmospheric pressure. Apparently, from local observations, very strong currents develope under the ice, through the Narrows during the winter. The currents are strong enough to cause signifigant ice erosion

from underneath. The Narrows are dangerous to cross during the winter because of the phenomena. A study might show that the currents are caused by differences in atmospheric pressures in the two basins. The research would be interesting in that water reaction due to differences in atmospheric pressure could be separated and identified from that due to set-up from wind. This, to the authors knowledge, has never been done.

(3) Wind set-up should be studied on the basis of longer records, both before and after the causeway is built. The Highways Department has on file, and will continue to record for some time, wind set-up phenomena at the Narrows. This data should be studied and compared to the relationships developed in this report.

(4) The effect of building the causeway, on water quality could be studied. The Province of Manitoba has water quality records on file, dating from 1966, and in a few cases earlier. Records will be kept for some time after the causeway is built. When sufficient records are available, they could be studied to determine the causeways effect on exchanges of water through the Narrows, from a standpoint of water quality, and could give an insight of circulation in the lake.

The above are but a few possible areas of future research on Lake Manitoba. The reader, no doubt, will also be able to think of various studies that would prove worthwhile. As is evident from this report, the lake is quite vast and little is known about it.

BIBLIOGRAPHY

1. Editors of Life and Rand McNally, Life Pictorial and Atlas, Time Incorporated, New York, 1961.

2. Lakes Winnipeg and Manitoba Board, Report on Measures for the Control of the Waters of Lake Winnipeg and Manitoba, Province of Manitoba, 1958.

3. Picot, J. Histoire de Geneve, Geneva, 1811.

4. Hellstrom, B. Wind Effect on Lakes and Rivers, Royal Swedish Institute for Engineering Research, Proc. No. 158, 1951.

5. Langhaar, H.L. Wind Tides in Inland Waters, Proc. No. 4, First Midwestern Conference on Fluid Mechanics, 1951.

6. Corps of Engineers, U.S. Army, Waves and Wind Tides in Shallow Lakes and Reservoirs, Civil Works Investigation, Project CW-167, June 1955.

7. Einarsson, E and Lowe, A.B., Seiches and Set-up on Lake Winnipeg, Meteorological Branch, Department of Transport, Canada, Limnology and Oceanography, April, 1968.

8. Sibul, O.J. and Johnson, J. W., Laboratory Study of Wind Tides in Shallow Water, Journal of the Waterways and Harbors Division, A.S.C.E., Paper 1210, April, 1957.

9. Keulegan, G. H., Wind Tides in Small Closed Channels, Journal of Res. of National Bu. Stds., Vol. 46, No.5, May 1951.

10. Ekman, V.W., On the Influence of the Earths Rotation on Ocean Currents, Arkiv for Matematik, Astron. och fysik, Vol.2, No. 11, Stockholm, 1905.

11. Flood Control and Other Purposes, Part lV, Lake Okeechobee and Outlets, Jan. 21, 1954, unpublished.

12. Thijsse, J. Th., On Wind Effects, United States Waterways Experimental Station, Bull. Vol. No. 2. 1938.

13. Creager, W. P., Justin, J.D., and Hinds, J., Engineering for Dams, New York, 1945.

14. Saville, T., Jr., Wind Set-up and Waves in Shallow Water, Tech. Memo. No. 27, Beach Erosion Board, 1952.

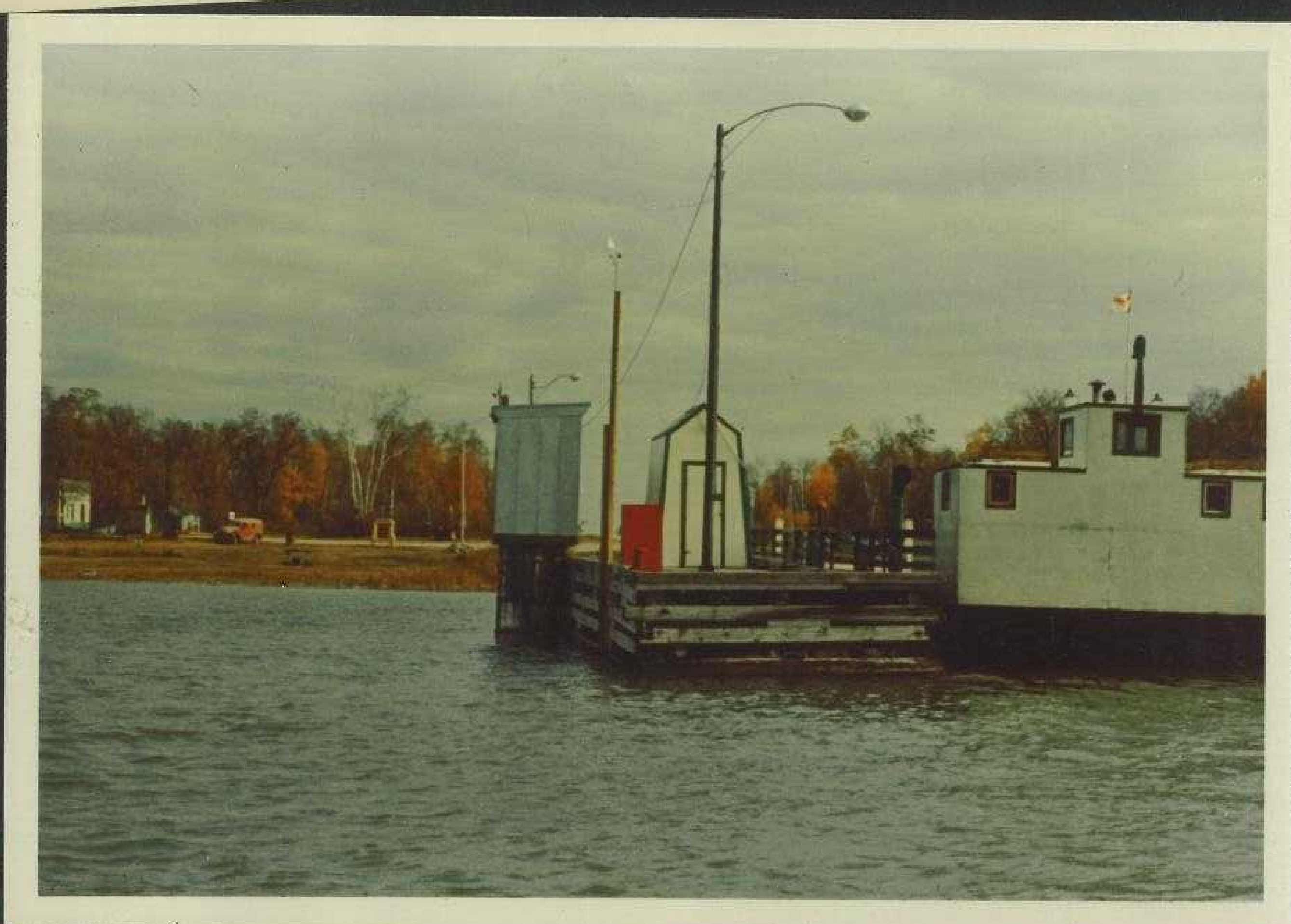
15. McKay, G.A., Design Winds for Reservoirs in Southern Manitoba Canada Department of Agriculture, P.F.R.A.. Engr. Branch, Hydrology Division, May, 1966.

16. Newbury, R., Wind Set-up Parameters, M. Sc. Thesis, University of Manitoba, 1964.

17. McCaig, I.W., Jonker, F. H. and Hamilton, W., Selection of Dike Freeboard and Spillway Capacity for Grand Rapids Generating Station, Engineering Journal EIC, Nov., 1962.

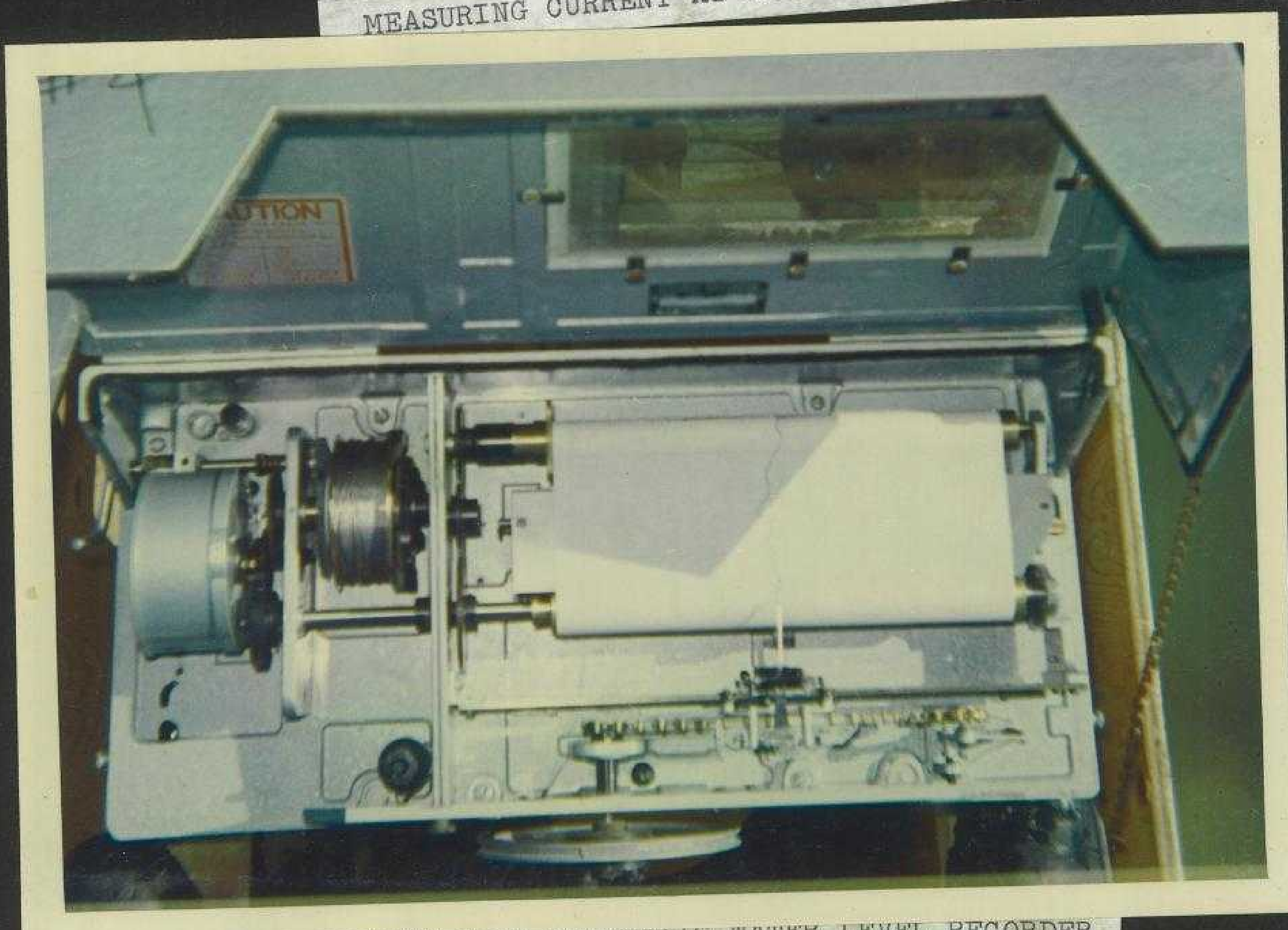
18. Hunt, I.A., Wind, Wind Set-ups, and Seiches on Lake Erie, Second National Conference on Applied Meteorology, Engineering, September, 1958.

19. Chow, V. T.. Open Channel Hydraulics, McGraw-Hill, Toronto, 1959.



WIND ANENOMETER

MEASURING CURRENT AT HYDRO CAUSEWAY



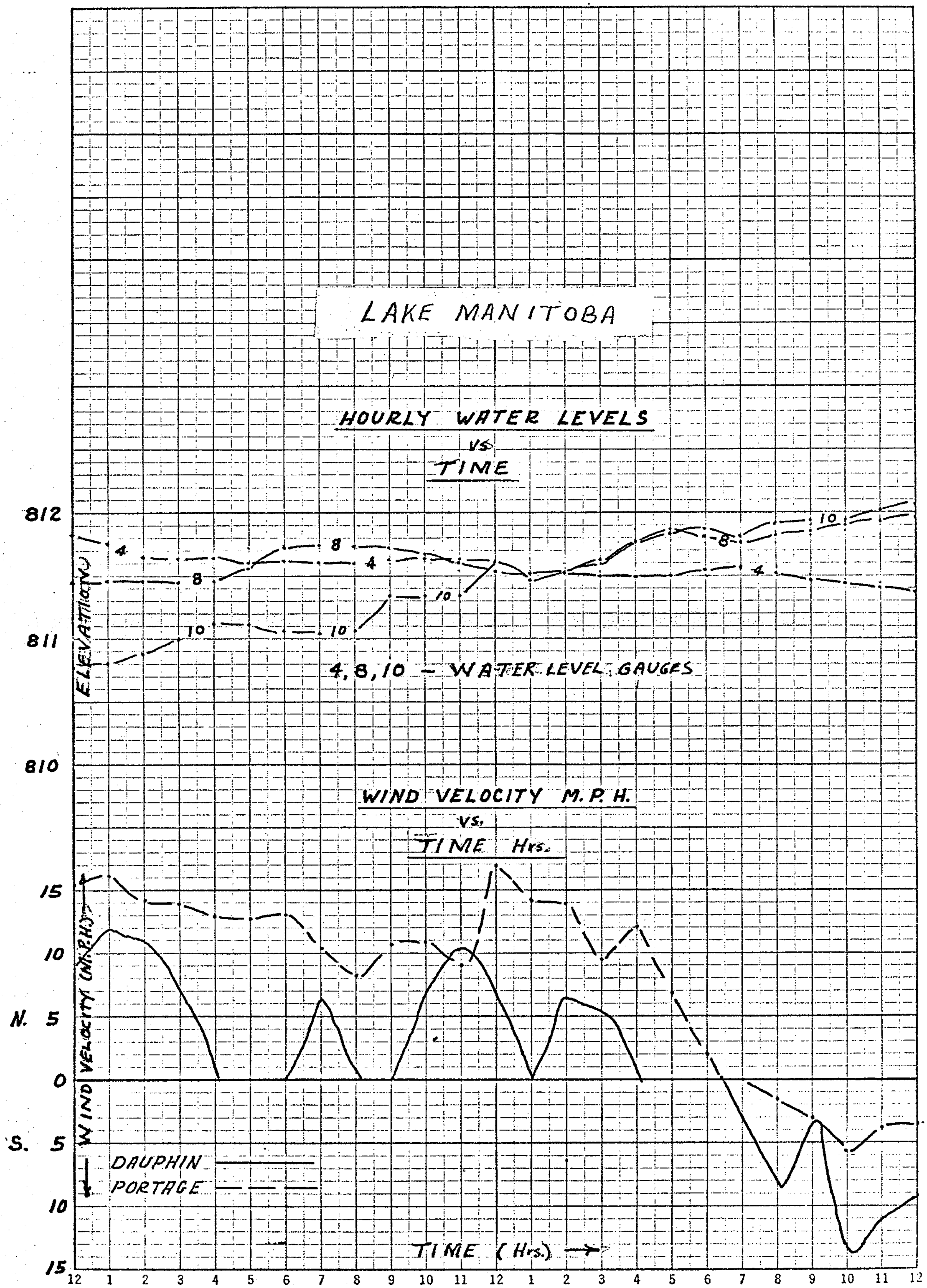
STEVENS A-35 AUTOMATIC WATER LEVEL RECORDER

