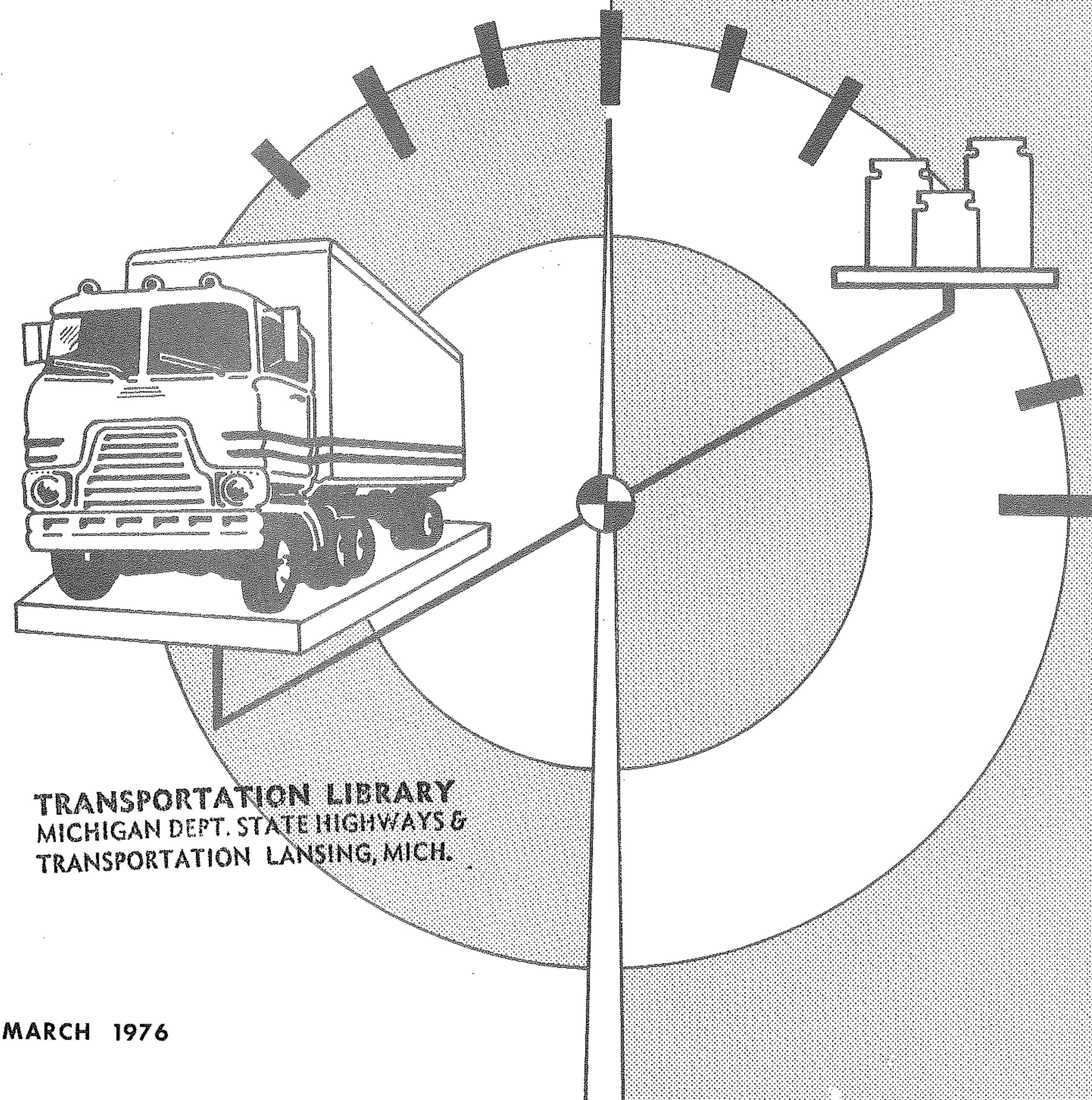
WEIGH STATION DESIGN AND OPERATION STUDY IN MICHIGAN



MARCH 1976

WEIGH STATION DESIGN AND OPERATION STUDY IN MICHIGAN

A Joint Study Conducted By
The Department's of State Highways and Transportation,
Commerce, Management and Budget and
The Federal Highway Administration

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Lansing, March 1976

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ABSTRACT

This report describes the weigh station operations as currently being conducted on the Michigan trunkline system. It discusses numerous problems which are being experienced at various stations, and analyzes the probable causes. The importance of having an effective weigh system compatible with the truck axle loads and axle arrangements legally permitted in Michigan are also discussed. Recommendations are presented for design of future weigh stations as well as modifications of existing ones.

SUMMARY AND RECOMMENDATIONS

Determining the most functional system for weighing vehicles traveling Michigan's highways necessitates defining the need for any such system. In order to satisfy this need, it is essential to recognize the assignments of responsibility in design, procurement of rights-of-way, construction of weigh stations, and their operation and maintenance.

An analysis of the problems presently being experienced in Michigan's existing weigh system points up the necessity for an improved concept. The geometric layout of these weigh stations, their scale platform, and their weigh operations buildings, while performing adequate service for a past era, all lack much needed accommodations to effectively provide for weight surveillance and control of today's and future traffic.

In order to effectively meet these demands, an ideal system should handle the full commercial volume of traffic on an adjacent roadway such as to cause a minimum delay to all vehicles subject to inspection. Additionally, it should provide an accurate method of weighing that will weigh individual axles as well as axle groups. The number of axles, their arrangements, and their loads are many and varied; the weighing system, of necessity, becomes extremely complex.

In this report, mechanical and electronic scale systems are examined. Since mechanical scales are exclusively used in the present system, experience affords extensive knowledge of their capabilities and attendant problems. Knowledge of electronic weighing operations is based on information gained through a research project conducted in the 1960's by Michigan Department of State Highways and Transportation, plus the recognition of advances made in electronic technology since that time.

Both dynamic and static weighing systems are discussed - the former to weigh vehicles under motion - the latter to weigh vehicles while at full stop. This report attempts to show that dual operation of the two systems at a weigh station could provide numerous benefits to the State (weighing authority), as well as the trucking industry.

Detailed recommendations for the design of future weigh stations, and the upgrading of existing stations conclude the report.

Recommendations

Since the inception of this committee, its foremost concern has been the design to be used for new stations on I 75 at Erie. A recommendation for these stations, together with an upgrading of existing weigh stations, is presented here in brief. A more comprehensive and detailed explanation, and the concepts of weigh station classification are presented later in the report.

1) Erie Weigh Stations I 75 NB and SB

Construct two Class I stations (static and dynamic weighing capability) at a new location along I 75.

The two existing stations are the busiest in the State and are incapable of safely handling current volumes. They are also poorly located, close to an interchange.

Since greater rights-of-way are required for Class I stations, it is imperative that steps be initiated to purchase the necessary land.

Estimated Construction Cost: $1,855,600.00

2) Coldwater Weigh Stations I 69 NB

Construct a Class III station having static electronic scales at existing site.

At the present time, approach lanes and parking area pavement have been placed.

Completion of this site will require the construction of a scale house using a proposed new design and the installation of a static-electronic scale and associated electrical appurtenances.

Estimated Construction Cost: $130,000.00

3) Portland Weigh Stations I 96 EB and WB

a. Repair scale platforms which have several bad cracks. Since these platforms were built in January 1974, an examination of the records should be made to determine if it is legally possible to seek damages from the contractor.

b. Repair scale pit walls which are cracked.

c. Replace 160 ft of pavement in scale area and remove curbing to provide for drainage away from the scale pit.

Estimated Construction Cost: $17,000.00

4) New Buffalo Weigh Station I 94 EB

Because this station experiences the third highest truck volume in the State, plans should be formulated to reconstruct this site into a Class I station. Since this type requires additional right-of-way, it would seem prudent to acquire as soon as possible the necessary adjacent undeveloped land.

Until the station is rebuilt, the approach ramps, which have experienced base failure, should be repaired. The 10-ft concrete slabs on either side of the scale platform are pumping water and need to be replaced if the station is not rebuilt.

Estimated Construction Cost of New Station:	$927,000.00
Estimated Cost of Repairs to Existing Station:	$ 6,700.00

5) Grass Lake Weigh Station I 94

Eastbound - Remove 150 ft of approach pavement and 125 ft of leaving pavement and replace at 0.0 percent grade. Grade to drain away from scale. Remove curb in scale area and place a 4-ft bituminous aggregate shoulder to improve drainage. Remove and replace guardrail.

Westbound - Remove 150 ft of leaving pavement and replace at 0.0 percent grade. Replace concrete curb with 4-ft bituminous shoulder and make necessary drainage corrections. Repair bad pavement in the approach area. Also, complete work on the scale. Add an OPEN-CLOSED electric sign.

Estimated Cost: $17,100.00

6) Birch Run Weigh Station I 75 SB

Accurate axle weighings at this site are practically impossible due to the vertical curve in the scale platform as well as the approach pavement. The scale platform is badly spalled and cracked and should be replaced.

Remove 125 ft of approach pavement and 100 ft of leaving pavement and replace at 0.0 percent grade. Replace curb with 4-ft bituminous shoulder to improve drainage in the scale area and adjust catch basins. Remove and replace guardrail.

Estimated Cost: $11,500.00

7) Pontiac Weigh Station I 75 NB

Remove 150 ft of approach pavement and 70 ft of leaving pavement and replace at 0.0 percent grade. Remove curbing and replace with a 4-ft bituminous shoulder in the scale area to improve drainage. Repair bad pavement slab. Remove and replace guardrail.

Estimated Cost: $8,200.00

The approach work which is deemed necessary to correct pavement and drainage problems at nine specific stations is estimated to cost $58,500.00. Some of this reconstruction work may qualify for Federal aid and should be investigated.

In addition to the repairs required to provide weighing precisions, there are additional items which need early attention. The committee recognizes that some of these recommendations are the responsibility of Departments other than MDSHT; however, they are presented in order that corrective measures may be undertaken.

1) It is recommended that approach and leaving roadways of all existing stations be striped.

2) Platform and area lighting, traffic signal relocation, energizing of OPEN-CLOSED electric signing, and repair of loud speaker systems should be implemented.

3) The duties of motor carrier officers at weigh stations has increased substantially since the Department of State Highways Weighmaster Section was transferred to the Public Service Commission of the Department of Commerce. Today the motor carrier officer is responsible for vehicle safety inspections, driver qualification inspection, reciprocal agreement compliance checking, issuing special permits and several other miscellaneous assignments together with vehicle weighing. It is unreasonable to expect the motor carrier officer to perform all of these assignments effectively as well as maintain an even flow of traffic through the weigh station.

It is therefore recommended that serious consideration be given to staffing stations according to the suggestion of the Executive Motor Carrier Officer as given in Exhibit G. This recommendation is conditioned on a periodic review of operations to assess the continuing and additional manpower needs.

4) It is recommended that a position be created within the MDSHT for an individual to:

a. Collect truck traffic and weigh data for each of Michigan's major trunklines
b. Study the effect of newly planned highways or commercial movements
c. Monitor weigh station operations
d. Become knowledgeable in the latest weighing techniques and equipment
e. Plan new stations
f. Recommend station maintenance and upgrading as required.

This individual would work independently and through a small committee having representation from the Commerce Department and the Department of Management and Budget.

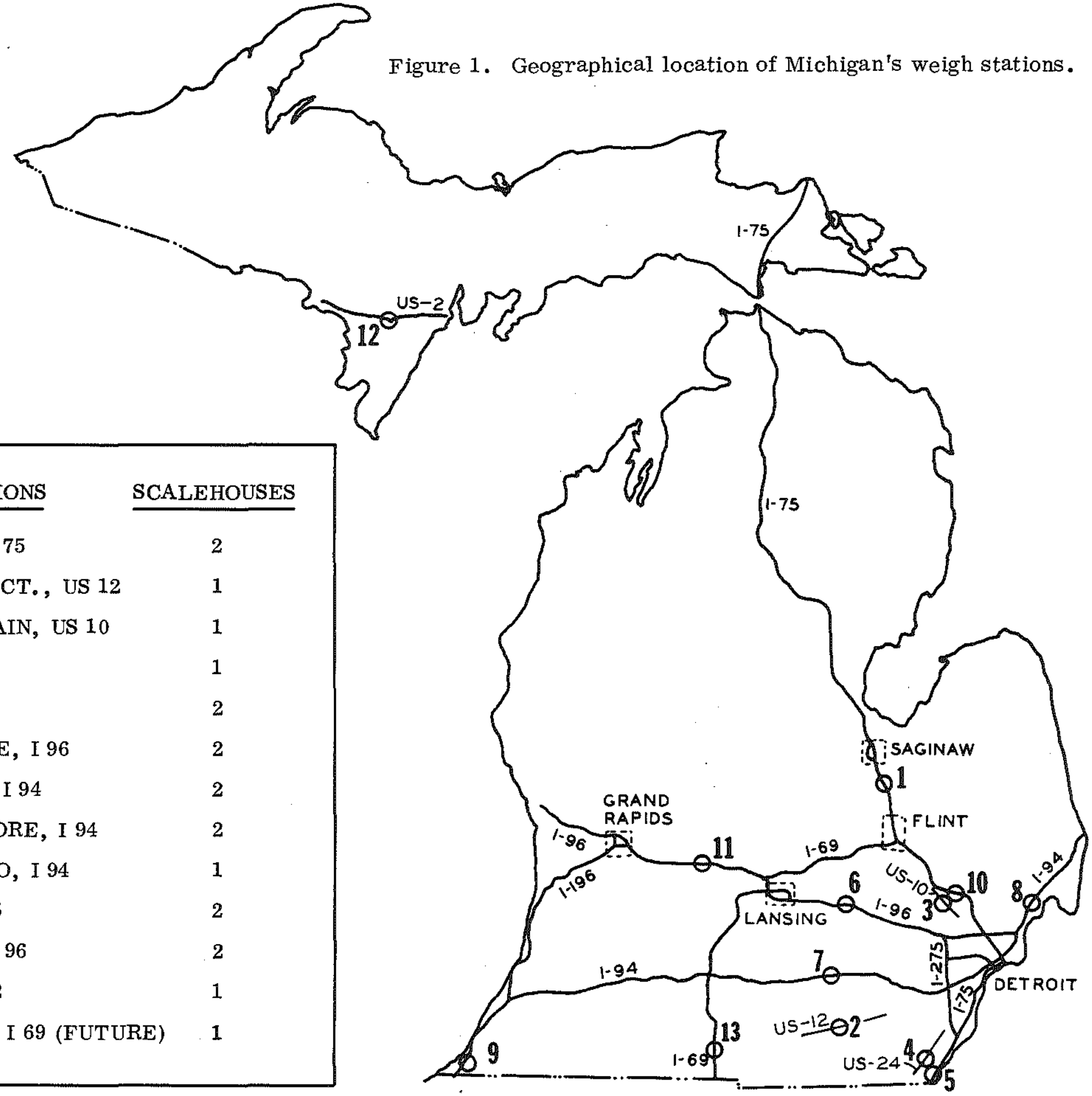


Figure 1. Geographical location of Michigan's weigh stations.

	LOCATIONS	SCALEHOUSES
1	BIRCH RUN, I 75	2
2	CAMBRIDGE JCT., US 12	1
3	DRAYTON PLAIN, US 10	1
4	ERIE, US 24	1
5	ERIE, I 75	2
6	FOWLERVILLE, I 96	2
7	GRASS LAKE, I 94	2
8	NEW BALTIMORE, I 94	2
9	NEW BUFFALO, I 94	1
10	PONTIAC, I 75	2
11	PORTLAND, I 96	2
12	POWERS, US 2	1
13	COLDWATER, I 69 (FUTURE)	1

INTRODUCTION

Purpose

The purpose of this report is to present the results of a study undertaken by an ad hoc committee of the Michigan Departments of Highways and Transportation, Commerce, and Management and Budget to determine the most suitable weigh system for regulating highway vehicle axle weights and perform necessary vehicle inspections.

Need

The State presently has 19 weigh stations in operation (Fig. 1). All of these, with the exception of one located in the south central portion of the Upper Peninsula, are located south of a line connecting Port Huron and Saginaw, and Saginaw and Benton Harbor in the Lower Peninsula. The majority of these 18 are located in pairs along interstate highways radiating out from, and within, a 75 mile radius of metropolitan Detroit. The remainder, all located on State trunklines, are at locations where it is presumed that the most effective surveillance of truck movements can be exercised. A quick glance at a map of the State of Michigan would reveal that stations so located lie along routes connecting the larger cities - the biggest generators or recipients of industrial and commercial shipping.

Truck volumes vary considerably when comparing activity at one station against another. An analysis of records for five consecutive days in May 1973 for 15 stations shows an average hourly rate of traffic passing over the scales ranging from 7.3 to 85.1 (Exhibit D). While the periods of time or the length of total recorded time for the stations were neither identical nor even similar, they do indicate a wide variance in volumes. Although the records obtained also listed the overweights, the oversized, the citations, the warnings and the fines, etc., issued by these same stations during this five-day period, such information had to be evaluated conditionally in the light of the operational problems characteristic to them all.

It should be noted that the total truck counts as stated in the survey do not include those trucks which passed through the station during those times that inspections were being made, or the operator was engaged in other operations away from the scales. Definitely, 24-hour truck traffic surveys taken concurrently and extending over a period of time, such as five consecutive days, would provide a more accurate activity picture at each station. Such surveys should be taken for more than one period to avoid low volumes which could result from major strikes or economic slow downs. The Committee recommends that such traffic surveys be made.

In the Committee's observations of the station activities at the Erie, the New Buffalo, and the Grass Lake Stations it was most apparent that some means of expediting the weighing of vehicles was urgently needed. The five-day activity analysis substantiates this with truck rates per hour of 85.1 at Erie, 77.1 at New Buffalo, and 71.5 at Grass Lake.