WATER LEVEL RECORDER IN POSITION

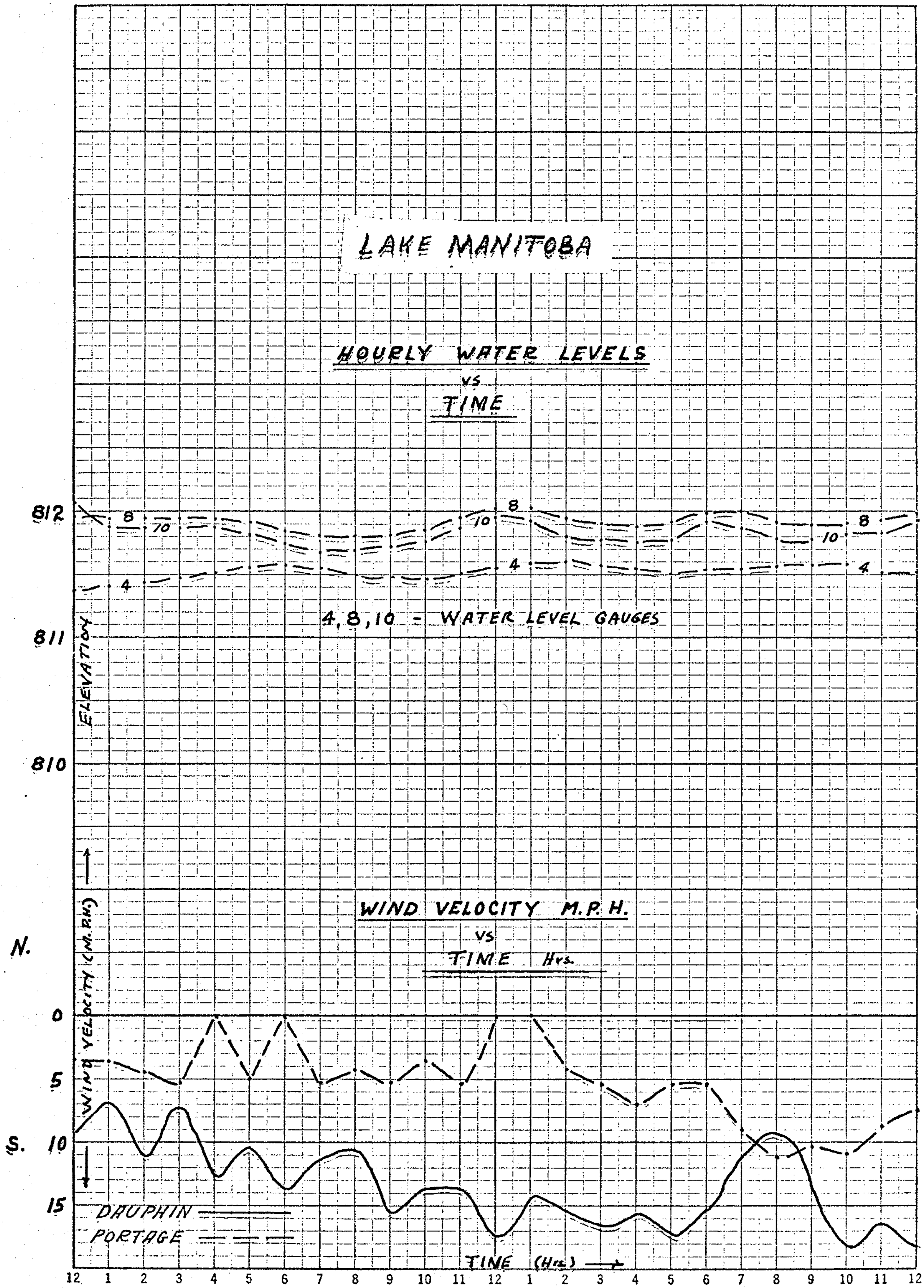
VIEW OF WATER LEVEL RECORDER IN LAKE

SURVEY [illegible] THROUGH ICE

SNOW VEHICLE USED BY SURVEY CREWS

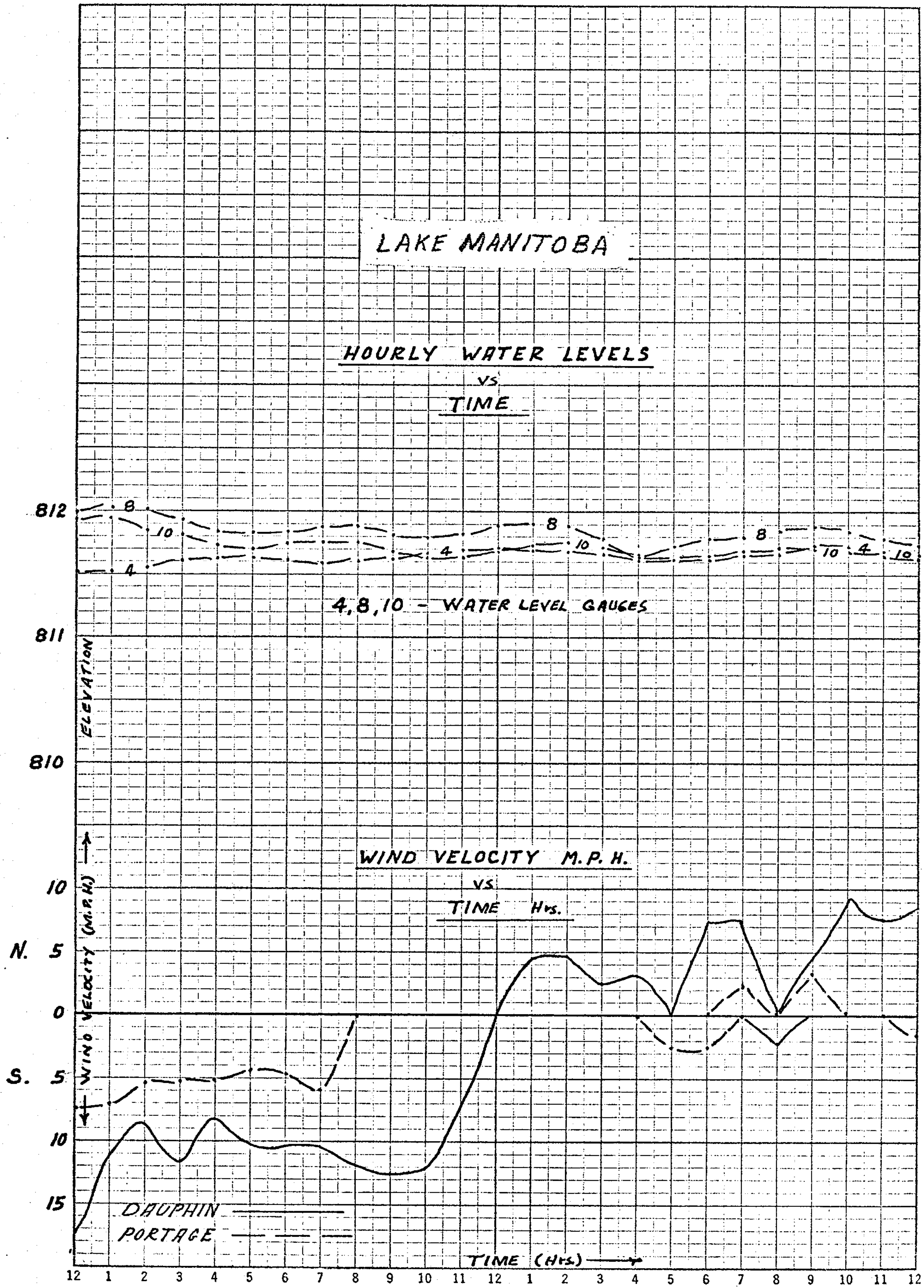


OCTOBER 4, 1966



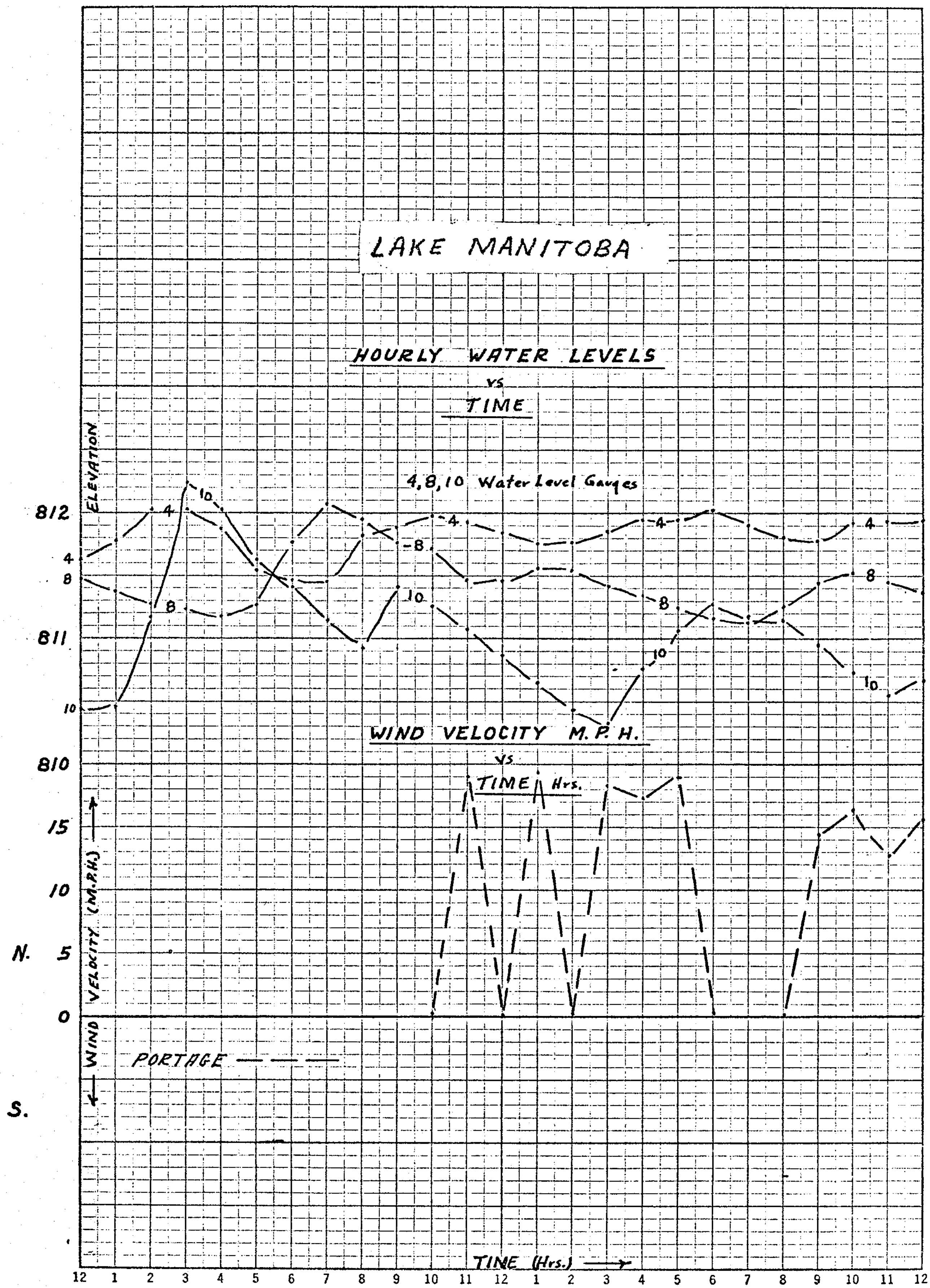
OCTOBER 5, 1966

Graph № 2



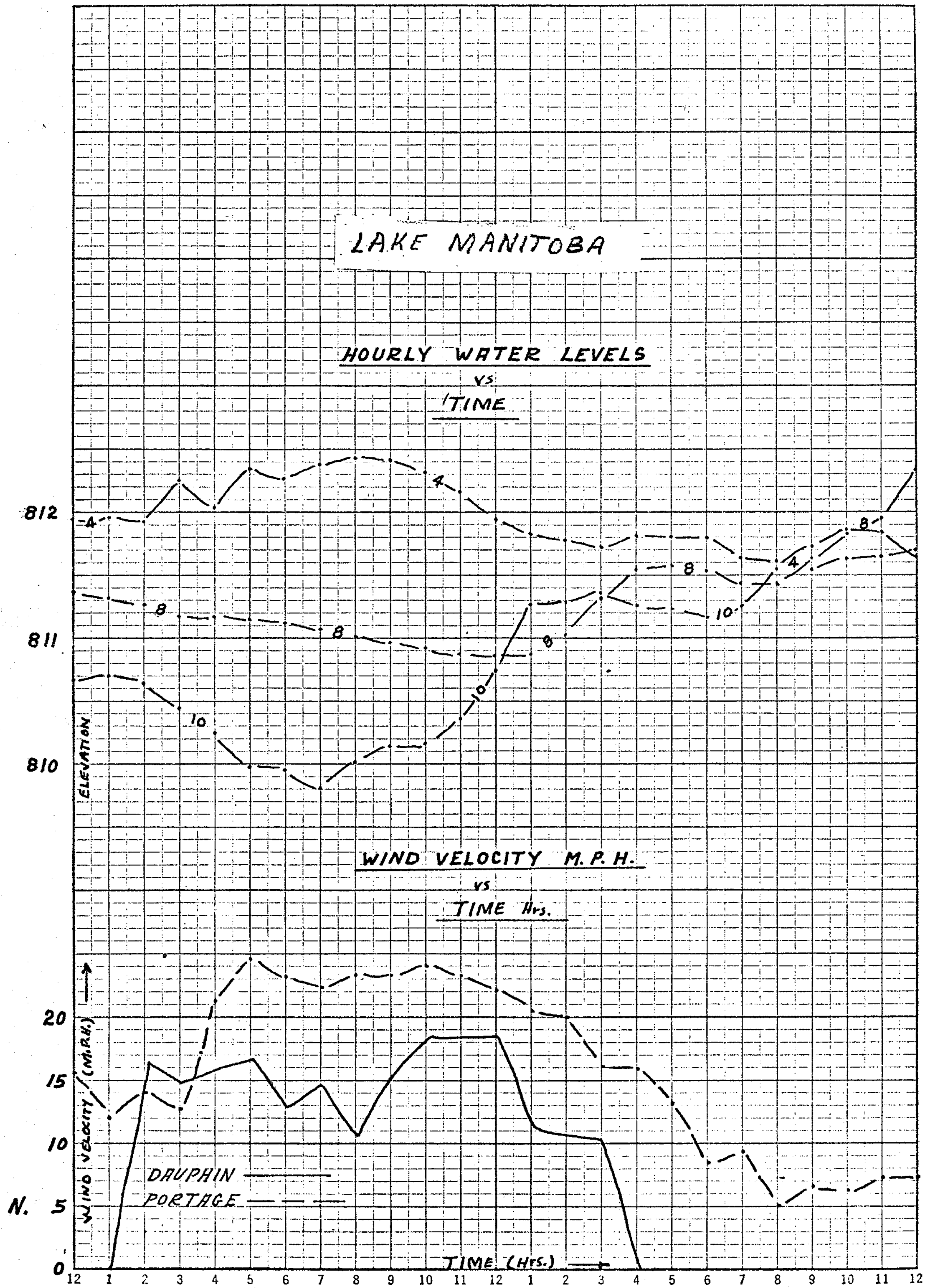
OCTOBER 6, 1966

Graph Nº 3



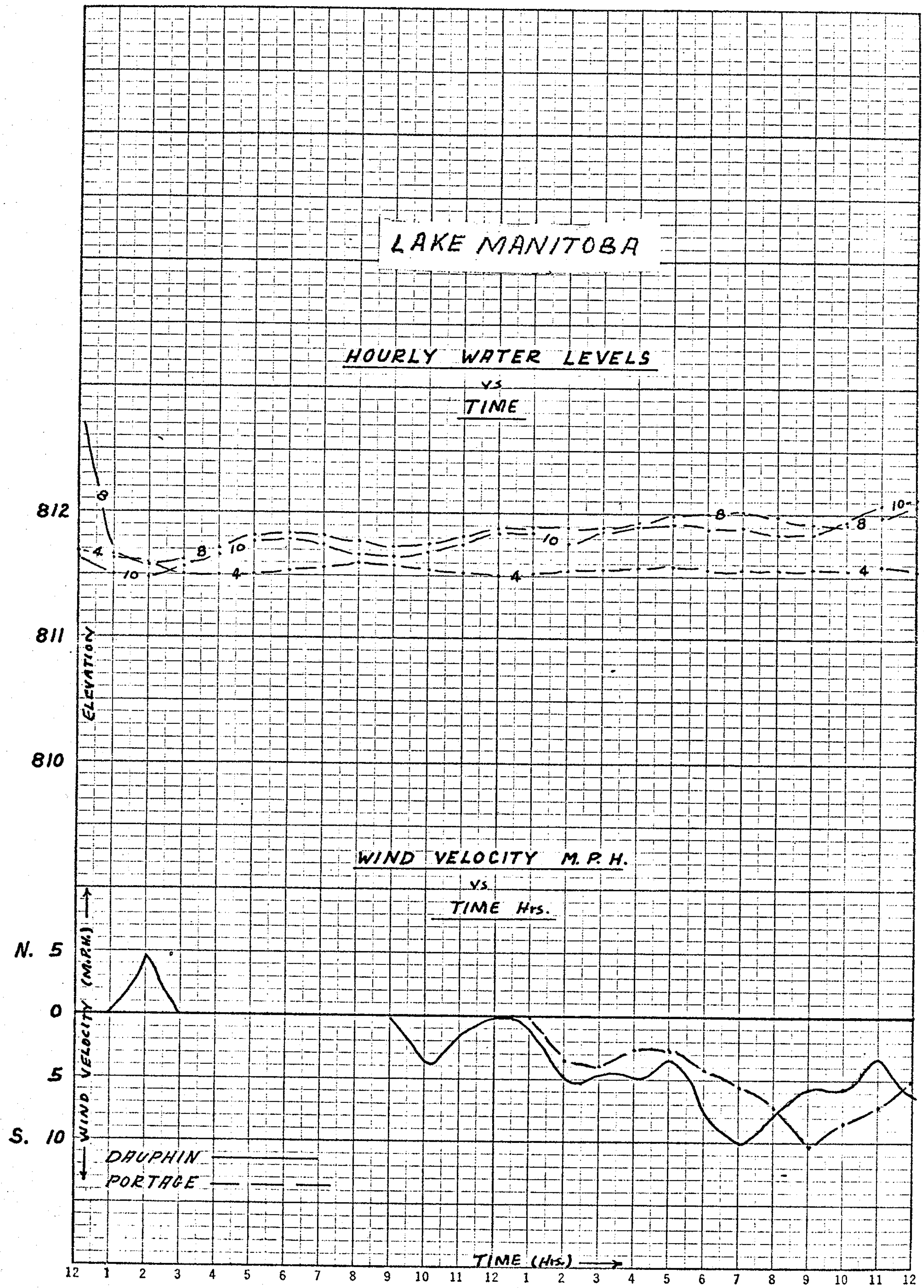
OCTOBER 9, 1966

Graph No. 4



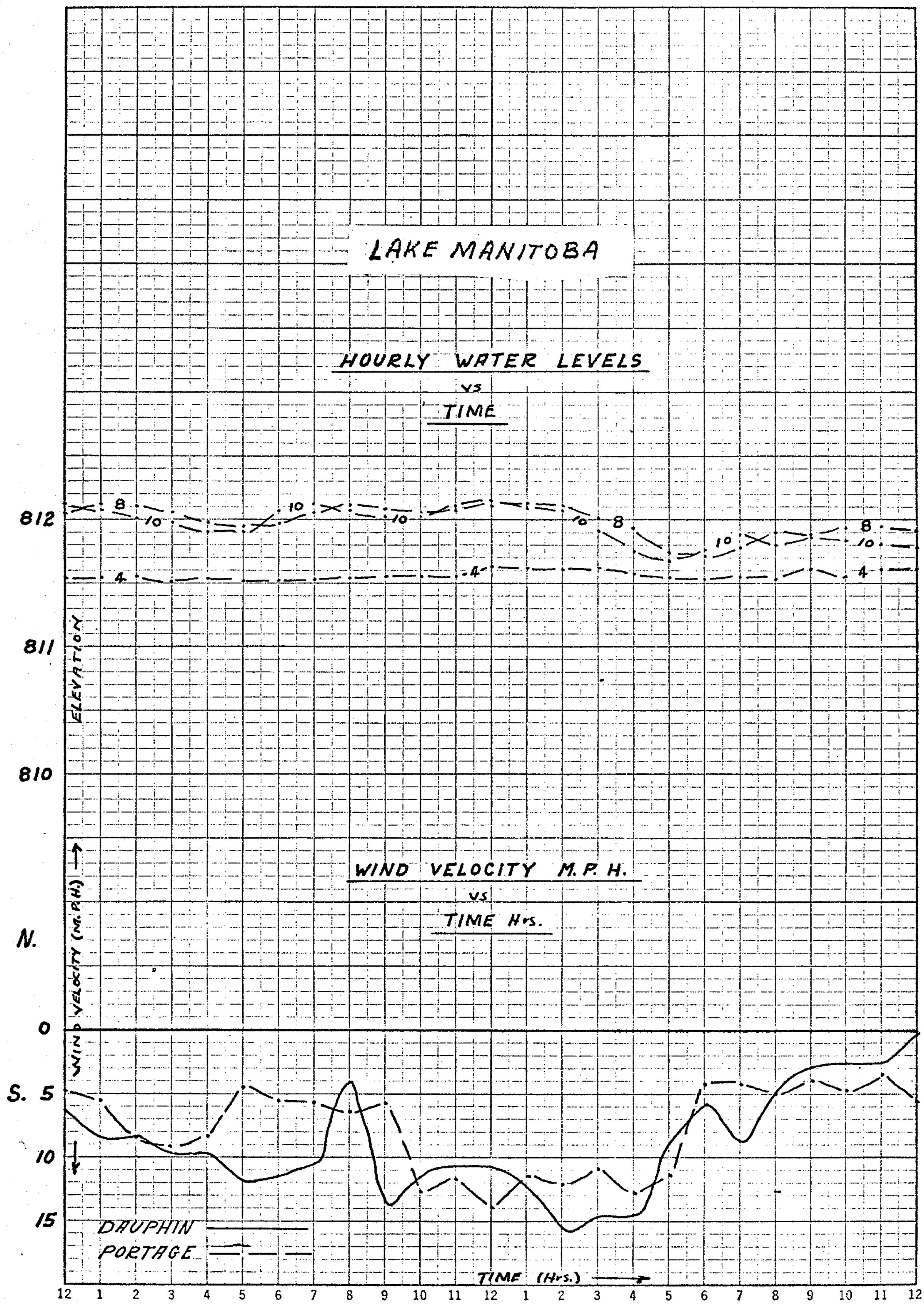
OCTOBER 10, 1966

Graph No 5



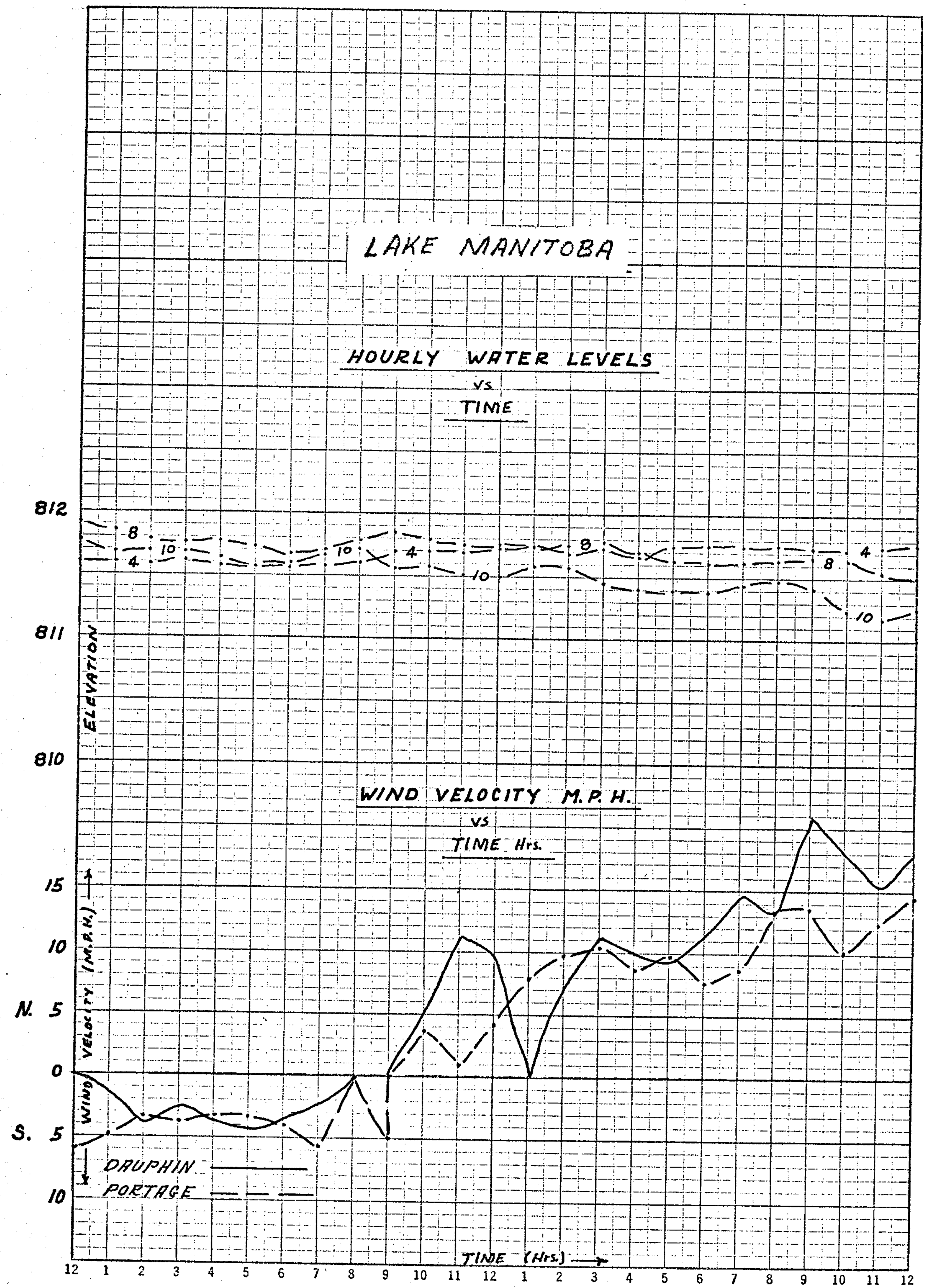
OCTOBER 11, 1966

Graph No 6



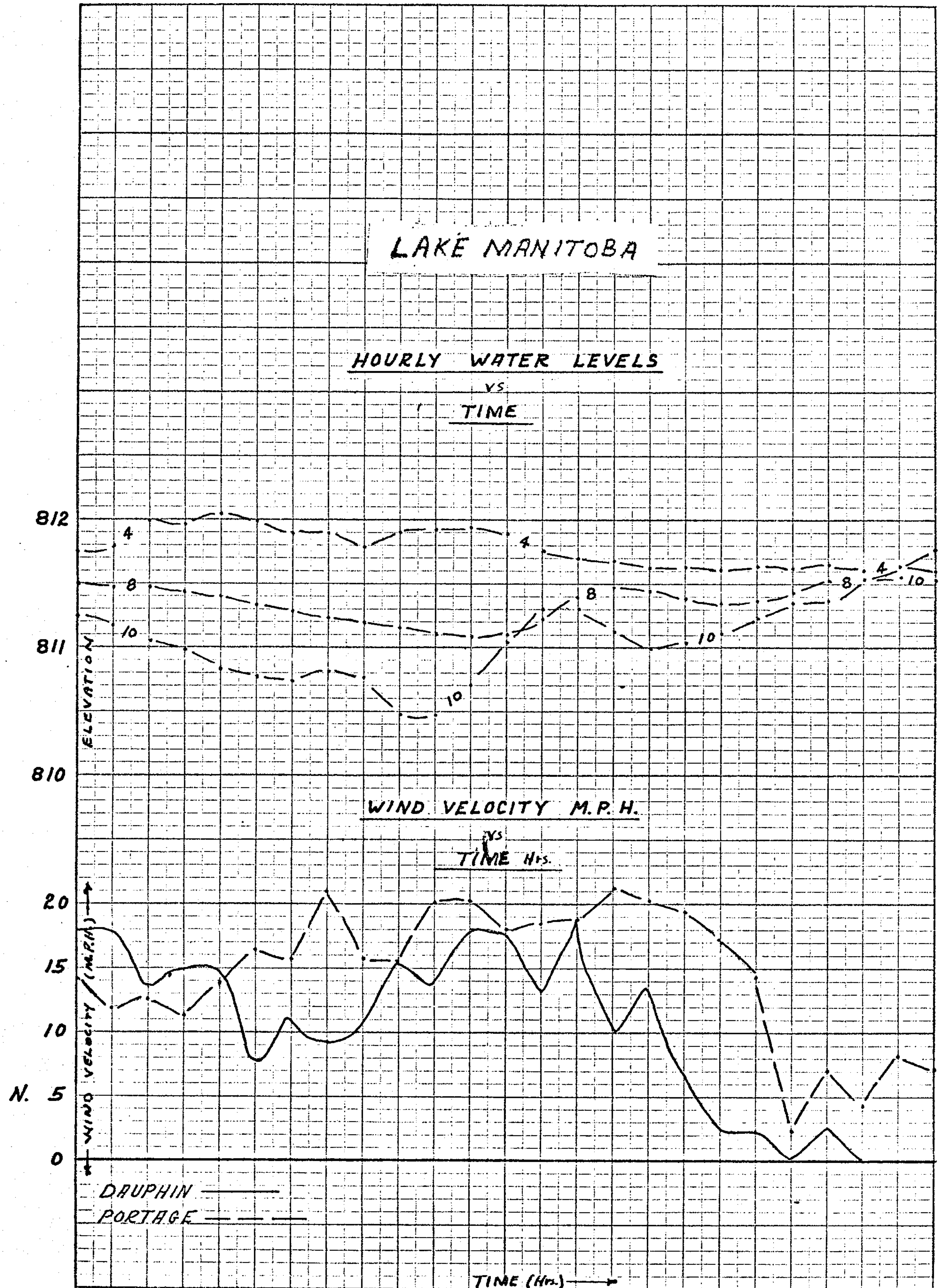
OCTOBER 12, 1966

Graph № 7



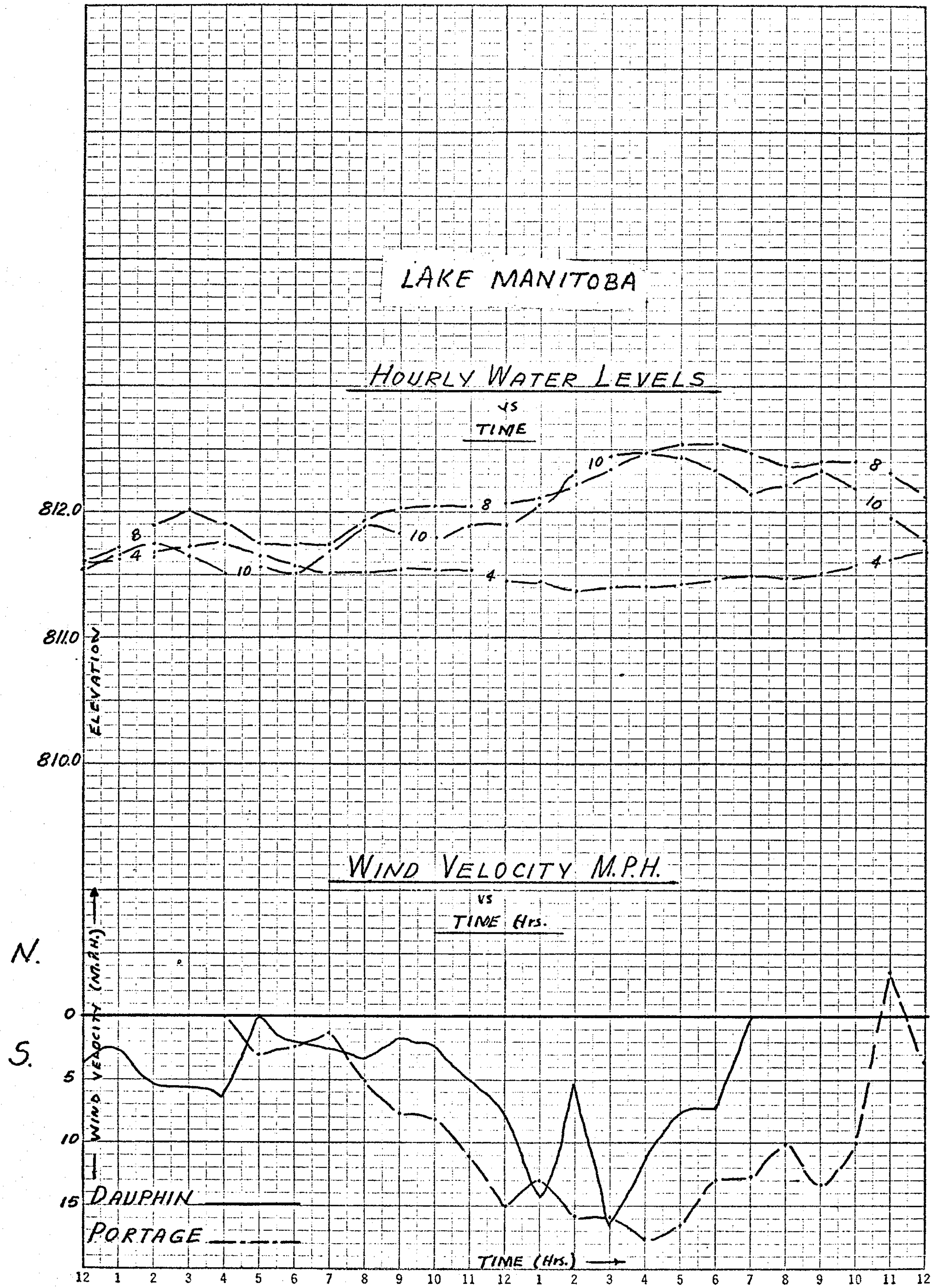
OCTOBER 13, 1966

Graph No 8



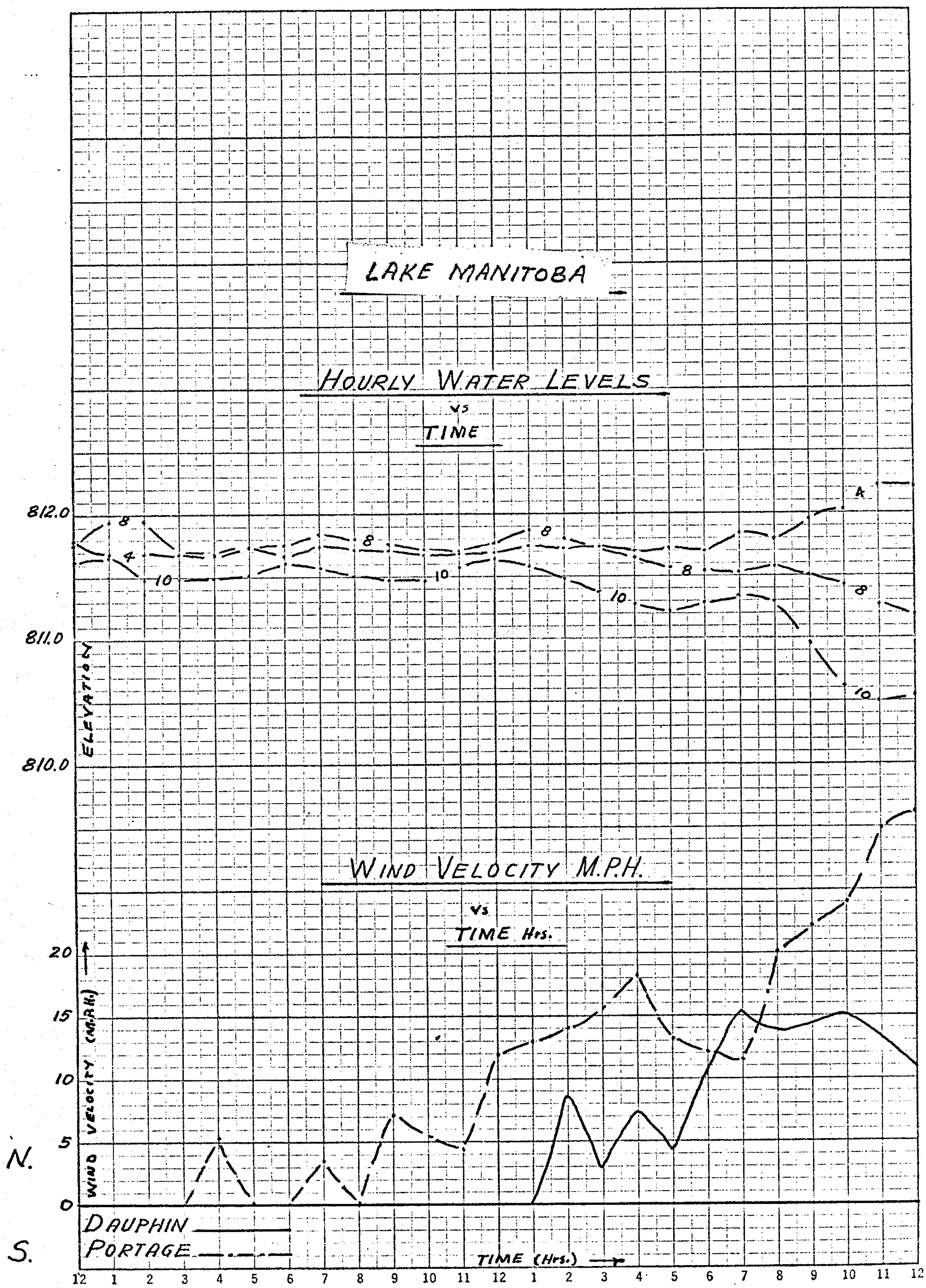
OCTOBER 14, 1966

Graph № 9



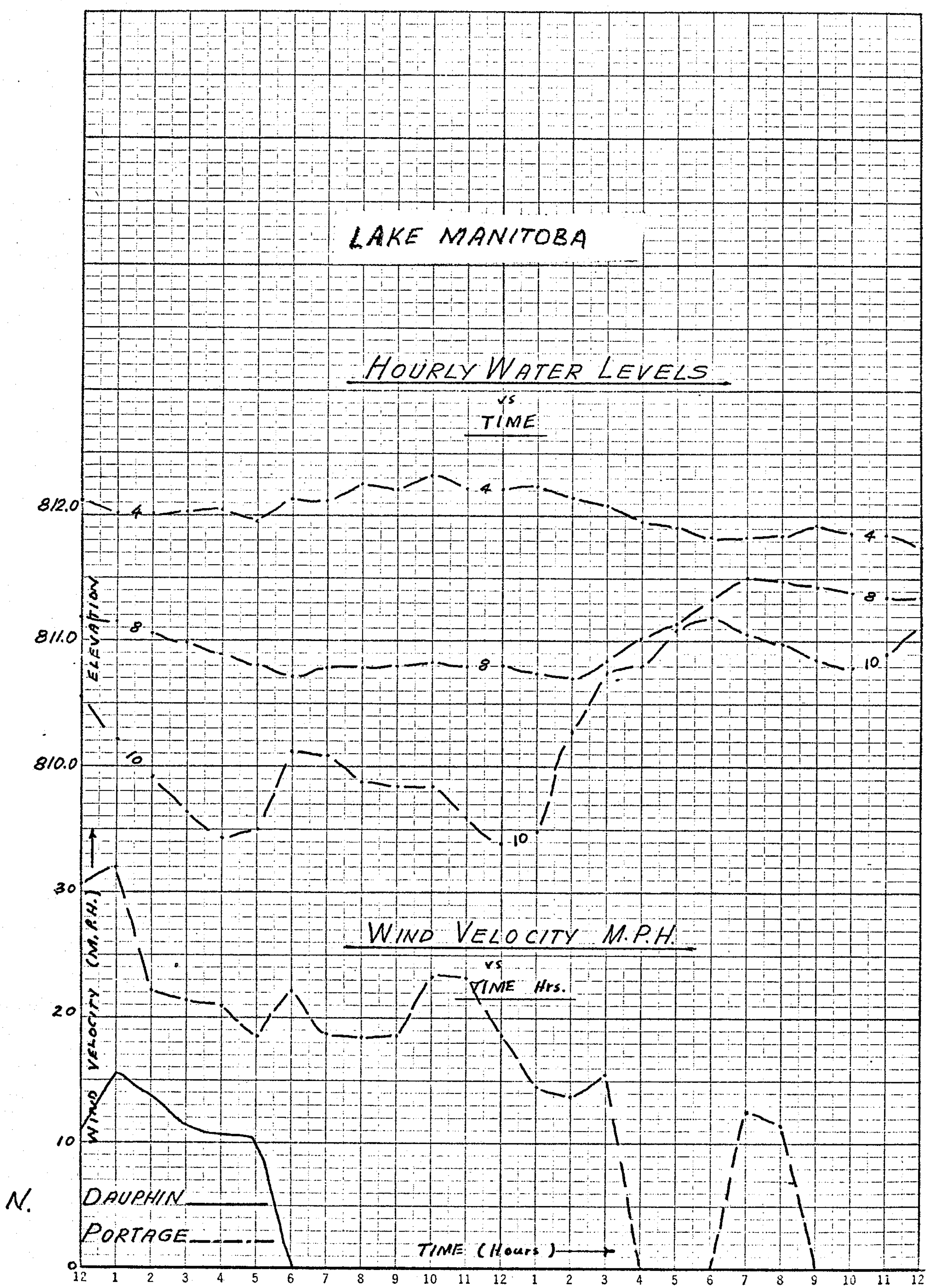
Oct. 19, 1966

Graph No 10



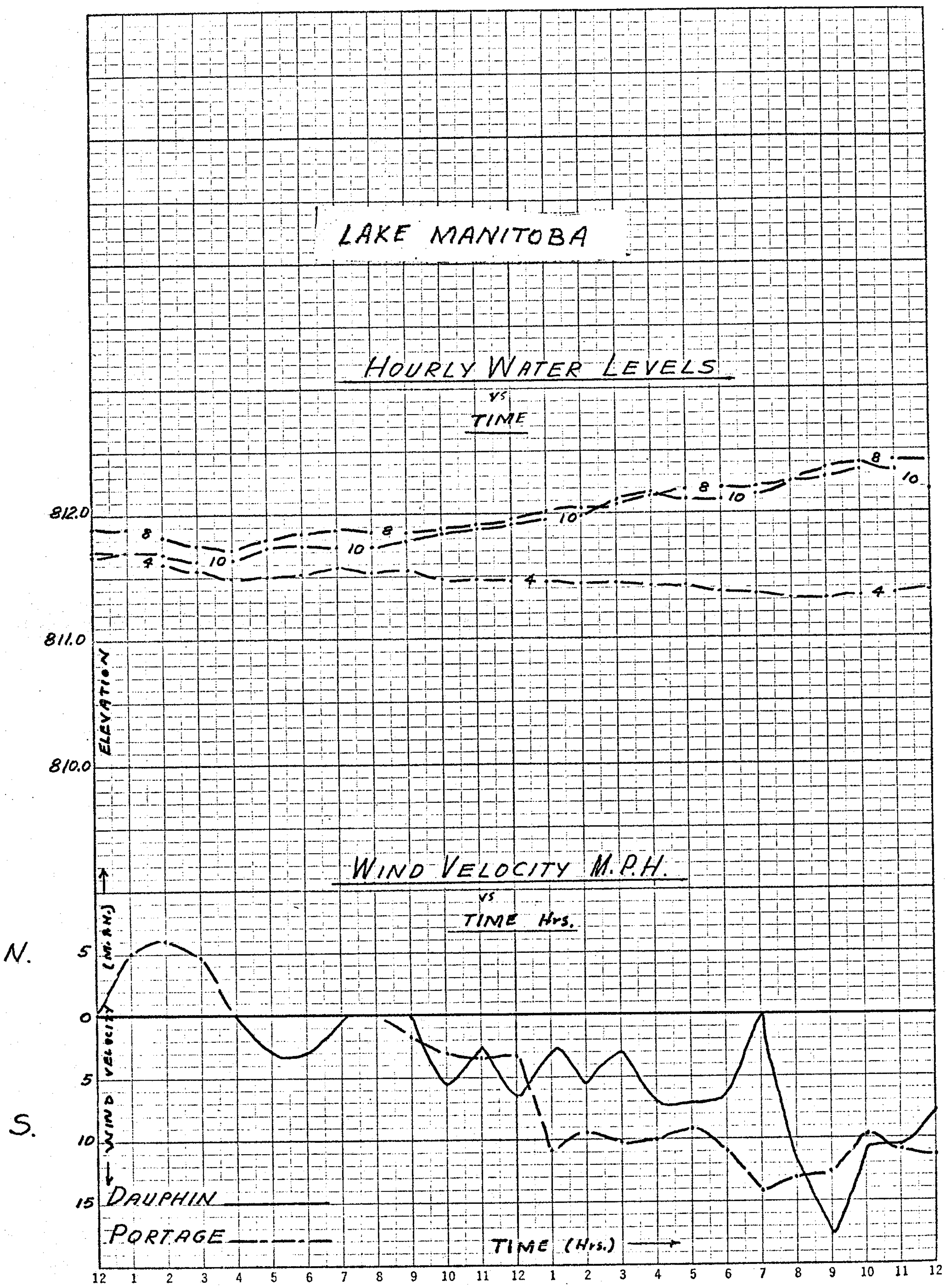
Oct. 21, 1966

Graph No. 11



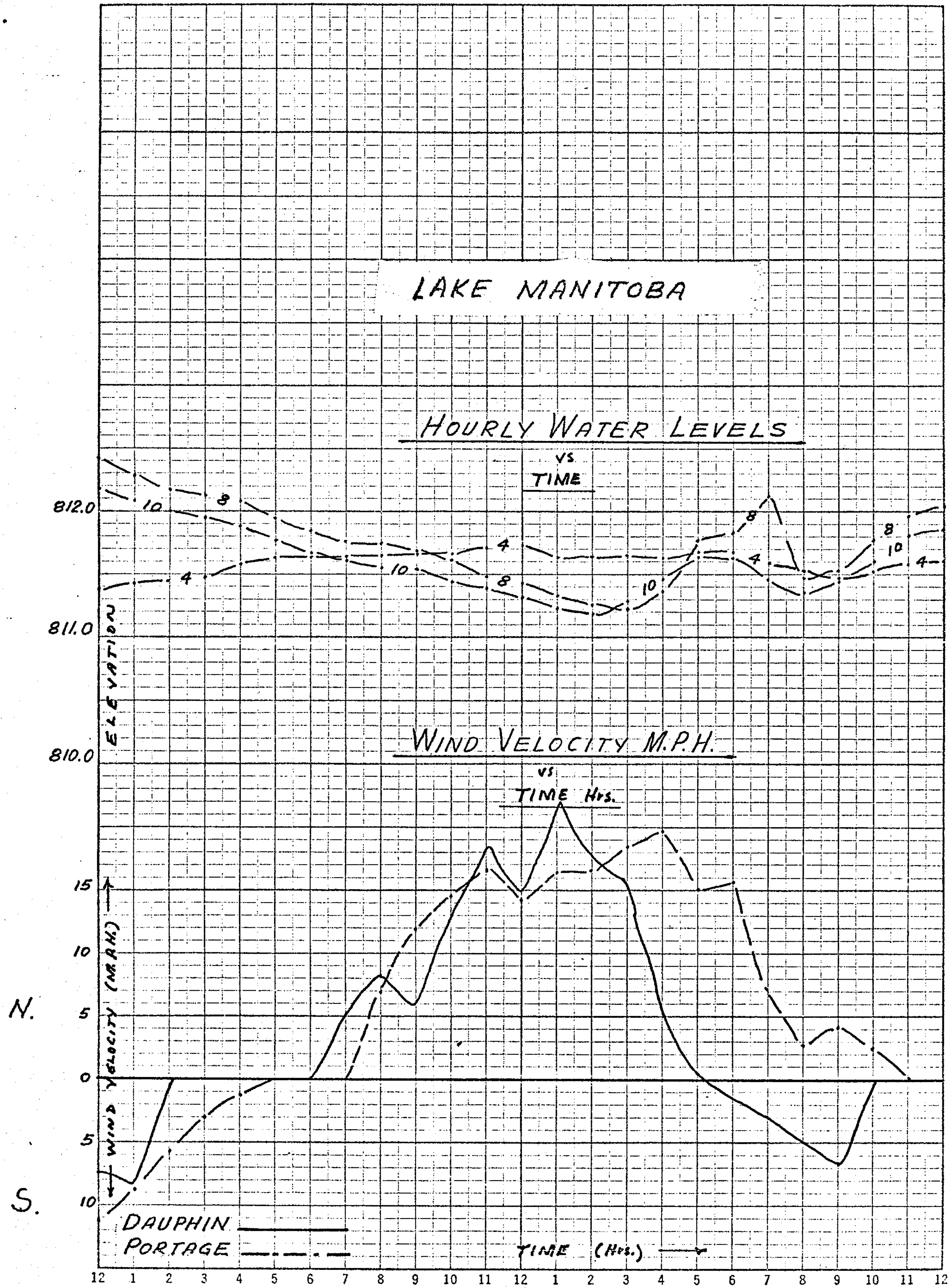
Oct. 22, 1966

Graph No 12



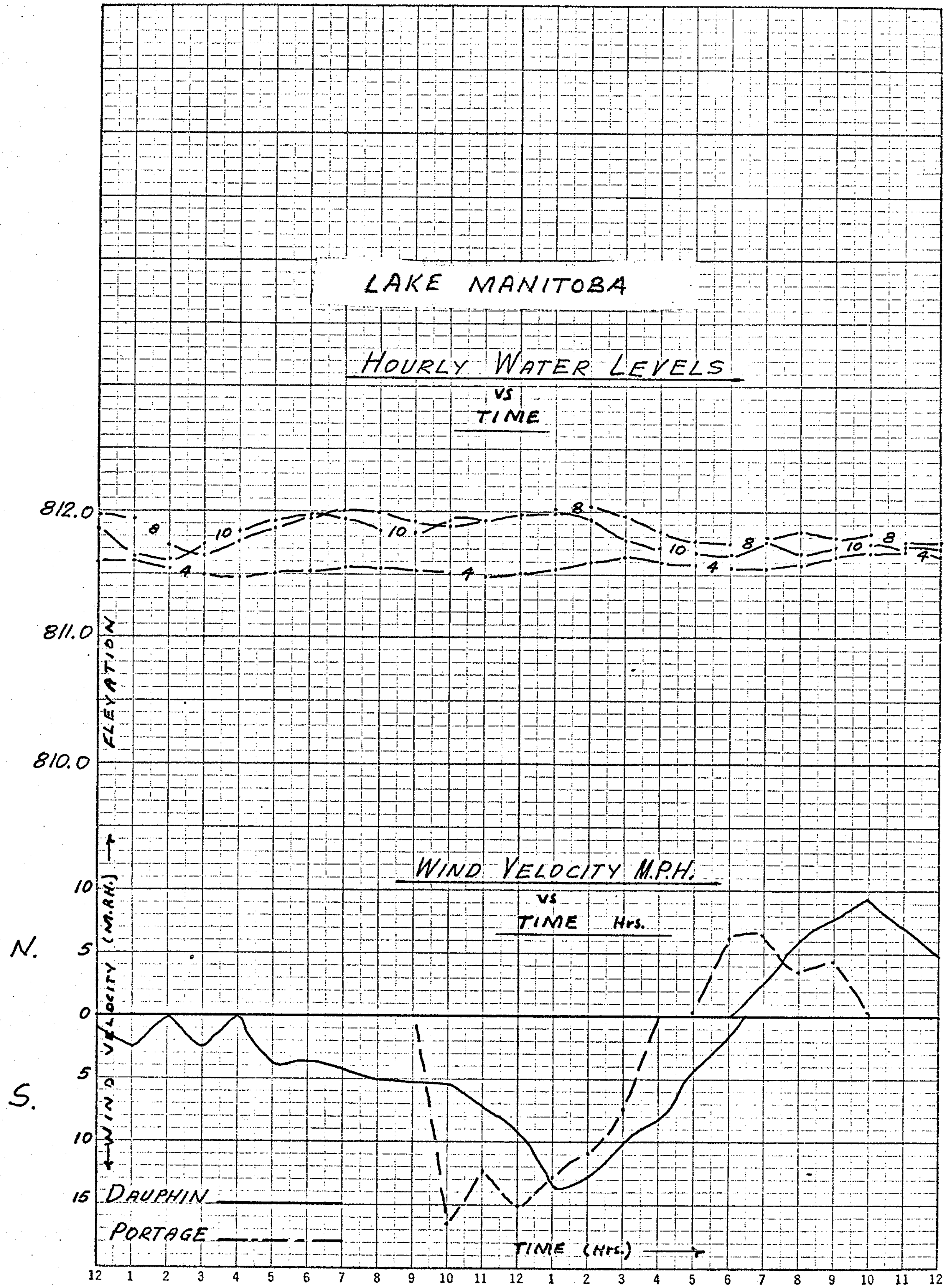
Oct. 24, 1966

Graph No 13



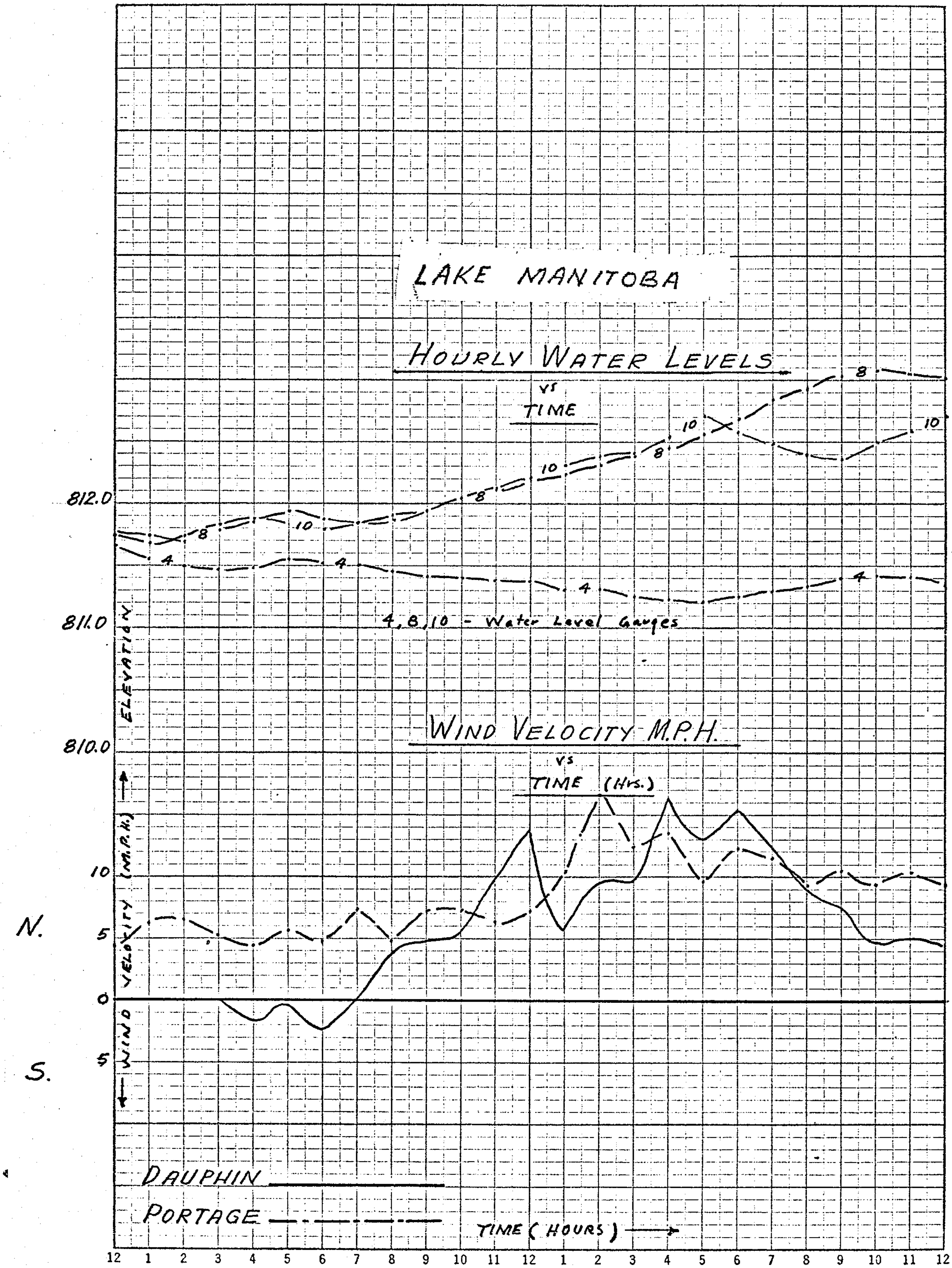
Oct. 25, 1966

Graph No 14



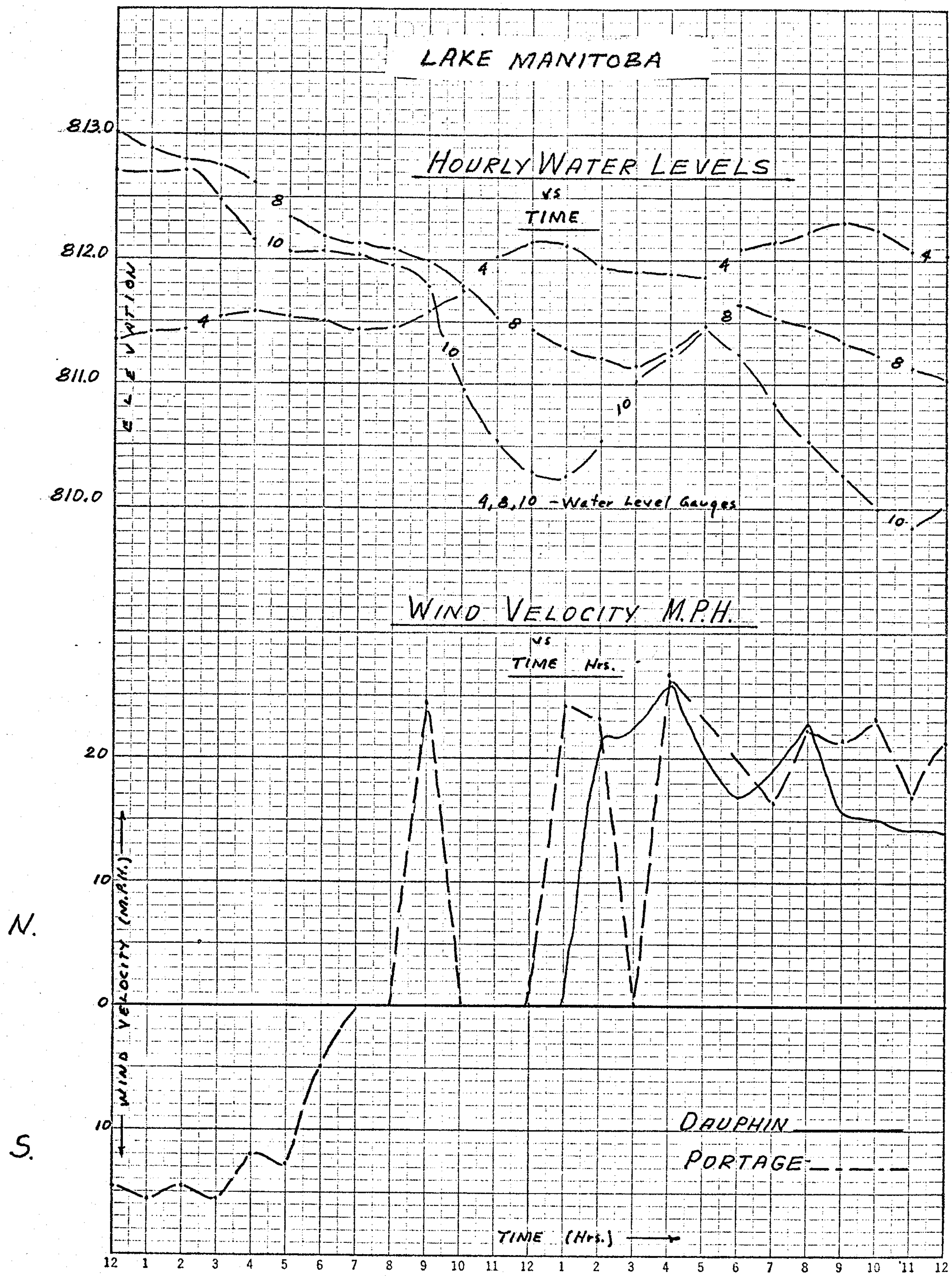
Oct. 26, 1966

Graph No. 15



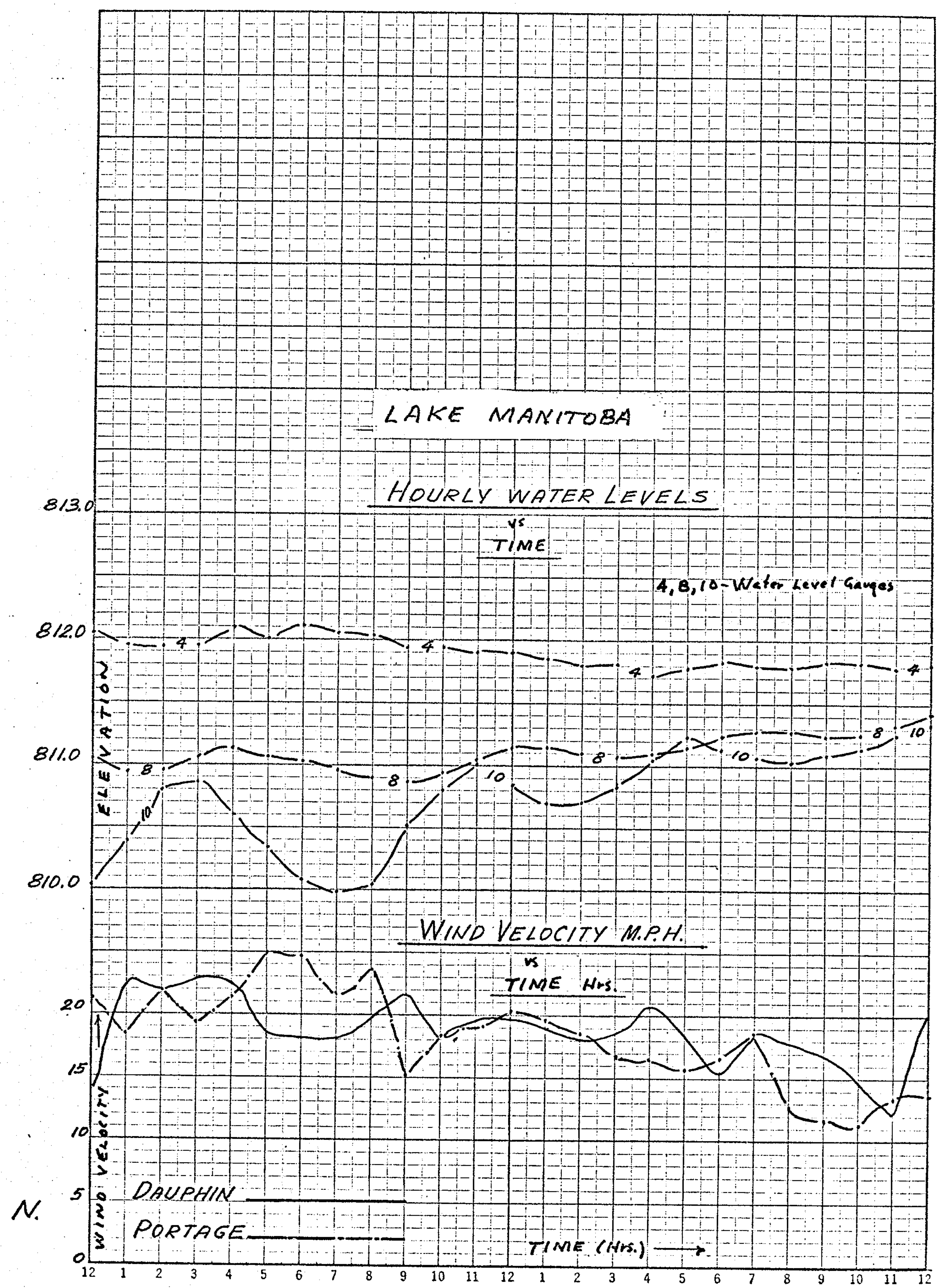
Oct. 29, 1966

Graph No 16



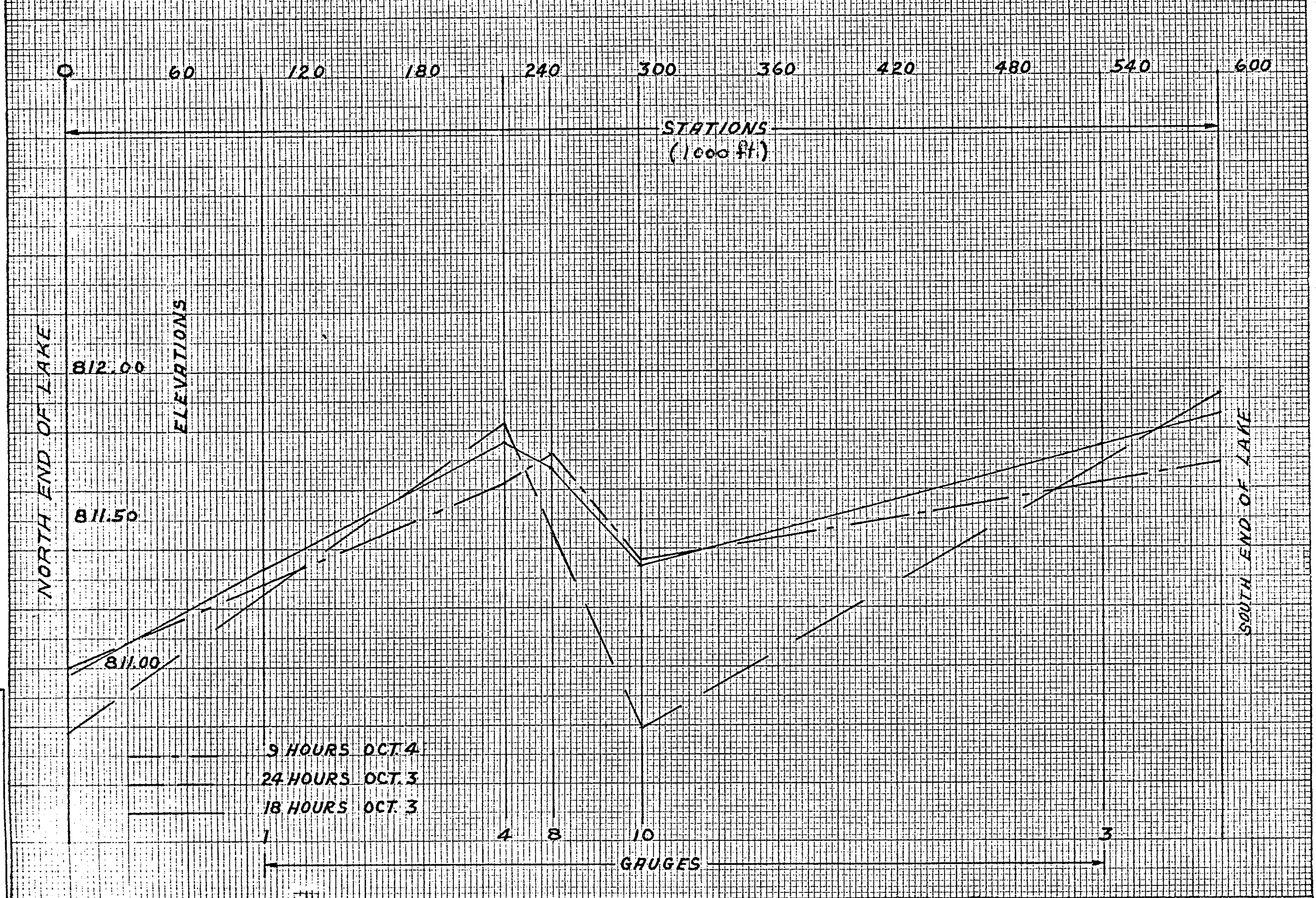
Oct. 30, 1966

Graph No. 17

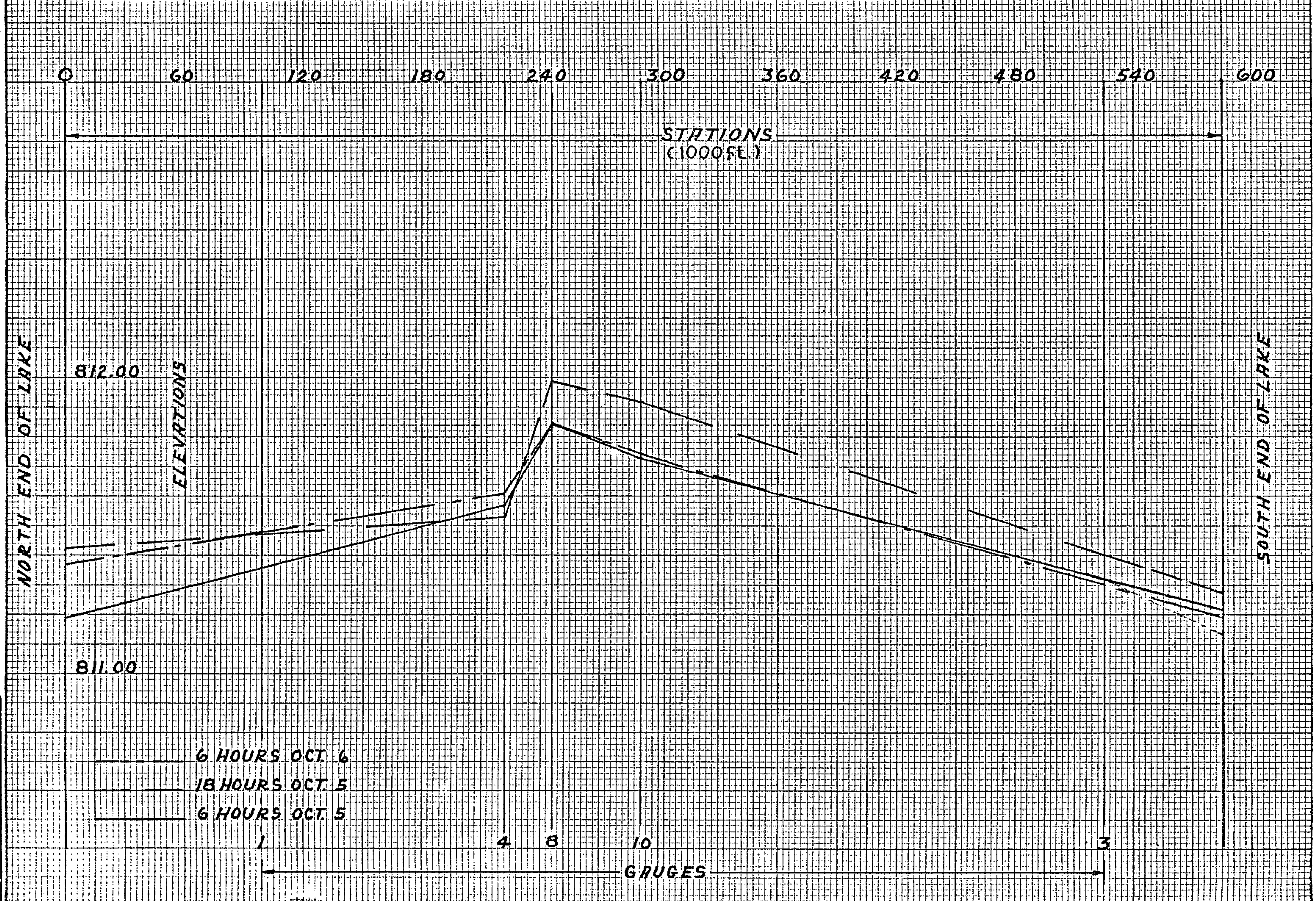

LAKE MANITOBA
HOURLY WATER LEVELS
vs
TIME
4,8,10-Water Level Gauges
813.0
812.0
811.0
810.0
ELEVATION
WIND VELOCITY M.P.H.
vs
TIME Hrs.
20
15
10
5
0
WIND VELOCITY
N.
DAUPHIN
PORTAGE
TIME (Hrs.)
12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12

Oct. 31, 1966

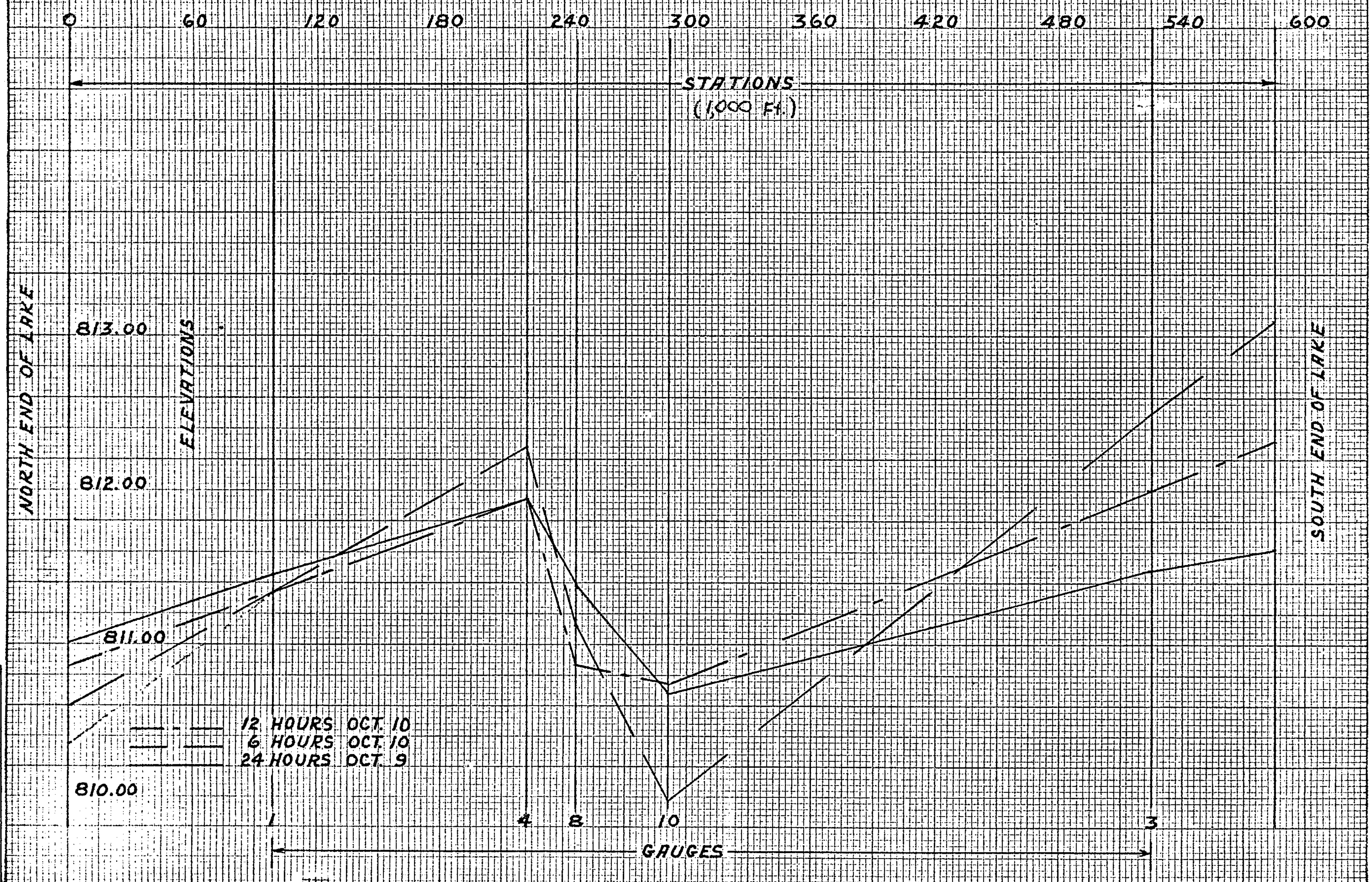
LAKE PROFILE — NORTH WIND OCTOBER 3, 4, 1966.