Theoretically, if all vehicles passing over the existing 9-ft mechanical scale platform were held to the 5 mph speed limit, and if none had to be stopped for individual axle weighings, etc., the scale could accommodate five units per minute. While this is substantially greater than the 85.1 trucks per hour or 1.4 trucks per minute, the highest rate indicated in the May 1973 period, the detention of only an occasional truck in the weighing lane, or the slowing of trucks to less than 5 mph quickly precipitates a backup. This is the situation for long periods of time at these stations in particular. The long lines of trucks waiting to pass over the scales at these three locations is costly to the shipper, frustrating to the driver and motor carrier officer, and is a hazard to expressway traffic when the backup extends to, and onto the highway. While traffic volumes at other stations might not indicate the immediate need, they can be anticipated to increase over the years, and possibly require special consideration at a later date. Therefore, it is imperative that the weigh operation itself, as presently conducted at least at some stations, be revised.

Scope

The study was devised to establish criteria for design of future weigh stations as well as modifications to existing stations based on physical demands placed upon these installations. Once the criteria were delineated, the four basic elements in the system (scales, scale house, approaches, and parking area) were analyzed separately to see which scale method, what building type and arrangement, and what geometric layout of approaches and parking area would best satisfy the criteria. Weigh station operations and personnal requirements were also investigated.

The Committee responsible for this study and report was made up of representatives from the Design, Traffic and Safety, Testing and Research, Route Location and Programming Divisions of the Department of State Highways and Transportation; the Department of Commerce; the Department of Management and Budget; and the Federal Highway Administration. Such broad representation is necessary by virtue of vested interests of the various governmental units in the total weigh station operation.

Objectives

The course of action decided upon by the Committee early in its existence was one designed to draw upon the experience and knowledge of those who are familiar with vehicle weighing practices and procedures. While objectives 1 through 7 do not necessarily represent a prescribed order of study, they all had to be acted upon prior to pursuing objectives 9 through 12.

1) Solicit evaluations and suggestions from motor carrier officer personnal. Recognizing the value of input from those most closely allied with Michigan's weigh station activities, questionnaires focusing on seven specific areas of concern were sent requesting their candid comments. These areas of concern were the scales, approaches, parking area, and buildings, with emphasis on the location or layout, operational, and maintenance aspects of each.

2) Visit State weigh station sites and observe operations. Existing weigh stations were visited to acquaint the committee members with current operations and physical layout.

3) Research past year's operations of Michigan's weigh stations. With a desire to acquire information regarding the activity at various stations, the motor carrier officers were requested to furnish statistics covering incidence of operation, numbers of overweight and oversized infractions, citations issued, fines collected, attendants used, etc. These data were most beneficial in establishing priorities for modernizing existing stations as well as aiding in the design of new ones.

4) Investigate the capabilities of the scale industry. Existing scales at Michigan stations are all of the mechanical type with a single load platform. The Committee thought it worthwhile to contact manufacturers to study their most up-to-date systems, electronic as well as mechanical, and their capabilities of handling special designs.

5) Research other States' experiences with electronic weighing. The Federal Highway Administration was consulted as to any knowledge it might have as to various States' usage of electronic weigh systems. Contacts were made with specific States presently employing or experimenting with electronic scales in an endeavor to learn from their experience.

6) Study Michigan's electronic research project. The Committee would direct special attention towards Michigan's experience with its own research

project on weighing vehicles in motion (1). A movie made by the Department was viewed and participants in the project questioned.

7) Establish design guidelines. Based on all investigation, study, and interviews, a list of guidelines was prepared which can be used not only for upgrading existing stations, but also for designing new ones.

8) Investigate the legality of electronic weighing in Michigan. A question as to the legality of overload citations based on weighing made on a type of scale different from the existing mechanical one should be answered. An opinion from the State's Attorney General was requested regarding acceptability of electronic scales.

9) Prepare a design for a Class I or a high volume weigh station.

a. Following evaluation of all the information collected and studied, a determination of the scale type was made. Consideration was given to the employment of a dynamic sorting system in conjunction with a static weighing one. Based on this decision, a geometric layout was prepared.

b. Considering the scale type(s) decided upon, the number of platforms together with their layout were designed.

c. A basic layout for the weigh station building oriented and located such as to accommodate all the required operations was prepared. In addition, a basic elevation view showing suggested architecture was drawn.

d. A construction cost comparison of the above scheme with that of our present weigh station design, with respective right-of-way costs added to each was prepared.

10) Prepare designs for stations other than high volume ones. Scale type and weigh system, geometric layout, scale platform, and building, were designed as needed. Cost estimates were prepared.

11) Design a weigh station for I 75 SB location at Erie, Michigan. Inasmuch as high tension power lines paralleling the Interstate highway pass over the site for the proposed weigh station, a geometric layout had to accommodate the two towers located therein. Likewise, the location of the building had to satisfy clearance requirements of the utility company. Conceivably the basic ultimate weigh station might be suitable for this location.

12) Prepare a plan for upgrading existing weigh stations. Taking into account operational records of existing stations, their age, as well as any

large anticipated maintenance costs, a priority for upgrading based on need was determined. Cost estimates were provided for various construction needs.

Vehicle Weighing Responsibilities

Prior to 1968, complete responsibility for design, construction, operation and maintenance of all of Michigan highway weigh stations was assigned, by State law, to the Highway Department. Effective July 1, 1968, in accordance with Act 77, Michigan Public Acts of 1968, the powers, duties and functions of the Department of State Highways Weighmaster Section relating to the administration and enforcement of the size, weight, and load of vehicles were transferred to the Public Service Commission of the Department of Commerce. Subsequently, both departments being of one accord as to a practical and efficient conduct of maintenance, mutually agreed that certain maintenance services in the weigh station areas should be performed by the Department of State Highways and Transportation in conjunction with its trunkline maintenance. Such maintenance would extend to pavement resurfacings, base corrections and pavement widenings; however, it did not include special maintenance and repairs to the scale, scale house, and its appurtenances.

On February 15, 1974, upon request of the Department of State Highways and Transportation, an opinion was rendered by a State's assistant Attorney General relative to construction of new weigh stations on the Interstate system. There being nothing contained in 1968 P.A. 77, prohibiting the expenditures of motor vehicle highway funds for the purpose of matching Federal aid highway funds (as authorized by Michigan P. A. 286 of 1964) the MDSHT was authorized to construct weigh stations on the Interstate system for the purpose of complying with Federal requirements. However, the use of such stations for the purpose of administration and enforcement of the size, weight, and load of motor vehicles is placed under the control of the Department of Commerce, Michigan Public Service Commission.

The opinion, as written, did not address design and construction responsibility of stations on highways other than Interstate. The Federal government does not control the establishment nor the enforcement of States' laws regulating the number and spacing of vehicle axles, and their loads other than setting a maximum allowable axle load limit for Interstate highways. Therefore, the Federal Highway Administration does not participate in the costs of the scales and the scale houses for weigh stations on the Interstate system, nor for highways other than Interstate. An exception to this participation is the approval of Highway Planning and Research funds for research purposes.

The State's Department of Management and Budget's chief concern is the design, construction and maintenance of weigh station buildings, as it is their function to act in this capacity for the Department of Commerce.

WEIGH STATION PROBLEMS

In May 1973 the Enforcement Section of the Department of Commerce's Public Service Commission advised the Department of State Highways and Transportation that considerable difficulty was being experienced at 11 truck weighing stations located on trunklines throughout the State. Known axle loads, verified by other weighing devices and techniques, were registering substantially different weights for certain vehicle types on the scales at these stations. The pavement grades of the approaches to the scales were not level, and believed to be the problem. A recommendation for remedial action was sought.

Pursuant to the request, the Bureau of Highways had level surveys run on scale approach pavements for each of the subject scales. Without a complete understanding of a weighing operation as related to the physical features of a station, the profiles after being plotted aroused question as to whether the approach grade was the sole contributor to erroneous scale readings.

Recognizing that further study was warranted, the Bureau of Highways appointed a team from its Design and Testing and Research Divisions to investigate the problem at each site. The team found not just one problem (pavement grade), but numerous problem areas, collectively affecting weighing accuracy. Simply put, the physical structure (layout, building, and appurtenances) at each station did not lend itself to an efficient operation in its present design. Eventually, these findings were instrumental in the creation of the Committee responsible for this report.

To fully comprehend the problem areas which were observed it is necessary to first understand the weighing procedure (Fig. 2).