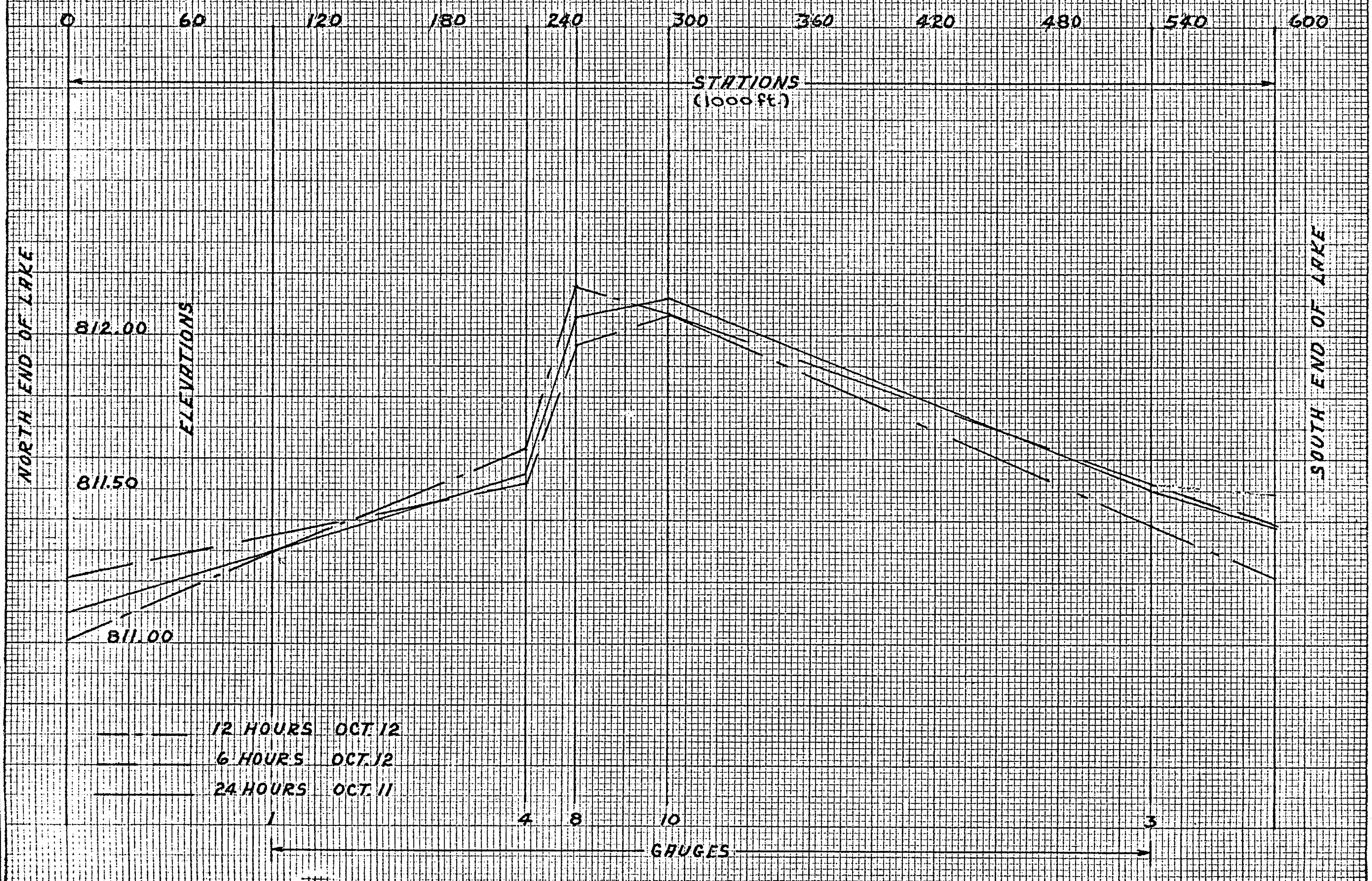
LAKE PROFILE - SOUTH WIND OCTOBER 4, 5, 6, 1966.



LAKE PROFILE - NORTH WIND OCTOBER 9,-10, 1966.



LAKE PROFILE - SOUTH WIND OCTOBER 11, 12, 1966

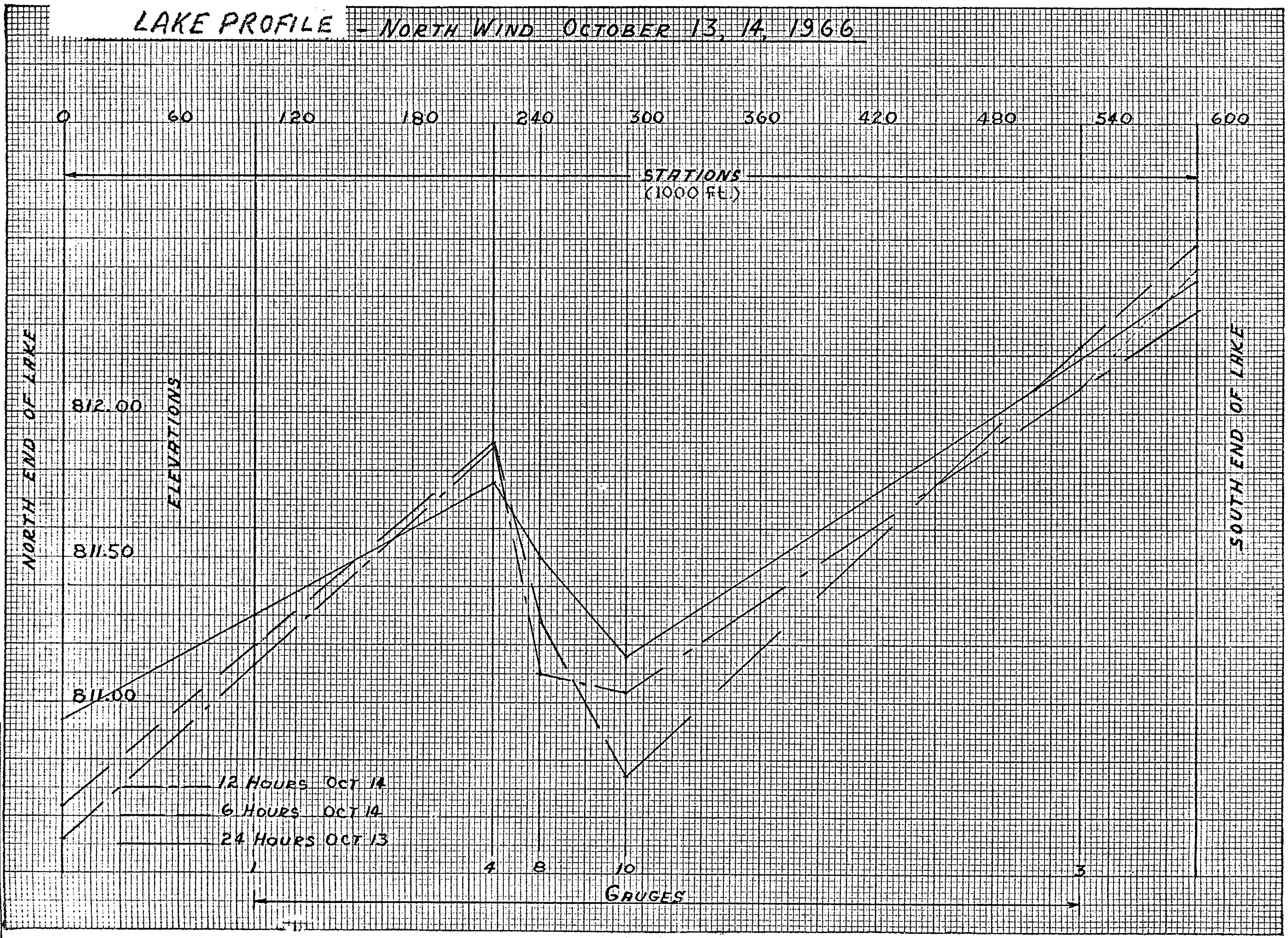


Graph No 22

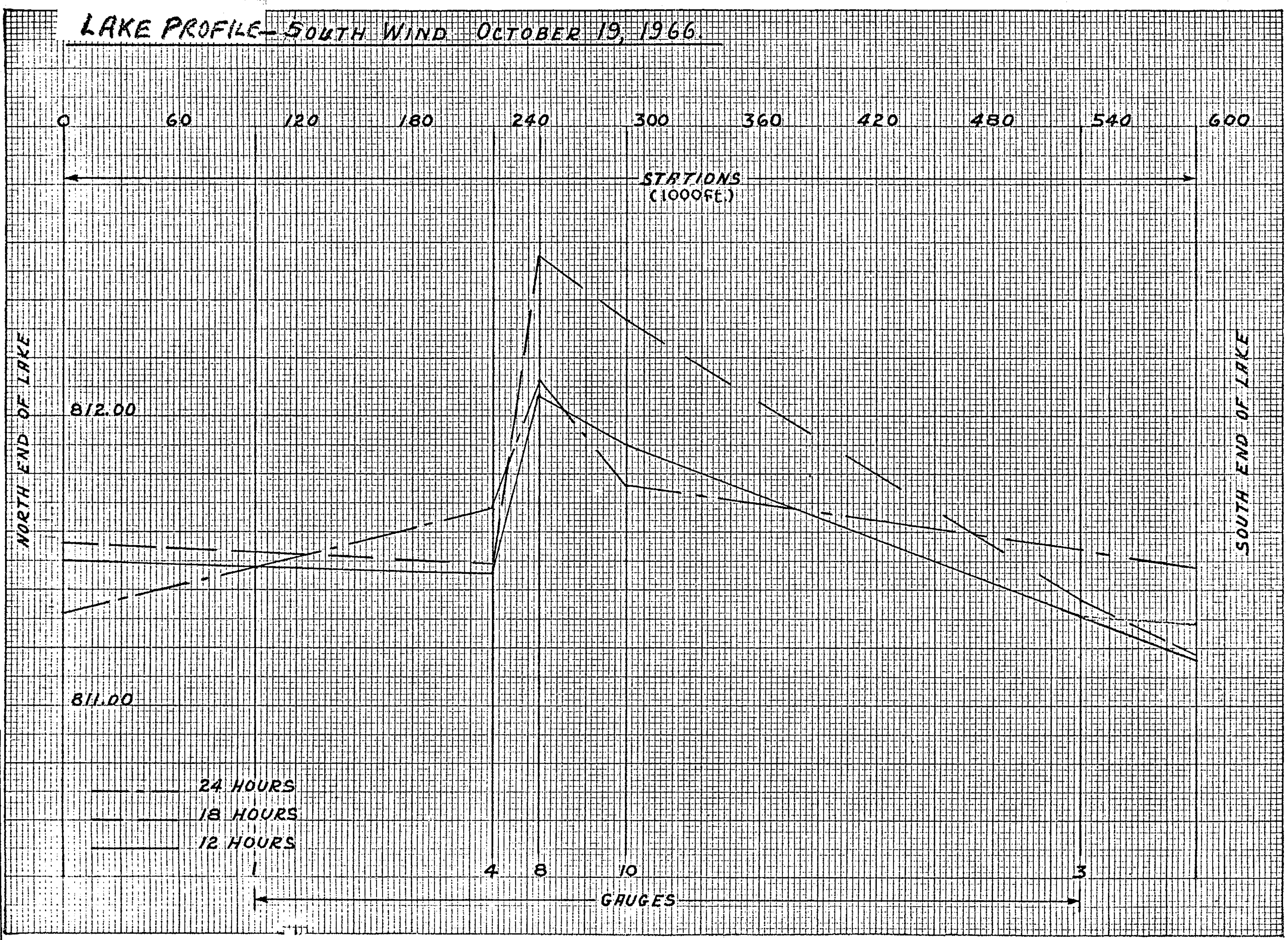
THIS MARGIN RESERVED FOR BINDING.

IF SHEET IS READ THIS WAY (HORIZONTALLY), THIS MUST BE TOP.

IF SHEET IS READ THE OTHER WAY (VERTICALLY), THIS MUST BE LEFT-HAND SIDE.

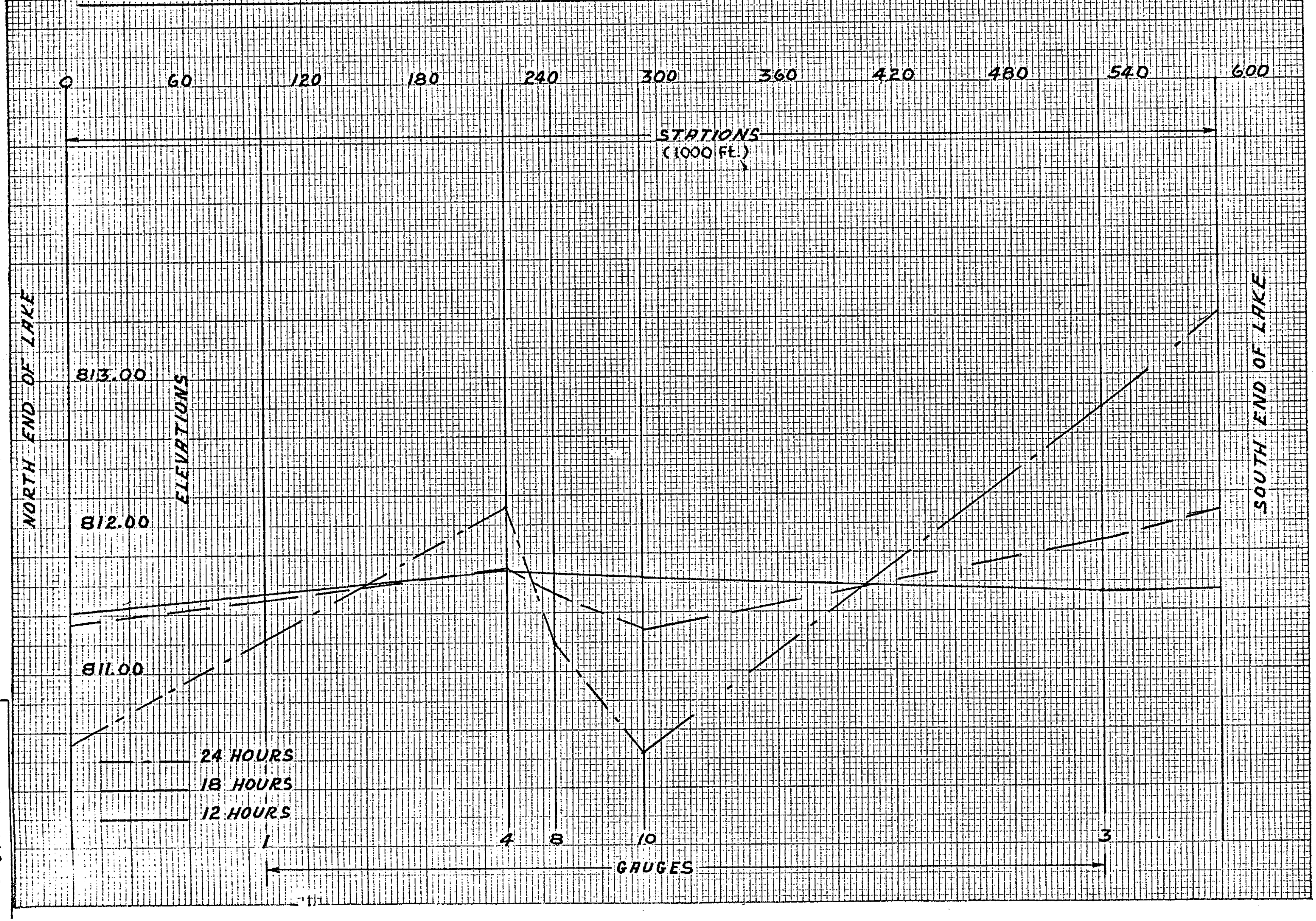


Graph Nº 23


LAKE PROFILE - SOUTH WIND OCTOBER 19, 1966.
0
60
120
180
240
300
360
420
480
540
600
STATIONS
(1000 ft.)
NORTH END OF LAKE
SOUTH END OF LAKE
812.00
811.00
24 HOURS
18 HOURS
12 HOURS
1
4
8
10
3
GAUGES

Graph No 24

LAKE PROFILE - NORTH WIND OCTOBER 21, 1966.



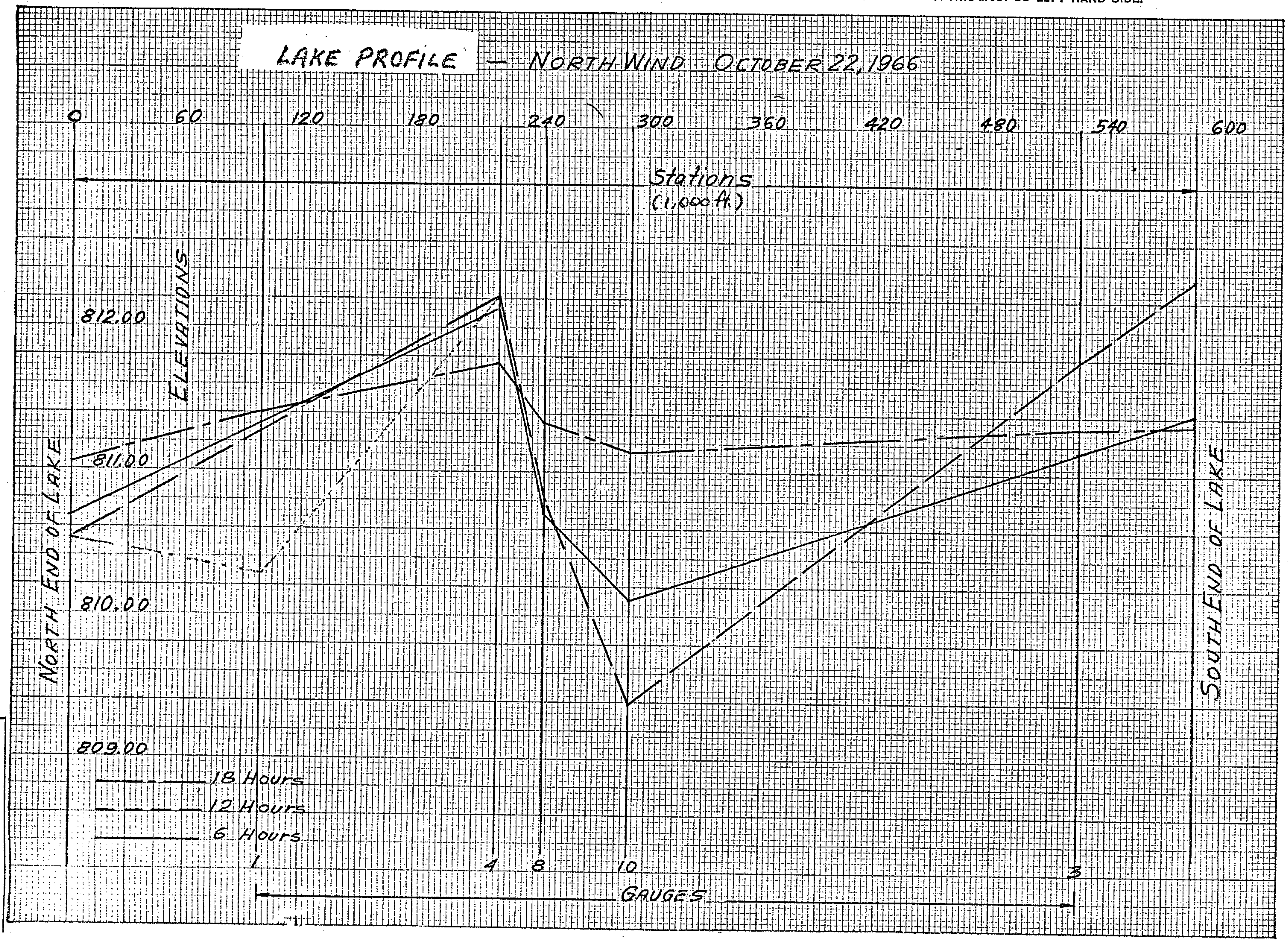
Graph No 25

40

THIS MARGIN RESERVED FOR BINDING.

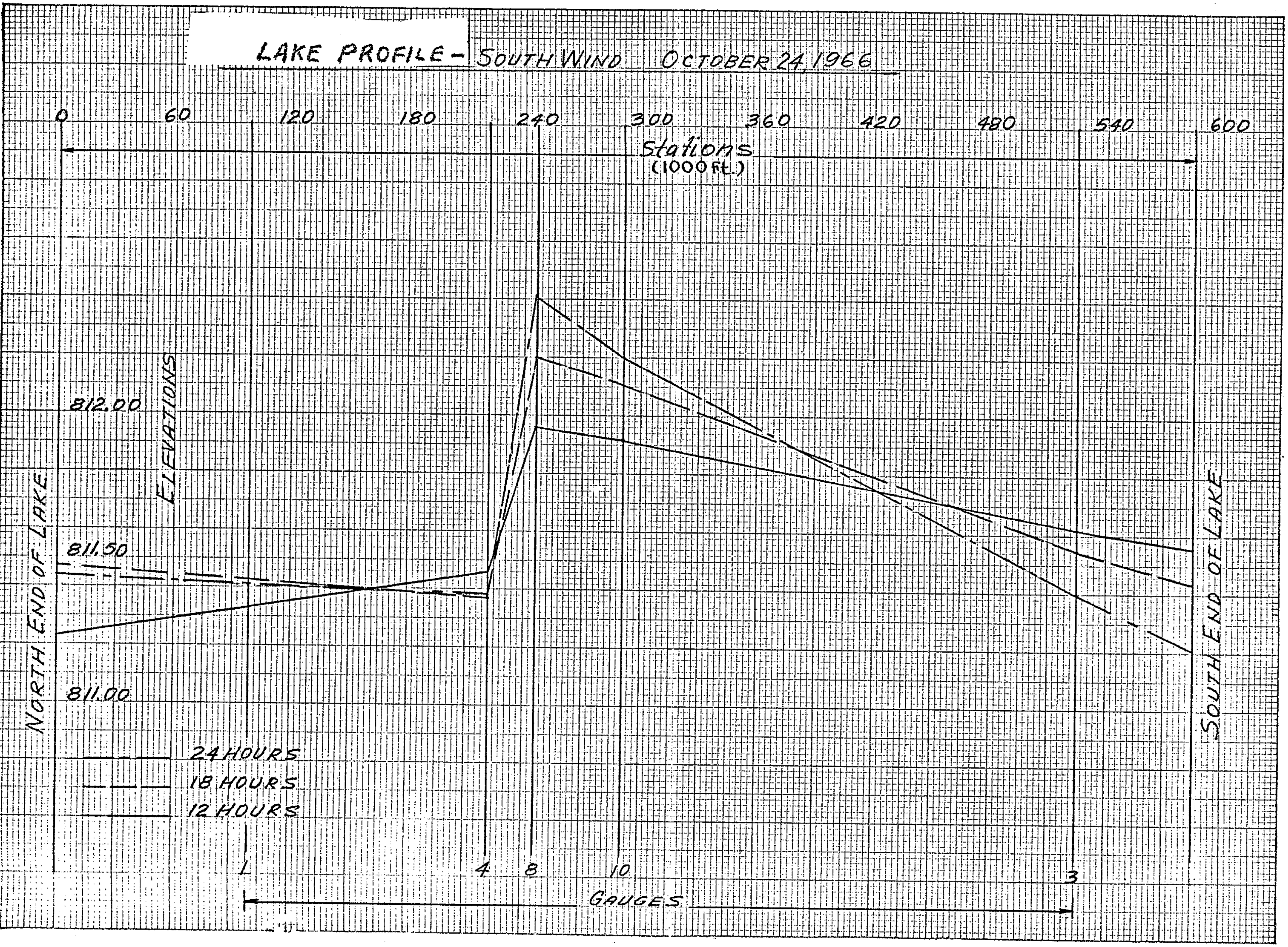
IF SHEET IS READ THIS WAY (HORIZONTALLY), THIS MUST BE TOP.

IF SHEET IS READ THE OTHER WAY (VERTICALLY), THIS MUST BE LEFT-HAND SIDE.



MANUFACTURED BY RENOUF PUBLISHING CO., MONTREAL

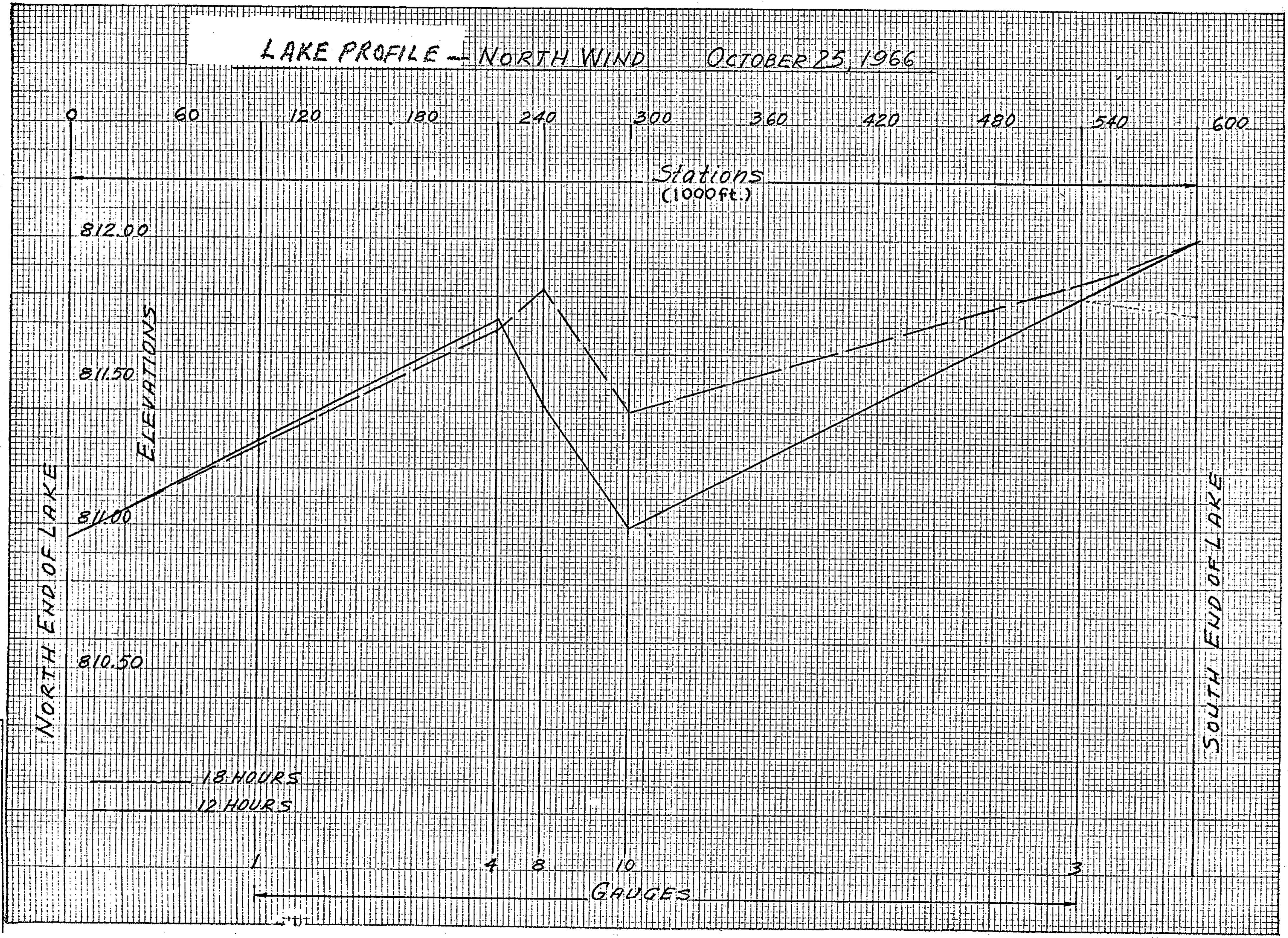
FORM 100


LAKE PROFILE - SOUTH WIND OCTOBER 24, 1966
0
60
120
180
240
300
360
420
480
540
600
Stations
(1000 ft.)
ELEVATIONS
812.00
811.50
811.00
NORTH END OF LAKE
SOUTH END OF LAKE
24 HOURS
18 HOURS
12 HOURS
1
4
8
10
3
GAUGES

THIS MARGIN RESERVED FOR BINDING.

IF SHEET IS READ THIS WAY (HORIZONTALLY), THIS MUST BE TOP.

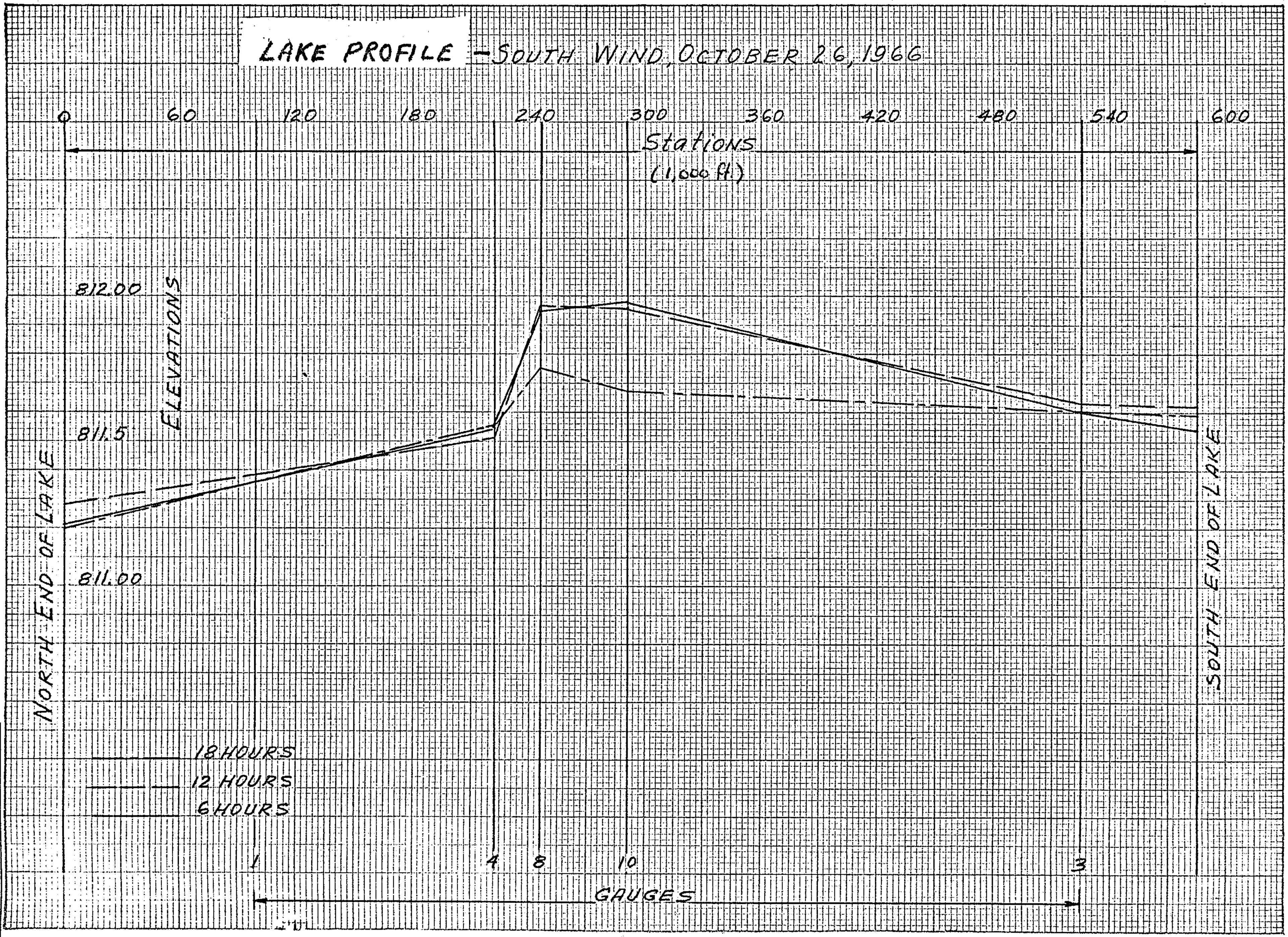
IF SHEET IS READ THE OTHER WAY (VERTICALLY), THIS MUST BE LEFT-HAND SIDE.



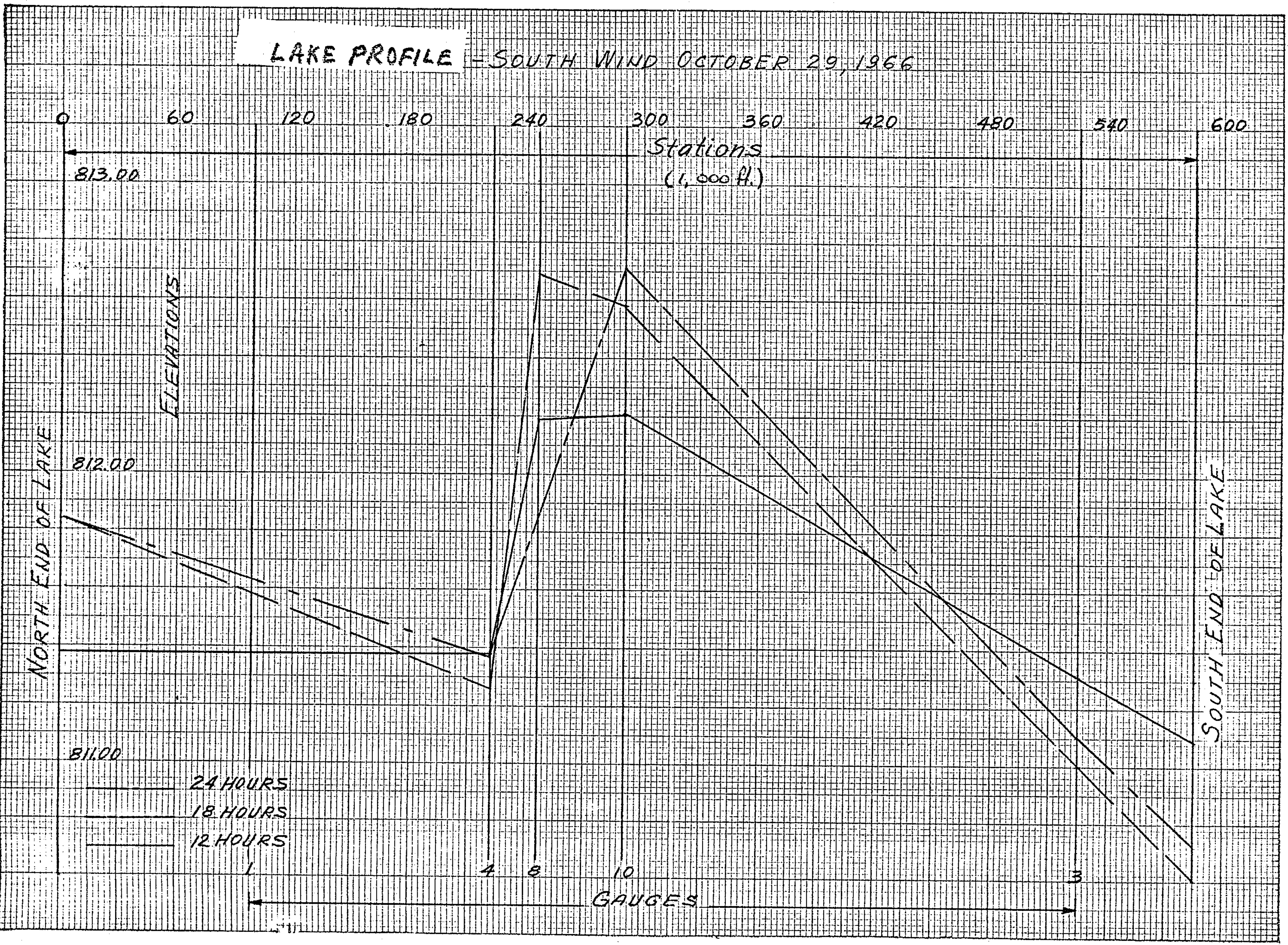
MANUFACTURED BY, RENOUF PUBLISHING CO., MONTREAL

FORM 100

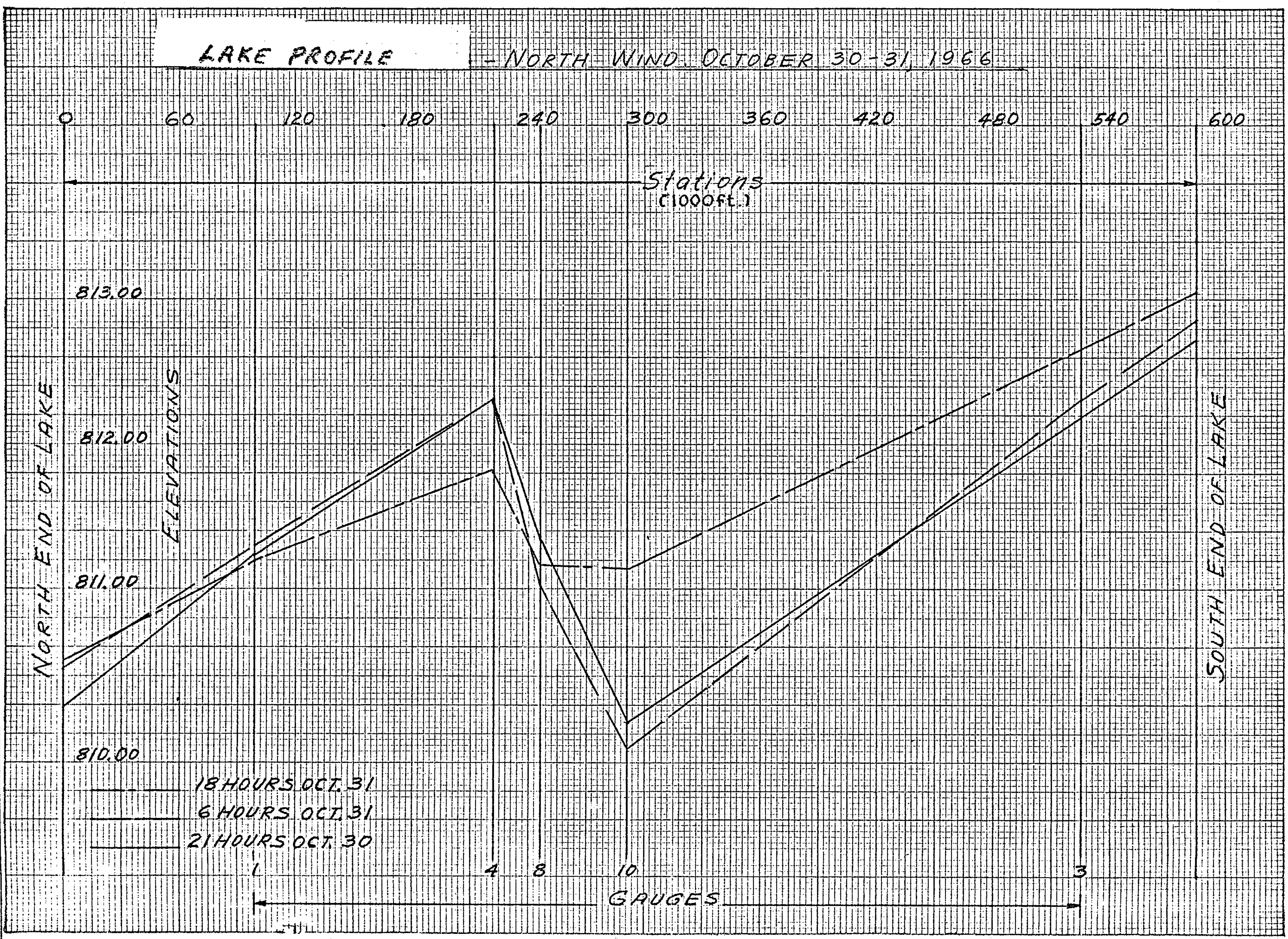
Graph No 28


LAKE PROFILE - SOUTH WIND, OCTOBER 26, 1966
0
60
120
180
240
300
360
420
480
540
600
Stations
(1,000 ft.)
812.00
811.5
811.00
ELEVATIONS
NORTH END OF LAKE
SOUTH END OF LAKE
18 HOURS
12 HOURS
6 HOURS
1
4
8
10
3
GAUGES

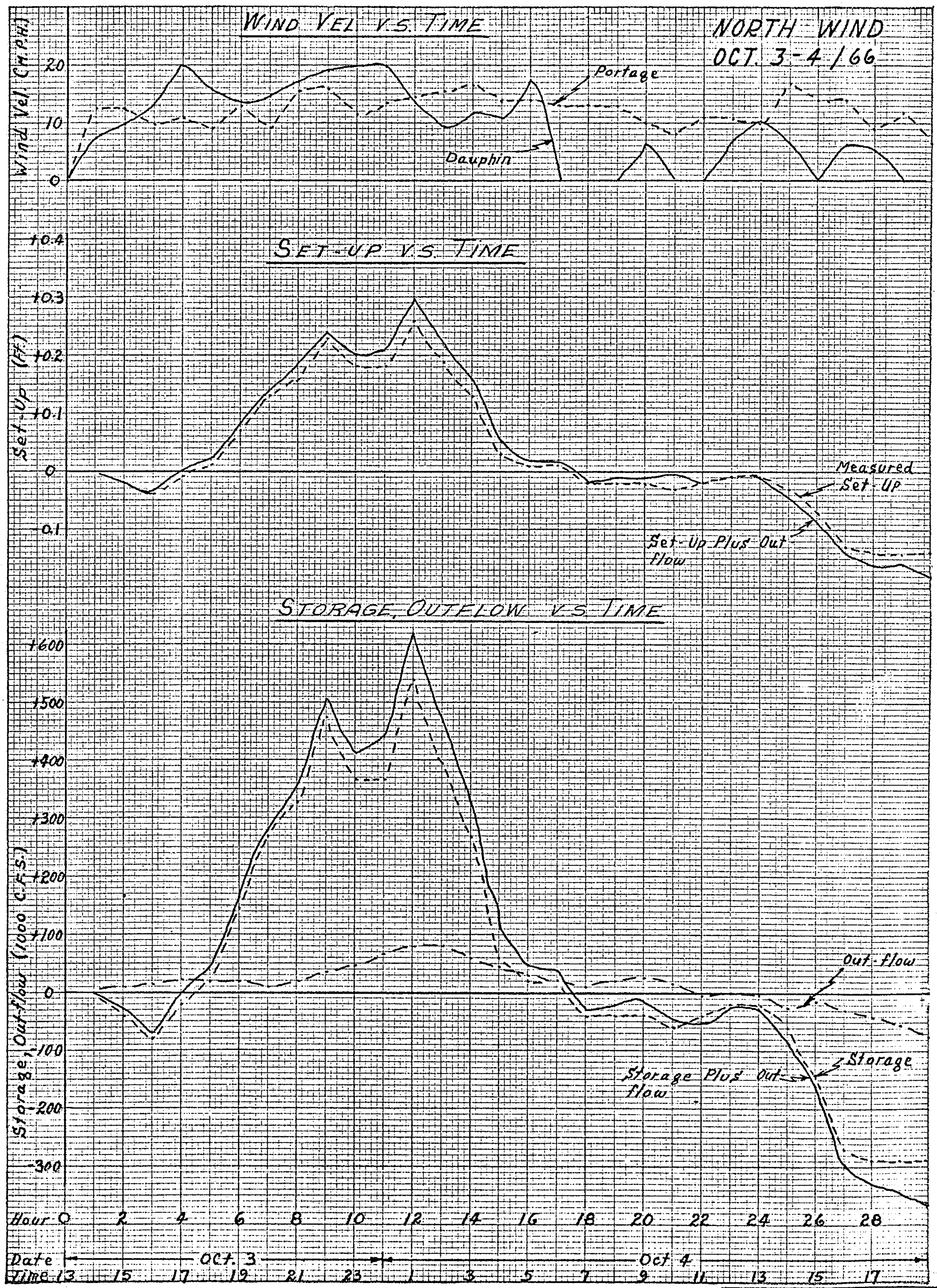
Graph No 29


LAKE PROFILE - SOUTH WIND OCTOBER 29, 1966
0
60
120
180
240
300
360
420
480
540
600
Stations
(1,000 ft.)
813.00
812.00
811.00
ELEVATIONS
NORTH END OF LAKE
SOUTH END OF LAKE
24 HOURS
18 HOURS
12 HOURS
1
4
8
10
3
GAUGES

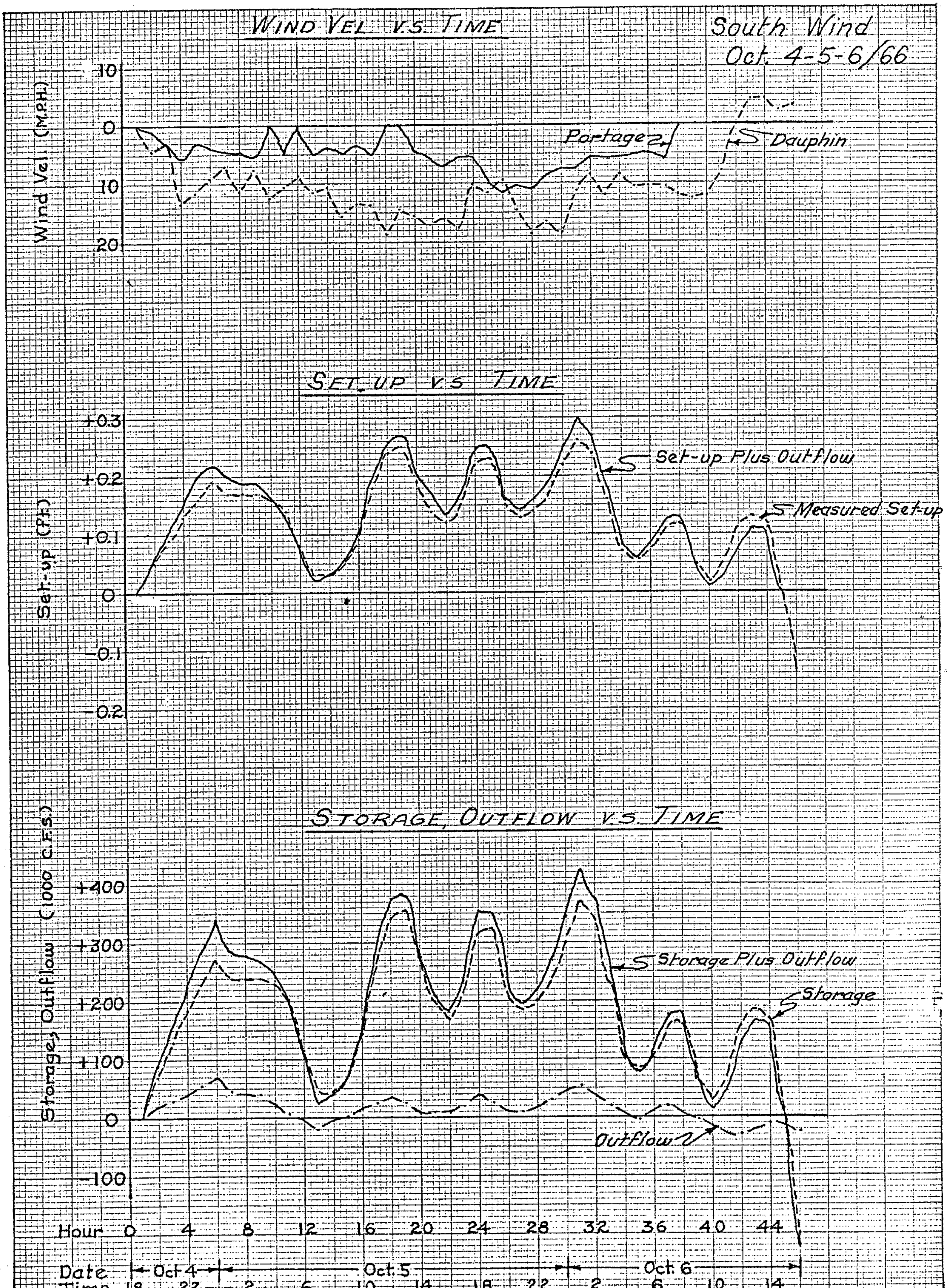
Graph No 30


LAKE PROFILE - NORTH WIND OCTOBER 30-31, 1966
0
60
120
180
240
300
360
420
480
540
600
Stations
(1000 ft.)
813.00
812.00
811.00
810.00
NORTH END OF LAKE
ELEVATIONS
SOUTH END OF LAKE
18 HOURS OCT. 31
6 HOURS OCT. 31
21 HOURS OCT. 30
1
4
8
10
3
GAUGES

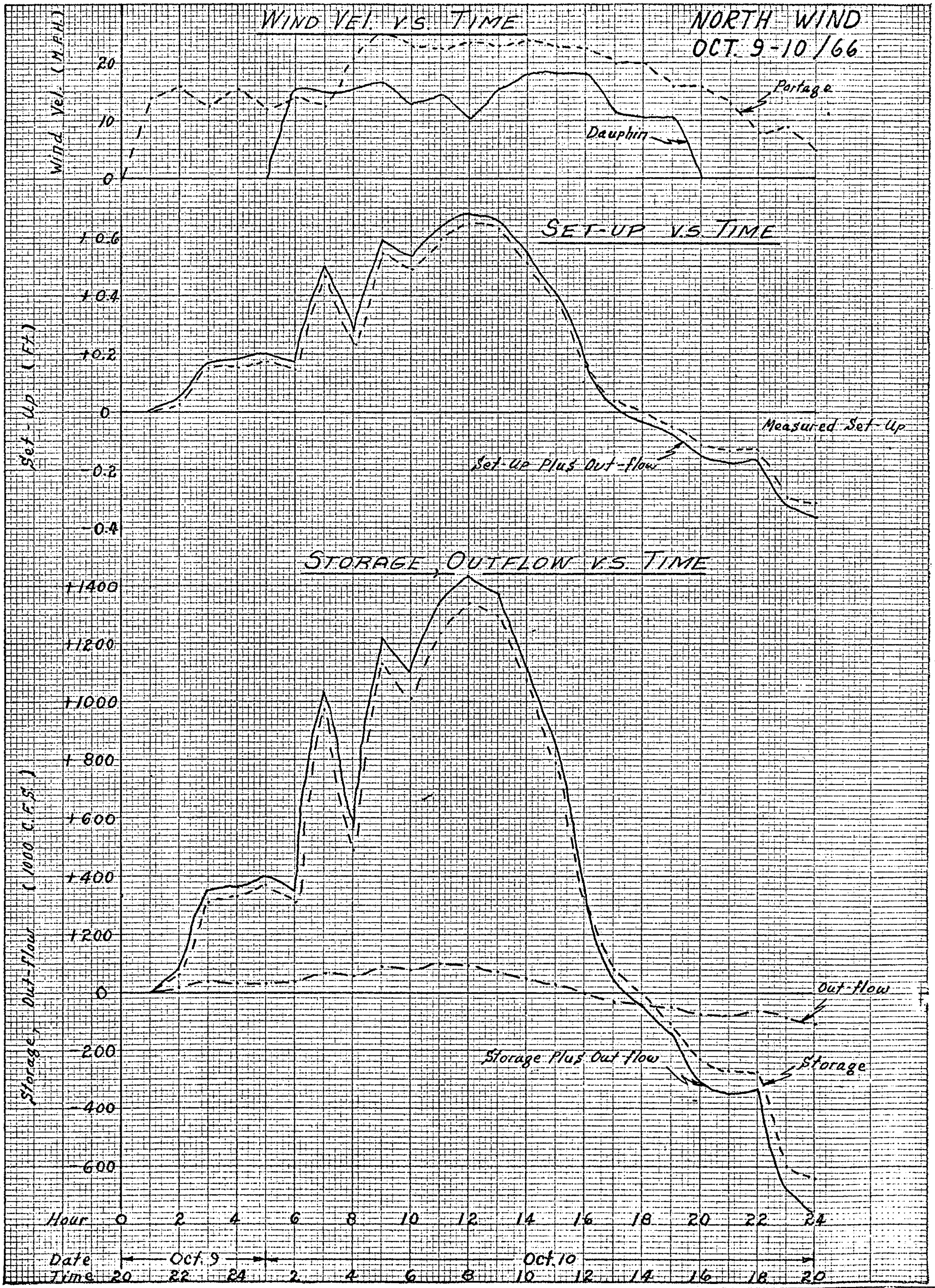
Graph No 31


WIND VEL V.S. TIME
NORTH WIND
OCT. 3-4/66
Wind Vel. (M.P.H.)
20
10
0
Portage
Dauphin
SET-UP V.S. TIME
Set-Up (Ft.)
+0.4
+0.3
+0.2
+0.1
0
-0.1
Measured Set-Up
Set-Up Plus Out flow
STORAGE, OUTFLOW V.S. TIME
Storage, Out-flow (1000 C.F.S.)
+600
+500
+400
+300
+200
+100
0
-100
-200
-300
Out-flow
Storage
Storage Plus Out-flow
Hour 0 2 4 6 8 10 12 14 16 18 20 22 24 26 28
Date OCT. 3 Oct 4
Time 13 15 17 19 21 23 1 3 5 7 9 11 13 15 17

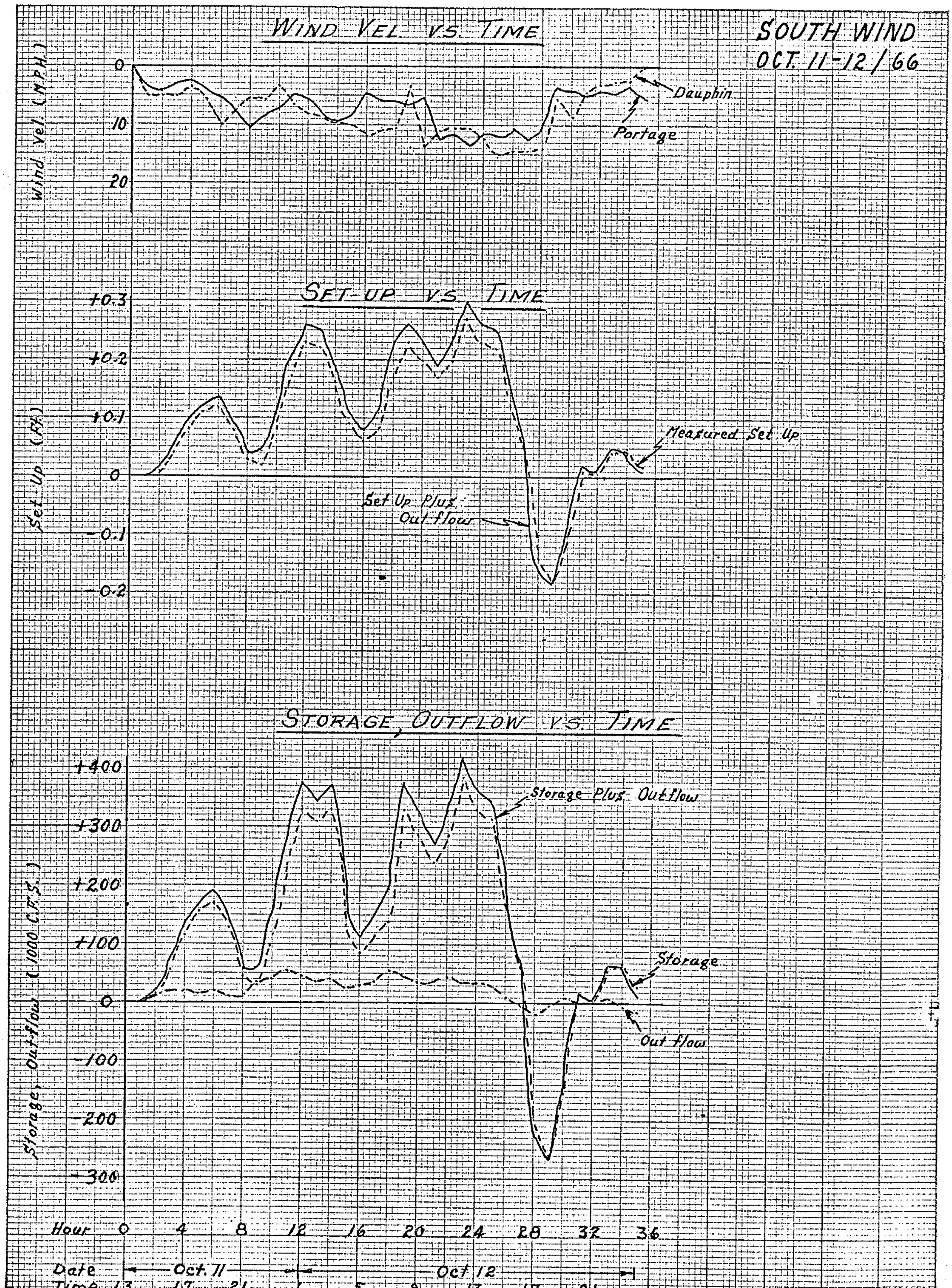
Graph No. 32


WIND VEL V.S. TIME
South Wind
Oct. 4-5-6/66
Wind Vel. (M.P.H.)
10
0
10
20
Portage
Dauphin
SET-UP V.S. TIME
Set-up (Ft.)
+0.3
+0.2
+0.1
0
-0.1
-0.2
Set-up Plus Outflow
Measured Set-up
STORAGE, OUTFLOW V.S. TIME
Storage, Outflow (1000 C.F.S.)
+400
+300
+200
+100
0
-100
Storage Plus Outflow
Storage
Outflow
Hour 0 4 8 12 16 20 24 28 32 36 40 44
Date Oct 4 Oct. 5 Oct. 6
Time 18 22 2 6 10 14 18 22 2 6 10 14

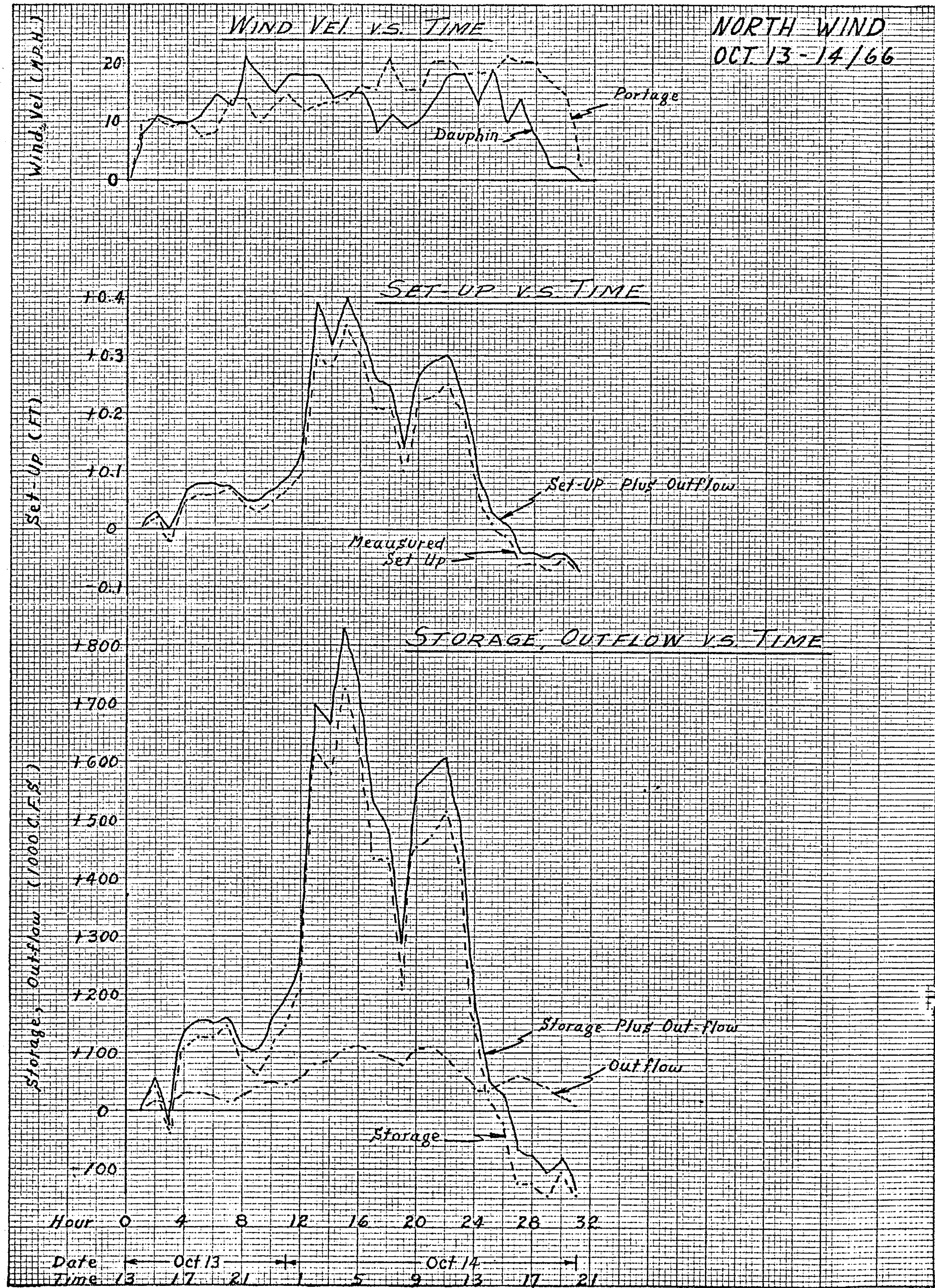
Graph No 33

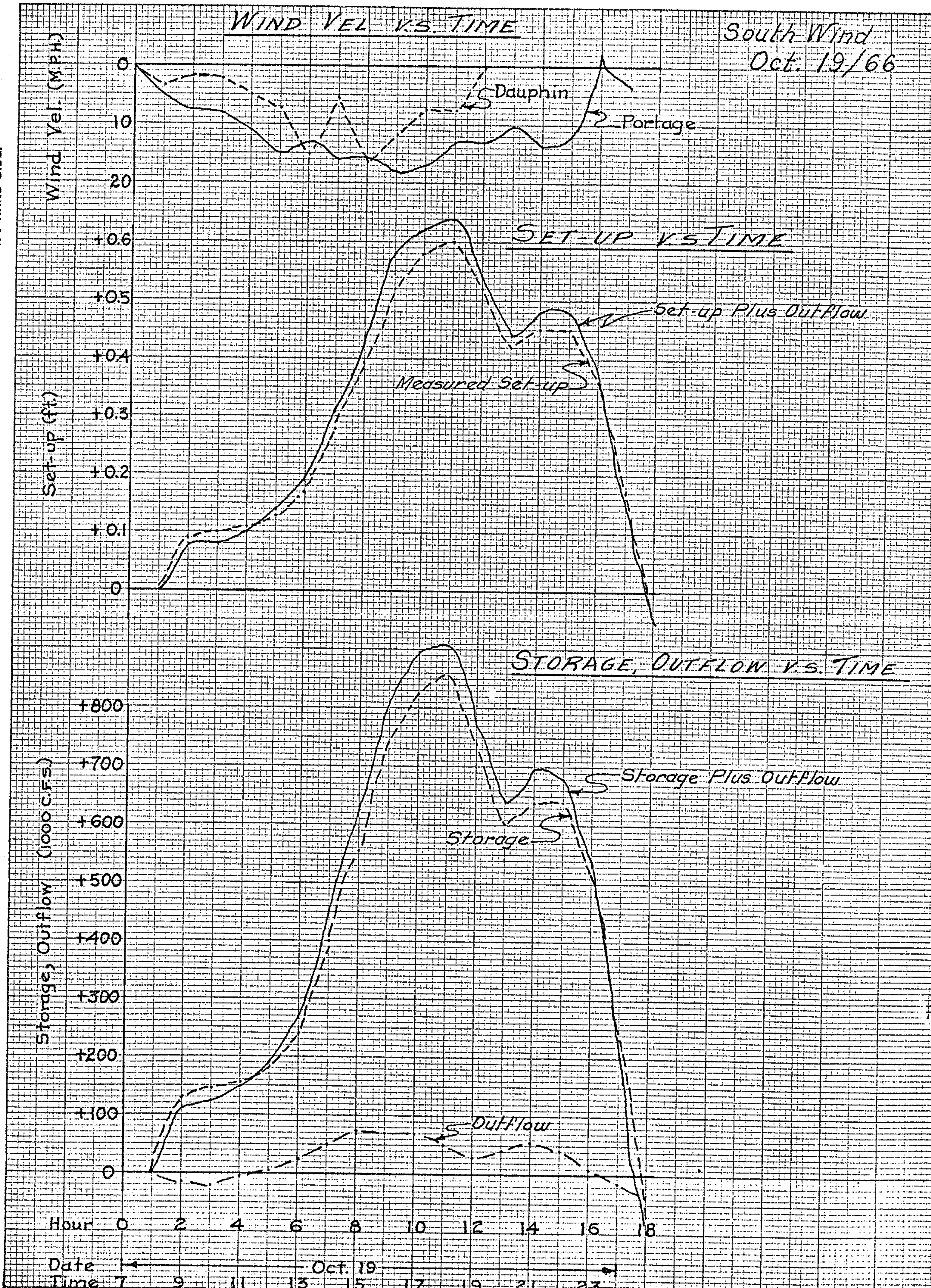

WIND VEL. V.S. TIME
NORTH WIND
OCT. 9-10/66
Wind Vel. (M.P.H.)
20
10
0
Portage
Dauphin
SET-UP V.S. TIME
Set-Up (Ft.)
+0.6
+0.4
+0.2
0
-0.2
-0.4
Measured Set-Up
Set-Up Plus Out-flow
STORAGE, OUTFLOW V.S. TIME
Storage, Out-flow (1000 C.F.S.)
+1400
+1200
+1000
+800
+600
+400
+200
0
-200
-400
-600
Out-flow
Storage Plus Out flow
Storage
Hour 0 2 4 6 8 10 12 14 16 18 20 22 24
Date Oct. 9 Oct. 10
Time 20 22 24 2 4 6 8 10 12 14 16 18 20

Graph No. 34

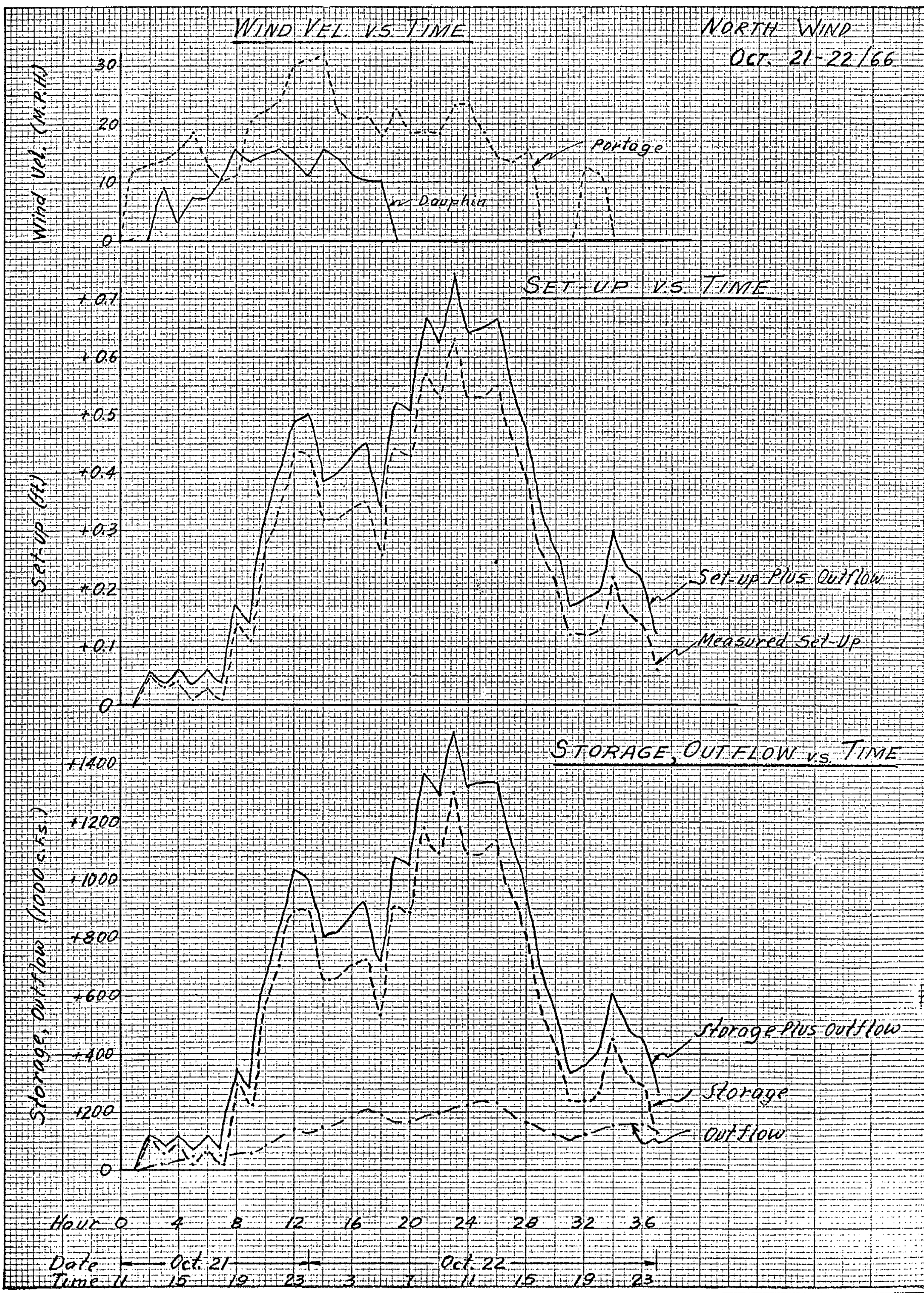

WIND VEL. VS. TIME
SOUTH WIND
OCT. 11-12/66
Wind Vel. (MPH)
0
10
20
Dauphin
Portage
SET-UP VS. TIME
Set Up (Ft.)
+0.3
+0.2
+0.1
0
-0.1
-0.2
Measured Set Up
Set Up Plus Out flow
STORAGE, OUTFLOW VS. TIME
Storage, Out-flow (1000 C.F.S.)
+400
+300
+200
+100
0
-100
-200
-300
Storage Plus Outflow
Storage
Out flow
Hour 0 4 8 12 16 20 24 28 32 36
Date Oct. 11 Oct. 12
Time 13 17 21 1 5 9 13 17 21

Graph No. 35

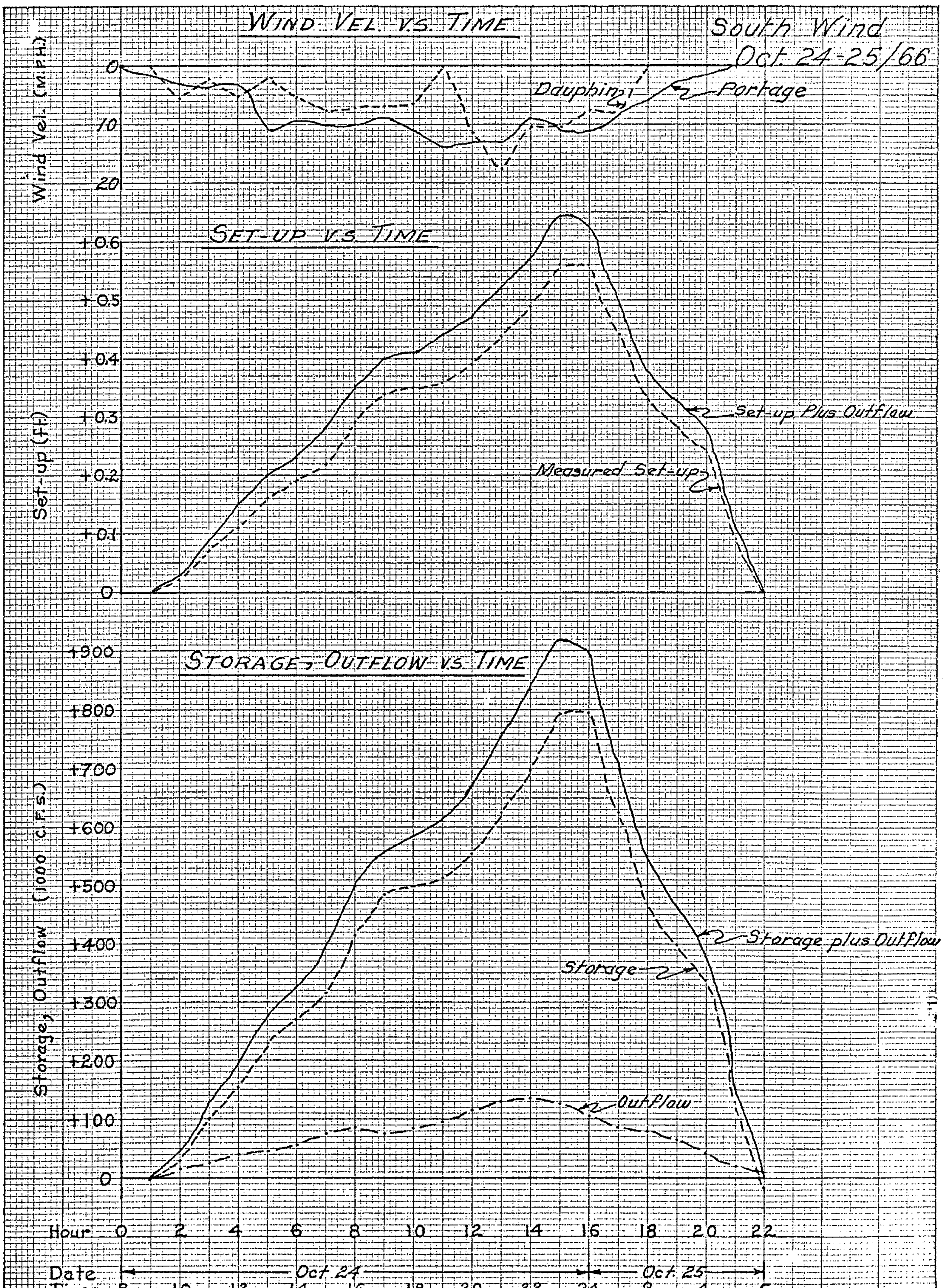

WIND VEL. V.S. TIME
NORTH WIND
OCT. 13-14/66
Wind Vel. (M.P.H.)
20
10
0
Portage
Dauphin
SET-UP V.S. TIME
Set-Up (FT)
+0.4
+0.3
+0.2
+0.1
0
-0.1
Set-UP Plus Outflow
Meausured Set Up
STORAGE, OUTFLOW V.S. TIME
Storage, Outflow (1000 C.F.S.)
+800
+700
+600
+500
+400
+300
+200
+100
0
-100
Storage Plus Out-flow
Outflow
Storage
Hour 0 4 8 12 16 20 24 28 32
Date Oct 13 Oct 14
Time 13 17 21 1 5 9 13 17 21


WIND VEL V.S. TIME
South Wind
Oct. 19/66
Wind Vel. (M.P.H.)
0
10
20
Dauphin
Portage
SET-UP V.S TIME
Set-up (ft.)
+0.6
+0.5
+0.4
+0.3
+0.2
+0.1
0
Set-up Plus Outflow
Measured Set-up
STORAGE, OUTFLOW V.S. TIME
Storage, Outflow (1000 C.F.S.)
+800
+700
+600
+500
+400
+300
+200
+100
0
Storage Plus Outflow
Storage
Outflow
Hour 0 2 4 6 8 10 12 14 16 18
Date
Oct. 19
Time 7 9 11 13 15 17 19 21 23

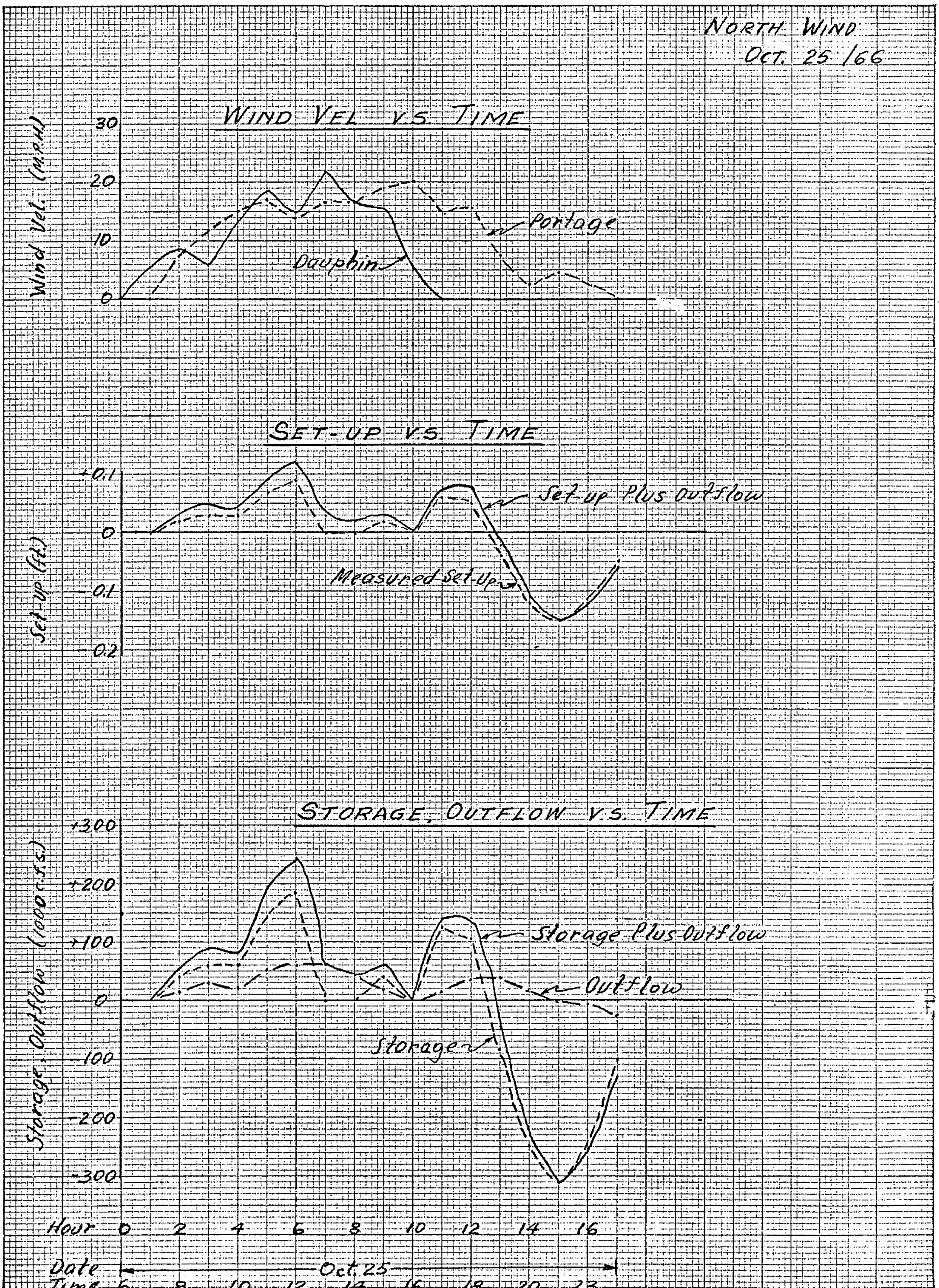
Graph No 37


WIND VEL. V.S. TIME
NORTH WIND
Oct. 21-22/66
Wind Vel. (M.P.H.)
30
20
10
0
Portage
Dauphin
SET-UP V.S. TIME
Set-up (ft.)
+0.7
+0.6
+0.5
+0.4
+0.3
+0.2
+0.1
0
Set-up Plus Outflow
Measured Set-Up
STORAGE, OUTFLOW V.S. TIME
Storage, Outflow (1000 c.f.s.)
+1400
+1200
+1000
+800
+600
+400
+200
0
Storage Plus Outflow
Storage
Outflow
Hour 0 4 8 12 16 20 24 28 32 36
Date Oct. 21 Oct. 22
Time 11 15 19 23 3 7 11 15 19 23

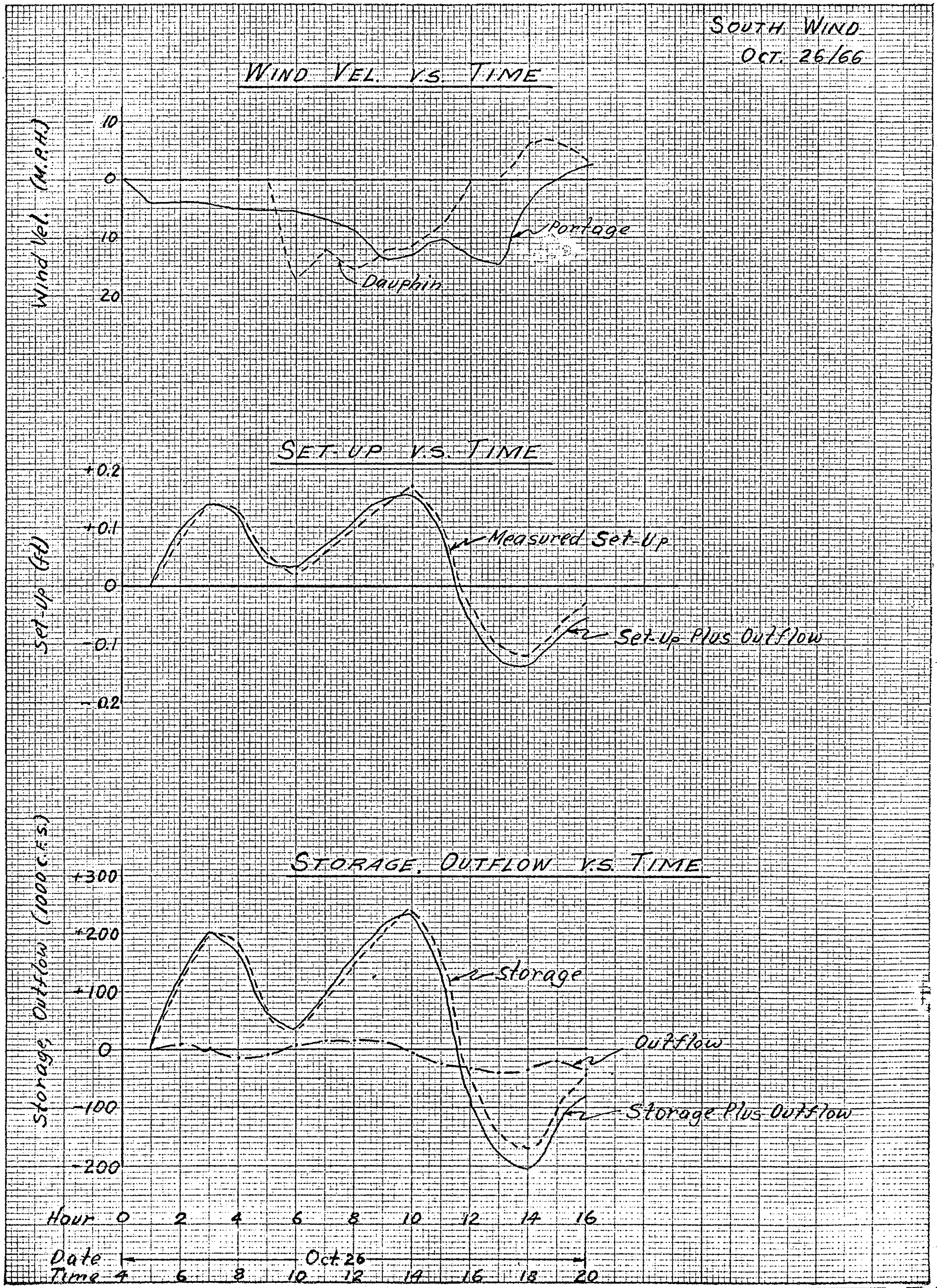
Graph No 38

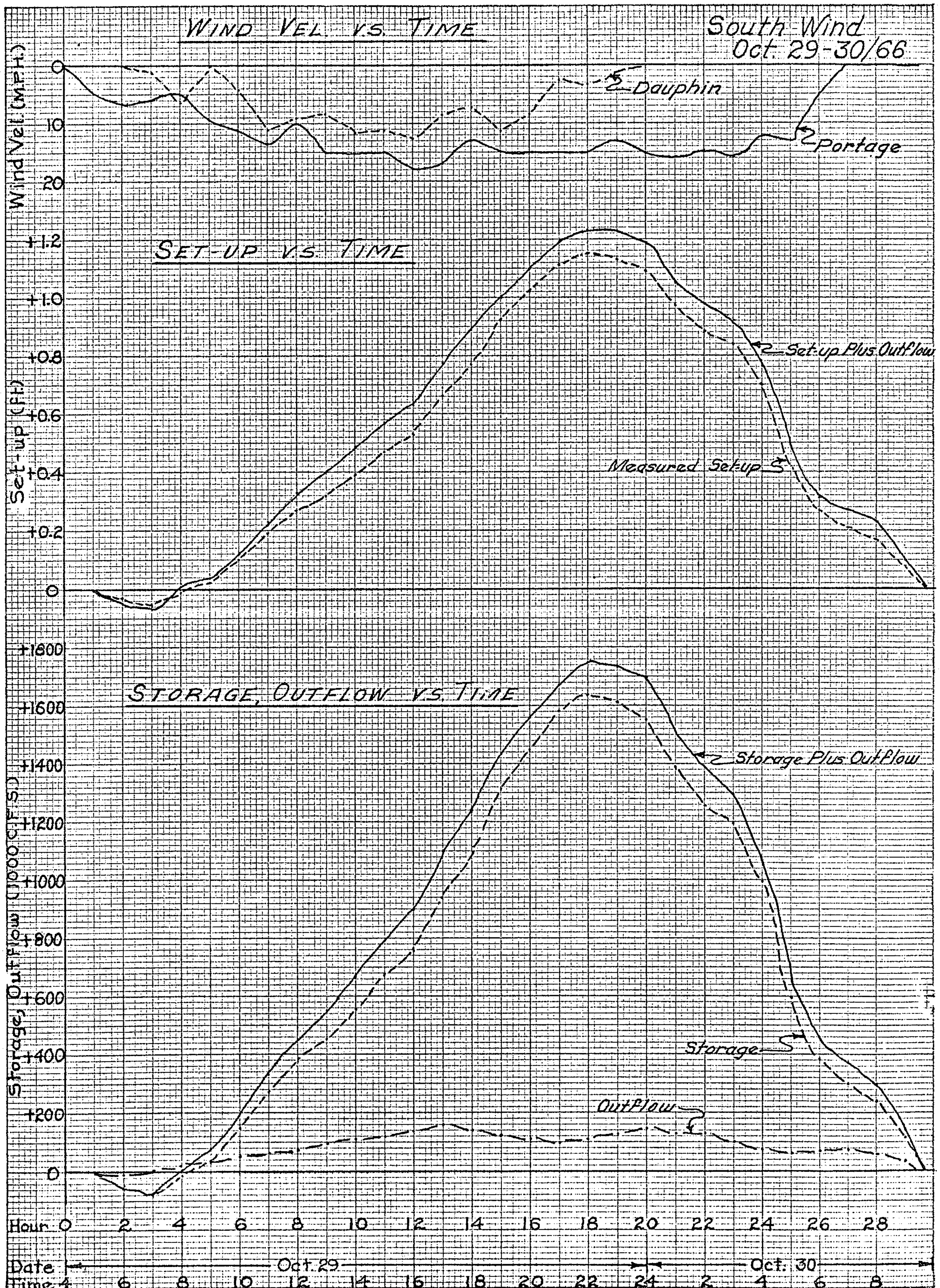

WIND VEL. VS. TIME
South Wind
Oct 24-25/66
Wind Vel. (M.P.H.)
0
10
20
Dauphin
Portage
SET-UP VS. TIME
Set-up (Ft)
+0.6
+0.5
+0.4
+0.3
+0.2
+0.1
0
Set-up Plus Outflow
Measured Set-up
STORAGE, OUTFLOW VS. TIME
Storage, Outflow (1000 C.F.S.)
+900
+800
+700
+600
+500
+400
+300
+200
+100
0
Storage plus Outflow
Storage
Outflow
Hour 0 2 4 6 8 10 12 14 16 18 20 22
Date Oct 24 Oct 25
Time 8 10 12 14 16 18 20 22 24 2 4 6

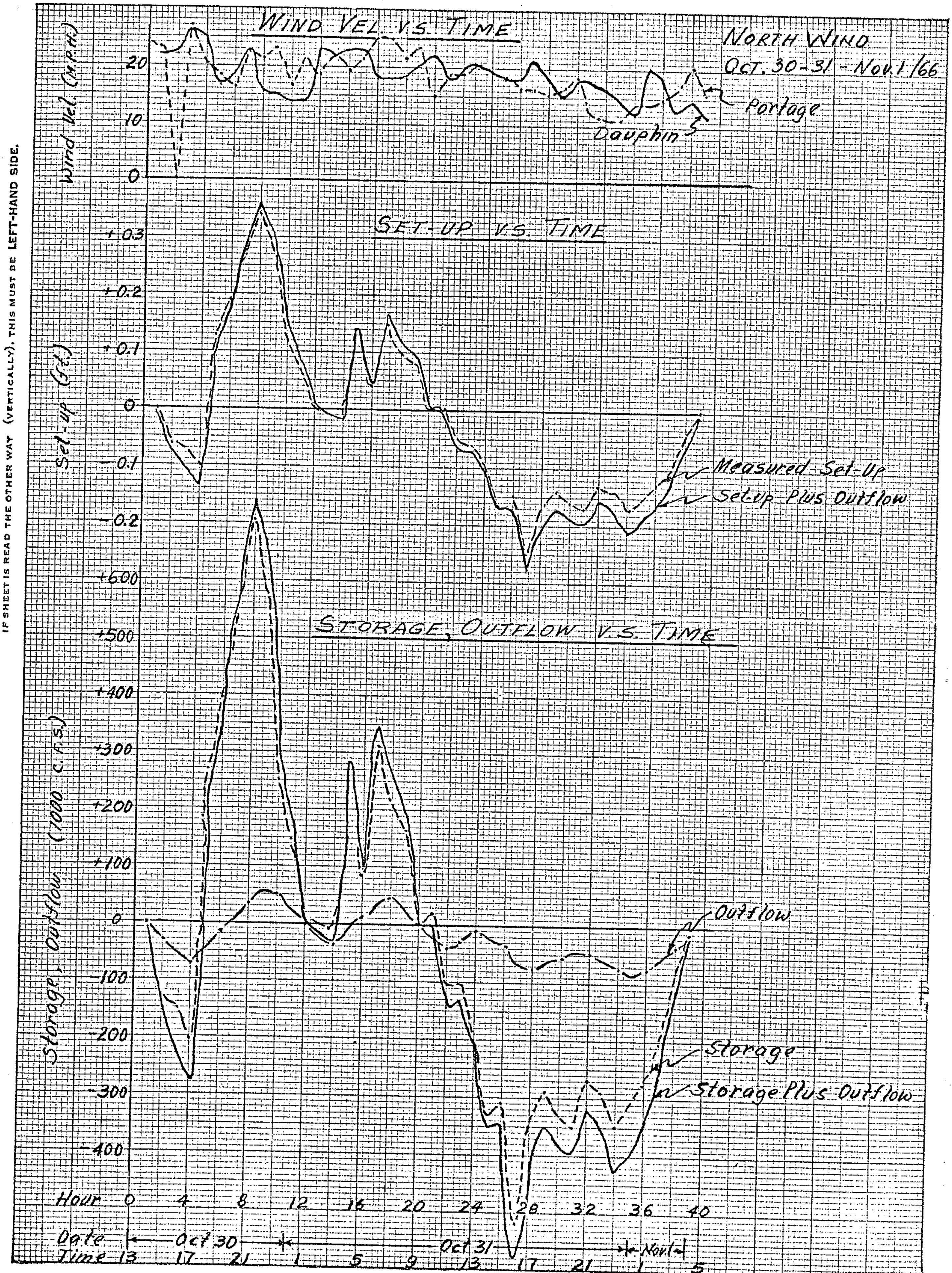
Graph No 39


NORTH WIND
OCT. 25 /66
WIND VEL V.S. TIME
Wind Vel. (m.p.h.)
30
20
10
0
Portage
Dauphin
SET-UP V.S. TIME
Set-up (ft.)
+0.1
0
-0.1
-0.2
Set-up Plus Outflow
Measured Set-Up
STORAGE, OUTFLOW V.S. TIME
Storage, Outflow (1000 c.f.s.)
+300
+200
+100
0
-100
-200
-300
Storage Plus Outflow
Outflow
Storage
Hour 0 2 4 6 8 10 12 14 16
Date Oct. 25
Time 6 8 10 12 14 16 18 20 23