The driver of a truck approaching a weigh station site is notified by signs off the shoulder of the highway that a station is located ahead, and whether it is open or closed. If closed, he is permitted to remain on the highway and pass the station unchecked. If it is open, he must turn off the highway at the station's exit ramp, decelerate to 5 mph maximum and drive over the scales. Usually only one attendant is on duty at any given time. He will quickly observe the type of truck and its load if exposed. He will visually gauge the truck as to any oversize infraction, as well as check for registration plates. Taking note of the axle arrangement he positions the counterweight of the scale's beam to the maximum allowable load for the front axle. As the vehicle proceeds over the scale, he anticipates each axle or combination of axles and repositions the counterweight prior to their rolling onto the scale platform. Any harsh "kick up" of the beam is suffi-

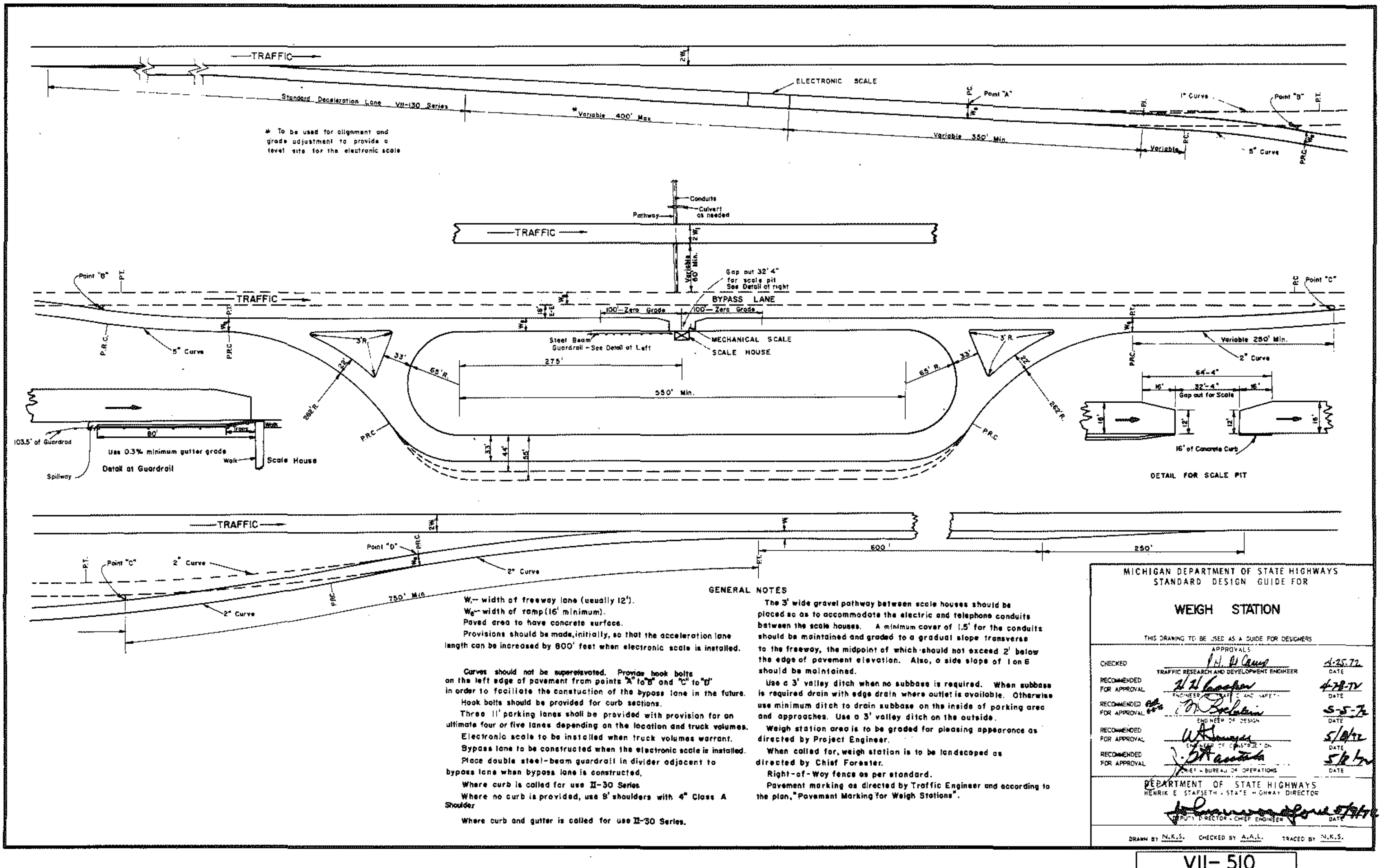


Figure 2. Existing standard design guide for weigh stations.

cient reason to stop the vehicle for static weighing. By using a red-green traffic signal adjacent to the check lane he signals the "stop" or the "go-ahead" as the case may be. If the truck is halted for a weight check, depending on the proximity of a following truck, the attendant may advise the driver by a public address speaker to either drive around the loop behind the building and stop at the scales, or ask him to back up for a reweighing. Then, using the loud speaker he instructs the driver in positioning each axle on the platform, and records its weight. If the truck is overweight, the driver is directed to park in back of the station, and come into the building at which time he is cautioned or issued a citation depending on the severity of the overload. If the overweight is substantial, the unit is detained until the load can either be lightened by transfer to another vehicle, or shifted. The latter concession is made if other axles are carrying well below maximum allowable loads. Following any adjustment of load, the unit is again weighed. The truck once more, because of geometric layout, has to pass over the scales before re-entering the highway. With an understanding of this basic operation the problem areas, as observed, become most relevant in the total operation of the system.

Weighing Problems

1) Axle spacing of units being weighed (Exhibit B). Axle spacings are a problem singularly unique to Michigan. Up to 11 axles may legally be used in a truck-tractor combination, some with or without additional trailer, total length not to exceed 60 ft. Current regulations on allowable truck loadings and dimensions are given in Exhibit A. Typical commercial vehicles in Michigan, and maximum legal gross loads, are given in Exhibit B. The recently adopted House Bill 5368 which allows larger axle loads is presented in Exhibit C. With these controls, plus an additional 5 ft length tolerance for units hauling certain specified cargoes, the variations of axle spacings together with their loadings are numerous. To weigh each individual axle, as well as groups of axles, becomes an impossibility for some units with the single 8 or 9-ft long scale platform currently in use.

2) Position of wheels on scales. Although, by design, the weight of an axle should be constant regardless of its position on the platform, experience shows that a several hundred pound variance can be realized on platforms of several of our stations depending on the axle's location.

3) Axle springing system of vehicles. Air axles have become very common on the multi-axle trucks. With their controls located in the cab, the driver has the ability to raise these wheels from contact with the pavement as he executes sharp turning movements, or if he decides to distribute his load over fewer axles. Unfortunately, he also has the ability to

lift and lower this type of axle as his truck is being positioned on a platform for a static weighing. Station attendants, while aware of such axle load adjustment capability, cannot easily detect a manipulation of air axle loads from their position in the scale house.

4) Length of platform. With the many axle spacings permitted, the length of platform dictates or restricts the axle configuration which can be positioned simultaneously thereon. It also prescribes the number of weighings necessary to effectively weigh the completed unit. In many instances positioning pairs of axles, then repositioning these same axles with different pairings, is needed. This method, while not completely accurate, appears to be the only solution for existing conditions. Unfortunately, it is time consuming.

5) Makeup and condition of platform (Fig. 3). At many stations the platform, and especially the support system, was in poor condition. With a necessity of maintaining an ice and snow free condition on the approaches leading to the scale, chlorides are being used extensively. In time the salt laden slush is tracked onto the platform; the runoff drains over the edges of the platform and into the scale pit below. The platform universally in use is a 6-in. $\pm$ concrete slab on steel plates, supported in turn by a steel stringer-floor beam framework. Considerable deterioration of the underside of the slab, along with portions of the framework, has taken place because of corrosive drainage. In due course, stations are closed due to excessive deterioration, and the platform, including the support system, must be replaced. The shutdown time of the station while repairs are made is usually quite lengthy.

An additional problem occurs from deterioration, in that a flush condition between the top of the approach pavement and platform cannot easily be retained. A platform drop causes an impact loading onto the scales as an axle rolls from a rigid approach onto the platform giving a false reading for the moving or static axle.

6) Approaches on grade. A 0.0 percent grade for the immediate approaches (to and from the scale) is desirable. Where the grade is either convex or concave, inaccurate weighings are obtainable, especially for a long semi-trailer with 9-ft axle spacings.

7) Grade on scale platform. Where the grade on the scale platform is concave or convex, inaccurate weighings result as axles (supporting a rigid trailer frame) off the scale affect the weighing of the one on the scale.