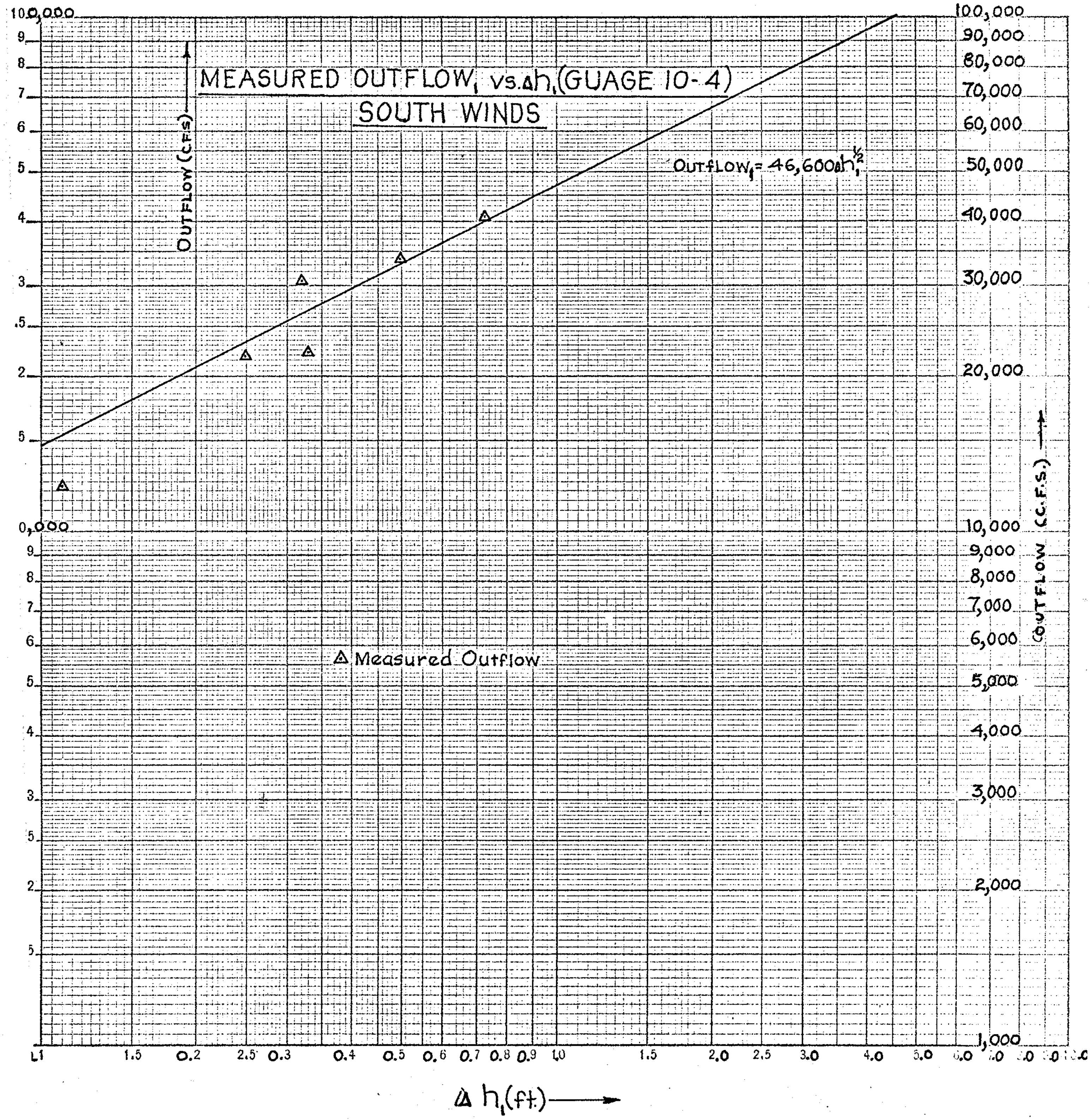
Graph Nº 40

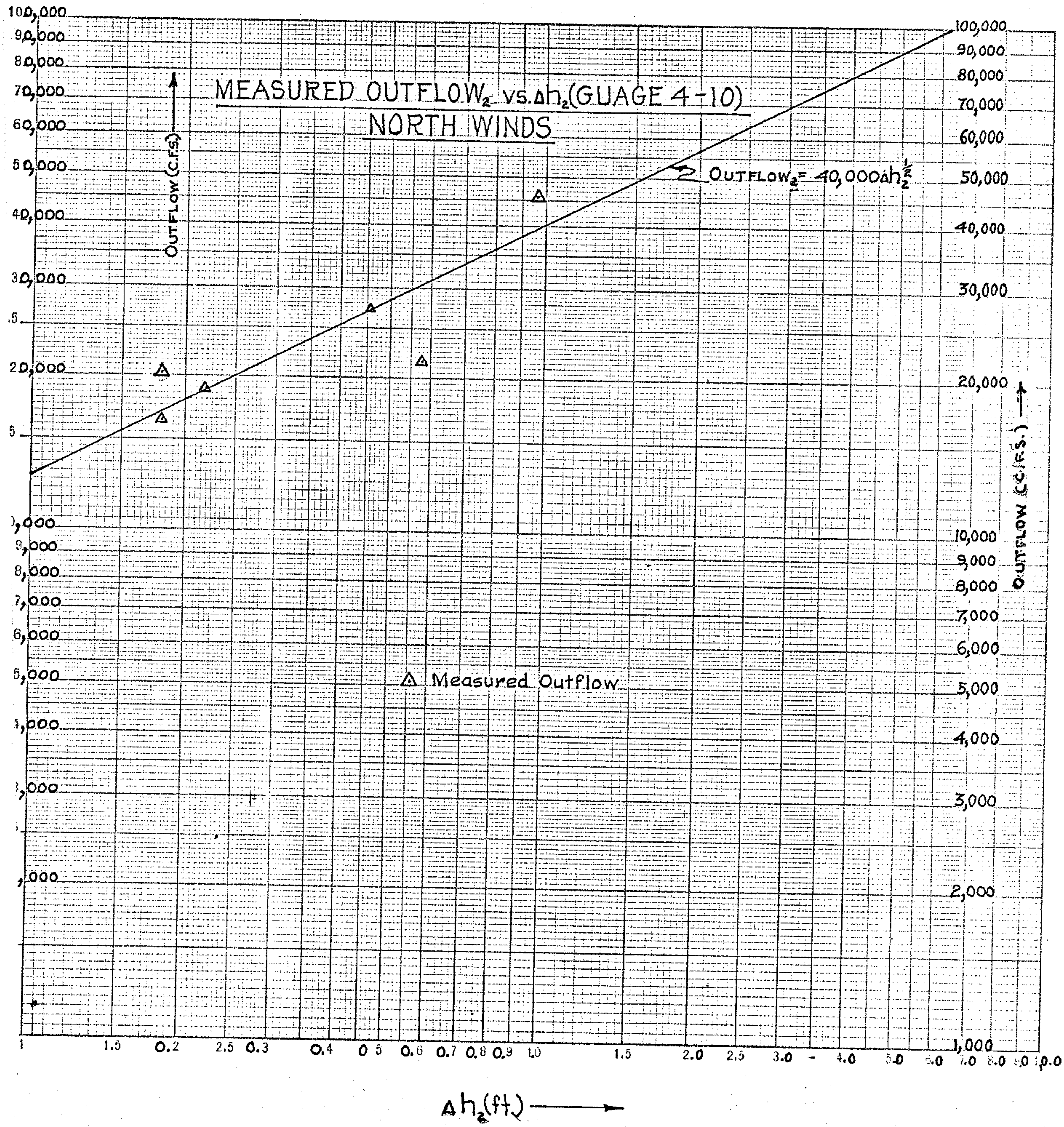

SOUTH WIND
Oct. 26/66
WIND VEL. V.S. TIME
Wind Vel. (M.P.H.)
10
0
10
20
Portage
Dauphin
SET-UP V.S. TIME
Set-Up (Ft)
+0.2
+0.1
0
-0.1
-0.2
Measured Set-Up
Set-Up Plus Outflow
STORAGE, OUTFLOW V.S. TIME
Storage, Outflow (1000 C.F.S.)
+300
+200
+100
0
-100
-200
Storage
Outflow
Storage Plus Outflow
Hour 0 2 4 6 8 10 12 14 16
Date Oct 26
Time 4 6 8 10 12 14 16 18 20

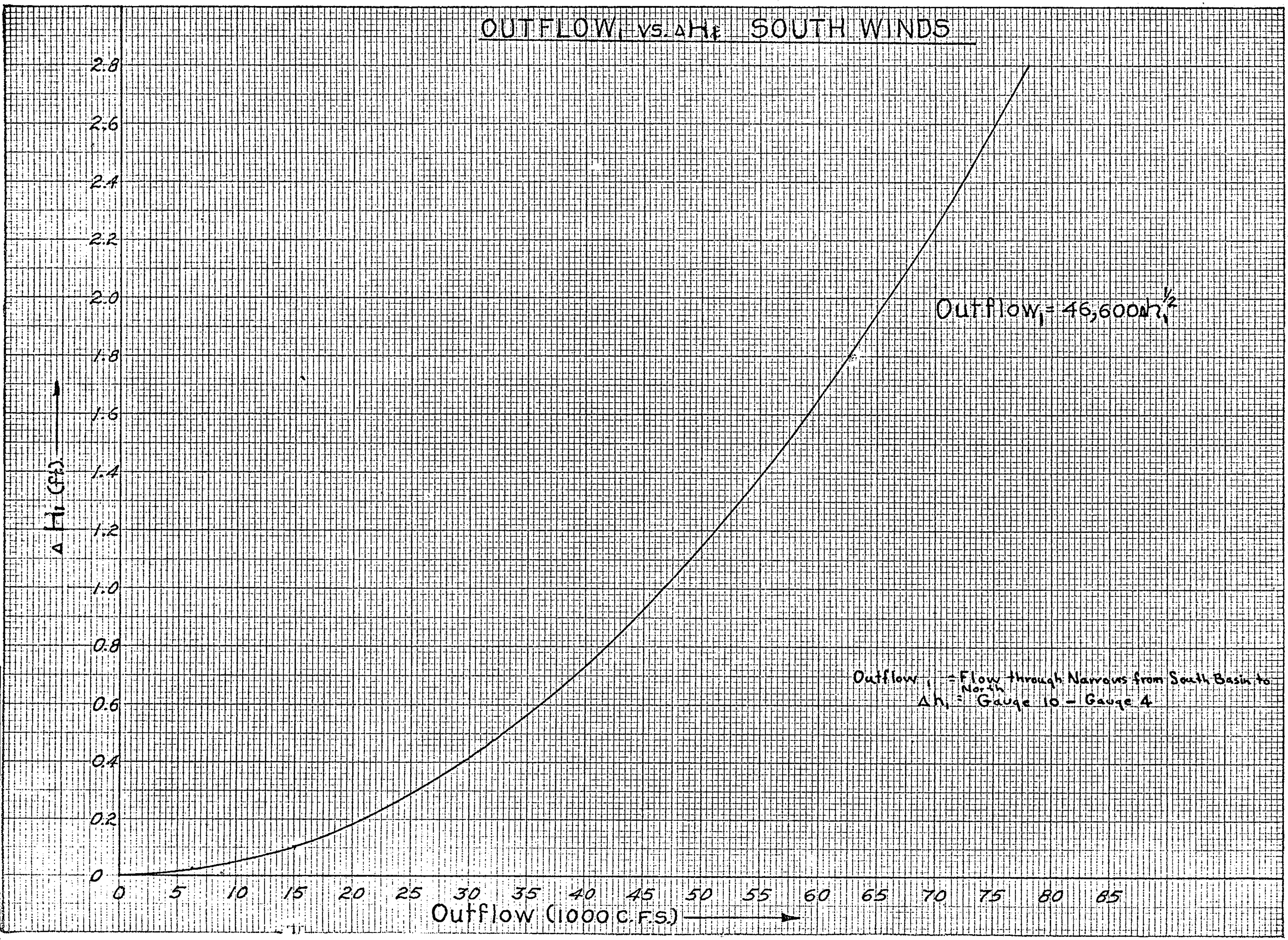

WIND VEL. VS. TIME
South Wind
Oct. 29-30/66
Wind Vel. (M.P.H.)
0
10
20
Dauphin
Portage
SET-UP VS. TIME
Set-up (Ft.)
+1.2
+1.0
+0.8
+0.6
+0.4
+0.2
0
Set-up Plus Outflow
Measured Set-up
STORAGE, OUTFLOW VS. TIME
Storage, Outflow (1000 C.F.S.D.)
+1800
+1600
+1400
+1200
+1000
+800
+600
+400
+200
0
Storage Plus Outflow
Storage
Outflow
Hour 0 2 4 6 8 10 12 14 16 18 20 22 24 26 28
Date Oct. 29 Oct. 30
Time 4 6 8 10 12 14 16 18 20 22 24 2 4 6 8


WIND VEL. V.S. TIME
NORTH WIND
Oct. 30-31 - Nov. 1/66
Wind Vel. (M.P.H.)
20
10
0
Portage
Dauphin
SET-UP V.S. TIME
Set-up (ft.)
+0.3
+0.2
+0.1
0
-0.1
-0.2
Measured Set-Up
Set-Up Plus Outflow
STORAGE, OUTFLOW V.S. TIME
Storage, Outflow (1000 C.F.S.)
+600
+500
+400
+300
+200
+100
0
-100
-200
-300
-400
Outflow
Storage
Storage Plus Outflow
Hour 0 4 8 12 16 20 24 28 32 36 40
Date Oct 30 Oct 31 Nov 1
Time 13 17 21 1 5 9 13 17 21 1 5

Graph No 43


MEASURED OUTFLOW1 vs. Δh1 (GUAGE 10-4)
SOUTH WINDS
OUTFLOW (CFS)
OUTFLOW1 = 46,600 Δh1^½
Δ Measured Outflow
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
OUTFLOW (C.F.S.)
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.5
2.0
2.5
3.0
4.0
5.0
Δ h1 (ft)


MEASURED OUTFLOW2 VS. Δh2 (GUAGE 4-10)
NORTH WINDS
OUTFLOW (C.F.S.)
OUTFLOW2 = 40,000Δh2^1/2
Measured Outflow
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.5
2.0
2.5
3.0
4.0
10.0
Δh2(ft)

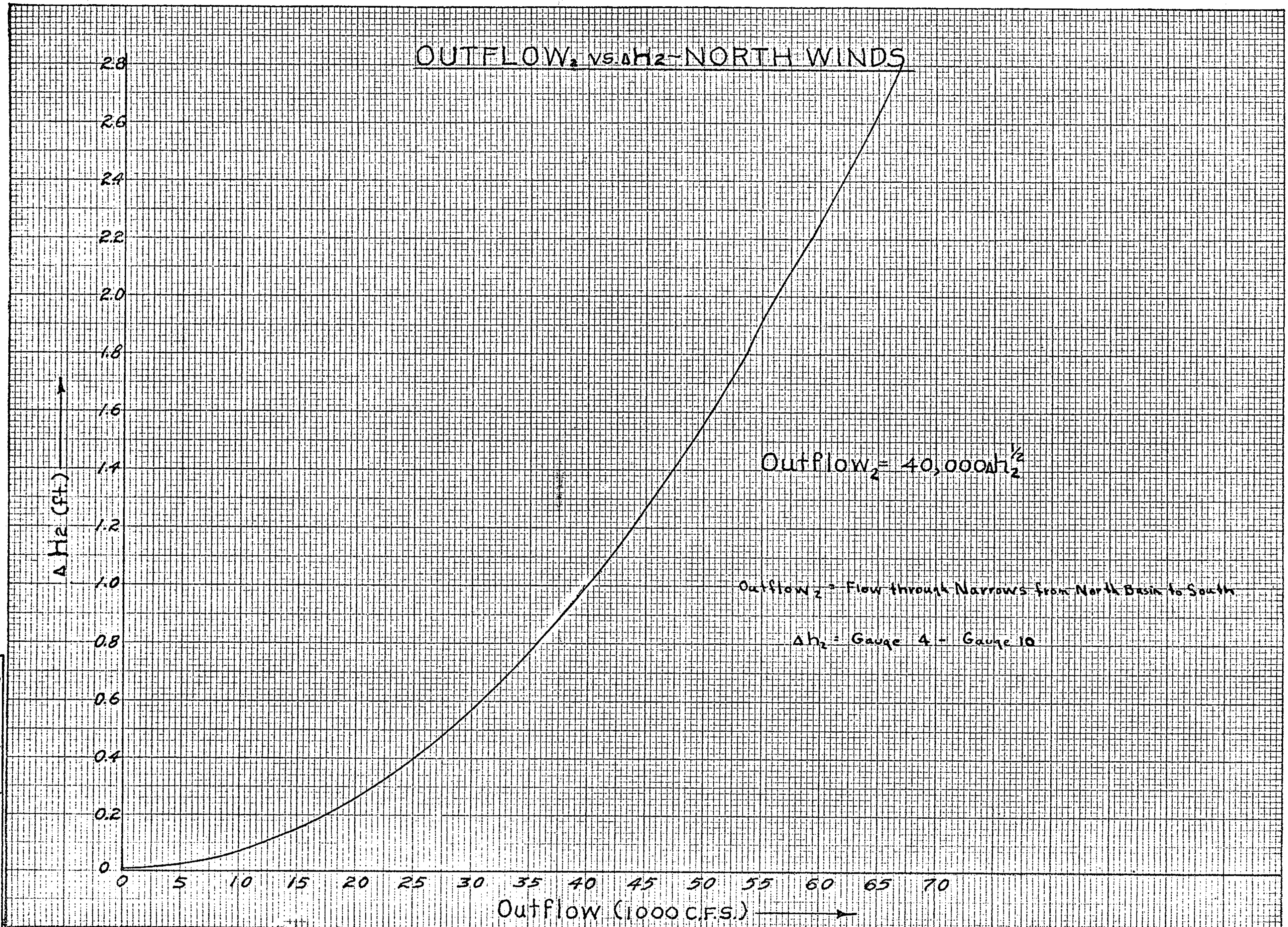

OUTFLOW$_1$ VS. ΔH_1 SOUTH WINDS
Outflow$_1$ = 46,600$h_1^{1/2}$
Outflow$_1$ = Flow through Narrows from South Basin to North
Δh_1 = Gauge 10 − Gauge 4
ΔH_1 (ft)
Outflow (1000 C.F.S.)
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85

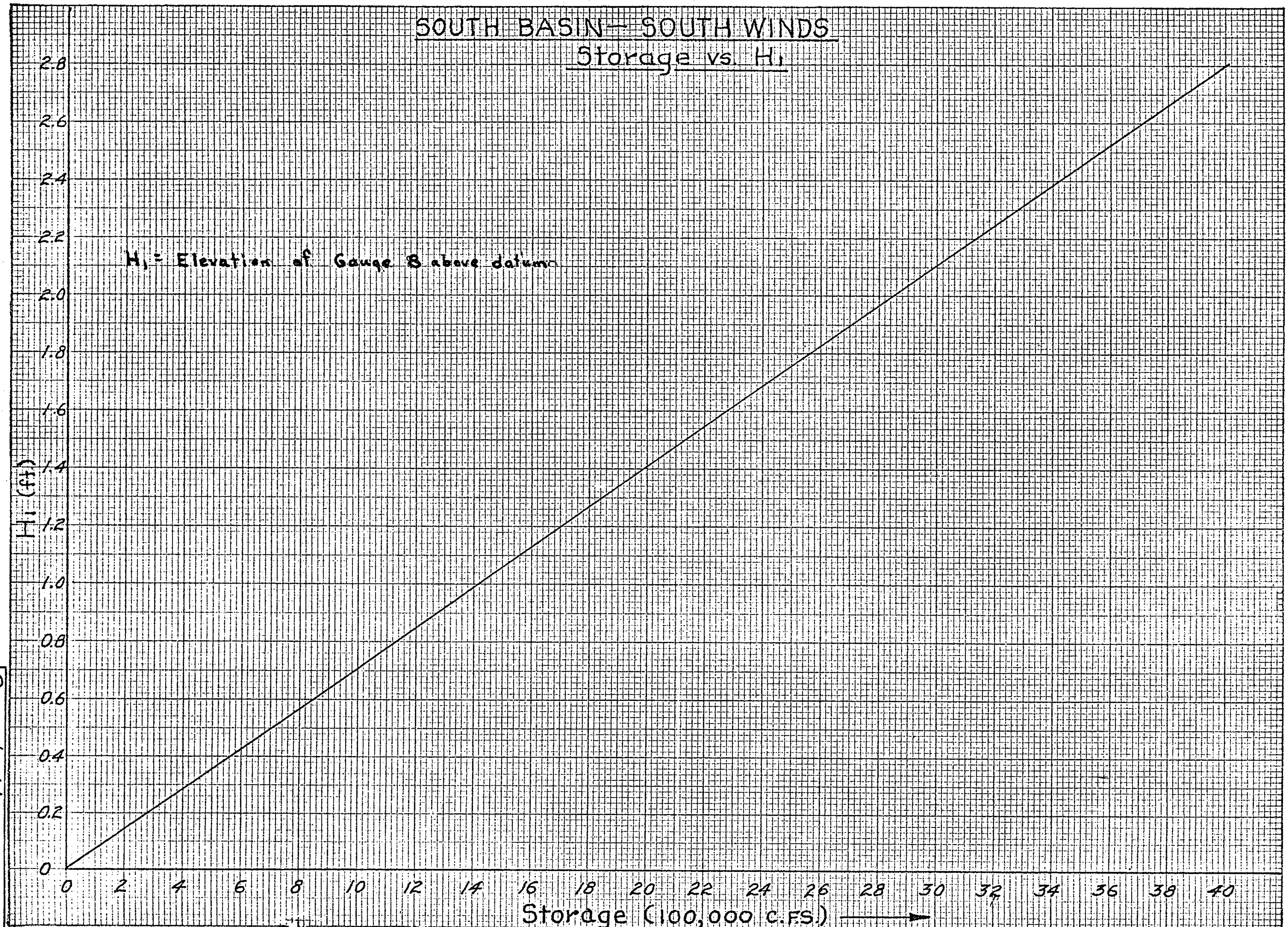
Graph No. 46

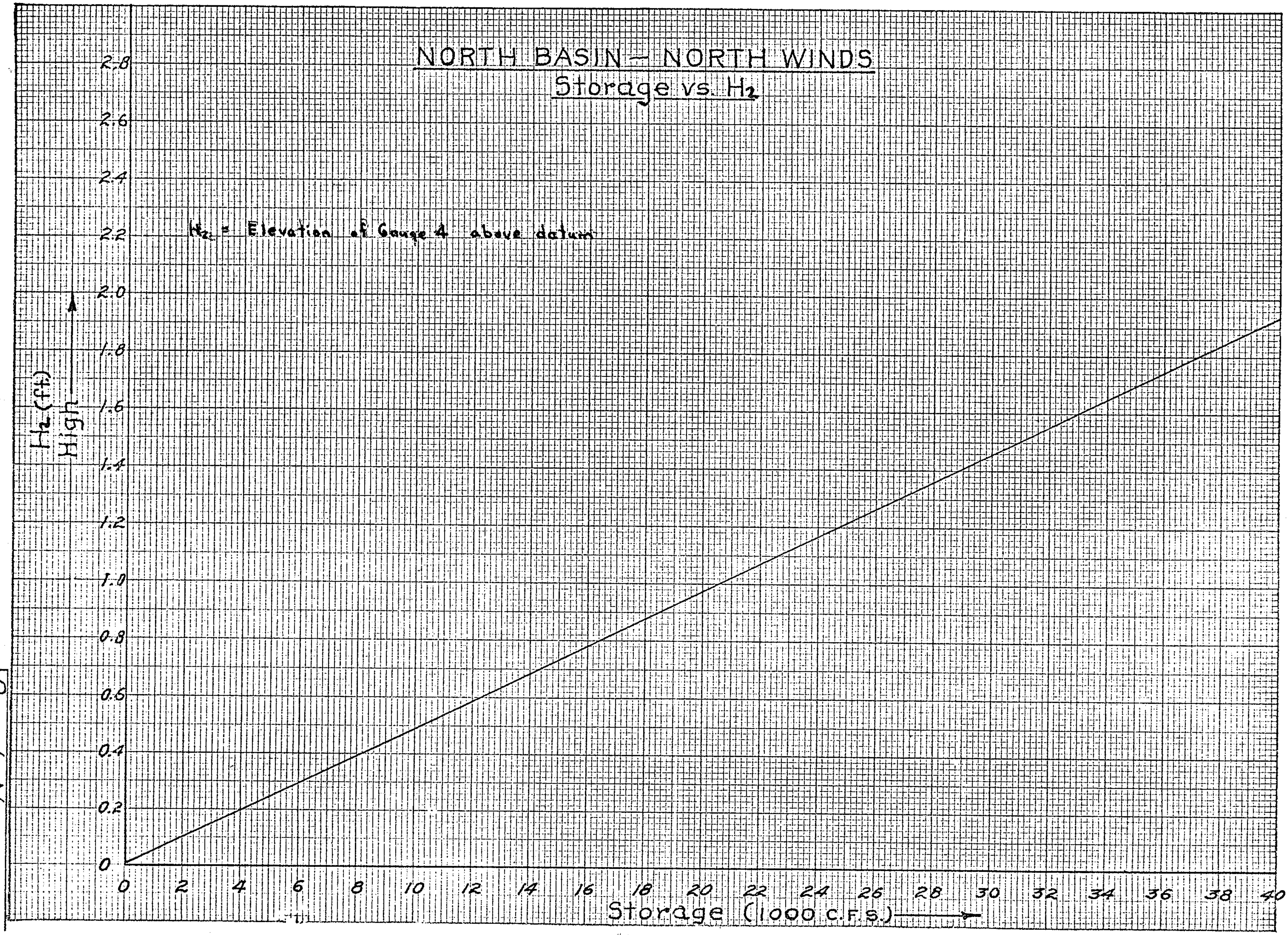
THIS MARGIN RESERVED FOR BINDING.

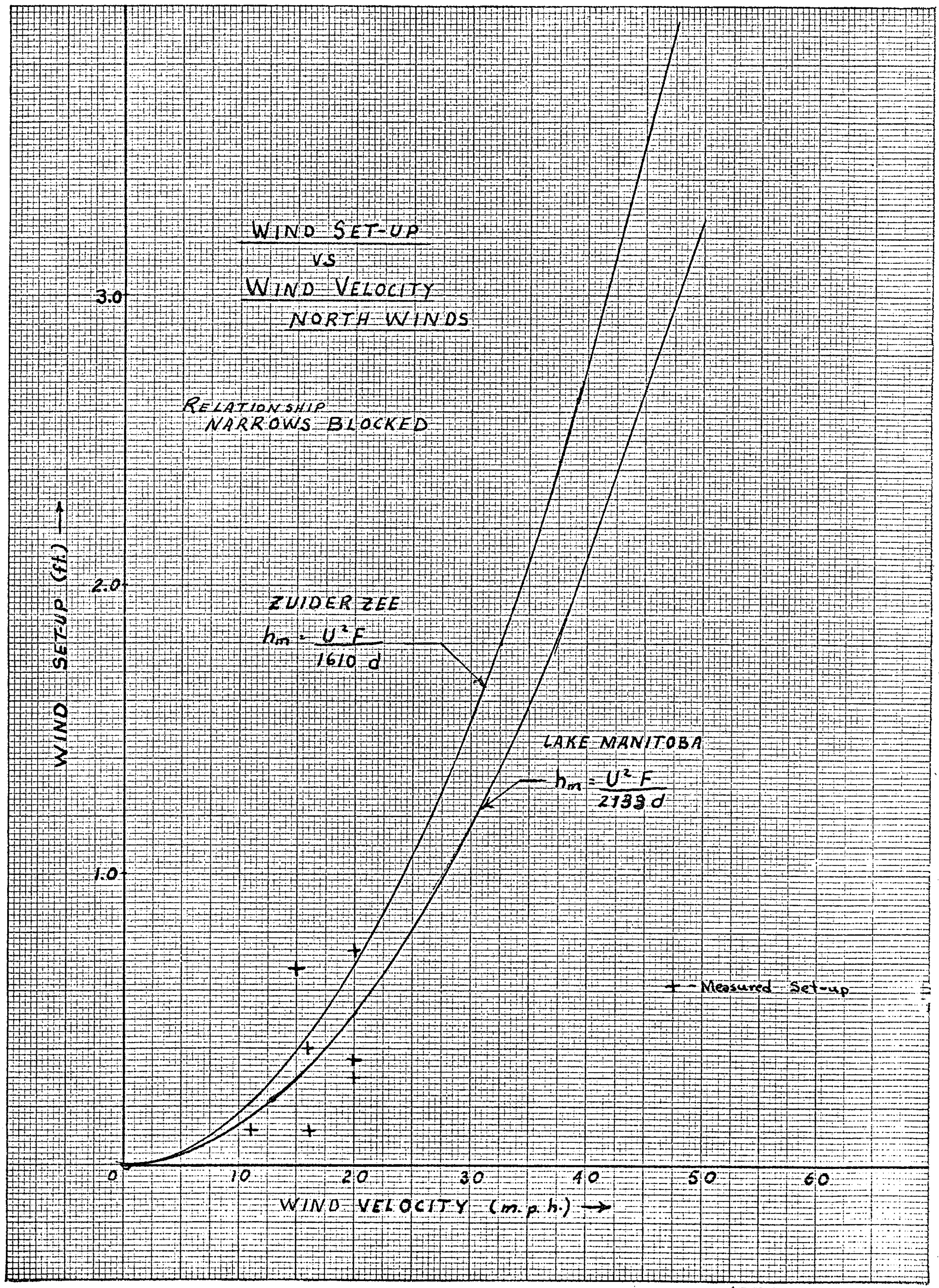
IF SHEET IS READ THIS WAY (HORIZONTALLY), THIS MUST BE TOP.

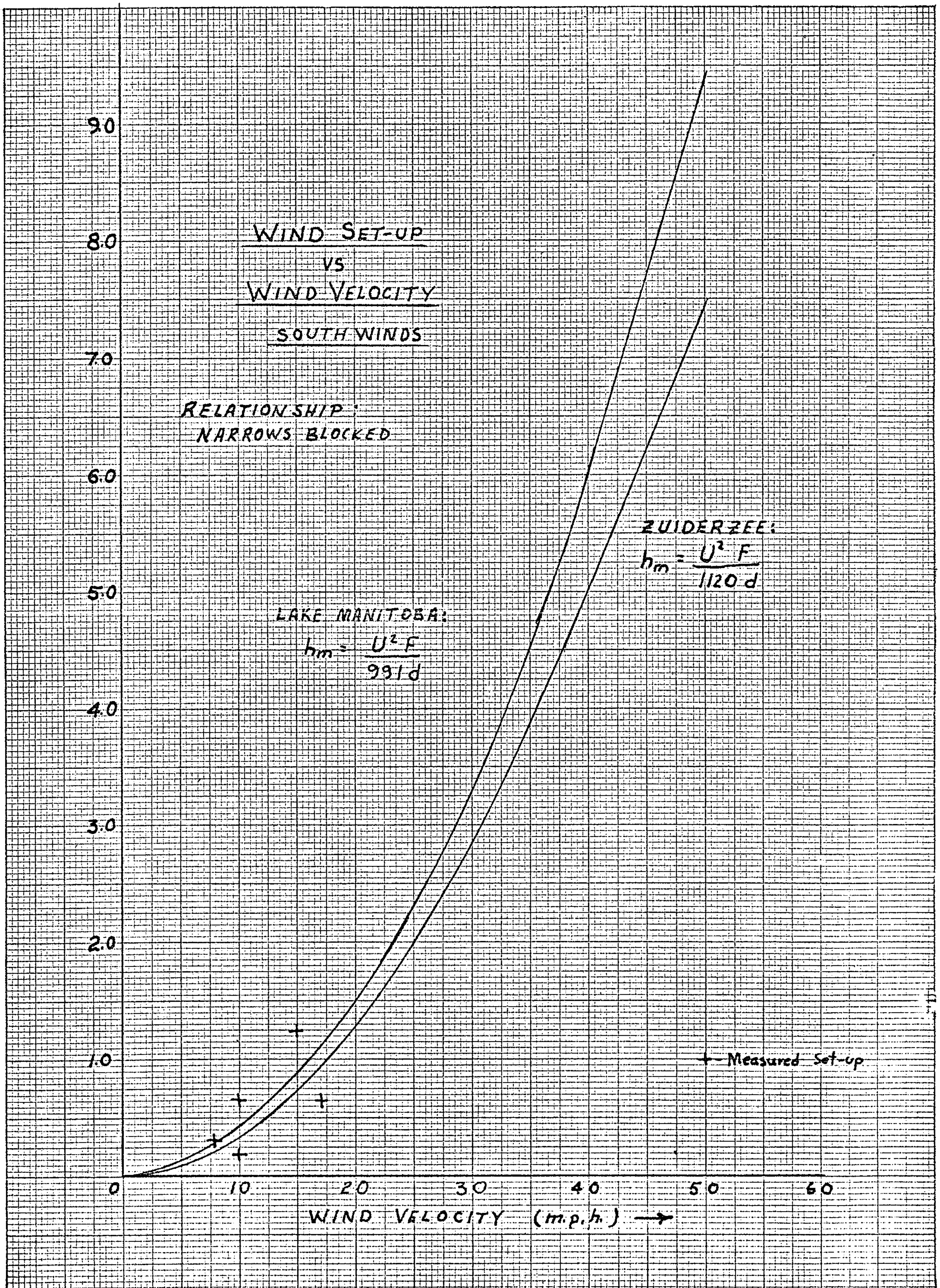
IF SHEET IS READ THE OTHER WAY (VERTICALLY), THIS MUST BE LEFT-HAND SIDE.

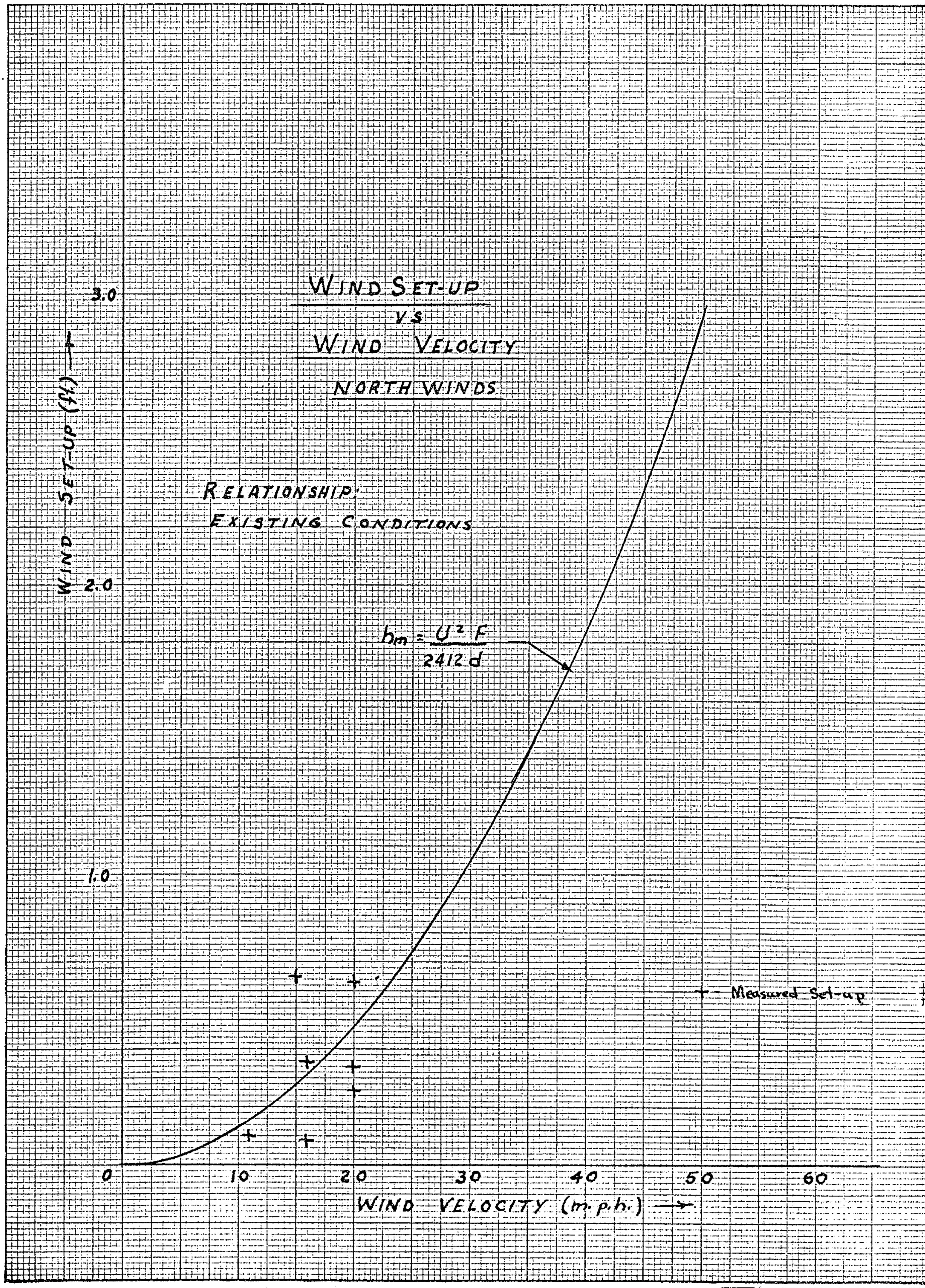


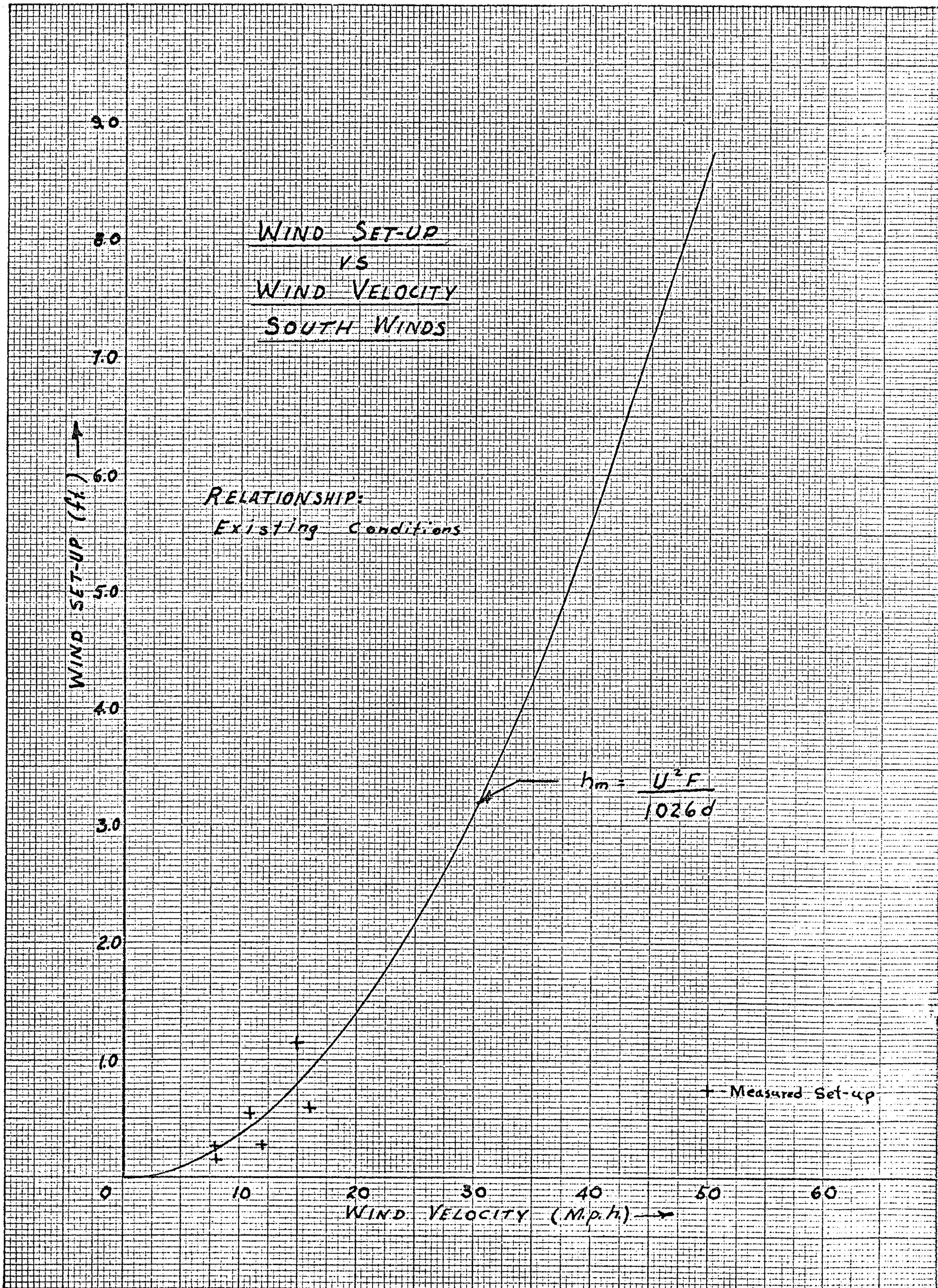

SOUTH BASIN — SOUTH WINDS
Storage vs. H1
H1 = Elevation of Gauge 8 above datum
H1 (ft)
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40
Storage (100,000 c.f.s.)

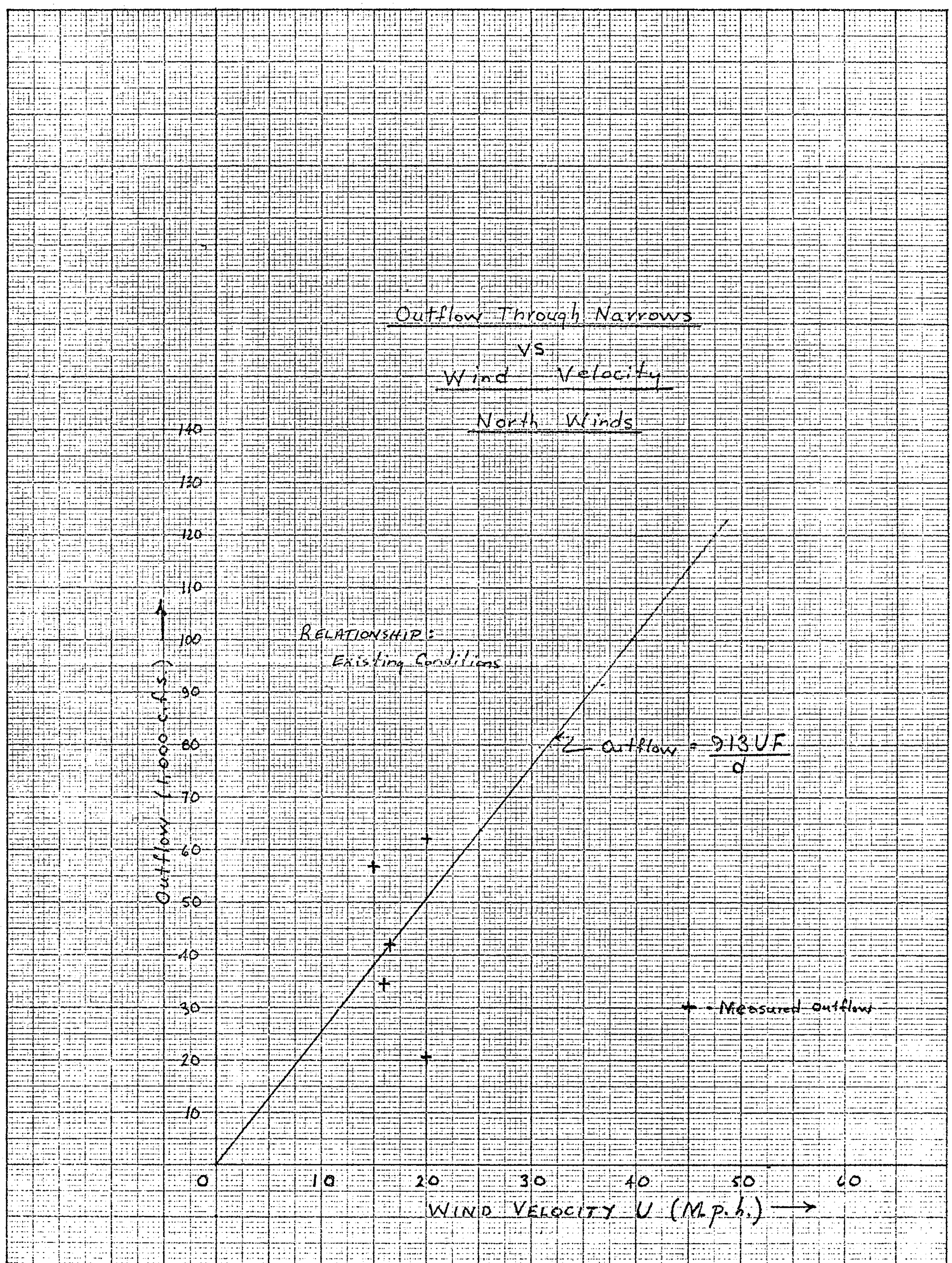

NORTH BASIN – NORTH WINDS
Storage vs. H_2
H_2 = Elevation of Gauge 4 above datum
H_2 (ft)
High
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40
Storage (1000 c.f.s.)


WIND SET-UP
VS
WIND VELOCITY
NORTH WINDS
RELATIONSHIP
NARROWS BLOCKED
ZUIDER ZEE
$h_m = \frac{U^2 F}{1610\ d}$
LAKE MANITOBA
$h_m = \frac{U^2 F}{2133\ d}$
+ - Measured Set-up
WIND SET-UP (ft) →
WIND VELOCITY (m.p.h.) →
0
1.0
2.0
3.0
10
20
30
40
50
60

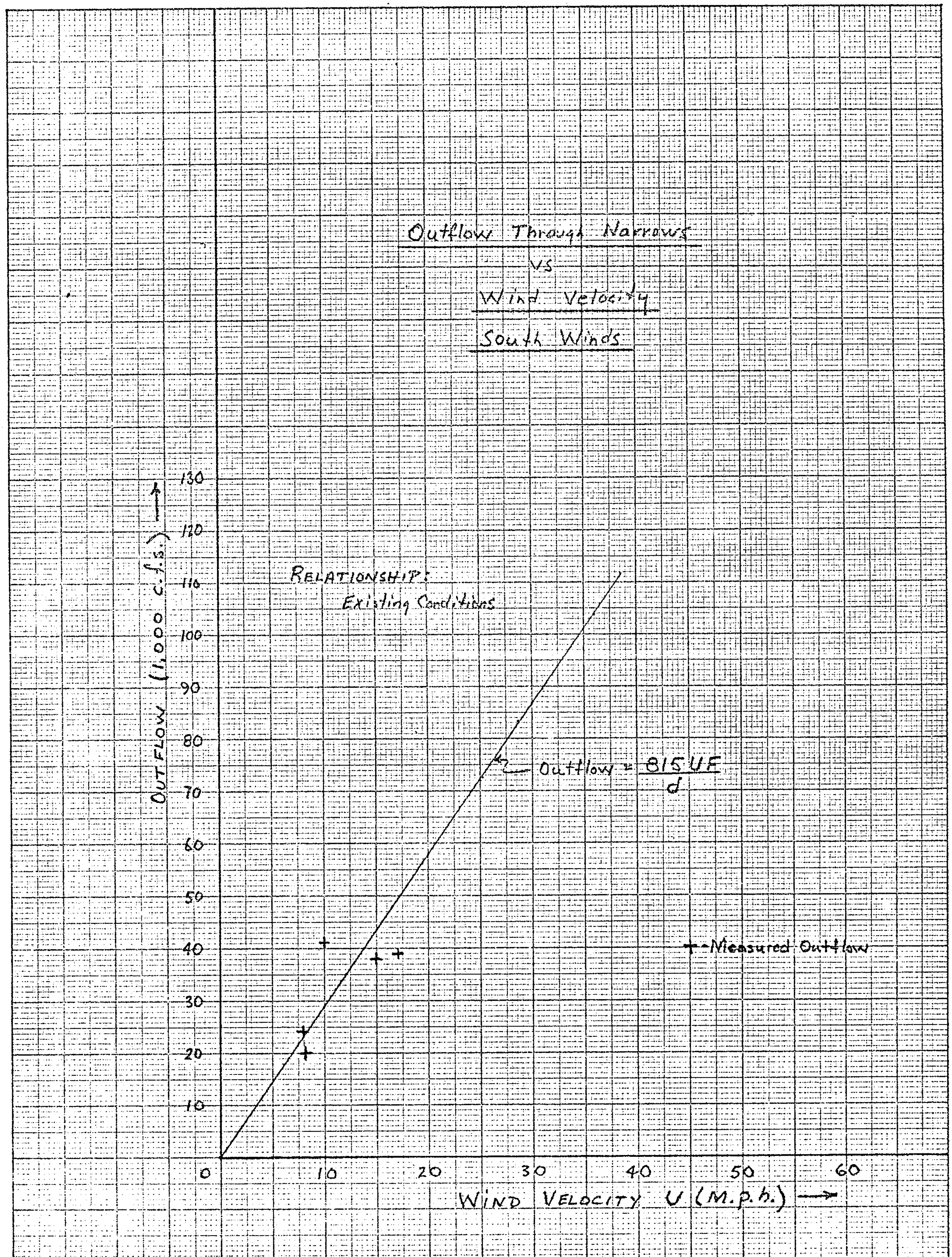

WIND SET-UP
VS
WIND VELOCITY
SOUTH WINDS
RELATIONSHIP:
NARROWS BLOCKED
LAKE MANITOBA:
$h_m = \frac{U^2 F}{991 d}$
ZUIDERZEE:
$h_m = \frac{U^2 F}{1120 d}$
+ — Measured Set-up
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
10
20
30
40
50
60
WIND VELOCITY (m.p.h.) →


WIND SET-UP
VS
WIND VELOCITY
NORTH WINDS
RELATIONSHIP:
EXISTING CONDITIONS
$h_m = \frac{U^2 F}{2412 d}$
+ Measured Set-up
WIND SET-UP (ft.) →
3.0
2.0
1.0
0
10
20
30
40
50
60
WIND VELOCITY (m.p.h.) →


WIND SET-UP
VS
WIND VELOCITY
SOUTH WINDS
RELATIONSHIP:
Existing Conditions
hm = U²F / 1026d
+ - Measured Set-up
WIND SET-UP (ft.) →
0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10
20
30
40
50
60
WIND VELOCITY (M.p.h.) →


Outflow Through Narrows
VS.
Wind Velocity
North Winds
RELATIONSHIP:
Existing Conditions
Outflow = 913UF / d
+ - Measured outflow
Outflow (1,000 c.f.s.)
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
10
20
30
40
50
60
WIND VELOCITY U (M.p.h.)

Graph Nº 54



Outflow Through Narrows
vs
Wind Velocity
South Winds
RELATIONSHIP:
Existing Conditions
Outflow = 815 UF / d
+ - Measured Outflow
OUTFLOW (1,000 c.f.s.)
WIND VELOCITY U (M.p.h.)
0
10
20
30
40
50
60
70
80
90
100
110
120
130

Graph Nº 55

APPENDIX A

SUMMARY OF WIND SET-UP EQUATIONS

SUMMARY OF RESULTS OF VARIOUS WIND SET-UP INVESTIGATORS

(1) Hellstrom: integrated the differential equation

$$z_s^2 = \frac{2\lambda\tau_s}{\gamma}(x + C_1) \qquad (11)$$

which indicated that the water surface was parabollic in form and can be written in coordinates ς and ξ as follows:

$$\varsigma^2 = \frac{2\lambda\tau_s}{\gamma}\xi \qquad (12)$$

This equation, known as the "Characteristic Water Surface Profile:, is plotted in Figure 5. The first step is to cut out a portion of the parabola in length F so that the area between the curve and the horizontal axis is equal to F_d (cross hatched area in figure 5), where F is the length of the channel and d is the still-water depth. The distance between the z and ς axis gives the constant C_1 as indicated in Figure 5. The case where the bottom is not exposed is represented by Figure 5a, where C_1 is a positive value. Figure 5b represents the case where $C_1 = 0$ wherein the water surface at the beginning of the basin has the same elevation as the bottom and 5c represents the case of exposed bottom where C_1 is negative.

Finally, the set-up h can be computed

$$h = \sqrt{\frac{2\lambda\tau_s}{\gamma}(x + C_1)} - d \qquad (13)$$

The nodal-line can be computed from this equation for h= 0

When the depth is great as compared to set-up, the equation becomes

$$h = \frac{\lambda\tau_s}{\gamma d}\left(x - \frac{F}{2}\right) \qquad (14)$$

The nodal-line for (14) is at x = F/2 and the set-up at the windward shore, x= 0, is:

$$h_{x=0} = \frac{\lambda\,\tau_s\,F}{2\,\gamma d} \qquad (15)$$

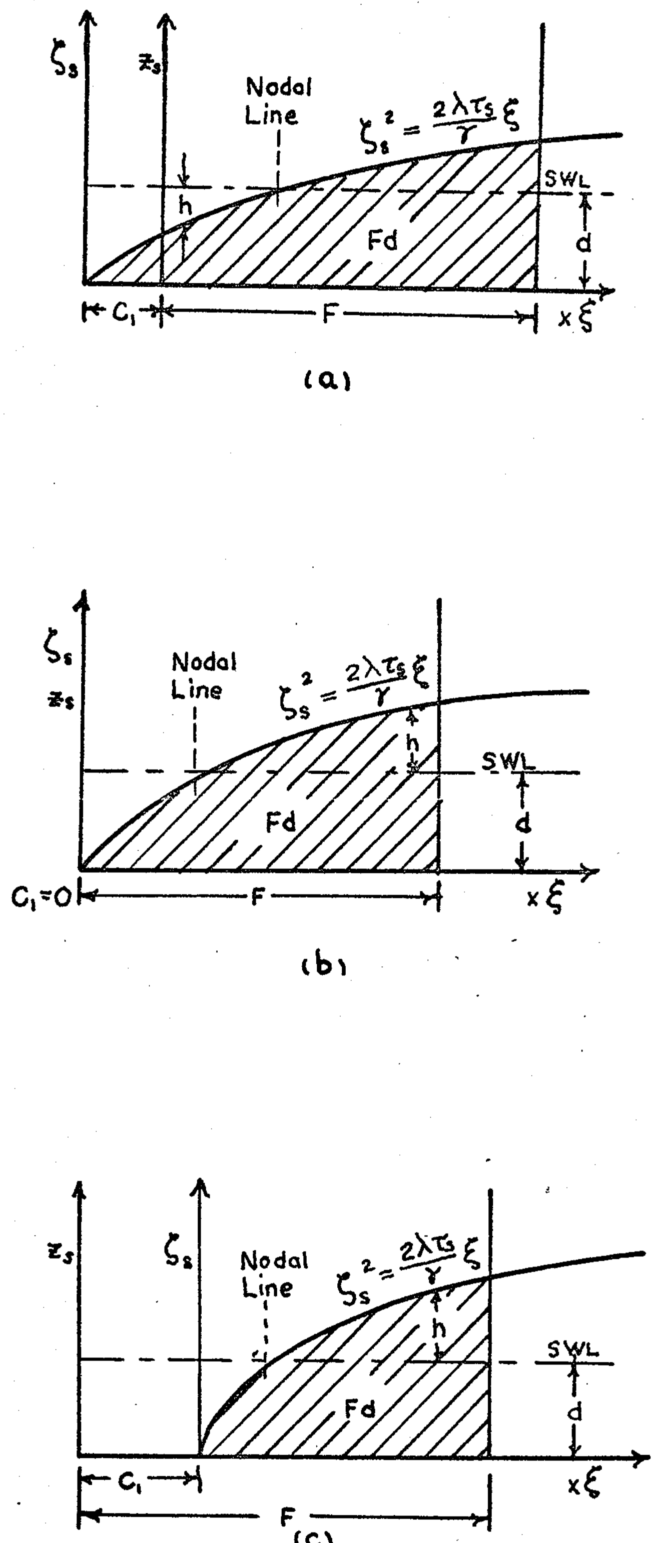


FIGURE 8 8/

CHARACTERISTIC WATER SURFACE PARABOLA

and at the leeward shore, x=F

$$h_{x=F} = \frac{\lambda \tau_s F}{2 \gamma d} \quad (16)$$

(2) Langhaar: 5/ The analysis of wind tides as given by this approach separates wind effects into statical and dynamic components. Two formulas were derived for the solution of statical tides. For a condition of nonexposed bottom, the setup above MWL was expressed as

$$h = \frac{\tau_s F}{2 \gamma d} \quad (17)$$

which is identical with the equation for deep water lakes presented by Hellstrom when $\lambda = 1.0$.

For a condition in which the windward bottom is exposed, the set-up can be obtained from the equation

$$h' = \sqrt[3]{\frac{3 F d \tau_s}{\gamma}} \quad (18)$$

Langhaar's equations are applicable to any lake with a horizontal bottom and a fairly symetrical planform. For lakes with variable shoreline planform and bottom conditions, the effect of planform must be evaluated and an integration procedure employed to obtain the wind tide profile. (Indeed, this is the case in any wind tide analysis, no matter what formula is used).

The Jacksonville District, Corps of Engineers, U. S. Army 11 / have found numerous applications for this equation, however they have modified it to

$$h = \sqrt[3]{\frac{3.373 \tau_s F d N}{\gamma}} - d \quad (19)$$

N in equation (19) is the planform factor. For the case where the body has a constant width, the planform factor N=1. For a converging planform, $N > 1$ and for a diverging planform $N < 1$

(3) Keulegan: 9/ Using data obtained in a model Keulegan separated the total wind tide, s into set-up due to skin friction between wind and water surface, S_1 and that due to the form resistance of the waves, S_2. For wind tides without wave action, the setup is

$$S_1 = 3.30 \times 10^{-6} \frac{U^2 F}{g d} \tag{20}$$

and for the amount of wind tide due to waves is

$$S_2 = 2.08 \times 10^{-4} \frac{(U - U_0)^2 F}{g d} \left(\frac{d}{F}\right)^{1/2} \tag{21}$$

The total set-up between windward and leeward ends of the lake may be expressed as

$$S = S_1 + S_2 \quad \text{or}$$

$$S = \left[3.30 \times 10^{-6} \frac{U^2}{g d} + 2.08 \times 10^{-4} \frac{(U - U_0)^2}{g d} F \left(\frac{d}{F}\right)^{1/2}\right] F \tag{22}$$

where U_0 is the critical wind velocity found for initiating wave action, equal to about 3.0 ft./sec. in his model experiments.

The set-up formula for a large body of water is given as:

$$S = 3.3 \times 10^{-6} \left[1 + 63 \left(\frac{d}{F}\right)^{1/2}\right] \frac{U^2 F}{g d} \tag{23}$$

and it applies when the body of water approximates the shape of a rectangular channel of uniform cross-section.

(4) Zuider Zee and Modified Formula: 12, 13/ In studying the problem of wind tides in Holland, the Dutch emplyed a formula originally stated as

$$S = \frac{U^2 F}{800 d} \tag{24}$$

where F is in miles, U in Miles an hour and S is the total difference in wind tide between windward and leeward shores. The equation was later modified to compute the setup in feet above MWL as

$$h_s = \frac{U^2 F}{1400 D} \cos A \tag{25}$$

where A is the angle between the wind and tidal axes.

(5) Beach Erosion Board: 14/ An investigation of observed wind tides on Lake Okeechobee by the Beach Erosion Board resulted in the development of an equation in which the total set-up, between the windward and leeward shores, is

$$S = \frac{K \lambda \rho_a U^2 F}{\rho g d} \cos A \quad , \text{ or} \qquad (26)$$

$$S = \frac{1.165 \times 10^{-3} U^2 F}{d} \cos A \qquad (27)$$

The constant K is evaluated as about equal to 0.003, which agrees closely with that obtained by Keulegan.

ρ_a is the air density

ρ the density of water

λ is a coefficient depending on the turbulence of flow.

For laminar flow $\lambda = 1.5$

turbulent flow $\lambda = 1.25$

which agrees with Keulegan.

MODIFICATIONS TO THE IDEAL CASE

A brief description of the factors that may have an effect on computing wind tide is as follows:

(a) Depth and Fetch are physical features of the body of water that can usually be obtained from hydrographic maps. In the Lake Manitoba study, Hydrographic maps of the underwater features were not available, consequently numerous soundings had to be taken to establish water depths.

Lake Manitoba is generally uniform in depth so that depth variations were not taken into account in calculations (other than average depth of each basin). In lakes of varying depth and shape, an integration procedure should be used in which the lake is divided up into a sufficient number of segments so that the variations in depth and shape can be taken into account. In most cases, the fetch can be taken as the straight line distance that the wind travels across the water surface. However, when there is an appriciable curve in the wind stream lines, the fetch should be measured along the curved line. Straight line fetch measurements were used in this study.

(b) Shear Stresses: τ_s and τ_b , are the principal unknowns in the wind-tide equation. Unfortunately, the computation of shear stresses is extremely complicated. The surface shear is a function of the velocity, temperature, density, stability, and turbulence of the air, and the roughness and velocity of the water surface over which the air is moving. The bottom shear is a function of temperature, viscosity, depth, and turbulence of the water, as well as bottom roughness.

Numerous model studies as well as full scale investigations have been made, however, definite relations between τ_b and bottom roughness, depth or other factors have not been determined. Most investigators use empherical data obtained from studies on Lake Okeechobee.

The formulas developed in this study are unique to Lake Manitoba only.

(c) Planform: A planform factor N is used when the center of gravity of a body is not at the mid point of th fetch. For a triangular lake, the factor varies from 0.67 when the wind tide is occuring along a side of the triangle to 1.33 when the wind tide occurs at an apex. If the shorelines form an approximate trapezoid, the planform factor can be obtained from the formula

$$N = \frac{2}{3}\left(\frac{2\,b_o + b}{b_o + b}\right) \qquad (28)$$

where b_o is the width of the windward shore

b is the width of the leeward shore.

(d) Atmospheric Pressure:[4] When a storm passes over a large body of water, the reduction in atmospheric pressure near the center of the storm may cause the water level to rise. This factor should be considered in computing wind tides when the difference in atmospheric pressure may be considerable, such as in wind tides due to huricanes. In the Lake Manitoba study atmospheric differences were considered negligable.

APPENDIX B

WATER LEVEL GAUGE ELEVATIONS

WATER LEVEL ELEVATION AT GAUGE LOCATIONS

OCTOBER 4, 1966

Hours	Gauge 1	Gauge 2	Gauge 3	Gauge 4	Gauge 5	Gauge 6	Gauge 7	Gauge 8	Gauge 9	Gauge 10	Gauge 11
1	811.28	811.35	812.02	811.76	812.05	811.53	811.47	811.47		810.80	
2	811.31	811.35	812.05	811.66	812.11	811.51	811.50	811.48		810.89	
3	811.32	811.37	811.94	811.64	812.11	811.56	811.57	811.47		811.00	
4	811.29	811.42	812.05	811.64	812.10	811.57	811.61	811.47		811.11	
5	811.30	811.42	812.08	811.61	812.09	811.58	811.61	811.57		811.11	
6	811.28	811.42	811.80	811.61	812.10	811.58	811.60	811.71		811.06	
7	811.30	811.43	811.68	811.61	812.10	811.59	811.65	811.74		811.04	
8	811.30	811.55	811.72	811.60	812.03	811.71	811.81	811.73		811.06	
9	811.28	811.65	811.62	811.62	811.96	811.75	811.86	811.72		811.36	
10	811.28	811.65	811.63	811.63	811.95	811.75	811.86	811.67		811.35	
11	811.27	811.62	811.84	811.63	811.95	811.74	811.84	811.61		811.36	
12	811.28	811.57	811.88	811.61	811.98	811.67	811.78	811.53		811.62	
13	811.28	811.47	811.78	811.57	812.03	811.61	811.70	811.51		811.49	811.40
14	811.29	811.42	811.80	811.51	812.13	811.55	811.63	811.53		811.53	811.41
15	811.30	811.39	811.70	811.50	812.14	811.55	811.63	811.60		811.62	811.46
16	811.28	811.47	811.60	811.50	812.13	811.60	811.71	811.79		811.78	811.68
17	811.33	811.57	811.70	811.50	812.03	811.74	811.81	811.88		811.95	811.77
18	811.28	811.71	811.69	811.56	811.96	811.82	811.98	811.82		811.89	811.71
19	811.27	811.67	811.66	811.57	811.95	811.76	811.92	811.77		811.81	811.70
20	811.29	811.59	811.62	811.51	812.03	811.71	811.87	811.82		811.92	811.76
21	811.34	811.65	811.60	811.49	812.03	811.74	811.93	811.86		811.94	811.77
22	811.33	811.65	811.52	811.45	812.03	811.75	811.96	811.90		811.95	811.84
23	811.37	811.65	811.50	811.41	812.07	811.75	811.97	811.93		812.01	811.92
24	811.49	811.67	811.41	811.38	812.07	811.78	812.01	811.96		812.07	811.91

WATER LEVEL ELEVATION AT GAUGE LOCATIONS

OCTOBER 5, 1966.

Hours	Gauge 1	Gauge 2	Gauge 3	Gauge 4	Gauge 5	Gauge 6	Gauge 7	Gauge 8	Gauge 9	Gauge 10	Gauge 11
1	811.38	811.67	811.40	811.41	812.11	811.75	812.00	811.94		811.88	811.92
2	811.38	811.68	811.38	811.43	812.09	811.75	812.02	811.94		811.88	811.94
3	811.38	811.69	811.39	811.47	812.08	811.78	812.02	811.94		811.87	811.92
4	811.37	811.72	811.38	811.51	812.06	811.80	812.03	811.93		811.87	811.88
5	811.36	811.73	811.40	811.56	811.99	811.80	812.03	811.91		811.80	811.81
6	811.36	811.71	811.32	811.57	811.99	811.76	811.96	811.85		811.75	811.73
7	811.40	811.67	811.31	811.55	812.02	811.70	811.89	811.80		811.68	811.73
8	811.43	811.62	811.31	811.50	812.07	811.68	811.89	811.80		811.69	811.77
9	811.44	811.62	811.30	811.49	812.09	811.67	811.92	811.82		811.72	811.82
10	811.46	811.65	811.18	811.47	812.09	811.67	811.94	811.86		811.76	811.90
11	811.46	811.67	811.30	811.50	812.09	811.78	811.99	811.95		811.87	811.97
12	811.41	811.76	811.43	811.56	812.03	811.82	812.06	812.01		811.96	811.95
13	811.39	811.79	811.37	811.59	812.03	811.88	812.13	812.02		811.92	811.90
14	811.40	811.77	811.30	811.60	811.97	811.81	812.13	811.96		811.80	811.82
15	811.41	811.73	811.38	811.57	811.93	811.66	812.05	811.91		811.78	811.80
16	811.48	811.69	811.39	811.55	811.99	811.62	812.01	811.89		811.76	811.80
17	811.48	811.67	811.38	811.51	812.02	811.62	811.99	811.92		811.77	811.87
18	811.47	811.72	811.40	811.53	812.05	811.66	812.02	811.99		811.92	811.88
19	811.46	811.75	811.50	811.54	812.01	811.70	812.08	812.00		811.87	811.86
20	811.47	811.77	811.44	811.57	811.97	811.70	812.08	811.92		811.77	811.84
21	811.46	811.72	811.40	811.58	811.97	811.66	812.04	811.90		811.78	811.82
22	811.43	811.71	811.38	811.58	812.00	811.63	811.99	811.91		811.82	811.83
23	811.48	811.69	811.33	811.52	812.03	811.63	811.99	811.94		811.82	811.86
24	811.51	811.72	811.38	811.52	812.03	811.65	812.03	811.98		811.93	811.90

WATER LEVEL ELEVATION AT GAUGE LOCATIONS

October 6, 1966.

Hours	Gauge 1	Gauge 2	Gauge 3	Gauge 4	Gauge 5	Gauge 6	Gauge 7	Gauge 8	Gauge 9	Gauge 10	Gauge 11
1	811.48	811.75	811.45	811.52	812.08	811.81	812.06	812.03		811.95	811.87
2	811.49	811.79	811.42	811.56	812.01	811.82	812.12	812.01		811.86	811.85
3	811.48	811.79	811.40	811.61	812.00	811.79	812.11	811.93		811.81	811.78
4	811.48	811.72	811.30	811.62	812.02	811.75	812.01	811.84		811.73	811.74
5	811.48	811.69	811.25	811.63	812.02	811.72	811.95	811.83		811.70	811.75
6	811.48	811.67	811.30	811.61	812.05	811.71	811.94	811.84		811.74	811.58
7	811.50	811.68	811.32	811.59	812.03	811.73	811.96	811.88		811.76	811.81
8	811.49	811.72	811.38	811.61	812.01	811.75	812.00	811.89		811.76	811.76
9	811.50	811.72	811.39	811.62	812.00	811.75	812.00	811.82		811.68	811.69
10	811.48	811.69	811.42	811.67	811.98	811.73	811.95	811.79		811.64	811.65
11	811.48	811.68	811.44	811.69	811.98	811.74	811.95	811.82		811.64	811.67
12	811.48	811.72	811.44	811.71	811.97	811.75	811.96	811.88		811.69	811.72
13	811.48	811.77	811.50	811.69	811.95	811.79	812.01	811.90		811.73	811.74
14	811.46	811.77	811.60	811.69	811.97	811.78	812.02	811.89		811.76	811.72
15	811.48	811.69	811.61	811.66	812.00	811.71	811.95	811.78		811.72	811.66
16	811.50	811.65	811.59	811.62	812.06	811.67	811.89	811.63		811.66	811.64
17	811.48	811.65	811.58	811.61	812.06	811.65	811.87	811.72		811.62	811.63
18	811.48	811.62	811.52	811.62	812.03	811.66	811.87	811.79		811.65	811.64
19	811.47	811.67	811.52	811.66	812.01	811.71	811.92	811.80		811.69	811.69
20	811.44	811.69	811.50	811.67	811.94	811.75	811.95	811.86		811.72	811.70
21	811.40	811.73	811.54	811.74	812.01	811.79	811.99	811.89		811.71	811.71
22	811.40	811.77	811.55	811.73	812.07	811.78	812.02	811.85		811.69	811.67
23	811.43	811.67	811.62	811.66	812.08	811.71	811.93	811.78		811.69	811.65
24	811.46	811.66	811.59	811.63	812.00	811.67	811.90	811.73		811.65	811.64

WATER LEVEL ELEVATION AT GAUGE LOCATIONS

OCTOBER 7, 1966

Hours	Gauge 1	Gauge 2	Gauge 3	Gauge 4	Gauge 5	Gauge 6	Gauge 7	Gauge 8	Gauge 9	Gauge 10	Gauge 11
1	811.44	811.62	811.59	811.61	811.95	811.65	811.84	811.73		811.67	811.66
2	811.44	811.66	811.58	811.63	811.97	811.71	811.89	811.78		811.65	811.67
3	811.41	811.67	811.62	811.67	811.97	811.73	811.91	811.78		811.64	811.68
4	811.38	811.69	811.62	811.73	812.07	811.76	811.92	811.78		811.60	811.64
5	811.37	811.67	811.70	811.74	812.09	811.71	811.91	811.76		811.62	811.65
6	811.35	811.67	811.70	811.72	812.12	811.71	811.88	811.72		811.55	811.39
7	811.36	811.65	811.80	811.73	812.12	811.66	811.85	811.67		811.47	811.52
8	811.38	811.57	811.80	811.64	812.11	811.61	811.78	811.61		811.46	811.50
9	811.40	811.52	811.81	811.63	812.12	811.58	811.74	811.60		811.44	811.50
10	811.33	811.52	811.80	811.65	812.14	811.57	811.73	811.59		811.49	811.48
11	811.33	811.49	811.72	811.62	812.14	811.57	811.72	811.60		811.50	811.53
12	811.36	811.52	811.64	811.61	812.13	811.58	811.73	811.61		811.46	811.53
13	811.30	811.53	811.68	811.61	812.11	811.57	811.75	811.59		811.49	811.60
14	811.33	811.49	811.69	811.60	812.09	811.56	811.73	811.60		811.51	811.61
15	811.37	811.52	811.67	811.58	812.05	811.57	811.74	811.62		811.55	811.60
16	811.34	811.52	811.67	811.58	812.02	811.58	811.75	811.63		811.58	811.63
17	811.33	811.55	811.65	811.58	812.02	811.60	811.76	811.68		811.53	811.64
18	811.37	811.57	811.64	811.59	812.04	811.62	811.81	811.71		811.66	811.66
19	811.34	811.62	811.61	811.58	812.06	811.67	811.85	811.77		811.71	811.70
20	811.29	811.67	811.62	811.65	812.02	811.71	811.92	811.83		811.72	811.73
21	811.34	811.68	811.67	811.63	812.04	811.71	811.93	811.81		811.72	811.72
22	811.33	811.67	811.73	811.61	812.02	811.68	811.93	811.80		811.76	811.75
23	811.34	811.66	811.72	811.59	812.04	811.67	811.91	811.82		811.75	811.76
24	811.36	811.67	811.69	811.56	812.03	811.71	811.92	811.86		811.73	811.78

WATER LEVEL ELEVATION AT GAUGE LOCATIONS

OCTOBER 8, 1966

Hours	Gauge 1	Gauge 2	Gauge 3	Gauge 4	Gauge 5	Gauge 6	Gauge 7	Gauge 8	Gauge 9	Gauge 10	Gauge 11
1	811.36	811.68	811.69	811.61	812.02	811.71	811.94	811.87		811.75	811.73
2	811.37	811.67	811.59	811.53	812.00	811.71	811.91	811.81		811.69	811.77
3	811.37	811.67	811.39	811.62	812.09	811.72	811.91	811.82		811.75	811.74
4	811.36	811.67	811.84	811.60	812.08	811.73	811.91	811 80		811.81	811.73
5	811.32	811.67	811.89	811.63	812.06	811.71	811.90	811.88		811.75	811.77
6	811.36	811.68	811.79	811.57	812.01	811.74	811.94	811.81		811.91	811.56
7	811.43	811.57	811.59	811.52	811.98	811.61	811.87	811.66		811.90	811.68
8	811.40	811.57	811.59	811.50	811.92	811.58	811.75	811.84		811.97	811.85
9	811.38	811.67	811.29	811.51	811.93	811.71	811.94	811.91		811.97	811.94
10	811.38	811.75	811.49	811.55	812.08	811.77	812.01	811.98		811.77	812.02
11	811.38	811.75	811.57	811.54	812.08	811.82	812.05	812.04		811.58	811.90
12	811.33	811.82	811.57	811.64	812.05	811.86	812.10	811.91		811.66	811.69
13	811.42	811.67	811.49	811.59	812.06	811.74	811.98	811.70		811.70	811.63
14	811.42	811.57	811.49	811.56	812.01	811.61	811.80	811.70		811.85	811.54
15	811.39	811.59	811.49	811.53	811.95	811.65	811.82	811.79		811.93	811.55
16	811.34	811.65	811.39	811.54	811.97	811.67	811.89	811.87		811.89	811.48
17	811.50	811.67	811.44	811.52	811.99	811.72	811.95	811.97		811.78	811.47
18	811.46	811.77	811.51	811.57	812.01	811.79	812.02	811.97		811.72	811.46
19	811.43	811.77	811.49	811.60	812.03	811,80	812.05	811.92		811.61	811.46
20	811.46	811.75	811.41	811.61	812.12	811.76	812.00	811.83		811.39	811.47
21	811.47	811.67	811.19	811.61	812.02	811.71	811.93	811.80		811.21	811.45
22	811.43	811.67	810.91	811.60	811.96	811.70	811.90	811.76		810.87	811.47
23	811.48	811.59	811.19	811.57	811.92	811.65	811.85	811.63		810.48	811.54
24	811.50	811.57	811.39	811.62	812.01	811.61	811.75	811.49		810.42	811.50

WATER LEVEL ELEVATION AT GAUGE LOCATIONS

October 9, 1966.

Hours	Gauge 1	Gauge 2	Gauge 3	Gauge 4	Gauge 5	Gauge 6	Gauge 7	Gauge 8	Gauge 9	Gauge 10	Gauge 11
1	811.50	811.49	811.69	811.78	812.25	811.62	811.60	811.37		810.46	811.05
2	811.28	811.47	812.19	812.02	812.27	811.60	811.50	811.28		811.67	810.70
3	811.22	811.46	811.34	812.02	812.28	811.60	811.45	811.24		812.23	810.74
4	811.37	811.37	810.69	811.88	811.79	811.46	811.36	811.18		812.01	810.80
5	811.51	811.19	810.89	811.53	811.71	811.28	811.30	811.27		811.62	811.75
6	811.68	811.22	811.08	811.48	811.69	811.34	811.35	811.77		811.41	812.32
7	811.61	811.62	810.96	811.48	811.75	811.81	811.81	812.07		811.15	812.20
8	811.56	811.92	811.12	811.81	811.85	811.98	812.10	811.95		810.92	811.82
9	811.43	811.87	811.12	811.89	811.92	811.91	812.08	811.77		811.40	811.50
10	811.47	811.77	811.12	811.99	811.99	811.84	811.85	811.62		811.26	811.15
11	811.56	811.67	810.99	811.93	811.96	811.74	811.75	811.48		811.08	811.23
12	811.58	811.55	811.09	811.85	811.93	811.61	811.61	811.47		810.87	811.54
13	811.63	811.49	811.34	811.78	811.87	811.61	811.59	811.56		810.63	811.54
14	811.68	811.57	811.50	811.78	811.89	811.66	811.67	811.55		810.42	811.40
15	811.68	811.57	811.51	811.83	811.92	811.67	811.66	811.42		810.33	811.25
16	811.63	811.56	811.52	811.94	812.05	811.65	811.57	811.35		810.76	811.00
17	811.48	811.47	811.49	811.95	812.09	811.58	811.48	811.25		811.08	810.78
18	811.50	811.42	811.49	812.01	812.12	811.55	811.42	811.16		811.28	810.63
19	811.58	811.31	811.51	811.90	811.99	811.49	811.34	811.12		811.16	811.04
20	811.60	811.25	811.37	811.81	811.89	811.37	811.24	811.25		811.13	811.34
21	811.66	811.31	811.38	811.79	811.85	811.46	811.36	811.46		810.95	811.58
22	811.53	811.47	811.69	811.82	811.92	811.60	811.55	811.51		810.72	811.39
23	811.45	811.55	811.83	811.94	811.95	811.66	811.61	811.46		810.55	811.15
24	811.46	811.55	811.48	811.95	811.91	811.65	811.55	811.38		810.68	810.96

WATER LEVEL ELEVATION AT GAUGE LOCATIONS

OCTOBER 10, 1966

Hours	Gauge 1	Gauge 2	Gauge 3	Gauge 4	Gauge 5	Gauge 6	Gauge 7	Gauge 8	Gauge 9	Gauge 10	Gauge 11
1	811.48	811.47	811.39	811.97	811.86	811.57	811.46	811.32		810.70	
2	811.40	811.42	811.59	811.94	811.86	811.58	811.39	811.27		810.64	
3	811.40	811.45	811.82	812.26	811.74	811.62	811.30	811.18		810.44	
4	811.40	811.37	812.29	812.03	812.82	811.53	811.29	811.18		810.24	
5	811.38	811.45	812.14	812.34	811.56	811.53	811.23	811.17		809.99	
6	811.34	811.42	812.49	812.28	811.56	811.61	811.23	811.12		809.97	
7	811.36	811.45	812.17	812.39	811.80	811.67	811.21	811.08		809.81	
8	811.23	811.45	812.22	812.44	811.88	811.66	811.16	811.01		810.02	
9	811.18	811.37	812.35	812.42	811.96	811.56	811.11	810.98		810.14	
10	811.16	811.29	812.25	812.31	812.13	811.50	811.07	810.92		810.18	
11	811.23	811.19	811.94	812.17	812.20	811.41	811.02	810.88		810.37	
12	811.33	811.12	812.00	811.95	812.20	811.28	810.97	810.87		810.74	
13	811.43	811.05	811.90	811.83	812.11	811.21	810.95	810.88		811.28	
14	811.39	811.05	811.79	811.79	812.01	811.24	810.97	811.02		811.29	
15	811.38	811.15	811.80	811.74	811.91	811.31	811.12	811.32		811.36	
16	811.38	811.42	811.89	811.82	811.91	811.56	811.42	811.55		811.27	
17	811.33	811.56	811.99	811.80	812.00	811.65	811.60	811.58		811.24	
18	811.29	811.57	811.89	811.80	812.06	811.65	811.67	811.53		811.17	
19	811.38	811.47	811.77	811.64	812.07	811.51	811.57	811.45		811.26	
20	811.40	811.39	811.62	811.62	812.01	811.47	811.49	811.45		811.53	
21	811.35	811.39	811.59	811.55	811.95	811.46	811.50	811.62		811.71	
22	811.33	811.55	811.70	811.63	811.82	811.66	811.59	811.82		811.85	
23	811.28	811.71	811.82	811.65	811.86	811.78	811.82	811.95		811.84	
24	811.28	811.77	811.79	811.70	811.90	811.85	811.94	812.83		811.66	

WATER LEVEL ELEVATION AT GAUGE LOCATIONS

OCTOBER 11, 1966

Hours	Gauge 1	Gauge 2	Gauge 3	Gauge 4	Gauge 5	Gauge 6	Gauge 7	Gauge 8	Gauge 9	Gauge 10	Gauge 11
1	811.29	811.72	811.69	811.64	812.02	811.74	811.87	811.65		811.50	
2	811.30	811.57	811.70	811.59	812.04	811.57	811.69	811.58		811.49	
3	811.31	811.47	811.69	811.51	811.98	811.51	811.62	811.63		811.57	
4	811.34	811.49	811.57	811.51	811.95	811.56	811.62	811.72		811.67	
5	811.31	811.57	811.60	811.51	811.92	811.65	811.72	811.81		811.77	
6	811.30	811.63	811.69	811.54	811.89	811.68	811.80	811.84		811.79	
7	811.28	811.67	811.69	811.57	811.90	811.72	811.85	811.82		811.75	
8	811.26	811.67	811.67	811.60	811.94	811.72	811.87	811.77		811.67	
9	811.28	811.73	811.67	811.58	811.97	811.67	811.80	811.74		811.66	
10	811.29	811.69	811.61	811.55	811.97	811.64	811.77	811.75		811.69	
11	811.28	811.69	811.61	811.52	811.96	811.65	811.77	811.82		811.74	
12	811.30	811.72	811.65	811.51	811.94	811.66	811.80	811.87		811.84	
13	811.31	811.67	811.69	811.52	811.92	811.71	811.85	811.89		811.85	
14	811.29	811.67	811.69	811.54	811.90	811.73	811.89	811.89	811.69	811.76	811.70
15	811.28	811.68	811.69	811.56	811.91	811.74	811.89	811.89	811.69	811.87	811.74
16	811.28	811.69	811.69	811.57	811.72	811.76	811.91	811.93	811.73	811.90	811.76
17	811.28	811.73	811.68	811.59	811.70	811.79	811.97	811.97	811.74	811.92	811.81
18	811.30	811.73	811.65	811.56	811.72	811.79	811.98	812.00	811.77	811.87	811.84
19	811.30	811.73	811.65	811.56	811.72	811.79	811.99	812.01	811.79	811.90	811.80
20	811.30	811.75	811.67	811.56	811.73	811.79	811.98	811.98	811.76	811.84	811.74
21	811.30	811.69	811.59	811.56	811.73	811.77	811.93	811.92	811.73	811.84	811.73
22	811.28	811.67	811.50	811.56	811.74	811.73	811.89	811.91	811.73	811.94	811.84
23	811.28	811.69	811.49	811.59	811.72	811.75	811.93	811.97	811.78	812.08	811.94
24	811.30	811.75	811.50	811.55	811.72	811.80	812.00	812.06	811.87	812.12	811.99

WATER LEVEL ELEVATION AT GAUGE LOCATIONS

OCTOBER 12, 1966

Hours	Gauge 1	Gauge 2	Gauge 3	Gauge 4	Gauge 5	Gauge 6	Gauge 7	Gauge 8	Gauge 9	Gauge 10	Gauge 11
1	811.32	811.77	811.54	811.55	811.87	811.84	812.08	812.12	811.90	812.08	811.95
2	811.33	811.82	811.57	811.56	811.87	811.87	812.08	812.11	811.91	812.02	811.89
3	811.36	811.77	811.57	811.52	811.91	811.82	812.04	812.05	811.89	811.99	811.80
4	811.36	811.76	811.54	811.53	811.92	811.80	811.99	811.98	811.81	811.91	811.79
5	811.35	811.69	811.54	811.52	811.94	811.75	811.94	811.95	811.78	811.91	811.79
6	811.35	811.69	811.52	811.52	811.95	811.75	811.94	811.97	811.78	812.07	811.93
7	811.37	811.72	811.50	811.53	811.91	811.78	811.95	812.06	811.85	812.12	811.94
8	811.38	811.79	811.52	811.54	811.88	811.84	812.08	812.12	811.89	812.07	811.91
9	811.37	811.81	811.59	811.56	811.87	811.86	812.08	812.09	811.92	812.03	811.85
10	811.36	811.79	811.39	811.56	811.87	811.85	812.06	812.06	811.88	812.03	811.86
11	811.36	811.77	811.22	811.56	811.88	811.84	812.04	812.09	811.90	812.11	811.96
12	811.30	811.85	811.39	811.63	811.81	811.89	812.12	812.16	811.93	812.11	812.04
13	811.33	811.87	811.57	811.62	811.81	811.91	812.18	812.12	811.98	812.10	811.97
14	811.37	811.89	811.58	811.61	811.78	811.94	812.19	812.11	811.98	812.07	811.85
15	811.36	811.87	811.57	811.62	811.81	811.93	812.14	812.01	811.89	811.92	811.70
16	811.38	811.77	811.59	811.57	811.86	811.72	811.99	811.94	811.77	811.76	811.60
17	811.37	811.67	811.71	811.56	811.94	811.71	811.84	811.75	811.62	811.69	811.54
18	811.37	811.57	811.75	811.54	811.97	811.67	811.71	811.71	811.57	811.76	811.70
19	811.37	811.57	811.71	811.56	811.96	811.71	811.74	811.78	811.65	811.89	811.73
20	811.37	811.67	811.72	811.54	811.92	811.79	811.87	811.90	811.72	811.80	811.66
21	811.33	811.72	811.88	811.61	811.87	811.82	811.91	811.89	811.71	811.88	811.74
22	811.34	811.67	811.77	811.56	811.90	811.80	811.87	811.93	811.76	811.84	811.73
23	811.36	811.72	811.78	811.61	811.86	811.84	811.93	811.94	811.75	811.80	811.70
24	811.31	811.72	811.90	811.61	811.87	811.83	811.91	811.91	811.72	811.78	811.64

WATER LEVEL ELEVATION AT GAUGE LOCATIONS

October 13, 1966.

Hours	Gauge 1	Gauge 2	Gauge 3	Gauge 4	Gauge 5	Gauge 6	Gauge 7	Gauge 8	Gauge 9	Gauge 10	Gauge 11
1	811.33	811.69	811.89	811.60	811.97	811.81	811.88	811.85	811.64	811.68	811.60
2	811.34	811.65	811.84	811.59	812.01	811.75	811.81	811.78	811.60	811.69	811.56
3	811.34	811.65	811.99	811.61	812.00	811.74	811.80	811.77	811.59	811.69	811.55
4	811.37	811.62	811.91	811.58	812.03	811.73	811.80	811.78	811.55	811.64	811.50
5	811.39	811.61	811.68	811.57	812.04	811.71	811.78	811.73	811.53	811.58	811.47
6	811.39	811.58	811.91	811.57	812.05	811.68	811.74	811.67	811.50	811.60	811.45
7	811.39	811.58	812.00	811.58	812.05	811.70	811.72	811.70	811.50	811.67	811.59
8	811.39	811.58	811.89	811.60	812.03	811.72	811.74	811.78	811.59	811.71	811.53
9	811.37	811.72	811.69	811.69	811.91	811.83	811.87	811.85	811.62	811.56	811.46
10	811.34	811.67	811.80	811.69	811.93	811.76	811.80	811.79	811.54	811.58	811.45
11	811.38	811.61	811.87	811.69	811.96	811.72	811.74	811.75	811.52	811.51	811.41
12	811.36	811.59	811.71	811.71	811.97	811.73	811.71	811.74	811.48	811.50	811.44
13	811.33	811.58	811.89	811.73	811.97	811.72	811.70	811.73	811.49	811.59	811.47
14	811.36	811.58	811.99	811.69	811.98	811.73	811.74	811.76	811.53	811.58	811.45
15	811.38	811.65	811.89	811.71	811.95	811.75	811.76	811.77	811.51	811.44	811.36
16	811.37	811.57	811.79	811.67	812.01	811.68	811.69	811.69	811.48	811.40	811.33
17	811.34	811.52	811.92	811.74	812.01	811.67	811.60	811.63	811.44	811.39	811.32
18	811.32	811.49	811.91	811.75	812.01	811.64	811.58	811.62	811.41	811.39	811.30
19	811.29	811.47	811.97	811.75	812.01	811.65	811.57	811.61	811.41	811.44	811.36
20	811.28	811.49	811.98	811.76	812.01	811.64	811.57	811.63	811.45	811.48	811.38
21	811.28	811.52	811.98	811.73	812.01	811.67	811.61	811.65	811.44	811.41	811.26
22	811.28	811.55	812.02	811.72	812.01	811.67	811.62	811.65	811.38	811.23	811.16
23	811.29	811.47	812.16	811.74	812.05	811.61	811.55	811.54	811.34	811.18	811.10
24	811.30	811.42	812.19	811.76	812.06	811.59	811.47	811.50	811.31	811.24	811.16

WATER LEVEL ELEVATION AT GAUGE LOCATIONS

October 14, 1966

Hours	Gauge 1	Gauge 2	Gauge 3	Gauge 4	Gauge 5	Gauge 6	Gauge 7	Gauge 8	Gauge 9	Gauge 10	Gauge 1
1	811.29	811.39	812.21	811.79	812.06	811.63	811.47	811.48	811.26	811.18	811.15
2	811.27	811.47	812.30	811.99	811.96	811.68	811.47	811.48	811.29	811.06	811.14
3	811.22	811.47	812.27	811.97	812.01	811.66	811.44	811.44	811.27	810.99	811.04
4	811.20	811.45	812.09	812.04	811.96	811.66	811.40	811.40	811.24	810.84	810.83
5	811.19	811.42	812.11	811.99	812.01	811.61	811.34	811.34	811.16	810.78	810.84
6	811.20	811.35	812.23	811.90	812.11	811.52	811.30	811.28	811.13	810.74	810.81
7	811.26	811.27	812.24	811.90	812.11	811.48	811.24	811.23	811.06	810.81	810.90
8	811.33	811.22	812.37	811.79	812.21	811.42	811.20	811.20	811.06	810.77	810.72
9	811.34	811.22	812.50	811.91	812.16	811.45	811.18	811.16	811.04	810.49	810.60
10	811.28	811.22	812.27	811.92	812.16	811.43	811.14	811.12	810.94	810.48	810.58
11	811.10	811.17	811.99	811.94	812.16	811.42	811.10	811.09	810.91	810.70	810.77
12	811.13	811.17	812.09	811.89	812.16	811.39	811.09	811.10	810.96	811.04	811.00
13	811.18	811.17	812.04	811.76	812.26	811.41	811.14	811.22	811.09	811.30	811.25
14	811.26	811.27	812.07	811.70	812.21	811.47	811.27	811.40	811.24	811.30	811.25
15	811.26	811.37	812.10	811.68	812.16	811.55	811.43	811.48	811.26	811.13	811.16
16	811.27	811.37	812.14	811.63	812.21	811.51	811.42	811.45	811.22	811.00	811.04
17	811.27	811.32	812.00	811.63	812.21	811.46	811.38	811.39	811.19	811.04	811.01
18	811.20	811.27	812.15	811.62	812.26	811.43	811.33	811.36	811.15	811.12	811.12
19	811.20	811.27	812.19	811.64	812.16	811.44	811.33	811.37	811.19	811.24	811.24
20	811.23	811.27	812.24	811.62	812.26	811.48	811.39	811.44	811.27	811.36	811.27
21	811.18	811.37	812.19	811.65	812.16	811.54	811.46	811.52	811.34	811.37	811.34
22	811.18	811.37	812.04	811.61	812.16	811.54	811.49	811.54	811.39	811.53	811.45
23	811.18	811.47	811.91	811.64	812.16	811.61	811.59	811.63	811.49	811.56	811.45
24	811.18	811.57	811.79	811.60	812.06	811.70	811.70	811.77	811.49	811.53	811.46

WATER LEVEL ELEVATION AT GAUGE LOCATIONS

October 15, 1966

Hours	Gauge 1	Gauge 2	Gauge 3	Gauge 4	Gauge 5	Gauge 6	Gauge 7	Gauge 8	Gauge 9	Gauge 10	Gauge 1
1	811.18	811.57	811.77	811.51	812.16	811.65	811.71	811.76	811.51	811.74	811.62
2	811.24	811.56	811.69	811.45	812.21	811.67	811.70	811.82	811.59	811.87	811.77
3	811.24	811.58	811.69	811.43	812.20	811.72	811.80	811.92	811.63	811.85	811.77
4	811.28	811.65	811.84	811.43	812.18	811.74	811.87	811.95	811.62	811.85	811.77
5	811.28	811.65	811.81	811.47	812.17	811.72	811.82	811.89	811.56	811.73	811.67
6	811.26	811.57	811.71	811.50	812.17	811.68	811.65	811.79	811.46	811.63	811.59
7	811.23	811.57	811.71	811.54	812.16	811.62	811.61	811.69	811.41	811.51	811.48
8	811.24	811.51	811.70	811.52	812.19	811.66	811.68	811.74	811.47	811.58	811.50
9	811.26	811.57	811.70	811.52	812.16	811.70	811.74	811.83	811.56	811.67	811.56
10	811.26	811.61	811.71	811.46	812.17	811.73	811.83	811.92	811.65	811.81	811.67
11	811.30	811.67	811.71	811.45	812.17	811.78	811.89	811.99	811.66	811.90	811.77
12	811.33	811.67	811.70	811.45	812.16	811.76	811.90	811.94	811.56	811.78	811.72
13	811.30	811.62	811.69	811.48	812.16	811.70	811.80	811.82	811.52	811.64	811.60
14	811.28	811.57	811.64	811.52	812.17	811.67	811.71	811.78	811.50	811.63	811.57
15	811.28	811.59	811.63	811.54	812.16	811.73	811.79	811.86	811.56	811.71	811.63
16	811.28	811.67	811.64	811.54	812.11	811.80	811.85	811.94	811.64	811.77	811.71
17	811.28	811.68	811.64	811.53	812.11	811.81	811.91	812.01	811.67	811.86	811.76
18	811.32	811.68	811.64	811.49	812.13	811.80	811.92	811.99	811.68	811.84	811.76
19	811.34	811.67	811.64	811.48	812.14	811.80	811.91	811.97	811.66	811.80	811.71
20	811.33	811.67	811.57	811.47	812.15	811.76	811.89	811.95	811.63	811.77	811.67
21	811.34	811.65	811.54	811.44	812.17	811.75	811.86	811.94	811.62	811.77	811.69
22	811.36	811.65	811.51	811.44	812.17	811.76	811.87	811.96	811.63	811.78	811.72
23	811.36	811.66	811.51	811.42	812.16	811.77	811.89	811.99	811.66	811.84	811.77
24	811.38	811.67	811.44	811.40	812.18	811.84	811.94	812.04	811.67	811.88	811.80

WATER LEVEL ELEVATION AT GAUGE LOCATIONS

October 16, 1966.