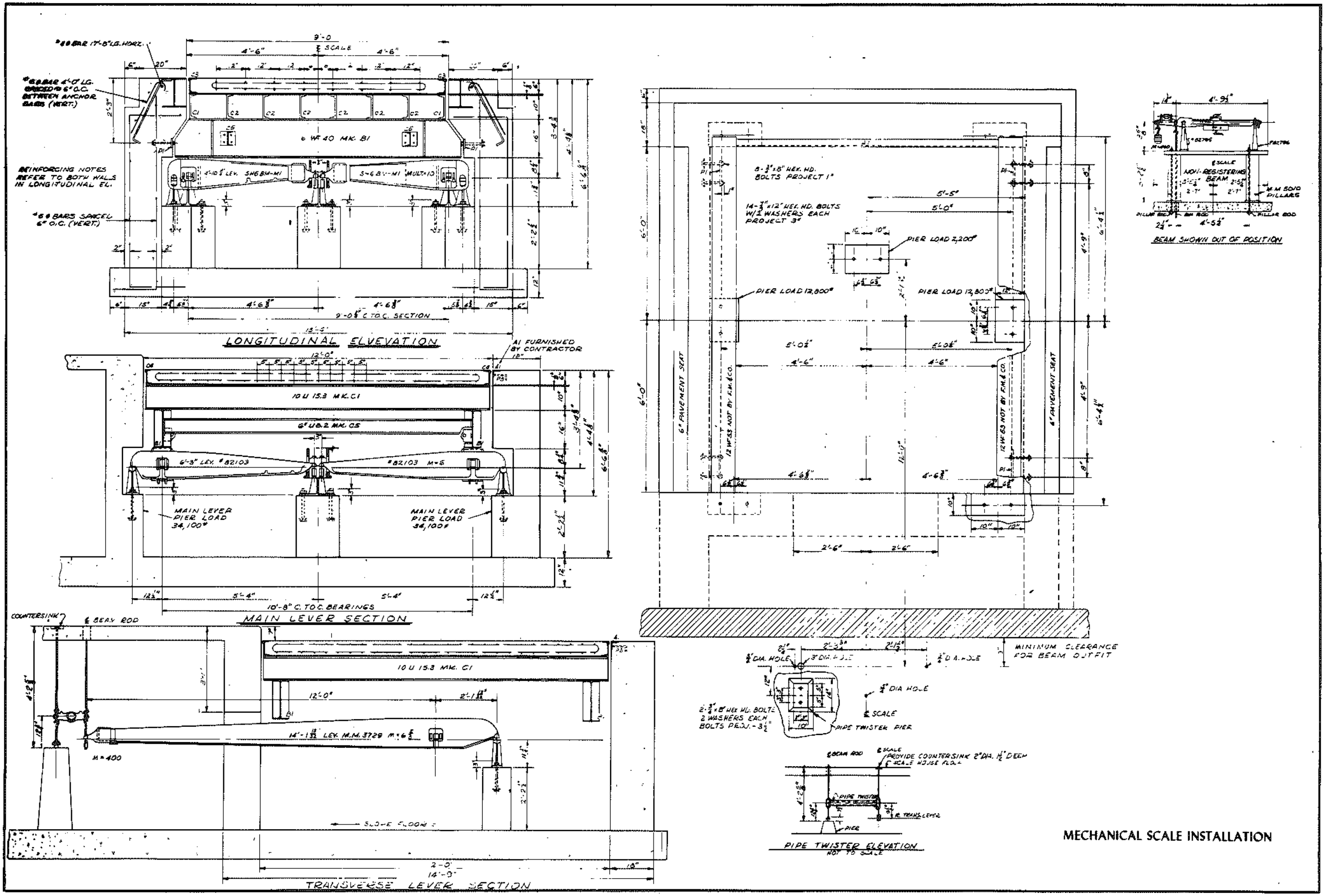


Figure 3. Typical mechanical scale platform at Michigan weigh stations.

8) Roughness of approach and platform surface. As the trucks pass over the existing scales, the roughness of the approaches as well as that of the platform induces vibrations of sufficient time duration into the rolling unit which cause questionable weighings. These can only be resolved by halting the vehicle and weighing it at a complete stop.

9) Speed of units passing over scales. Basically the present mechanical scale system is a static one. However, it is being operated somewhat in a dynamic fashion as units are permitted to pass slowly (5 mph) over the scales while the operator positions the counterweight on the beam for maximum allowable weights. The speed of the vehicle coupled with pavement irregularities can cause fasle indications, sometimes resulting in unnecessary static weighing; requiring full stop of the vehicle for weighing each axle and/or groups of axles. Some trucks, such as those with liquid loads, when subjected to braking or acceleration while approaching the scales, or stopping on scales, produce erratic scale readings due to liquid movement.

Approach Lane and Parking Area (Fig. 2)

It is desirable to have a 0.0 percent grade immediately adjacent to the scale platform. Any short vertical curve in this area as a result of pavement settlement or of construction error introduces weighing problems.

Drainage must be directed away from the scale platform. This becomes a problem when considering the desired approach grade. Sod as well as high shoulders in some flush shoulder areas prevent water from running off the pavement as desired. Where it drains toward the platform, it leaves an accumulation of sediment in the pit.

The length of deceleration lanes and approach roads causes serious problems at some of the older stations. These lengths are insufficient to allow the deceleration of trucks approaching the scale without excessive braking. They are also inadequate to store a lineup of units waiting their turn to pass over the scales. This latter problem is of greatest concern for those stations experiencing the largest volume of trucks, as the lineup backs up onto the expressway itself.

Inadequate length of road leaving the scale and short acceleration lanes do not afford the necessary distance to accelerate to properly merge with other vehicles on the freeway.

The proximity of interchanges to a weigh station can be beneficial as well as detrimental. If the interchanges are too close, interchange traffic will interfere with the entering and exiting of trucks to and from the weigh station. However, interchanges properly located both upstream and downstream of the weigh station do afford a way for a driver who has bypassed the station to "double back" for a weight check. In some instances truckers have been observed using maintenance crossovers, after being directed to return for a weighing. Such maneuvering is definitely hazardous.

Proximity of the parking area to the weigh house is of concern primarily where a single attendant has to operate the scales as well as make safety inspections. To conduct these operations, in areas several hundred feet apart, lessens the time he can devote to either assignment. Safety inspections are addressed more fully in this report under "Operational Problems."

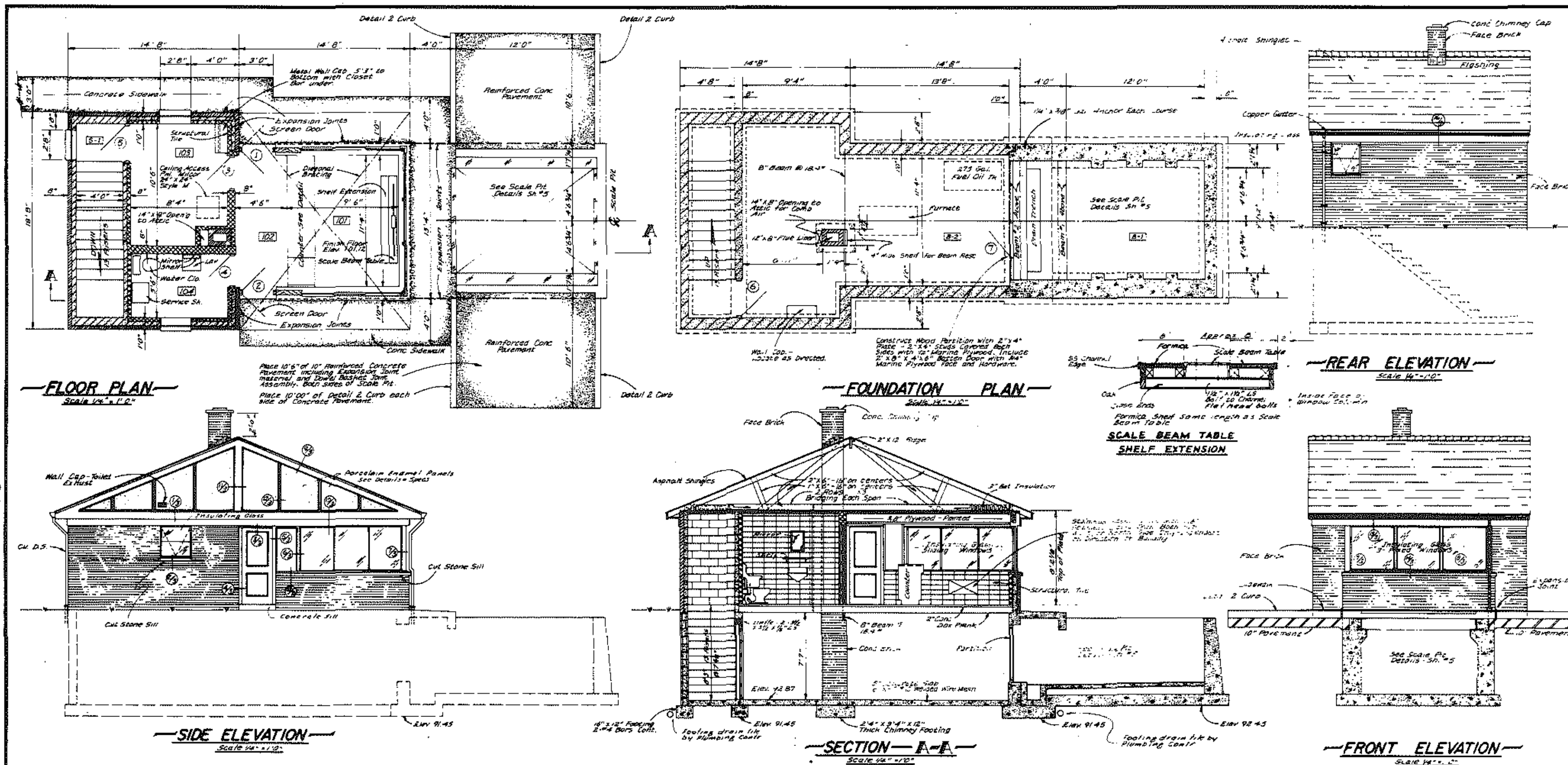
Exterior Lighting

Inadequate lighting of the approaches, specifically at the scales, appears to be a problem. There is a positive need for the motor carrier officer to view the complete truck and load (if exposed) as it approaches. He must also be able to observe the axles as they are positioned on the platform. In addition, he must be able to read the license plates and determine the State of registry of the truck. During the hours of darkness, unless critical areas are properly illuminated, the attendant cannot effectively perform his job.