Hours	Gauge 1	Gauge 2	Gauge 3	Gauge 4	Gauge 5	Gauge 6	Gauge 7	Gauge 8	Gauge 9	Gauge 10	Gauge 11
1	811.43	811.68	811.34	811.35	812.24	811.79	811.98	812.06	811.69	811.92	811.85
2	811.38	811.67	811.34	811.39	812.24	811.81	811.97	812.06	811.71	811.90	811.83
3	811.40	811.71	811.39	811.41	812.21	811.81	811.97	812.06	811.70	811.92	811.88
4	811.40	811.71	811.49	811.47	812.20	811.83	811.98	812.07	811.72	811.96	811.87
5	811.38	811.75	811.49	811.55	812.11	811.89	812.00	812.10	811.74	811.87	811.80
6	811.33	811.77	811.48	811.60	812.07	811.89	812.01	812.05	811.71	811.70	811.67
7	811.38	811.75	811.43	811.55	812.11	811.80	811.96	811.93	811.60	811.67	811.60
8	811.39	811.63	811.43	811.50	812.19	811.71	811.81	811.85	811.52	811.69	811.65
9	811.40	811.59	811.43	811.47	812.20	811.71	811.79	811.89	811.57	811.81	811.75
10	811.48	811.62	811.39	811.46	812.23	811.76	811.82	811.95	811.62	811.86	811.78
11	811.46	811.67	811.44	811.52	812.17	811.82	811.90	812.01	811.65	811.76	811.72
12	811.40	811.72	811.54	811.57	812.11	811.83	811.94	811.98	811.65	811.70	811.66
13	811.38	811.72	811.49	811.67	812.11	811.82	811.90	811.94	811.60	811.69	811.60
14	811.38	811.71	811.39	811.64	812.08	811.82	811.87	811.91	811.58	811.67	811.57
15	811.38	811.69	811.48	811.63	812.09	811.80	811.86	811.90	811.58	811.73	811.60
16	811.40	811.67	811.47	811.61	812.10	811.80	811.84	811.92	811.65	811.91	811.76
17	811.44	811.72	811.41	811.60	812.08	811.89	811.91	812.04	811.69	811.93	811.84
18	811.44	811.77	811.49	811.60	812.08	811.89	812.00	812.08	811.75	811.90	811.83
19	811.46	811.78	811.58	811.62	812.06	811.91	812.01	812.09	811.73	811.74	811.66
20	811.44	811.77	811.49	811.64	812.04	811.85	811.94	811.95	811.62	811.59	811.55
21	811.46	811.67	811.39	811.63	812.06	811.72	811.84	811.79	811.51	811.61	811.55
22	811.48	811.59	811.39	811.58	812.14	811.71	811.74	811.79	811.52	811.68	811.60
23	811.48	811.62	811.39	811.57	812.16	811.76	811.79	811.85	811.60	811.73	811.67
24	811.49	811.67	811.39	811.55	812.16	811.78	811.84	811.92	811.65	811.83	811.75

WATER LEVEL ELEVATION AT GAUGE LOCATIONS

OCTOBER 17, 1966

Hours	Gauge 1	Gauge 2	Gauge 3	Gauge 4	Gauge 5	Gauge 6	Gauge 7	Gauge 8	Gauge 9	Gauge 10	Gauge 11
1	811.48	811.67	811.45	811.56	812.08	811.83	811.90	811.98	811.66	811.76	811.73
2	811.48	811.75	811.47	811.61	812.03	811.86	811.96	811.98	811.64	811.62	811.55
3	811.48	811.73	811.44	811.63	812.03	811.80	811.89	811.84	811.53	811.54	811.46
4	811.46	811.66	811.39	811.62	812.06	811.72	811.78	811.78	811.47	811.62	811.53
5	811.46	811.62	811.34	811.57	812.10	811.73	811.79	811.83	811.49	811.74	811.65
6	811.48	811.66	811.34	811.53	812.11	811.80	811.85	811.94	811.59	811.81	811.74
7	811.53	811.69	811.35	811.50	812.11	811.81	811.90	812.02	811.64	811.86	811.80
8	811.56	811.69	811.38	811.47	812.13	811.83	811.94	812.05	811.68	811.93	811.83
9	811.58	811.73	811.39	811.52	812.10	811.89	811.99	812.09	811.70	811.83	811.80
10	811.53	811.77	811.29	811.54	812.05	811.89	812.02	812.09	811.73	811.95	811.83
11	811.48	811.77	811.29	811.63	812.03	811.96	812.01	812.13	811.76	811.98	811.83
12	811.48	811.87	811.29	811.71	811.92	811.97	812.08	812.16	811.81	812.05	811.92
13	811.43	811.87	811.29	811.66	811.95	812.01	812.13	812.23	811.87	812.12	811.98
14	811.48	811.92	811.37	811.66	811.91	812.02	812.18	812.26	811.90	812.06	811.97
15	811.53	811.92	811.49	811.67	812.01		812.18	812.24	811.87	811.83	811.77
16	811.53	811.87	811.59	811.68	812.03		812.07	812.02	811.68	811.54	811.45
17	811.53	811.72	811.59	811.70	812.11		811.84	811.72	811.54	811.50	811.36
18	811.52	811.59	812.44	811.73	812.15		811.74	811.72	811.45	811.40	811.29
19	811.48	811.57	811.41	811.71	812.16		811.68	811.69	811.44	811.38	811.40
20	811.48	811.57	811.44	811.71	812.17		811.69	811.74	811.49	811.60	811.54
21	811.48	811.62	811.47	811.69	812.14		811.80	811.89	811.64	811.71	811.61
22	811.49	811.75	811.50	811.69	812.08		811.93	811.99	811.70	811.70	811.56
23	811.50	811.76	811.49	811.67	812.08		811.89	811.91	811.65	811.63	811.45
24	811.52	811.67	811.48	811.66	812.15		811.79	811.84	811.53	811.46	811.33

WATER LEVEL ELEVATION AT GAUGE LOCATIONS

OCTOBER 18, 1966

Hours	Gauge 1	Gauge 2	Gauge 3	Gauge 4	Gauge 5	Gauge 6	Gauge 7	Gauge 8	Gauge 9	Gauge 10	Gauge 11
1	811.53	811.59	811.40	811.67	812.07		811.73	811.69	811.42	811.37	811.33
2	811.53	811.50	811.41	811.66	812.12		811.64	811.65	811.42	811.44	811.40
3	811.52	811.55	811.47	811.73	812.07		811.69	811.71	811.46	811.48	811.40
4	811.48	811.62	811.51	811.75	812.03		811.74	811.74	811.46	811.41	811.33
5	811.53	811.63	811.50	811.79	812.01		811.74	811.74	811.45	811.36	811.25
6	811.47	811.57	811.49	811.76	812.05		811.69	811.69	811.39	811.18	811.16
7	811.46	811.57	811.44	811.76	812.07		811.63	811.61	811.31	811.09	811.06
8	811.48	811.47	811.49	811.67	812.16		811.54	811.56	811.25	811.11	811.13
9	811.53	811.41	811.41	811.67	812.17		811.51	811.55	811.23	811.20	811.20
10	811.48	811.41	811.34	811.66	812.17		811.51	811.55	811.28	811.28	811.29
11	811.50	811.45	811.39	811.70	812.14		811.59	811.58	811.35	811.41	811.36
12	811.58	811.52	811.49	811.70	812.08		811.68	811.68	811.44	811.48	811.44
13	811.48	811.62	811.49	811.76	812.02		811.78	811.77	811.52	811.56	811.51
14	811.48	811.67	811.49	811.74	812.01		811.81	811.83	811.59	811.60	811.49
15	811.54	811.67	811.59	811.71	812.01		811.84	811.83	811.55	811.57	811.47
16	811.56	811.65	811.39	811.64	812.06		811.79	811.79	811.53	811.57	811.50
17	811.58	811.62	811.44	811.74	812.02		811.74	811.75	811.56	811.58	811.54
18	811.43	811.57	811.54	811.58	812.11		811.69	811.74	811.51	811.58	811.53
19	811.56	811.63	811.88	811.76	812.00		811.77	811.80	811.52	811.54	811.47
20	811.38	811.67	811.59	811.86	811.93		811.79	811.78	811.54	811.49	811.33
21	811.38	811.67	811.64	811.81	811.97		811.79	811.80	811.51	811.41	811.35
22	811.46	811.62	811.70	811.73	812.06		811.73	811.73	811.46	811.40	811.20
23	811.48	811.57	811.28	811.66	812.11		811.69	811.68	811.42	811.28	811.34
24	811.48	811.47	811.39	811.58	812.17		811.59	811.61	811.39	811.54	811.47

WATER LEVEL ELEVATION AT GAUGE LOCATIONS

OCTOBER 19, 1966

Hours	Gauge 1	Gauge 2	Gauge 3	Gauge 4	Gauge 5	Gauge 6	Gauge 7	Gauge 8	Gauge 9	Gauge 10	Gauge 11
1	811.48	811.47	811.59	811.62	812.10		811.65	811.72	811.52	811.65	811.66
2	811.46	811.65	811.59	811.68	811.94		811.86	811.89	811.64	811.75	811.67
3	811.40	811.77	811.57	811.73	811.88		811.98	812.01	811.72	811.64	811.46
4	811.39	811.82	811.59	811.74	811.91		811.92	811.90	811.60	811.51	811.44
5	811.43	811.67	811.43	811.66	812.03		811.77	811.75	811.54	811.56	811.44
6	811.44	811.57	811.41	811.58	812.07		811.74	811.73	811.48	811.51	811.48
7	811.48	811.57	811.47	811.52	812.11		811.71	811.73	811.52	811.70	811.70
8	811.48	811.56	811.49	811.52	812.07		811.81	811.94	811.69	811.90	811.79
9	811.47	811.68	811.39	811.55	812.02		811.95	812.03	811.74	811.84	811.72
10	811.47	811.75	811.40	811.54	812.01		812.00	812.04	811.74	811.80	811.76
11	811.48	811.75	811.40	811.54	812.02		811.98	812.05	811.75	811.90	811.76
12	811.48	811.75	811.31	811.46	812.06		811.99	812.07	811.76	811.90	811.83
13	811.50	811.73	811.29	811.46	812.06		812.03	812.11	811.83	812.07	812.03
14	811.53	811.73	811.39	811.38	812.10		812.09	812.22	811.94	812.32	812.15
15	811.56	811.77	811.28	811.40	812.04	811.91	812.20	812.34	812.04	812.44	812.24
16	811.53	811.87	811.24	811.41	812.01	811.98	812.30	812.47	812.14	812.47	812.25
17	811.53	811.97	811.29	811.42	811.97	812.04	812.41	812.53	812.23	812.44	812.23
18	811.53	811.99	811.37	811.49	811.92	812.07	812.44	812.55	812.22	812.33	812.10
19	811.57	812.02	811.27	811.50	811.91	812.07	812.39	812.47	812.11	812.16	811.97
20	811.57	811.97	811.13	811.49	811.95	812.00	812.34	812.37	812.08	812.21	812.10
21	811.56	811.92	811.15	811.52	811.93	811.97	812.32	812.40	812.09	812.32	812.16
22	811.52	811.97	811.29	811.58	811.90	812.02	812.30	812.40	812.09	812.19	812.05
23	811.50	811.97	811.50	811.62	811.87	812.01	812.28	812.31	811.99	811.96	811.85
24	811.48	811.92	811.54	811.68	811.88	811.92	812.10	812.12	811.82	811.76	811.60

WATER LEVEL ELEVATION AT GAUGE LOCATIONS

October 20, 1966

Hours	Gauge 1	Gauge 2	Gauge 3	Gauge 4	Gauge 5	Gauge 6	Gauge 7	Gauge 8	Gauge 9	Gauge 10	Gauge 1
1	811.48	811.77	811.49	811.69	811.88	811.79	811.89	811.91	811.63	811.54	811.40
2	811.48	811.67	811.40	811.67	811.96	811.67	811.78	811.76	811.45	811.34	811.22
3	811.49	811.57	811.39	811.61	812.03	811.61	811.69	811.63	811.38	811.36	811.36
4	811.50	811.48	811.38	811.59	812.07	811.55	811.61	811.66	811.45	811.67	811.56
5	811.50	811.49	811.44	811.62	812.00	811.66	811.77	811.85	811.64	811.80	811.74
6	811.49	811.77	811.49	811.66	811.88	811.84	811.98	812.02	811.76	811.81	811.66
7	811.50	811.78	811.50	811.71	811.85	811.87	812.00	812.02	811.73	811.70	811.54
8	811.50	811.77	811.47	811.70	811.88	811.86	811.89	811.88	811.60	811.50	811.37
9	811.49	811.67	811.39	811.70	811.94	811.67	811.79	811.73	811.49	811.52	811.45
10	811.50	811.59	811.39	811.64	811.99	811.64	811.74	811.74	811.54	811.62	811.52
11	811.51	811.62	811.44	811.62	811.97	811.71	811.83	811.87	811.61	811.75	811.70
12	811.53	811.67	811.45	811.61	811.95	811.78	811.90	811.99	811.74	811.92	811.81
13	811.53	811.77	811.50	811.61	811.92	811.85	811.99	812.10	811.83	811.97	811.76
14	811.53	811.82	811.54	811.64	811.87	811.88	812.08	812.11	811.82	811.83	811.64
15	811.48	811.82	811.49	811.64	811.88	811.85	812.03	812.01	811.73	811.70	811.58
16	811.48	811.77	811.39	811.68	811.91	811.78	811.90	811.91	811.67	811.70	811.37
17	811.48	811.69	811.33	811.66	811.91	811.77	811.89	811.93	811.62	811.82	811.70
18	811.43	811.77	811.39	811.67	811.91	811.80	811.94	812.01	811.76	811.91	811.77
19	811.58	811.77	811.38	811.66	811.88	811.84	812.00	812.07	811.84	811.97	811.80
20	811.58	811.78	811.49	811.60	811.92	811.86	812.04	812.10	811.85	811.97	811.85
21	811.48	811.82	811.29	811.71	811.82	811.90	812.08	812.12	811.83	811.84	811.65
22	811.50	811.87	811.39	811.70	811.86	811.86	812.04	812.02	811.69	811.59	811.48
23	811.53	811.77	811.39	811.69	811.91	811.68	811.89	811.79	811.56	811.57	811.50
24	811.53	811.61	811.49	811.62	812.00	811.65	811.74	811.76	811.58	811.78	811.65

WATER LEVEL ELEVATION AT GAUGE LOCATIONS

October 21, 1966

Hours	Gauge 1	Gauge 2	Gauge 3	Gauge 4	Gauge 5	Gauge 6	Gauge 7	Gauge 8	Gauge 9	Gauge 10	Gauge
1	811.52	811.62	811.40	811.66	811.85	811.71	811.85	811.94	811.66	811.69	811.5
2	811.56	811.77	811.44	811.68	811.82	811.73	811.94	811.93	811.62	811.48	811.3
3	811.56	811.67	811.39	811.68	811.90	811.64	811.79	811.69	811.50	811.49	811.3
4	811.53	811.59	811.39	811.67	811.92	811.56	811.69	811.69	811.45	811.49	811.4
5	811.50	811.59	811.45	811.73	811.89	811.64	811.75	811.72	811.47	811.52	811.4
6	811.53	811.63	811.49	811.67	811.88	811.64	811.76	811.76	811.56	811.61	811.5
7	811.50	811.67	811.54	811.74	811.81	811.71	811.84	811.83	811.57	811.57	811.4
8	811.50	811.70	811.50	811.71	811.85	811.68	811.82	811.80	811.58	811.51	811.3
9	811.54	811.67	811.50	811.71	811.87	811.66	811.79	811.74	811.53	811.47	811.3
10	811.58	811.62	811.49	811.67	811.91	811.61	811.74	811.71	811.51	811.47	811.3
11	811.56	811.59	811.49	811.68	811.61	811.61	811.74	811.70	811.50	811.58	811.5
12	811.54	811.59	811.54	811.69	811.61	811.64	811.78	811.77	811.57	811.64	811.5
13	811.52	811.67	811.69	811.74	811.51	811.63	811.90	811.87	811.62	811.59	811.4
14	811.50	811.75	811.79	811.72	811.55	811.73	811.84	811.80	811.59	811.48	811.3
15	811.50	811.67	811.77	811.73	811.63	811.67	811.77	811.72	811.50	811.38	811.2
16	811.50	811.57	811.80	811.70	811.65	811.60	811.64	811.64	811.44	811.28	811.1
17	811.49	811.51	811.79	811.72	811.67	811.55	811.60	811.57	811.35	811.22	811.2
18	811.50	811.47	811.89	811.70	811.69	811.51	811.56	811.53	811.35	811.29	811.1
19	811.43	811.47	811.79	811.83	811.61	811.57	811.56	811.53	811.37	811.33	811.3
20	811.43	811.49	811.89	811.80	811.61	811.56	811.58	811.57	811.39	811.30	811.2
21	811.50	811.53	812.09	811.96	811.52	811.62	811.54	811.50	811.39	810.96	810.8
22	811.43	811.52	812.23	812.03	811.55	811.62	811.44	811.43	811.29	810.62	810.6
23	811.28	811.45	812.49	812.12	811.53	811.56	811.32	811.27	811.16	810.50	810.7
24	811.23	811.37	812.79	812.12	811.60	811.52	811.26	811.19	811.09	810.54	810.4

WATER LEVEL ELEVATION AT GAUGE LOCATIONS

October 22, 1966

Hours	Gauge 1	Gauge 2	Gauge 3	Gauge 4	Gauge 5	Gauge 6	Gauge 7	Gauge 8	Gauge 9	Gauge 10	Gauge 1
1	811.30	811.31	812.92	812.01	811.92	811.42	811.19	811.16	810.99	810.21	810.11
2	811.48	811.27	812.75	812.01	811.94	811.40	811.10	811.05	810,94	809.91	809.90
3	811.28	811.17	812.48	812.03	811.93	811.33	811.06	810.98	810.82	809.64	809.49
4	811.28	811.17	813.10	812.04	811.98	811.32	810.99	810.89	810.73	809.43	809.22
5	811.39	811.07	812.30	811.95	812.07	811.22	810.89	810.80	810.59	809.50	809.90
6	811.33	811.02	811.16	812.13	811.98	811.23	810.74	810.71	810.63	810.11	810.20
7	811.20	811.05	812.30	812.12	811.97	811.27	810.84	810.79	810.64	810.09	810.29
8	811.23	811.09	812.65	812.26	811.89	811.32	810.89	810.79	810.65	809.89	810.04
9	811.23	811.15	812.35	812.22	811.89	811.36	810.89	810.80	810.63	809.84	810.03
10	811.14	811.17	812.02	812.32	811.84	811.40	810.94	810.83	810.64	809.83	810.02
11	811.26	811.17	812.33	812.22	811.92	811.36	810.90	810.80	810.64	809.60	809.57
12	811.28	811.12	811.78	812.22	811.90	811.33	810.90	810.80	810.56	809.38	809.56
13	811.30	811.12	811.70	812.24	811.91	811.33	810.88	810.74	810.54	809.49	809.90
14	811.33	811.07	811.78	812.15	811.97	811.26	810.84	810.70	810.56	810.28	810.47
15	811.38	811.07	811.82	812.09	812.02	811.23	810.89	810.84	810.69	810.76	810.90
16	811.38	811.07	811.49	811.96	812.02	811.26	811.00	811.02	810.82	810.81	810.98
17	811.38	811.17	811.58	811.91	812.01	811.33	811.19	811.14	810.94	811.10	811.26
18	811.40	811.27	811.64	811.82	811.96	811.40	811.34	811.34	811.14	811.20	811.36
19	811.39	811.45	811.65	811.82	811.87	811.53	811.54	811.50	811.21	811.06	811.14
20	811.39	811.52	811.78	811.83	811.86	811.56	811.57	811.48	811.19	810.98	811.06
21	811.40	811.49	811.89	811.92	811.82	811.58	811.50	811.44	811.17	810.84	810.87
22	811.40	811.47	811.80	811.86	811.91	811.51	811.44	811.39	811.12	810.79	810.87
23	811.43	811.39	811.58	811.84	811.94	811.46	811.40	811.35	811.09	810.90	811.00
24	811.48	811.37	811.31	811.76	811.98	811.42	811.39	811.34	811.11	811.14	811.25

WATER LEVEL ELEVATION AT GAUGE LOCATIONS

October 23, 1966.

Hours	Gauge 1	Gauge 2	Gauge 3	Gauge 4	Gauge 5	Gauge 6	Gauge 7	Gauge 8	Gauge 9	Gauge 10	Gauge 11
1	811.50	811.27	811.49	811.76	811.96	811.44	811.48	811.47	811.29	811.36	811.44
2	811.41	811.47	811.56	811.79	811.88	811.54	811.64	811.59	811.40	811.54	811.62
3	811.48	811.62	811.65	811.81	811.77	811.69	811.80	811.77	811.58	811.58	811.55
4	811.48	811.75	811.35	811.88	811.61	811.80	811.97	811.87	811.58	811.46	811.49
5	811.43	811.87	811.50	812.04	811.62	811.90	811.91	811.84	811.57	811.22	811.25
6	811.33	811.73	811.80	812.01	811.67	811.75	811.78	811.68	811.49	811.12	811.14
7	811.26	811.69	811.70	812.10	811.66	811.76	811.69	811.62	811.41	811.24	811.24
8	811.27	811.55	811.40	811.98	811.77	811.65	811.59	811.56	811.40	811.31	811.32
9	811.30	811.67	811.70	812.03	811.72	811.67	811.62	811.58	811.39	811.24	811.24
10	811.33	811.62	811.85	811.98	811.77	811.68	811.60	811.55	811.36	811.00	811.15
11	811.36	811.57	811.90	811.95	811.81	811.60	811.54	811.45	811.29	810.91	811.08
12	811.38	811.47	812.08	811.91	811.86	811.55	811.48	811.38	811.20	810 90	811.03
13	811.38	811.43	812.05	811.91	811.89	811.50	811.41	811.35	811.16	810 89	810.96
14	811.38	811.39	811.78	811.87	811.92	811.47	811.38	811.31	811.13	810 87	810.92
15	811.38	811.37	811.70	811.89	811.92	811.45	811.36	811.31	811.13	810.98	811.10
16	811.38	811.37	811.81	811.82	811.97	811.42	811.36	811.32	811.19	811.37	811.39
17	811.36	811.37	811.78	811.81	811.93	811.46	811.51	811.53	811.41	811.62	811.54
18	811.37	811.57	811.84	811.80	811.81	811.63	811.74	811.77	811.59	811.71	811.71
19	811.38	811.77	811.82	811.78	811.74	811.80	811.94	811.93	811.74	811.72	811.64
20	811.39	811.81	811.81	811.72	811.76	811.80	811.96	811.92	811.73	811.60	811.50
21	811.39	811.69	811.75	811.63	811.89	811.65	811.81	811.72	811.59	811.53	811.50
22	811.40	811.57	811.75	811.61	811.93	811.57	811.71	811.66	811.50	811.66	811.63
23	811.38	811.58	811.82	811.68	811.86	811.62	811.78	811.79	811.60	811.71	811.66
24	811.28	811.67	811.85	811.70	811.77	811.74	811.89	811.89	811.66	811.68	811.63

WATER LEVEL ELEVATION AT GAUGE LOCATIONS

October 24, 1966

Hours	Gauge 1	Gauge 2	Gauge 3	Gauge 4	Gauge 5	Gauge 6	Gauge 7	Gauge 8	Gauge 9	Gauge 10	Gauge 11
1	811.28	811.77	811.71	811.70	811.81	811.75	811.94	811.89	811.68	811.70	811.62
2	811.28	811.69	811.72	811.60	811.88	811.66	811.84	811.82	811.65	811.68	811.61
3	811.29	811.66	811.72	811.55	811.94	811.61	811.79	811.76	811.57	811.63	811.58
4	811.36	811.58	811.72	811.49	811.98	811.65	811.73	811.72	811.55	811.64	811.62
5	811.36	811.56	811.72	811.50	811.97	811.57	811.74	811.80	811.56	811.73	811.68
6	811.30	811.59	811.74	811.51	811.94	811.62	811.82	811.84	811.63	811.75	811.69
7	811.28	811.67	811.70	811.58	811.89	811.68	811.88	811.88	811.65	811.73	811.62
8	811.28	811.69	811.66	811.53	811.91	811.68	811.88	811.87	811.65	811.73	811.63
9	811.28	811.67	811.65	811.55	811.92	811.66	811.86	811.85	811.65	811.79	811.65
10	811.31	811.67	811.62	811.49	811.96	811.65	811.87	811.87	811.67	811.84	811.74
11	811.31	811.65	811.64	811.48	811.95	811.65	811.90	811.92	811.71	811.89	811.81
12	811.33	811.67	811.62	811.46	811.95	811.69	811.96	811.96	811.74	811.92	811.84
13	811.33	811.69	811.64	811.46	811.94	811.71	811.99	812.01	811.77	811.95	811.84
14	811.36	811.72	811.60	811.43	811.94	811.72	812.03	812.04	811.79	811.98	811.85
15	811.34	811.73	811.60	811.44	811.93	811.73	812.07	812.07	811.83	812.10	811.98
16	811.33	811.77	811.60	811.42	811.93	811.75	812.11	812.14	811.93	812.17	812.04
17	811.38	811.77	811.61	811.42	811.91	811.81	812.15	812.19	811.95	812.12	812.02
18	811.43	811.81	811.55	811.37	811.94	811.81	812.17	812.20	811.96	812.11	811.95
19	811.38	811.79	811.40	811.35	811.95	811.80	812.16	812.21	811.95	812.15	811.98
20	811.40	811.79	811.32	811.31	811.96	811.81	812.18	812.24	811.95	812.24	811.09
21	811.44	811.81	811.34	811.31	811.96	811.82	812.27	812.29	812.01	812.35	812.02
22	811.44	811.83	811.38	811.33	811.93	811.85	812.32	812.34	812.07	812.39	812.29
23	811.42	811.82	811.35	811.34	811.89	811.89	812.36	812.41	812.12	812.34	812.27
24	811.42	811.91	811.40	811.38	811.87	811.93	812.36	812.41	812.13	812.20	812.13

WATER LEVEL ELEVATION AT GAUGE LOCATIONS

October 25, 1966.

Hours	Gauge 1	Gauge 2	Gauge 3	Gauge 4	Gauge 5	Gauge 6	Gauge 7	Gauge 8	Gauge 9	Gauge 10	Gauge 11
1	811.46	811.92	811.50	811.41	811.86	811.92	812.23	812.29	812.09	812.09	811.97
2	811.43	811.92	811.55	811.45	811.86	811.89	812.24	812.18	812.00	812.10	811.95
3	811.46	811.83	811.50	811.49	811.86	811.83	812.14	812.13	811.96	812.03	811.91
4	811.39	811.83	811.65	811.58	811.81	811.84	812.13	812.09	811.89	811.84	811.73
5	811.37	811.85	811.65	811.62	811.81	811.83	812.04	811.94	811.76	811.73	811.63
6	811.37	811.77	811.60	811.63	811.85	811.70	811.89	811.84	811.67	811.70	811.60
7	811.39	811.67	811.60	811.63	811.86	811.67	811.78	811.76	811.61	811.64	811.57
8	811.36	811.67	811.90	811.65	811.85	811.69	811.84	811.75	811.55	811.54	811.52
9	811.36	811.67	811.95	811.66	811.87	811.65	811.78	811.69	811.54	811.40	811.36
10	811.36	811.61	812.20	811.66	811.91	811.60	811.69	811.60	811.44	811.24	811.21
11	811.33	811.57	812.10	811.70	811.94	811.53	811.59	811.49	811.39	811.10	811.11
12	811.30	811.47	811.80	811.72	811.97	811.47	811.50	811.42	811.32	811.00	811.99
13	811.33	811.37	811.70	811.63	812.05	811.39	811.39	811.33	811.23	811.91	810.83
14	811.32	811.31	811.76	811.63	812.06	811.36	811.35	811.25	811.19	811.10	811.11
15	811.28	811.27	811.78	811.65	812.11	811.30	811.24	811.23	811.29	811.44	811.35
16	811.33	811.26	812.00	811.63	812.01	811.35	811.34	811.47	811.47	811.73	811.64
17	811.23	811.47	812.10	811.69	811.84	811.64	811.73	811.78	811.64	811.60	811.47
18	811.28	811.71	811.85	811.68	811.81	811.72	811.90	811.83	811.64	811.40	811.27
19	811.33	811.72	811.60	811.59	811.95	811.59	811.79	811.62	811.45	811.28	811.14
20	811.36	811.52	811.60	811.51	812.05	811.44	811.60	811.49	811.35	811.45	811.37
21	811.36	811.39	811.65	811.48	812.07	811.41	811.53	811.52	811.46	811.74	811.57
22	811.34	811.47	811.62	811.51	811.93	811.54	811.74	811.79	811.60	811.90	811.82
23	811.32	811.69	811.70	811.58	811.85	811.72	811.94	811.98	811.80	812.02	811.88
24	811.28	811.81	811.75	811.60	811.82	811.79	812.03	812.05	811.86	811.82	811.66

WATER LEVEL ELEVATION AT GAUGE LOCATIONS

October 26, 1966.

Hours	Gauge 1	Gauge 2	Gauge 3	Gauge 4	Gauge 5	Gauge 6	Gauge 7	Gauge 8	Gauge 9	Gauge 10	Gauge 11
1	811.30	811.82	811.72	811.60	811.86	811.81	812.04	811.94	811.75	811.64	811.54
2	811.32	811.77	811.62	811.53	811.94	811.66	811.89	811.72	811.59	811.62	811.52
3	811.33	811.57	811.62	811.50	811.98	811.52	811.69	811.65	811.53	811.74	811.63
4	811.34	811.52	811.60	811.48	811.98	811.54	811.73	811.77	811.62	811.84	811.73
5	811.36	811.61	811.58	811.51	811.93	811.66	811.84	811.87	811.70	811.92	811.78
6	811.36	811.67	811.60	811.52	811.90	811.71	811.91	811.95	811.76	811.98	811.84
7	811.34	811.73	811.61	811.55	811.87	811.76	812.00	812.01	811.83	811.95	811.84
8	811.33	811.77	811.61	811.55	811.86	811.78	812.03	812.00	811.82	811.85	811.82
9	811.34	811.77	811.61	811.52	811.90	811.74	811.99	811.92	811.77	811.83	811.72
10	811.38	811.67	811.60	811.51	811.93	811.66	811.90	811.89	811.75	811.93	811.76
11	811.38	811.67	811.60	811.49	811.95	811.66	811.91	811.93	811.76	811.94	811.78
12	811.38	811.71	811.66	811.51	811.91	811.71	812.02	811.97	811.80	811.97	811.80
13	811.38	811.75	811.72	811.54	811.87	811.74	812.01	812.01	811.84	811.99	811.80
14	811.33	811.77	811.69	811.60	811.83	811.77	812.03	812.04	811.84	811.93	811.76
15	811.30	811.79	811.69	811.63	811.81	811.79	812.03	811.98	811.74	811.78	811.63
16	811.33	811.77	811.56	811.60	811.85	811.74	811.93	811.84	811.65	811.72	811.60
17	811.34	811.77	811.75	811.59	811.90	811.63	811.82	811.77	811.59	811.68	811.55
18	811.36	811.67	811.60	811.55	811.93	811.62	811.79	811.75	811.55	811.67	811.65
19	811.38	811.61	811.66	811.55	811.94	811.59	811.78	811.80	811.63	811.78	811.62
20	811.37	811.67	811.66	811.58	811.90	811.65	811.87	811.84	811.62	811.68	811.60
21	811.37	811.67	811.75	811.63	811.86	811.67	811.84	811.80	811.63	811.72	811.56
22	811.30	811.67	811.70	811.67	811.83	811.68	811.87	811.82	811.61	811.64	811.52
23	811.30	811.69	811.74	811.69	811.82	811.69	811.84	811.75	811.57	811.61	811.50
24	811.30	811.67	811.72	811.66	811.86	811.64	811.79	812.73	811.56	811.61	811.48

WATER LEVEL ELEVATION AT GAUGE LOCATIONS

October 27, 1966.

Hours	Gauge 1	Gauge 2	Gauge 3	Gauge 4	Gauge 5	Gauge 6	Gauge 7	Gauge 8	Gauge 9	Gauge 10	Gauge 11
1	811.30	811.65	811.64	811.66	811.86	811.63	811.77	811.72	811.55	811.57	811.44
2	811.30	811.62	811.66	811.59	811.92	811.62	811.76	811.71	811.54	811.59	811.50
3	811.32	811.57	811.72	811.59	811.93	811.57	811.74	811.71	811.57	811.72	811.60
4	811.32	811.62	811.71	811.60	811.90	811.64	811.82	811.83	811.65	811.74	811.61
5	811.30	811.71	811.73	811.63	811.85	811.68	811.87	811.85	811.67	811.75	811.61
6	811.29	811.71	811.90	811.66	811.83	811.69	811.85	811.83	811.66	811.75	811.61
7	811.27	811.67	811.92	811.67	811.81	811.68	811.86	811.83	811.65	811.67	811.52
8	811.25	811.72	811.91	811.71	811.81	811.70	811.84	811.76	811.61	811.60	811.49
9	811.23	811.67	811.90	811.66	811.86	811.65	811.78	811.74	811.59	811.62	811.49
10	811.25	811.62	811.92	811.64	811.89	811.61	811.75	811.72	811.56	811.60	811.46
11	811.27	811.64	811.85	811.61	811.91	811.59	811.74	811.71	811.55	811.58	811.46
12	811.25	811.57	811.84	811.59	811.95	811.57	811.71	811.67	811.54	811.60	811.49
13	811.28	811.57	811.83	811.60	811.94	811.55	811.70	811.66	811.52	811.59	811.50
14	811.29	811.57	811.93	811.58	811.96	811.56	811.70	811.65	811.51	811.57	811.50
15	811.25	811.55	812.01	811.62	811.94	811.55	811.68	811.63	811.51	811.58	811.43
16	811.27	811.50	812.07	811.57	811.95	811.55	811.68	811.64	811.49	811.55	811.49
17	811.28	811.51	812.00	811.59	811.97	811.51	811.64	811.63	811.49	811.55	811.41
18	811.26	811.53	812.00	811.61	811.95	811.54	811.67	811.62	811.46	811.48	811.37
19	811.23	811.49	811.95	811.56	811.98	811.50	811.62	811.57	811.42	811.40	811.32
20	811.26	811.47	812.00	811.58	811.98	811.48	811.59	811.53	811.42	811.44	811.38
21	811.27	811.43	812.02	811.54	812.02	811.44	811.56	811.53	811.43	811.50	811.37
22	811.27	811.49	812.00	811.56	812.00	811.47	811.59	811.56	811.42	811.48	811.38
23	811.25	811.47	811.95	811.54	811.99	811.53	811.61	811.57	811.44	811.50	811.41
24	811.22	811.48	811.90	811.59	811.96	811.50	811.64	811.60	811.44	811.50	811.38

WATER LEVEL ELEVATION AT GAUGE LOCATIONS

October 28, 1966.

Hours	Gauge 1	Gauge 2	Gauge 3	Gauge 4	Gauge 5	Gauge 6	Gauge 7	Gauge 8	Gauge 9	Gauge 10	Gauge 11
1	811.23	811.52	811.75	811.56	811.96	811.52	811.67	811.83	811.45	811.52	811.46
2	811.23	811.55	811.75	811.56	811.96	811.53	811.68	811.67	811.48	811.60	811.52
3	811.24	811.57	811.76	811.55	811.93	811.56	811.76	811.74	811.60	811.64	811.56
4	811.28	811.63	811.76	811.55	811.93	811.61	811.79	811.76	811.57	811.66	811.56
5	811.29	811.62	811.76	811.54	811.94	811.60	811.79	811.73	811.54	811.57	811.49
6	811.28	811.59	811.76	811.64	811.88	811.59	811.74	811.64	811.43	811.43	811.37
7	811.22	811.57	811.75	811.58	811.97	811.55	811.68	811.58	811.39	811.38	811.33
8	811.28	811.47	811.72	811.53	812.02	811.47	811.59	811.56	811.38	811.40	811.31
9	811.30	811.47	811.59	811.51	812.04	811.46	811.59	811.56	811.39	811.53	811.44
10	811.30	811.47	811.56	811.46	812.05	811.46	811.63	811.66	811.45	811.62	811.54
11	811.38	811.57	811.70	811.54	811.95	811.54	811.76	811.77	811.56	811.70	811.63
12	811.37	811.67	811.80	811.71	811.77	811.67	811.85	811.82	811.62	811.68	811.57
13	811.18	811.77	811.95	811.81	811.73	811.76	811.89	811.81	811.59	811.52	811.45
14	811.18	811.72	811.98	811.86	811.75	811.71	811.79	811.73	811.54	811.38	811.30
15	811.38	811.76	812.05	811.83	811.81	811.65	811.68	811.63	811.44	811.17	811.10
16	811.28	811.59	812.00	811.86	811.85	811.61	811.59	811.51	811.36	811.00	810.96
17	811.23	811.77	812.00	811.76	811.95	811.49	811.46	811.39	811.26	810.98	810.97
18	811.32	811.37	811.82	811.66	812.04	811.41	811.40	811.34	811.20	811.09	811.10
19	811.28	811.32	811.74	811.62	812.06	811.37	811.39	811.34	811.21	811.31	811.27
20	811.33	811.37	811.75	811.61	812.02	811.39	811.44	811.48	811.36	811.46	811.45
21	811.32	811.47	811.82	811.63	811.92	811.49	811.62	811.66	811.49	811.58	811.50
22	811.20	811.65	811.78	811.71	811.83	811.64	811.80	811.77	811.56	811.63	811.53
23	811.20	811.67	811.78	811.71	811.81	811.68	811.83	811.81	811.60	811.63	811.53
24	811.24	811.67	811.78	811.64	811.86	811.69	811.82	811.76	811.61	811.66	811.53

WATER LEVEL ELEVATION AT GAUGE LOCATIONS

October 29, 1966.

Hours	Gauge 1	Gauge 2	Gauge 3	Gauge 4	Gauge 5	Gauge 6	Gauge 7	Gauge 8	Gauge 9	Gauge 10	Gauge 1
1	811.24	811.62	811.70	811.56	811.95	811.60	811.77	811.74	811.59	811.69	811.55
2	811.28	811.59	811.68	811.50	811.97	811.58	811.76	811.74	811.59	811.70	811.58
3	811.28	811.57	811.69	811.48	811.98	811.55	811.75	811.79	811.63	811.82	811.71
4	811.28	811.59	811.69	811.49	811.95	811.60	811.85	811.86	811.66	811.88	811.75
5	811.26	811.67	811.65	811.53	811.90	811.71	811.90	811.92	811.69	811.83	811.69
6	811.27	811.71	811.64	811.52	811.88	811.69	811.92	811.89	811.69	811.79	811.67
7	811.27	811.67	811.59	811.50	811.94	811.65	811.89	811.86	811.69	811.85	811.71
8	811.28	811.67	811.55	811.46	811.95	811.65	811.89	811.91	811.69	811.89	811.71
9	811.33	811.67	811.50	811.41	811.97	811.64	811.91	811.94	811.72	811.89	811.76
10	811.36	811.67	811.38	811.40	811.98	811.66	811.95	812.02	811.75	811.96	811.89
11	811.38	811.72	811.35	811.39	811.96	811.74	812.00	812.11	811.81	812.05	811.98
12	811.38	811.77	811.31	811.38	811.95	811.78	812.09	812.19	811.86	812.13	812.02
13	811.38	811.79	811.32	811.31	811.97	811.80	812.15	812.24	811.95	812.21	812.13
14	811.43	811.79	811.35	811.31	811.95	811.81	812.20	812.31	812.07	812.31	812.20
15	811.46	811.87	811.30	811.26	811.96	811.87	812.28	812.39	812.08	812.39	812.23
16	811.48	811.87	811.20	811.23	811.96	811.89	812.36	812.45	812.15	812.41	812.26
17	811.56	811.92	811.00	811.21	811.95	811.91	812.44	812.58	812.35	812.54	812.34
18	811.58	811.97	811.00	811.26	811.90	811.97	812.51	812.69	812.35	812.71	812.46
19	811.56	812.07	811.10	811.30	811.81	812.09	812.64	812.84	812.46	812.59	812.62
20	811.58	812.17	811.10	811.33	811.77	812.18	812.78	812.94	812.52	812.49	812.76
21	811.60	812.31	811.02	811.40	811.68	812.25	812.88	813.03	812.72	812.40	812.87
22	811.57	812.32	811.00	811.41	811.65	812.33	812.96	813.07	812.73	812.38	812.80
23	811.58	812.37	810.92	811.41	811.64	812.35	812.96	813.05	812.73	812.50	812.69
24	811.63	812.37	811.10	811.37	811.67	812.33	812.89	813.01	812.65	812.59	812.61
										812.71	812.54

WATER LEVEL ELEVATION AT GAUGE LOCATIONS

October 30, 1966.