Illumination of the parking area is a necessity. This large surfaced area located in the vicinity of the weigh house primarily provides for parking of units whose drivers have need to "check in" for overload citation or vehicle safety check. The latter, especially, requires sufficient lighting during the hours of darkness to enable the motor carrier officer to check all those areas required by such inspection. In the absence of such lighting, the safety check cannot be properly made. Of additional concern is the safety of the attendant who is apprehensive about checking the truck of a hostile driver.

Building and Scale Operations

Some stations in locations of generally low terrain have incurred basement and pit flooding to a depth as great as 4-ft, causing extensive damage, especially to the furnace and hot water heater located in the basement. Most Michigan weigh stations have a scale pit floor elevation approximately flush with the basement floor of the building (Fig. 4). As potential flooding of the pit and the basement is of concern, a floor moat, designed to collect sediment as well as reduce the possibility of infestation of vermin, separates the two. This, along with a basement floor drain, flows to a sump pump outletting in a nearby drainage ditch.



DOOR SCHEDULE

NO.	SIZE	MATR'L	GLASS	FRAME	METAL LOUVRE	REMARKS
1 & 2	2'8" x 6'8" x 1¾"	Pine	¼" pl gl	Pine		Ext. Type Solid Stiles &
3	" " "	Hollow Metal		Steel	12" x 8"	Rails Fenestra Type M (Flush)
4	2'6" x 6'8" x 1¾"	"		"	"	" " " "
5	3'0" x 6'8" x 1¾"	"		"	"	" " " "
6	" " "	"		"	"	Fenestra Type M (Panel)
7	3'0" x 4'6" x 1¾"	Plywood				see note - This Sheet

ROOM FINISH SCHEDULE

NO.	NAME	WALLS	CEIL'G	FLOOR	BASE	WDW. STOOL	REMARKS
B-1	Scale Pit	Concrete		Concrete			
B-2	Basement	Conc Block	Dox Plank	"			
S-1	Stair	" "	Acous. Tile	"		Concrete	Concrete Treads and Risers
101	Scale Room	Str. Gl Tile	" "	Battleship Linoleum	Str. Gl Tile	Str. Gl Tile	All Ext. Corners and Stools Shall Be Bullnose Tile
102	Public	" " "	" "	" "	" " "	" " "	" " "
103	Storage	" " "	" "	" "	" " "	" " "	" " "
104	Toilet	" " "	" "	" "	" " "	" " "	" " "

Figure 4. Typical weigh station building used in Michigan.

The location of the scale beam and the heights of the attendant's chair and counter are not compatible for good vision of the trucks axles being positioned on the platform.

For some stations repeated difficulty with the loud speaker system makes it necessary for the motor carrier officer to walk out to the truck to instruct a driver in positioning wheels on the platform or to proceed to the parking area.

For all stations the signalized stop-go light is improperly positioned for the driver of a long truck. He cannot observe the signal light following weighing of the rear axle, as the light is too close to the scale platform.

Since weigh station functions are assigned to more than one governmental unit, all maintenance responsibilities do not appear to be completely understood. This understanding varies from station to station.

In addition to weighing trucks of Michigan registry for conformance to Michigan laws, out-of-state trucks, by reciprocal agreements with other States, are checked for maximum allowable loads as permitted by the States of their respective registry. These trucks are allowed to carry loads permitted by Michigan law by acquiring a special permit good for a specified time limit. Since Michigan laws permit much greater gross loads than all other States, it is not unusual to witness out-of-state units, at stations near the State border, attempting to carry Michigan loads. Many drivers gamble on the possibility the station may be closed or that they may not be discovered. If they are detected at the station, purchase of the permit allows them to continue.

Although the necessity to observe the State of registry may seem solely a concern of in-bound border stations, this is not the case. Weigh stations, for economic reasons, are not located on all routes leading in and out of the State, even though high volumes of truck traffic exist. While portable scales are periodically set up along some of these latter routes in attempt to apprehend illegal vehicles, the weighing process is laborious and time consuming.

It can be surmised that many out-of-state trucks carrying illegal loads manage to "beat the system." Such vehicles might even be operating intrastate without permit to carry Michigan allowable loads. Hopefully these trucks, during their driving in the State, will encounter one of the State's weigh stations and be subject to check. Thus, it is necessary for all stations to be concerned with the vehicle registry.

An awareness of other States' legal axle loads and the need to make special weight checks resulting in a high incidence of overweights of their respective maximum limits occupies a sizeable amount of an attendant's time.

Manpower appears to be a problem of varying proportions depending on the traffic volumes handled by the respective stations. The single motor carrier officer may be capable of fully handling the operations of a station experiencing low volumes. Alone, he is unable to handle them properly at stations having high volumes. Some of his duties, in addition to operating the scale and instructing drivers passing over the scale with the loudspeaker and traffic signal are:

Operating the radio transmitter and receiver
Manning the telephone
Checking driver's license
Explaining to drivers each infraction
Writing special permits
Collecting permit fees
Writing citations
Making safety checks
Performing miscellaneous housekeeping chores
Performing miscellaneous outdoor maintenance, i.e., snow-shoveling of platform, immediate approaches and walkways, salting, and grass mowing around the building.

Therefore, while he is engaged in any of these specific work assignments, attention to the scale is at a minimum or even nonexistent.

Special mention has been made of "safety checks." One of the many responsibilities of the Michigan Public Service Commission, as delegated by the Michigan State Police, is to make commercial vehicle inspections. While these may be, and are performed anywhere and at any time throughout the State, it is understandable why the State's weigh stations were selected as practical locations to make these inspections on a regular basis. The opportunity to size up a unit while it is traveling at a slow speed into the station, the ability to easily signal the driver to stop, not hindered by the stream of highway traffic flow, and the convenience of a large parking apron makes the weigh station a logical checkpoint.

Although all vehicles passing through the weigh station are subject to safety check, only a relatively few are inspected. Such vehicles are selected either on a random basis, or where the attendant notices an obvious fault in the vehicle or its loading. Unfortunately, the inspection itself takes a fair amount of time, depending on the unit being inspected. Using a standard form which itemizes all the areas to be checked, the attendant must leave his post at the scale, walk to the parking apron and perform his inspection regardless of weather, time of day (or night) or of truck volumes passing through the station at that time (Fig. 5).

Knowing that a station is unattended is of benefit to shippers of cargo being hauled by trucks. More than one motor carrier officer, when contacted by the investigating team, voiced suspicion that "decoys" are employed in an attempt to bypass another overweight vehicle through the station. A "decoy" with an obvious minor defect would be directed to stop, and an inspection would be initiated. While the attendant was making the inspection, leaving the scale unattended, the overloaded vehicle could pass undetected. This operation is difficult to spot with the present weigh station personnel.

As an extension of this technique to "beat the system," there is proof of such intent by the way citizens band radio is used. Most trucks have CB radios. Through the use of coded vocabulary the trucking fraternity is kept well informed by fellow drivers as to whether or not certain weigh stations are open. They are also forewarned of locations where the motor carrier officer may have set up a temporary check point with portable scales. Such messages have been intercepted by weigh personnel, who find it difficult to make their efforts worthwhile. It is also general knowledge that on occasion some truckers with an overloaded truck will wait for hours at truck stops or other locations until an "all clear" has been received informing them that the station is closed or the "blitz" down the road is "off." Whether the truck is overloaded deliberately or not, the motor carrier officer is unable to weigh each vehicle properly if he must perform multiple functions simultaneously.

Closely allied to the above issue are the operating hours of each station. Currently, no station is open "round the clock." This situation seemingly prevails mostly due to lack of funds, although a recognized reduction in truck movements during certain time periods do affect the scheduling of station operations. No estimate exists as to the number of illegal loads or trucks which pass unchecked during that period the station is closed, however one would be naive to assume that all the violators are traveling only during the hours the stations are open and are thus apprehended.

All of these problems and problem areas were observed by the investigative team during the 1973 study. Whereas a few were of major concern at a few locations, most of the problems were significant to some degree at all stations. With this basic knowledge the committee addressed itself to a more comprehensive understanding of their existence, to that end that the best practical solutions could be found.

STATE OF MICHIGAN VEHICLE INSPECTION

192749

0 1 2 3 4 5 6 7 8 9	1	
LOCATION 0 1 2 3 4 5 6 7 8 9	2	______ Registration
0 1 2 3 4 5 6 7 8 9	3	______ Sticker No.
0 1 2 3 4 5 6 7 8 9	4	
0 1	6	MILEAGE 0 1 2 3 4 5 6 7 8 9
MONTH 0 1 2 3 4 5 6 7 8 9	8	0 1 2 3 4 5 6 7 8 9
0 1 2 3	10	0 1 2 3 4 5 6 7 8 9
DAY 0 1 2 3 4 5 6 7 8 9	12	OPERATORS LICENSE — None (SUMMONS)
0 1 2 3 4 5 6 7	14	Susp. or Revoked
MODEL YEAR 0 1 2 3 4 5 6 7 8 9	16	PASS — Other
0 1 2 3 4 5 6 7 8 9	18	REGISTRATION — Improper (SUMMONS)
VEHICLE MAKE 0 1 2 3 4 5 6 7 8 9	20	PASS — None on Person
VEH. TYPE: FULL, INTER, COM, SPORT, CARRY ALL, JEEP TYPE, PANEL PICKUP, STR'T TRUCK, TRUCK TRACTOR, OTHER; PAL 1	22	INSURANCE — No Compliance (SUMMONS)
PASS — REJECT	24	PASS — None on Person
GLASS — Safety	26	1 2 3 4 TRIPS 5
GLASS — Vision Impaired	28	PASS — SCHOOL BUS — REJECT
WIPERS	30	Reflectors
WASHERS	32	Clearance Lights
LIGHTS — Front Direct.	34	Flashers
LIGHTS — High Beam	36	Fuel Tank
LIGHTS — Low Beam	38	Defroster
LIGHTS — Aim	40	Emergency Door
LIGHTS — Output	42	Fire Extinguisher
LIGHTS — Tail	44	Flares/Warning Equipment
LIGHTS — Stop	46	Color
LIGHTS — Rear Direct.	48	Bumpers
LIGHTS — Plate	50	Body Condition
LIGHTS — Beam Indicator	52	Floor
HORN	54	Heater
STEERING	56	First Aid Kit
BRAKES — Foot	58	Service Door
BRAKES — Parking	60	Steps
TIRES — Bulges or Break	62	Seats
TIRES — Tread	64	0 1 2 3 4 5 6 7 8 9
EXHAUST — Noisy	66	0 1 2 3 4 5 6 7 8 9
EXHAUST — Smoke	68	0 1 2 3 4 5 6 7 8 9
MIRROR	69	0 1 2 3 4 5 6 7 8 9
SEAT BELTS (NOT EQUIP, IN USE, NOT USED)	70	0 1 2 3 4 5 6 7 8 9
PASS — TOTAL VEHICLE — SUMMONS — REJECT	71	TO RECEIVE AN INSPECTION STICKER
0 1 2 3 4 5 6 7 8 9	72	
0 1 2 3 4 5 6 7 8 9	73	
0 1 2 3 4 5 6 7 8 9	74	
0 1 2 3 4 5 6 7 8 9	75	
0 1 2 3 4 5 6 7 8 9	76	
0 1 2 3 4 5 6 7 8 9	77	
0 1 2 3 4 5 6 7 8 9	78	
0 1 2 3 4 5 6 7 8 9	79	
0 1 2 3 4 5 6 7 8 9	80	______ DEPT.

TO RECEIVE AN INSPECTION STICKER

1. Make the necessary repairs.
2. Within 14 days present your vehicle and this inspection form to any station of the Police Department that inspected your vehicle.
3. If your vehicle headlamps were out of adjustment return your vehicle to the inspection team as soon as possible.
4. Corrections or repairs may be made by any person at any place.

DEPT.

ST-8

Figure 5. Vehicle safety checklist used in Michigan.

STUDY DEVELOPMENT

Site Visit

One of the first steps taken by the Committee was to assure that each member had a good understanding of a weigh station's physical make-up, its staffing, its mission, and its operation. In due course each would learn of its limitations and its problems. Visits to different sites were made by the members where they had ample opportunity to witness the total operation, inspect the installations, and question various motor carrier officers and supervisors. It was interesting to note that many of the problems which they themselves observed, were all emphasized in reports later received by the Committee.

Weigh Personnel Input

Reports were directed to the Committee in response to a comprehensive questionnaire embracing all areas of weigh station facilities as well as their operation. The Committee throughout its deliberations placed considerable emphasis on them; most of the guides for design are based on this operational input. The questionnaires were sent via the State's Executive Motor Carrier Officer to all his supervisors and their scale attendants. The response was excellent; the comments definitely indicated problems. Some, seemingly minor, required funds not readily available; others, suggested extensive changes. It was fair to conclude that from written responses as well as the answers given during interviews, each individual involved in Michigan's truck weight surveillance program desired an upgrading of the facilities, and the tools to make his job more functional. A summary of the written responses has been prepared and appears in this report as Exhibit E.

Weigh Station Activity

An activity report was obtained from the Office of the Executive Motor Carrier Officer so that a study could be made of the truck volumes handled by certain stations as well as the incidence of infractions. While the records were not for continuous 24-hour periods, they did give the Committee important information. The overweight citations were less than what some Committee members would have predicted. However, many attendants recognized their inability to properly weigh due to problems with site conditions stated earlier in this report.

Experience of Other States

The Committee made several contacts with other States either having experience with, or contemplating installation of, electronic scales. Extensive studies of effective weigh systems are presently being conducted by several States - Minnesota, Florida, Pennsylvania and Georgia, to name a few.

During October 1974, certain members of the Committee were able to visit an electronic scale system in Minnesota. The installation was a series of four adjacent platforms in line over a single pit. The pit was heated to discourage any corrosive moisture problem. The station was operated by a crew of five individuals, three of whom devoted full time to the safety inspection of each truck as it passed through the station. The weigh operation, a static one, was studied at length and answers were solicited for the many questions raised by the Committee. The station had been in operation since late 1972.

Georgia in its report on Static Scale Evaluation and Selection for Permanent Interstate Truck Weigh Stations, April 1975 states that; "Electronic scales are recommended primarily because of their fastest, possibly more accurate, operations and relative absence of maintenance. Pit and platforms requirements should not be as demanding. Cost differences were not felt to be prohibitively significant." Of further interest, it is noted in the Georgia report that results of a survey conducted last year indicate that 34 States plus Ontario are either using or planning for the use of electronic static scales. This report also indicates that 14 States plus Ontario are planning dynamic weighing systems.

Industry Capability

The Committee also pursued the capability of the electronics industry, meeting with representatives of Toledo Scales, of Toledo, Ohio; Torroid of Huntsville, Alabama; Aeronutronics-Ford of Willow Grove, Pennsylvania; and Weigh-Tronix of Armstrong, Iowa. With the expertise of Michigan's Bureau of Highway's Testing and Research representation on the Committee, the highly technical aspects of electronic installations were intelligently discussed. The Committee was assured that the industry was fully capable of producing systems that would answer our needs.

Michigan's Research

During the course of interviews with industry, along with intra-Committee discussions, references were repeatedly made to Michigan's own research project with electronic dynamic weighing. The 30 minute, 16-mm sound movie made during the conduct of the project, and the final report, dated March 1974, contributed to a more knowledgeable understanding of many facets of electronic weighing systems.

The confidence in the feasibility of dynamic electronic weigh systems as declared in the report's summary, and by individuals having participated in the project both in the Bureau of Highways and in the contracting firm involved in its later stages (Philco-Ford), cannot help but give credence to the concept as worthy of consideration.

DESIGN GUIDELINES FOR WEIGH STATIONS

Recognizing that the Michigan Department of State Highways and Transportation has at present a Standard Guide for the Design of Weigh Stations, VII-510 dated 1972 (Fig. 2), the Committee's attention has been directed understandably to the functional operations of those stations having a design influenced by this standard. Though the stations were built earlier than 1972, earlier forms of the Guide did not differ substantially from the latest one. After evaluating all the information garnered by the Committee in its study, the following guidelines are given as requisite for effective weigh station design.

Station Locations - Divided Highways

Where a station is located on the outside of a divided highway (exterior design), that station only serves one roadway. If a station is located in the median, it can serve both roadways.

At first glance, a seemingly obvious cost savings presumes that a station located in the median should be the best. However, further study points up the hazards of median lane exits and entrances of the slower vehicles. These could be eliminated by crisscross designs for the freeway or hourglass designs for the trucks; however the cost of extra rights-of-way, and necessary bridge overpasses could very easily offset the cost of the two stations with the exterior design.

The ideal location for weigh stations was studied by the Department of State Highways' Office of Planning in the late 1950's with a Comparative Cost Analysis Report made in May 1959. While the simple median design was the most economical, the exterior design rated second in economy. However, in considering the non-acceptance of median placement by the Federal Highway Administration, a State policy was established that exterior station designs would be used in all new station locations. ("Weigh Station Designs - A Comparative Cost Analysis," MDSHT, May 1959.)

As the Department presently shares the Federal Highway Administration's concern for median lane exit and entrance movements of trucks, the Committee did not depart from the 1959 policy and continued with its proposals using an exterior design.

Scale House

1) The building should be oriented such as to afford a view by the motor carrier officer of the parking area as well as the scale area.

2) Headlight and sun glare, as well as light reflections on the operator's area, should be reduced or eliminated through the use of tinted glass, tilting the glass, or other means.

3) The driver and motor carrier officer areas should be completely separated for reasons of personal safety.