Hours	Gauge 1	Gauge 2	Gauge3	Gauge 4	Gauge 5	Gauge 6	Gauge 7	Gauge 8	Gauge9	Gauge 10	Gauge 11
1	811.63	812.29	811.15	811.41	811.68	812.28	812.82	812.89	812.59	812.70	812.53
2	811.58	812.26	811.25	811.43	811.69	812.22	812.77	812.80	812.54	812.71	812.50
3	811.56	812.18	811.30	811.53	811.66	812.18	812.72	812.76	812.44	812.49	812.23
4	811.48	812.21	811.30	811.59	811.63	812.19	812.64	812.62	812.24	812.17	811.95
5	811.48	812.17	811.20	811.55	811.73	812.09	812.44	812.34	812.05	812.08	811.89
6	811.50	811.97	811.20	811.51	811.85	811.89	812.19	812.19	811.95	812.08	811.93
7	811.50	811.82	811.25	811.45	811.90	811.80	812.08	812.13	812.91	812.04	811.94
8	811.58	811.77	811.04	811.47	811.90	811.78	812.07	812.09	811.89	811.98	811.85
9	811.60	811.77	811.04	811.59	811.85	811.79	812.06	812.00	811.74	811.69	811.74
10	811.63	811.77	811.52	811.78	811.74	811.79	811.90	811.79	811.39	810.95	811.13
11	811.73	811.72	811.55	812.02	811.66	811.73	811.71	811.53	811.25	810.54	810.53
12	811.16	811.63	811.06	812.16	811.65	811.67	811.59	811.44	811.15	810.30	810.43
13	811.36	811.57	811.20	812.11	811.74	811.59	811.44	811.29	811.09	810.26	810.40
14	811.48	811.42	811.36	811.96	811.90	811.49	811.29	811.21	810.99	810.54	810.78
15	811.48	811.27	811.65	811.90	811.96	811.38	811.24	811.16	811.05	811.02	811.05
16	811.44	811.27	812.00	811.89	811.95	811.39	811.28	811.29	811.14	811.24	811.35
17	811.40	811.37	811.70	811.86	811.91	811.44	811.40	811.49	811.35	811.48	811.34
18	811.40	811.47	812.02	812.09	811.68	811.64	811.71	811.64	811.39	811.26	811.25
19	811.40	811.67	812.22	812.15	811.65	811.74	811.64	811.52	812.44	810.85	810.85
20	811.33	811.65	812.30	812.23	811.62	811.73	811.56	811.48	811.29	810.54	810.58
21	811.24	811.61	812.20	812.30	811.62	811.73	811.44	811.34	811.19	810.28	810.20
22	811.28	811.57	812.30	812.24	811.67	811.64	811.34	811.23	811.10	810.00	809.85
23	811.32	811.47	812.05	812.08	811.81	811.54	811.26	811.14	810.99	809.85	809.90
24	811.40	811.32	812.00	812.03	811.90	811.41	811.19	811.04	810.85	810.02	810.28

WATER LEVEL ELEVATION AT GAUGE LOCATIONS

October 31, 196~~7~~6

Hours	Gauge 1	Gauge 2	Gauge 3	Gauge 4	Gauge 5	Gauge 6	Gauge 7	Gauge 8	Gauge 9	Gauge 10	Gauge 11
1	811.38	811.22	812.08	811.96	811.97	811.31	811.09	810.96	810.82	810.39	810.53
2	811.38	811.17	812.35	811.96	811.98	811.30	811.04	810.96	810.91	810.80	810.80
3	811.43	811.13	812.51	811.96	811.98	811.27	811.06	811.07	810.96	810.88	810.87
4	811.38	811.23	812.65	812.10	811.86	811.40	811.16	811.12	810.99	810.60	810.60
5	811.30	811.28	812.40	812.00	811.92	811.41	811.16	811.07	810.96	810.34	810.25
6	811.30	811.27	812.30	812.11	811.87	811.40	811.14	811.02	810.86	810.08	810.09
7	811.29	811.27	812.21	812.06	811.91	811.39	811.06	810.97	810.81	809.99	810.02
8	811.29	811.17	812.20	812.04	811.95	811.33	811.00	810.90	810.79	810.06	810.31
9	811.33	811.16	812.10	811.96	812.01	811.27	810.97	810.88	810.79	810.51	810.63
10	811.30	811.08	812.30	811.97	812.04	811.23	810.99	810.95	810.85	810.80	810.88
11	811.28	811.17	812.40	811.91	812.00	811.29	811.08	811.05	810.98	811.01	810.95
12	811.28	811.19	812.25	811.90	811.98	811.32	811.18	811.15	811.02	810.84	810.81
13	811.30	811.27	812.20	811.86	811.98	811.38	811.22	811.15	811.01	810.70	810.74
14	811.30	811.25	812.30	811.80	812.05	811.22	811.99	811.10	810.99	810.70	810.72
15	811.30	811.17	812.28	811.81	812.05	811.28	811.14	811.08	810.99	810.86	810.95
16	811.30	811.17	812.40	811.71	812.11	811.27	811.14	811.10	811.05	811.05	811.06
17	811.27	811.17	812.55	811.79	812.00	811.28	811.17	811.16	811.12	811.23	811.16
18	811.20	811.25	812.65	811.82	811.98	811.34	811.24	811.23	811.16	811.13	811.13
19	811.13	811.27	812.40	811.80	811.99	811.36	811.29	811.28	811.20	811.08	810.97
20	811.26	811.28	812.00	811.79	811.97	811.39	811.31	811.28	811.15	811.03	810.98
21	811.23	811.31	811.95	811.83	811.97	811.40	811.29	811.24	811.19	811.09	811.10
22	811.18	811.28	812.10	811.82	811.98	811.40	811.29	811.26	811.19	811.14	811.18
23	811.16	811.29	812.10	811.79	811.99	811.40	811.35	811.32	811.19	811.26	811.30
24	811.18	811.32	811.90	811.81	811.93	811.44	811.44	811.42	811.24	811.34	811.35

APPENDIX C
STORAGE AND OUTFLOW CALCULATIONS

STORAGE AND OUTFLOW CALCULATIONS

North Wind Oct. 3-4

TIME	WIND VEL. (m.p.h.)		STORAGE				OUTFLOW					
(hr)	P.	D.	GAGE 4 Elev.	Δ H_2 (ft.)	Storage (c.f.s.)	Cum. Storage (c.f.s.)	GAGE 4 Elev.	GAGE 10 Elev.	Δ h_2 (ft.)	Increment (ft.)	Outflow (c.f.s.)	Cum. Outflow (c.f.s.)
Oct. 3 - 12 hrs.												
1	12.8	7.6	811.63	0	0	0	811.63	811.27	.36	0	0	0
2	12.8	9.8	811.61	-.02	-41,300	-41,300	811.61	811.18	.43	+.07	+10,580	10,580
3	10.0	13.0	811.59	-.02	-41,300	-82,600	811.59	811.19	.40	+.02	+5,660	+16,240
4	11.0	20.0	811.62	+.03	+61,950	-20,650	811.62	811.13	.49	.04 -.02	+8,000	+24,240
5	9.0	16.0	811.64	+.02	+41,300	+20,650	811.64	811.17	.47	0	-5600	+18,580
6	13.0	13.8	811.70	+.06	+123,900	+144,550	811.70	811.23	.47	-.05	0	+18,580
7	9.1	14.7	811.76	+.06	+123,900	+268,450	811.76	811.34	42	+.06	-8,950	+9,630
8	15.6	17.0	811.79	+.03	+61,950	+330,400	811.79	811.31	.68	+.16	+9900	+19,430
9	16.0	19.0	811.86	+.07	+144,800	+475,200	811.86	811.22	.64	+.08	+16,200	+35,630
10	11.2	20.0	811.81	-.05	-103,250	+371,950	811.81	811.09	.72	+.16	+11,300	+46,930
11	13.5	20.0	811.81	0	0	+371,950	811.81	810.93	.88	+.22	+16,200	+63,130
12	14.5	13.8	811.89	+.08	+165,300	+537,250	811.89	810.79	1.10	-.07	+18,800	+81,930
13	15.5	9.4	811.82	-.07	-144,800	+392,450	811.82	810.79	1.03	-.07	-10,580	+71,350
14	16.5	12.0	811.76	-.06	-123,900	+268,550	811.76	810.80	.96	-.19	-10,580	+60,770
15	14.0	11.0	811.66	-.10	-206,500	+62,050	811.66	810.89	.77	-.13	-17,500	+43,270
16	14.0	17.3	811.64	-.02	-41,300	+20,750	811.64	811.00	.64	-.11	-14,750	+28,520
17	13.0	0	811.64	0	0	+20,750	811.64	811.11	.53	-.03	-13,500	+15,020
18	13.0	0	811.61	-.03	-61,950	-41,200	811.61	811.11	.50	+.05	-6940	+8,080
19	13.0	0	811.61	0	0	-41,200	811.61	811.06	.55	.02	+8950	+17,030
20	10.0	6.2	811.61	0	0	-41,200	811.61	811.04	.57	-.03	+5660	+22,690
21	8.0	0	811.60	-.01	-20,650	-61,850	811.60	811.06	.54	-.08	-6900	+15,750
22	11.0	0	811.62	+.02	+20,650	-41,200	811.62	811.36	.26	+.02	-21,250	-5,500
23	11.0	7.2	811.63	+.01	+20650	-20,550	811.63	811.35	.28	-.01	+5660	+160
24	9.0	10.2	811.63	0	0	-20,550	811.63	811.36	.27	-.28	-4000	-3,840
25	17.0	6.5	811.61	-.02	-41,300	-61,850	811.61	811.63	-.02	+.07	-21,250	-25,090
26	14.0	0	811.57	-.04	-82,600	-144,450	811.57	811.49	.08	-.10	+10,580	-14,510
27	14.0	6.3	811.57	0	-123,900	-268,350	811.57	811.53	.04	-.06	-12680	-27,190
28	9.0	5.3	811.50	-.07	-20,650	-289,000	811.50	811.62	-.12	-.16	-12,680	-39,870
29	15.0	0	811.50	0	0	-289,000	811.50	811.73	-.23	-.11	-16,200	-56,070
30	[illegible]	0	[illegible]	0	0	-289,000	811.50	811.95	-.45	-.22	-16,750	-72,820

STORAGE AND OUTFLOW CALCULATIONS South Wind Oct 4-6/66

TIME	WIND VEL. (m.p.h.)		STORAGE				OUTFLOW					
(hr)	P.	D.	GAGE 8 Elev.	Δ H_1 (ft.)	Storage (c.f.s.)	Cum. Storage (c.f.s.)	GAGE ~~10~~ 4 Elev.	GAGE ~~4~~ 10 Elev.	Δ h_1 (ft.)	Increment (ft.)	Outflow (c.f.s.)	Cum. Outf[lo] (c.f.s.)
Oct 4 - 19 hrs												
1	0	4.2	811.77	0	0	0	811.57	811.81	0.24	0	0	0
2	1.8	8.5	811.82	+.05	+71,150	+71,150	811.51	811.92	0.41	+0.17	+19,700	+19,700
3	3.2	3.5	811.86	+.04	+56,920	+128,070	811.49	811.94	0.45	+0.04	+9,320	+29,020
4	6.2	13.5	811.90	+.04	+56,920	+184,990	811.45	811.95	0.50	+0.05	+10,420	+39,44[illegible]
5	3.2	11.2	811.93	+.03	+42,690	+227,680	811.41	812.01	0.60	+0.10	+14,730	+54,17[illegible]
6	3.8	9.0	811.96	+.03	+42,690	+270,370	811.38	812.07	0.69	+0.09	+13,980	+68,150
7	3.8	7.0	811.94	-.02	-28,460	+241,910	811.41	811.88	0.47	-0.22	-22,000	+46,150
8	4.5	11.3	811.94	0	0	+241,910	811.43	811.88	0.45	-0.02	-6,590	+39,560
9	5.3	7.3	811.94	0	0	+241,910	811.47	811.87	0.40	-0.05	-10,400	+29,190
10	0	12.9	811.93	-.01	-14,230	+227,680	811.51	811.87	0.36	-0.04	-9,320	+19,82[illegible]
11	5.0	10.7	811.91	-.02	-28,460	+199,220	811.56	811.80	0.24	-0.12	-16,250	+13,57[illegible]
12	0	13.8	811.85	-.06	-85,380	+113,840	811.57	811.75	0.18	-0.06	-11,420	-785[illegible]
13	5.3	11.2	811.80	-.05	-71,150	+42,690	811.55	811.68	0.13	-0.05	-10,420	-18,270
14	4.2	10.5	811.80	0	0	+42,690	811.50	811.69	0.19	+0.06	+11,420	-6,850
15	5.2	15.5	811.82	+.02	+28,460	+71,150	811.49	811.72	0.23	+0.04	+9,320	+2,470
16	3.5	13.8	811.86	+.04	+56,920	+128,070	811.47	811.76	0.29	+0.06	+11,420	+13,890
17	5.3	13.8	811.95	+.09	+128,070	+256,140	811.50	811.87	0.37	+0.08	+13,190	+27,080
18	0	17.6	812.01	+.06	+85,380	+341,520	811.56	811.96	0.40	+0.03	+8,070	+35,150
19	0	14.2	812.02	+.01	+14,230	+355,750	811.54	811.92	0.33	-0.07	-12,320	+22,830
20	4.8	15.5	811.96	-.06	-85,380	+270,370	811.60	811.80	0.20	-0.13	-13,000	+5,830
21	5.3	16.8	811.91	-.05	-71,150	+199,220	811.57	811.78	0.21	+0.01	+4,660	+10,440
22	7.0	15.8	811.89	-.02	-28,460	+170,760	811.55	811.76	0.21	0	0	+20,910
23	5.5	17.5	811.92	+.03	+42,690	+213,450	811.51	811.77	0.26	+0.05	+10,420	+32,910
24	5.5	10.0	811.99	+.07	+99,610	+313,060	811.53	811.92	0.39	+0.13	+17,000	+26,490
25	9.2	11.2	812.00	+.01	+14,230	+327,290	811.54	811.87	0.33	-0.06	-11,420	9,490
26	11.2	9.5	811.92	-.08	-113,840	+213,450	811.57	811.77	0.20	-0.13	-17,000	9,490
27	10.5	14.5	811.90	-.02	-28,460	+184,490	811.58	811.78	0.20	0	0	
28	11.0	18.5	811.91	+.01	+14,230	+199,220	811.58	811.82	0.24	+0.04	+9,320	18,81[illegible]
29	8.5	16.5	811.94	+.03	+42,690	+241,410	811.52	811.82	0.30	+0.06	+11,420	30,2[illegible]

STORAGE AND OUTFLOW CALCULATIONS Oct 4-6 cont.

TIME	WIND VEL. (m.p.h.)		STORAGE				OUTFLOW					
(hr)	P.	D.	GAGE 8 Elev.	Δ H_1 (ft.)	Storage (c.f.s.)	Cum. Storage (c.f.s.)	GAGE 14 Elev.	GAGE ~~4~~ 10 Elev.	Δ h_1 (ft.)	Increment (ft.)	Outflow (c.f.s.)	Cum. Outfow (c.f.s.)
30	7.5	18.5	811.98	+.04	+56,920	+298,830	811.52	811.93	0.41	.11	+15,520	45,730
31	7.5	11.2	812.03	+.05	+71,150	+369,980	811.52	811.95	0.43	.02	+6,590	52,320
32	5.5	8.5	812.01	-.02	-28,460	+341,520	811.56	811.86	0.30	-.13	-17,000	35,320
33	5.2	12.0	811.93	-.08	-113,840	+227,680	811.61	811.81	0.20	-.10	-14,730	20,590
34	5.3	8.3	811.84	-.09	-128,070	+99,610	811.62	811.73	0.11	-.09	-13,980	6610
35	4.7	10.5	811.83	-.01	-14,230	+85,380	811.63	811.70	0.07	-.04	-9,320	-2710
36	4.9	10.8	811.84	+.01	+14,230	+99,610	811.61	811.74	0.13	.06	11,420	8710
37	6.2	10.5	811.88	+.04	+56,920	+156,530	811.59	811.76	0.17	.04	9320	18,030
38	0	12.0	811.89	+.01	+14,230	+170,760	811.61	811.76	0.15	-.02	-6590	11,090
39	0	12.5	811.82	-.07	-99,610	+71,150	811.62	811.68	0.06	-.09	-13,980	-2540
40	0	12.0	811.79	-.03	-42,640	+28,460	811.67	811.64	-0.03	-.09	-13980	-16,520
41	0	8.0	811.82	+.03	+42,610	+71,150	811.69	811.64	-.05	-.02	-6590	-23,110
42	0	0	811.88	+.06	+85,380	+156,530	811.71	811.69	-.02	-.03	-8070	-31,180
43	0	-4.4	811.90	+.02	+28,460	+184,990	811.69	811.73	.04	.06	11,420	-19,760
44	0	-4.8	811.89	-.01	-14,230	+170,760	811.69	811.76	.07	.03	8,070	-11,640
45	0	-2.5	811.78	-.11	-156,800	+13,960	811.66	811.72	.06	-.01	-4660	-16,350
46	0	-3.1	811.63	-.15	-213,600	-199,640	811.62	811.66	.04	-.02	-6590	-27,940

STORAGE AND OUTFLOW CALCULATIONS North Wind Oct 9–10/66

TIME	WIND VEL. (m.p.h.)		STORAGE				OUTFLOW					
(hr)	P.	D.	GAGE 8 Elev. 4	ΔH_2 (ft.)	Storage (c.f.s.)	Cum. Storage (c.f.s.)	GAGE 10 Elev. 4	GAGE 4 Elev. 10	Δh_2 (ft.)	Increment (ft.)	Outflow (c.f.s.)	Cum. Outfow (c.f.s.)
	Oct.	9 -	21:00 hr.									
1	14.0	0	811.79	0	0	0	811.79	810.95	.84	0	0	0
2	16.0	0	811.82	.03	61,950	61,950	811.82	810.72	1.10	.26	20,500	20,500
3	12.5	0	811.94	.12	248,000	309,950	811.94	810.55	1.39	.29	21,500	42000
4	15.5	0	811.95	.01	20,650	330,600	811.95	810.68	1.27	-.12	-14,000	28000
5	12.0	0	811.97	.02	41,300	371,900	811.97	810.70	1.27	0	0	28000
6	14.0	16.5	811.94	-.03	-61,450	309,950	811.94	810.69	1.30	.03	6940	34,940
7	12.5	15.0	812.26	.32	661,000	970,950	812.26	810.44	1.82	.52	29000	63,940
8	21.0	15.8	812.03	-.23	-475,000	495,450	812.03	810.24	1.79	-.03	-6940	57000
9	25.0	16.5	812.34	.31	+640,000	1,135,950	812.34	809.99	2.35	.56	30,000	87000
10	23.0	13.0	812.28	-.06	-123,900	1,012,050	812.28	809.97	2.31	-.04	-8000	79000
11	22.5	14.7	812.39	.11	227000	1,239,050	812.39	809.81	2.58	.27	+20,800	99,800
12	23.5	10.5	812.44	.05	103,250	1,342,300	812.44	810.02	2.42	-.16	-16,100	83,700
13	23.0	15.6	812.42	-.02	-41,300	1,301,000	811.42	810.14	2.28	-.14	-15,100	68600
14	24.0	18.3	812.31	-.11	-227,000	1,074,000	812.31	810.18	2.13	-.15	-15,750	52,850
15	23.0	18.2	812.17	-.14	-289,000	785,000	812.17	810.37	1.80	-.33	-23000	29,850
16	22.5	18.3	811.95	-.22	-454,000	331,000	811.95	810.74	1.21	-.59	-30,800	-950
17	20.0	11.3	811.83	-.12	-248,000	83,000	811.83	811.28	.55	-.66	-32,500	-33450
18	20.0	10.5	811.79	-.04	-82,600	400	811.79	811.29	.50	-.05	-8450	-42,400
19	16.0	10.2	811.74	-.05	-103,250	-102,850	811.74	811.36	.38	-.12	-14,000	-56,400
20	16.0	0	811.82	-.06	-123,900	-226,750	811.82	811.27	.55	.17	-16,750	-73,150
21	13.0	0	811.80	-.02	-41,300	-268,050	811.80	811.24	.56	-.01	-4000	-77,150
22	8.0	0	811.80	0	0	-268,050	811.80	811.17	.63	.07	+10,580	-66,590
23	9.3	0	811.64	-.16	-330,500	-598,550	811.64	811.26	.38	-.25	-20,100	-86,670
24	5.0	0	811.62	-.02	-41,300	-639,850	811.62	811.53	.09	-.29	-21,600	-108,270

STORAGE AND OUTFLOW CALCULATIONS SOUTH-WIND Oct. 11-12/66

TIME	WIND VEL. (m.p.h.)		STORAGE				OUTFLOW					
(hr)	P.	D.	GAGE 8 Elev.	Δ H_1 (ft.)	Storage (c.f.s.)	Cum. Storage (c.f.s.)	GAGE 10 Elev.	GAGE 4 Elev.	Δ h_1 (ft.)	Increment (ft.)	Outflow (c.f.s.)	Cum. Outfow (c.f.s.)
		Oct 11/66		14:00 hrs								
1	3.5	5.0	811.89	0	0	0	811.76	811.54	.22	0	0	0
2	4.0	4.7	811.89	0	0	0	811.87	811.56	.31	.09	13,980	13,980
3	2.7	5.0	811.93	.04	56,920	56920	811.90	811.57	.33	.02	6590	20,570
4	2.2	3.2	811.97	.04	56,920	113840	811.92	811.59	.33	0	0	20570
5	4.2	7.6	812.00	.03	42,690	156,530	811.87	811.56	.31	-.02	-6590	13 980
6	5.5	16.0	812.01	.01	14,230	170,760	811.90	811.56	.34	.03	8070	22,050
7	7.1	7.5	811.98	-.03	-42,690	128070	811.84	811.56	.28	-.06	-11,420	10,630
8	10.2	5.8	811.92	-.06	-85,380	42690	811.84	811.56	.28	0	0	10,630
9	8.5	5.7	811.91	-.01	-14,230	28460	811.94	811.56	.38	.10	14,730	25,360
10	7.3	2.2	811.97	.06	85,380	113840	812.08	811.59	.49	.11	15,500	40860
11	5.0	6.5	812.06	.09	128,070	241910	812.12	811.55	.57	.08	13,190	54,050
12	5.5	8.3	812.12	.06	85380	327,290	812.08	811.55	.53	-.04	-9320	44,730
13	8.5	8.3	812.11	-.01	-14,230	313,060	812.02	811.56	.46	-.07	-12,320	32,410
14	9.2	9.8	812.05	-.06	-85 380	227,680	811.99	811.52	.47	.01	4660	37,070
15	8.5	9.8	811.98	-.07	-99,610	128,070	811.91	811.53	.38	-.09	-13,980	23,090
16	4.2	12.0	811.95	-.03	-42,690	85,380	811.91	811.52	.39	.01	4660	27,750
17	5.7	11.2	811.97	.02	28,460	113,840	812.07	811.52	.55	.16	18,800	46,550
18	5.7	10.5	812.06	.09	128,070	241,910	812.12	811.53	.59	.04	9320	55,870
19	6.3	3.8	812.12	.06	85,380	327,290	812.07	811.54	.53	-.06	-11,420	44,450
20	5.6	13.8	812.09	-.03	-42,690	284,600	812.03	811.56	.47	-.06	-11,420	33,030
21	12.6	11.3	812.06	-.03	-42,690	241,910	812.03	811.56	.47	0	0	33,030
22	11.2	10.5	812.09	.03	+42690	284,600	812.11	811.56	.55	.08	13,190	46,220
23	13.7	10.5	812.16	.07	99,610	384 210	812.11	811.63	.48	-.07	-12,320	33900
24	11.2	12.0	812.12	-.04	-56,920	327,290	812.10	811.62	.48	0	0	33900
25	12.0	15.6	812.11	-.01	-14,230	313,060	812.07	811.61	.46	-.02	-6590	27,310
26	10.6	14.9	812.01	-.10	-142,300	170,760	811.92	811.62	.30	-.16	-18,800	8510
27	12.8	14.8	811.94	-.07	-99,610	71,150	811.76	811.57	.19	-.11	-15,500	-6990
28	11.2	8.5	811.75	-.19	-270,500	-199,350	811.69	811.56	.13	-.06	-11,420	-18,410
29	3.8	5.5	811.71	-.04	-56,920	-256,270	811.76	811.54	.22	.09	+13,0[illegible]	-4[illegible]

STORAGE AND OUTFLOW CALCULATIONS SOUTH WIND Oct 11-12/66 cont.

TIME (hr)	WIND VEL. (m.p.h.) P.	WIND VEL. (m.p.h.) D.	STORAGE: GAGE 8 Elev.	STORAGE: ΔH_1 (ft.)	STORAGE: Storage (c.f.s.)	STORAGE: Cum. Storage (c.f.s.)	OUTFLOW: GAGE 10 Elev.	OUTFLOW: GAGE 4 Elev.	OUTFLOW: Δh_1 (ft.)	OUTFLOW: Increment (ft.)	OUTFLOW: Outflow (c.f.s.)	OUTFLOW: Cum. Outfow (c.f.s.)
30	4.0	8.5	811.78	.07	99,610	-156,660	811.89	811.56	.33	.11	15,500	11,070
31	4.9	4.5	811.90	.12	170,900	14,240	811.80	811.54	.26	-.07	-12,320	-1,250
32	3.8	3.0	811.89	-.01	-14,230	10	811.88	811.61	.27	.01	4660	3,410
33	4.6	2.5	811.93	.04	56,920	56,930	811.84	811.56	.28	.01	4660	8,070
34	3.3	2.5	811.94	.01	14,230	71,160	811.80	811.61	.19	-.09	-13980	-5910
35	5.5	0	811.91	-.03	-42,690	28,470	811.78	811.61	.17	-.02	-6590	-12,500

STORAGE AND OUTFLOW CALCULATIONS NORTH WIND OCT 13-14/66

TIME	WIND VEL. (m.p.h.)		STORAGE				OUTFLOW					
(hr)	P.	D.	GAGE ~~8~~ Elev. 4	ΔH_2 (ft.)	Storage (c.f.s.)	Cum. Storage (c.f.s.)	GAGE ~~18~~ Elev. 4	GAGE ~~4~~ Elev. 10	Δh_2 (ft.)	Increment (ft.)	Outflow (c.f.s.)	Cum. Outfow (c.f.s.)
		Oct	- 13	14:00	hrs.							
1	10.0	8.0	811.69	0	0	0	811.69	811.58	0.11	0	0	0
2	10.3	11.0	811.71	.02	41,300	41,300	811.71	811.44	.27	.16	16,250	16,250
3	9.0	10.0	811.67	-.04	-82,600	-41,300	811.67	811.40	.27	0	0	16,250
4	9.8	9.5	811.74	.07	144,800	103,500	811.79	811.39	.35	.08	11,300	27,550
5	7.5	11	811.75	.01	20,650	124,150	811.75	811.39	.36	.01	4000	31,550
6	8.5	14.5	811.75	0	0	124,150	811.75	811.44	.31	-.05	-8950	22,600
7	13.5	13	811.76	.01	20,650	144,800	811.76	811.48	.28	-.03	-6990	15,660
8	12.8	21	811.73	-.03	-61950	82,856	811.73	811.41	.32	.04	8000	23,660
9	10.0	18	811.72	-.01	-20650	62600	811.72	811.23	.49	.17	16,750	40410
10	13.0	15	811.74	.02	41,300	103,500	811.74	811.18	.56	.07	10,580	50990
11	14.5	18	811.76	.02	41,300	144,800	811.76	811.24	.52	-.04	-8000	42,990
12	12.0	18	811.79	.03	61,950	206,750	811.79	811.18	.61	.09	12000	54,990
13	12.8	19	811.99	.20	413,000	614,750	811.99	811.06	.93	.32	22,700	77690
14	11.3	14	811.97	-.02	-41,300	578,950	811.97	810.99	.98	.05	8950	86640
15	13.0	15	812.04	.07	144,800	723,250	812.04	810.84	1.20	.22	18,800	105,440
16	16.3	15	811.99	-.05	-103,250	629,000	811.99	810.78	1.21	.01	4000	109,440
17	15.5	8	811.90	-.09	-186,000	434,000	811.90	810.79	1.16	-.05	-8950	100,490
18	21.0	11	811.90	0	0	434,000	811.90	810.81	1.09	-.07	-10,580	89,910
19	15.5	9	811.79	-.11	-227,000	207,000	811.79	810.77	1.02	-.07	-10,580	79,330
20	15.0	10	811.91	.12	-248,000	455,000	811.91	810.49	1.42	.40	25,300	104,630
21	20.2	14	811.93	.01	20,650	475,650	811.92	810.48	1.44	.02	5660	110,290
22	20.2	18	811.94	.02	41,300	516,950	811.94	810.70	1.24	-.20	-17,900	92,390
23	18.0	18	811.89	-.05	103,250	413,700	811.89	811.04	.85	-.39	-25,000	67,390
24	18.5	13	811.76	-.13	-268,580	145,200	811.76	811.30	.46	-.39	-25000	42,390
25	18.6	19	811.70	-.06	-123,900	21,300	811.70	811.30	.40	-.06	-9800	32,590
26	21.2	10	811.68	-.02	-41,300	20,000	811.68	811.13	.55	.15	15,750	48,340
27	20.2	14	811.63	-.05	-103,250	-123,250	811.63	811.00	.63	.08	11,300	59,690
28	20.0	7.2	811.63	0	0	-123,250	811.63	811.04	.59	-.04	-8000	51640
29	17.0	2.3	811.62	-.01	-20,650	-143,900	811.62	811.12	.50	-.09	-12000	39,640

STORAGE AND OUTFLOW CALCULATIONS NORTH WIND Oct 13-14/66 cont

IME (hr)	WIND VEL. (m.p.h.) P.	D.	STORAGE GAGE ~~8~~ Elev. 4	Δ H_2 (ft.)	Storage (c.f.s.)	Cum. Storage (c.f.s.)	OUTFLOW GAGE ~~10~~ Elev. 4	GAGE ~~4~~ Elev. 10	Δ h_2 (ft.)	Increment (ft.)	Outflow (c.f.s.)	Cum. Outfow (c.f.s.)
30	14.8	2.3	811.64	-.02	41,300	-102,600	811.64	811.24	.40	-.10	-12,680	26,960
31	2.5	0	811.62	-.02	-41,300	-143,900	811.62	811.36	.26	-.14	-15,100	11,860

STORAGE AND OUTFLOW CALCULATIONS SOUTH WIND Oct 19-20/66

TIME	WIND VEL. (m.p.h.)		STORAGE				OUTFLOW					
(hr)	P.	D.	GAGE 8 Elev.	Δ H_1 (ft.)	Storage (c.f.s.)	Cum. Storage (c.f.s.)	GAGE 10 Elev.	GAGE 4 Elev.	Δ h_1 (ft.)	Increment (ft.)	Outflow (c.f.s.)	Cum. Outfow (c.f.s.)
	Oct. 19		8:00 hrs.									
1	5.0	0	811.94	0	0	0	811.90	811.52	.38	0	0	0
2	7.5	3.5	812.03	.09	128,070	128,070	811.84	811.55	.29	-.09	-13,980	-13,980
3	8.0	1.9	812.04	.01	14,230	142,300	811.80	811.54	.26	-.03	-8070	-22050
4	11.0	2.3	812.05	.01	14230	156,530	811.90	811.59	.36	.10	14730	-7320
5	15.0	5.0	812.27	.02	28,460	184,990	811.90	811.46	.44	.08	13,190	5870
6	13.0	7.2	812.11	.04	56,920	241,910	812.07	811.46	.61	.17	19,500	25,370
7	16.0	15.0	812.22	.11	156,800	398,710	812.32	811.38	.94	.27	24,250	49,620
8	16.0	5.5	812.34	.11	156,800	555,510	812.44	811.40	1.04	.20	20,850	70,470
9	18.0	16.5	812.47	.13	185,100	740,610	812.47	811.41	1.06	.02	6590	77060
10	17.0	11.5	812.53	.06	85,380	825,990	812.44	811.42	1.02	-.04	-9320	67740
11	13.0	7.5	812.55	.02	28,460	854,450	812.33	811.49	.84	-.18	-20 000	47,740
12	13.0	7.5	812.47	-.08	-113,840	740,610	812.16	811.50	.66	-.18	-20,000	27,740
13	10.0	0	812.37	-.10	-142,300	598,310	812.21	811.49	.72	.06	11 420	39,160
14	13.7	0	812.40	.03	48,690	641,000	812.32	811.52	.80	.08	13,190	52350
15	12.0	0	812.40	0	0	641,000	812.19	811.58	.71	-.09	-13,980	+38,370
16	0	0	812.31	-.09	-128,070	512,930	811.96	811.62	.34	-.37	-28,300	10,070
17	3.5	0	812.12	-.19	-270,500	242,430	811.76	811.68	.08	-.26	-23,750	-13,680
18	0	0	811.91	-.21	-299 000	-56,570	811.54	811.69	-.15	-.23	-22,500	-36,180

STORAGE AND OUTFLOW CALCULATIONS NORTH WIND Oct. 21-22/66

TIME	WIND VEL. (m.p.h.)		STORAGE				OUTFLOW					
(hr)	P.	D.	GAGE ~~8~~ Elev.4	Δ H_2 (ft.)	Storage (c.f.s.)	Cum. Storage (c.f.s.)	GAGE ~~10~~ Elev. 4	GAGE ~~4~~ Elev. 10	Δh_2 (ft.)	Increment (ft.)	Outflow (c.f.s.)	Cum. Outfow (c.f.s.)
	Oct. 21		-1200 hr.									
1	12.0	0	811.69	0	0	0	811.69	811.64	.05	0	0	0
2	13.0	0	811.74	.05	103,250	103,250	811.74	811.59	.15	.10	12,680	12,680
3	14.0	9.0	811.72	-.02	-41,300	61,950	811.72	811.48	.24	.09	12 000	24 680
4	15.5	3.0	811.73	.01	20,650	82600	811.73	811.38	.35	.11	13 500	38,180
5	18.5	1.5	811.70	-.03	-61,950	20 650	811.70	811.28	.42	.07	10,580	48,760
6	13.0	4.3	811.72	.02	41,300	61,950	811.72	811.22	.50	.08	11,300	60,060
7	12.0	10.6	811.70	-.02	-41,300	20,650	811.70	811.29	.41	-.09	-12000	48,060
8	11.2	15.3	811.83	.13	268,500	289,150	811.83	811.33	.50	.09	12000	60 060
9	20.5	13.7	811.80	-.03	-61,950	227,200	811.80	811.30	.50	0	0	60 060
10	22.2	14.7	811.96	.16	330,500	557,700	811.96	810.96	1.00	.50	28,300	88,360
11	24.0	15.5	812.03	.07	144,800	702,500	812.03	810.62	1.42	.42	26000	114,360
12	30.0	13.8	812.12	.09	186,000	888,500	812.12	810.50	1.62	.20	17,900	132,260
13	31.0	11.1	812.12	0	0	888500	812.12	810.54	1.58	-.04	-8000	124,260
14	32.0	15.5	812.01	-.11	-227000	661,500	812.01	810.21	1.80	.22	18,750	143,010
15	22.0	14.0	812.01	0	0	661 500	812.01	809.91	2.10	.30	21,950	164,960
16	21.0	11.2	812.03	.02	41,300	702,800	812.03	809.64	2.39	.29	21,500	186,460
17	21.2	10.3	812.04	.01	20,650	723,450	812.04	809.43	2.61	.22	18,750	205,210
18	18.0	10.3	811.95	-.09	-186,000	537,450	811.95	809.50	2.45	-.15	-15,750	189,460
19	22.5	0	812.13	.18	371,500	908,950	812.13	810.11	2.02	-.43	-26250	163,210
20	18.5		812.12	-.01	-20,650	888200	812.12	810.09	2.03	.01	4000	167,210
21	18.5		812.26	.14	289 000	1,177 300	812.26	809.89	2.37	.34	23 500	190,710
22	18.2		812.22	-.04	-82,600	1,094 700	812.22	809.84	2.38	.01	4000	194,710
23	23.2		812.32	.10	206,500	1,301,200	812.32	809.83	2.49	.11	13,500	208,210
24	23.2		812.22	-.10	-206,500	1,094,700	812.22	809.60	2.62	.13	14,750	222 960
25	18.5		812.22	0	0	1,094,700	812.22	809.38	2.84	.22	18,750	241,710
26	14.2		812.24	.02	41,300	1,136,000	812.24	809.49	2.75	-.09	-12000	229,710
27	13.5		812.15	-.09	-186,000	950,000	812.15	810.28	1.87	-.88	-37,500	192,210
28	15.5		812.09	-.07	-144,800	805,200	812.09	810.76	1.33	-.54	-29,500	162,710
29	0		811.96	-.13	-268,500	536,700	811.96	810.81	1.15	-.18	-17,000	145 710

STORAGE AND OUTFLOW CALCULATIONS NORTH WIND OCT 21-22/66 cont.

TIME (hr)	WIND VEL. (m.p.h.) P.	WIND VEL. (m.p.h.) D.	STORAGE: GAGE ~~8~~ Elev. 4	STORAGE: ΔH_z (ft.)	STORAGE: Storage (c.f.s.)	STORAGE: Cum. Storage (c.f.s.)	OUTFLOW: GAGE ~~10~~ Elev. 4	OUTFLOW: GAGE ~~4~~ Elev. 10	OUTFLOW: Δh_z (ft.)	OUTFLOW: Increment (ft.)	OUTFLOW: Outflow (c.f.s.)	OUTFLOW: Cum. Outfow (c.f.s.)
30	0	0	811.91	-.05	-103,250	433,450	811.91	811.10	0.81	-.34	-23,400	122,310
31	0	0	811.82	-.09	-186,000	247,450	811.82	811.20	0.62	-.16	-16,100	106,210
32	12.5	0	811.82	0	0	247,450	811.82	811.06	0.76	+.14	+15,100	121,310
33	11.3	0	811.83	.01	20,650	268,100	811.83	810.95	.85	+.09	+12 000	133310
34	0	0	811.92	.09	186,000	454,100	811.92	810.84	1.08	.23	+14,250	152,560
35	0	0	811.86	-.06	-123,900	330 200	811.86	810.79	1.07	-.01	-4000	148,560
36	0	0	811.84	-.02	-41,300	288,900	811.84	810.90	1.14	.07	+10580	159,140
37	0	0	811.76	-.08	-165,300	123,600	811.76	811.14	0.62	-.52	-29000	130,140

STORAGE AND OUTFLOW CALCULATIONS South Wind Oct. 24-25/66

TIME (hr)	WIND VEL. (m.p.h.) P.	D.	STORAGE GAGE 8 Elev.	Δ H_1 (ft.)	Storage (c.f.s.)	Cum. Storage (c.f.s.)	OUTFLOW GAGE 10 Elev.	GAGE 4 Elev.	Δ h_1 (ft.)	Increment (ft.)	Outflow (c.f.s.)	Cum. Outfow (c.f.s.)
	Oct. 24		9:00	hrs.								
1	1.8	0	811.85	0	0	0	811.79	811.55	.24	0	0	0
2	3.0	5.5	811.87	.02	28,460	28460	811.84	811.49	.35	.11	15,500	15,500
3	3.6	2.3	811.92	.05	71,150	99,610	811.89	811.48	.41	.06	11,420	26 920
4	3.1	5.3	811.96	.04	56,920	156,530	811.92	811.46	.46	.05	10,420	37,340
5	11.1	2.3	812.01	.05	71,150	227,680	811.95	811.46	.49	.03	8,070	45,410
6	9.2	5.5	812.04	.03	42,690	270 370	811.98	811.43	.55	.06	11,420	56,830
7	10.2	2.8	812.07	.03	42690	313,060	812.10	811.40	.66	.11	15,500	72,330
8	10.0	7.1	812.14	.07	99,610	412,670	812.17	811.42	.75	.09	13,980	86 310
9	9.0	7.0	812.19	.05	71,150	483,820	812.12	811.42	.70	-.05	-10,420	75,840
10	11.0	6.5	812.20	.01	14,230	489,050	812.11	811.37	.74	.04	9320	85,210
11	14.0	0	812.21	.01	14,230	512,280	812.15	811.35	.80	.06	11420	96,630
12	13.0	11.3	812.24	.03	42,690	554,970	812.24	811.31	.93	.13	17000	113,630
13	13.0	17.5	812.29	.05	71,150	626,120	812.35	811.31	1.04	.11	15,500	129,130
14	9.2	10.5	812.34	.05	71,150	697,270	812.39	811.33	1.06	.02	6590	135,720
15	11.0	10.5	812.41	.07	99,610	796,880	812.34	811.34	1.00	-.06	-11 420	124,300
16	11.1	7.7	812.41	0	0	796,880	812.20	811.38	.82	-.18	-20.000	104,300
17	8.2	8.2	812.29	-.12	-170,900	625,980	812.09	811.41	.68	-.14	-17,500	86,800
18	6.0	0	812.18	-.11	-156800	469,180	812.10	811.45	.65	-.03	-8070	78,730
19	2.8	0	812.13	-.05	-71,150	318,030	812.03	811.49	.54	-.11	-15 500	63,230
20	1.5	0	812.09	-.04	-56,920	341,110	811.84	811.58	.26	-.28	-24,750	38,480
21	0	0	811.94	-.15	-213,600	127,510	811.73	811.62	.11	-.15	-18250	20,230
22	0	0	811.84	-.10	-142,300	-14,790	811.70	811.63	.07	-.04	-9320	10,910

STORAGE AND OUTFLOW CALCULATIONS NORTH WIND Oct. 25/66

TIME	WIND VEL. (m.p.h.)		STORAGE				OUTFLOW					
(hr)	P.	D.	GAGE ~~8~~ Elev. 4	Δ H_2 (ft.)	Storage (c.f.s.)	Cum. Storage (c.f.s.)	GAGE ~~20~~ Elev. 4	GAGE ~~4~~ Elev. 10	Δ h_2 (ft.)	Increment (ft.)	Outflow (c.f.s.)	Cum. Outfow (c.f.s.)
	Oct. 25	/66	7:00 hrs.									
1	0	5.5	811.63	0	0	0	811.63	811.69	-.01	0	0	0
2	7.5	8.2	811.65	.02	41,300	41,300	811.65	811.54	.11	.12	14,000	14,000
3	12.0	6.0	811.66	.01	20 650	61 950	811.66	811.40	.26	.15	15,750	29,750
4	15.0	13.9	811.66	0	0	61 950	811.66	811.24	.22	-.04	-8000	21,750
5	17.0	19.5	811.70	.04	82600	144,550	811.70	811.10	.60	.42	26,000	47,750
6	14.0	14.8	811.72	.02	41300	185,850	811.72	811.00	.72	.12	14,000	61,750
7	16.5	22.0	811.63	-.09	-186,000	-000,150	811.63	810.91	.72	.0	0	61,750
8	16.5	16.5	811.63	0	0	- 150	811.63	811.10	.53	-.19	-17,600	44,150
9	19.0	15.5	811.65	.02	41,300	41,150	811.65	811.44	.21	-.32	-22,600	21,550
10	20.0	5.0	811.63	-.02	-41,300	- 150	811.63	811.73	-.10	-.31	-22,250	-700
11	15.0	0	811.69	.06	123,900	123,750	811.61	811.60	.09	.19	+17,600	16,900
12	15.8	0	811.68	-.01	-20650	103,100	811.68	811.40	.28	.19	17,600	35,500
13	7.5	0	811.59	-.09	-186 000	- 82,900	811.59	811.28	.31	.03	6940	41,440
14	2.5	0	811.51	-.08	-165,300	-248,200	811.51	811.45	.06	-.25	-20,100	21,340
15	4.5	0	811.48	-.03	-61,950	-310,150	811.48	811.74	-.26	-.32	-22,600	-1260
16	2.5	0	811.51	.03	+61,950	-248,200	811.51	811.90	-.39	.13	-14,750	-16,010
17	0	0	811.58	.07	144800	-103,400	811.58	812.02	-.44	.05	-8950	-24,960

STORAGE AND OUTFLOW CALCULATIONS SOUTH WIND Oct 26/66

TIME (hr)	WIND VEL. (m.p.h.)		STORAGE				OUTFLOW					
	P.	D.	GAGE 8 Elev.	Δ H_1 (ft.)	Storage (c.f.s.)	Cum. Storage (c.f.s.)	GAGE 10 Elev.	GAGE 4 Elev.	Δ h_1 (ft.)	Increment (ft.)	Outflow (c.f.s.)	Cum. Outflow (c.f.s.)
	Oct	26 –	5:00	hrs								
1	4.0	0	811.87	0	0	0	811.92	811.51	.41	0	0	0
2	3.8	0	811.95	.08	113,840	113,840	811.98	811.52	.46	.05	10,420	10,420
3	4.2	0	812.01	.06	85,380	199,220	811.95	811.55	.40	–.06	–11,420	–1,000
4	5.0	0	812.00	–.01	–14,230	184,990	811.85	811.55	.30	–.10	–14,730	–15,730
5	5.5	0	811.92	–.08	–113,840	71,150	811.83	811.52	.31	.01	4,660	–11,070
6	5.5	17.0	811.89	–.03	–42,690	28,460	811.93	811.51	.42	.11	15,500	4,430
7	7.0	12	811.93	.04	56,920	85,380	811.94	811.49	.45	.03	8,070	12,500
8	8.5	15.5	811.97	.04	56,920	142,300	811.97	811.51	.46	.01	4,660	17,160
9	14.0	12.5	812.01	.04	56,920	199220	811.99	811.54	.45	–.01	– 4,660	12,500
10	13.0	11.4	812.04	.03	42,690	241,910	811.93	811.60	.33	–.12	–17,200	– 4,700
11	10.0	7.8	811.98	–.06	–85,380	156,530	811.78	811.63	.15	–.18	–20,000	–24,700
12	13.5	0	811.84	–.19	– 199,300	–42,770	811.72	811.60	.12	–.03	– 8,070	–32,770
13	14.5	0	811.77	–.07	–99610	– 142,380	811.68	811.59	.09	–.03	–8,070	–40,840
14	5.8	–6.3	811.75	–.02	– 28,460	–170,840	811.67	811.55	.12	.03	8,070	–32,770
15	0	–6.3	811.80	.05	71,150	– 99,690	811.78	811.55	.23	.11	15,500	–17,270
16	–2.2	–3.1	811.84	.04	56,920	–42,770	811.68	811.58	.10	–.13	–17000	– 34,270

STORAGE AND OUTFLOW CALCULATIONS SOUTH WIND Oct 29-30/66

TIME	WIND VEL. (m.p.h.)		STORAGE				OUTFLOW					
(hr)	P.	D.	GAGE 8 Elev.	Δ H_1 (ft.)	Storage (c.f.s.)	Cum. Storage (c.f.s.)	GAGE 10 Elev.	GAGE 4 Elev.	Δ h_1 (ft.)	Increment (ft.)	Outflow (c.f.s.)	Cum. Outfow (c.f.s.)
	Oct.	29/	66	5:00	hrs							
1	4.5	0	811.92	0	0	0	811.83	81153	.30	0	0	0
2	6.5	0	811.89	-.03	-42,690	-42,690	811.79	811.52	.27	-.03	-8,070	-8,070
3	6.0	1.2	811.86	-.03	-42,690	-85,380	811.85	811.50	.35	.08	13,190	5,120
4	5.0	6.3	811.91	.05	71,150	-14,230	811.89	811.46	.43	.08	13,190	18,310
5	9.3	0	811.94	.03	42,690	28,460	811.96	811.41	.55	.12	16,200	34,510
6	11.2	4.2	812.02	.08	113,840	142,300	812.05	811.40	.65	.10	14,730	49,240
7	13.8	11.0	812.11	.09	128,070	270,370	812.13	811.39	.74	.09	13,980	63,220
8	10.0	9.2	812.19	.08	113,840	384,210	812.21	811.38	.83	.09	13,980	77,200
9	15.0	8.5	812.24	.05	71,150	455,360	812.31	811.31	1.00	.17	19500	96700
10	15.0	11.8	812.31	.07	99,610	554,970	812.39	811.31	1.08	.08	13190	109890
11	15.0	11.5	812.39	.08	113,840	668,810	812.41	811.26	1.15	.07	12320	122210
12	18.0	12.8	812.45	.06	85,380	754,190	812.54	811.23	1.31	.16	18750	140,960
13	17.0	8.6	812.58	.13	185,100	939,290	812.71	811.21	1.50	.19	20,500	161,460
14	13.0	7.2	812.69	.11	156,800	1,096,090	812.59	811.26	1.33	-.17	-19,500	141,960
15	15.0	11.2	812.84	.15	213,600	1,309,690	812.49	811.30	1.19	-.14	-17,500	124,460
16	15.0	8.5	812.94	.10	142,300	1,451,990	812.40	811.33	1.07	-.12	-16,200	108,260
17	15.0	2.8	813.03	.09	128,070	1,580,060	812.38	811.40	.98	-.09	-13,980	94,280
18	15.0	3.3	813.07	.04	56,920	1,636,980	812.50	811.41	1.09	.11	15,500	109,780
19	13.0	1.3	813.05	-.02	-28,460	#1,608,520	812.59	811.41	1.18	.09	13,980	123,760
20	15.0	0	813.01	-.04	-56,920	1,551,600	812.71	811.37	1.34	.16	18,750	142,510
21	15.8	0	812.89	-.12	-170,900	1,380,700	812.70	811.41	1.29	-.05	-10,420	132,090
22	14.8	0	812.80	-.09	-128,070	1,252,630	812.71	811.43	1.28	-.01	-4660	127,430
23	15.8	0	812.76	-.04	-56,920	1,195,710	812.49	811.53	.96	-.32	-26,400	101,030
24	12.0	0	812.62	-.14	-199,300	996,410	812.17	811.59	.58	-.38	-28,700	72,330
25	12.8	0	812.34	-.28	-398,800	597,610	812.08	811.55	.53	-.05	-10,420	61,910
26	5.0	0	812.19	-.15	-213,600	384,010	812.08	811.51	.57	.02	+6590	68,500
27	0	0	812.13	-.06	-85,380	298,630	812.04	811.45	.59	.02	+6590	75,090
28	0	0	812.09	-.04	-56,920	241,710	811.98	811.47	.51	-.08	-13,190	61,900
29	-22.8	0	812.00	-.09	-128,070	113,640	[illegible]	811.5[illegible]	.10	.41	-29500	32,400