4) The mechanical scale beam should be positioned sufficiently low so as to not obscure the attendant's view of the scale platform.

5) Interior lighting in the operations area should be provided with dimmer controls.

6) Household cleaning supplies and equipment should not be stored in the toilet room, but in a cabinet or closet outside of that room.

7) A room should be provided at one of each pair of stations to serve as an office or small meeting area.

8) Basements should be eliminated where possible; if necessary, the main floor elevations should be such as to permit the basement floor to be set as high as possible to maintain a dry condition. Ground surface should be graded to slope away from the building.

9) Basement and pit should be drained by gravity flow to a natural outlet, when possible.

10) The electrical service panel should be located on the ground floor; never in the basement.

11) If a basement is required, both interior and exterior access should be provided to the stairway.

12) A scale pit, if required, should always be accessible from a scale house basement.

13) Pit access manholes should not be located in the scale platforms unless complete structural integrity of the platform can be maintained.

14) Heating and water heater units should not be located in the basement.

15) A master lock and key security system should be installed for all stations.

16) Central air-conditioning should be provided.

17) Shatter-proof glass should be installed.

18) An escape area or an additional building exit should be provided for a motor carrier officer in case of emergencies.

19) The building should be constructed with materials requiring a minimum of maintenance.

20) Low angle flood lighting, directed away from the building, should be provided to illuminate the scale platform.

Approaches and Parking Area

1) Entrance ramps to stations should be sufficiently long to allow vehicles to leave the highway at or near the trunkline speed.

2) Station exit ramps should be sufficiently long to allow vehicles to accelerate and smoothly enter the flow of traffic.

3) All vehicles entering an open station should pass over the scales regardless of their being attended at the specific instant.

4) All vehicles should pass sufficiently close to the scale house to allow the motor carrier officer to make a visual safety inspection and identify license plates.

5) Manpower attending the station should be such as to properly perform all station assignments during peak activity periods.

6) Provisions should be made to allow a vehicle using the parking-inspection area to either leave the area directly or return to the static scales.

7) Parking-inspection area should be well lighted.

8) Parking area should be provided immediately adjacent to the building for a motor carrier officer's car.

9) The "stop-go" traffic signal adjacent to the scale ramp should be located a distance, downstream of the scale, greater than the longest truck-trailer combination legally permitted.

10) No dynamic electronic sorting scale should be incorporated into any existing station as constructed. Reference to an electronic scale in the location shown on MDSHT's Standard Design Guide for a Weigh Station should be deleted.

11) The approach pavement to the scales should have a 0.0 percent grade, a minimum of 100 ft both upstream and downstream of static scales.

12) The approach pavement should have an "A" crown with paved flush shoulders on both sides of the ramp taking drainage away from the scale. Curbs should be replaced with paved shoulders when feasible.

13) For existing approaches, not having curb and gutter in the vicinity of the scales, the shoulders should be reshaped so as to provide immediate transverse drainage away from the ramp and the scale. High sod on the shoulders causes water to pond at the edge of the ramp, and to drain into the pit.

14) The parking-inspection area should be located as near to the building as feasible to lessen the time an attendant must devote to walking to and from each inspection assignment.

Scale Platform (Refer to Fig. 9)

1) Design of the scale platform for the mechanical scales should be changed to one using a reinforced concrete slab only, resting on a girder-floor beam structural steel framework. The concrete should function compositely with the structural steel members through shear connectors welded to the upper flanges of the beams. This design, by eliminating the horizontal steel plate on which the concrete slab rests in present designs, eliminates an area subject to corrosion and deterioration not able to be inspected.

2) The edges of the scale platform should be constructed such as to prevent that water leaking through the joint between it and the pit wall from running along the bottom of the slab or down along the structural steel support framing. It is suggested that a rigid steel plate completely surround the platform edge to insure a uniform joint width between it and the inside edge of the pit wall. This plate should be anchored to the concrete of the platforms, and should extend a distance below it to provide a drip edge. The exposed surfaces should be coated with epoxy. The plate performs a secondary function as an edge form for placing the concrete (Fig. 6).

3) The inside face of the pit at its upper limit should be constructed such as to prevent the water leaking through the joint between it and the platform from running down the face of the pit wall. This can be done by providing a rigid steel plate or angle anchored to the inside face of the wall at this location. The plate should extend from the road surface (top of pit wall) down to an elevation below a set-back or indentation of the wall so as to provide a drip edge. Exposed surfaces of the plate should be coated with epoxy.

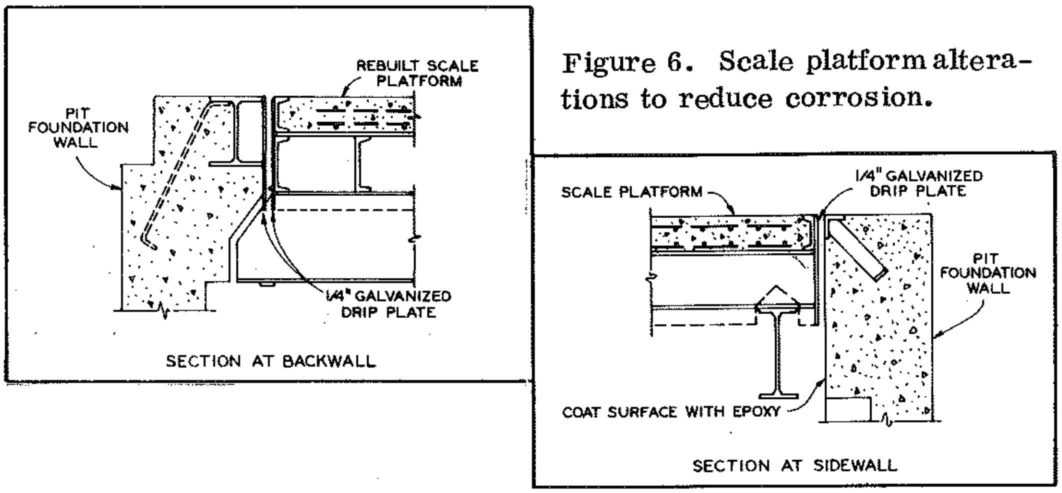


Figure 6. Scale platform alterations to reduce corrosion.

General

1) Maintenance responsibilities of the building and the area should be positively worked out and posted in each building for the specific understanding of all personnel.

2) Scale houses should have a common design, although, depending on a specific location, there may be a desire to vary the architectural treatment.

3) Landscaping should be provided, however it should not interfere with the needed clear vision for both the motor carrier officer and the driver.

4) An outside pay telephone should be located adjacent to the truck parking area, and an indoor pay phone should be located in the scale house for the convenience of the driver.

5) Where electrical transmission lines span over a weigh station area, special clearance requirements, both vertical and horizontal, must be adhered to if the lines are to be left in place.

ANALYSIS FOR DESIGN OF A HIGH VOLUME STATION

Alternate Proposals

The first station design alternate or consideration for handling high volumes of truck traffic which the Committee examined was:

A. Increase the number of personnel on duty at an existing station at any one time.

It is most apparent that a lone motor carrier officer or attendant cannot possibly perform all of his assigned duties in a desired manner if his station is subjected to heavy traffic volumes. This same observation can be made even at stations experiencing moderate traffic volumes. While the axle overloads can be witnessed by an attendant who positions and repositions the counterweight on the beam balance arm as a truck moves very slowly over the mechanical scale platform, the necessity of making a safety inspection takes him away from his post at the scale. During his absence for reasons of inspection, housecleaning assignments or otherwise, drivers approaching the scale, often come to a complete stop on the scale anticipating instruction from an attendant who is not there. Though a temporary sign may have been posted by the attendant immediately prior to his leaving his post, instructing the drivers to continue on, the cautious ones delay sufficiently long to contribute to a back-up of vehicles.

Additionally, there are times that an attendant while conversing with, or writing a citation for a driver who has come into the house, or one who may be involved in a telephone or radio conversation, has to hold a truck on the scales until he can complete some immediate business. This delay in truck movement over the scales adds to the line. An extra attendant would definitely be desirable at the busier stations to allow for more vehicle inspections and keep the scale operative for the full time that the station is open, thereby providing a better surveillance of all trucks. Additional personnel would also expedite vehicle movements through the station by continued attention to the scales.

Although the Committee feels strongly that the manpower at each station should be of sufficient number to effectively accomplish the full mission of that station, it did not believe that the increase in number of attendants alone at our existing mechanical scale system would decrease the back-up to an acceptable length. It was concluded that multiple static scales may be required at some sites.

The second design alternative for handling high volumes of truck traffic examined was:

B. Additional approach lanes, each with a mechanical scale located therein.

This scheme would lessen the incidence of extremely long traffic backups proportionately to the number of lanes with scales installed and used. Although this seems to be a simple solution to the overall problem, such a scheme introduces many individual problems, resolutions of which would be costly. To enumerate a few:

1) Multiple lanes introduce added construction costs for the lanes, pits, and scales.

2) Extra right-of-way would be needed to accommodate extra lanes.

3) While a scale house could be positioned between two approach lanes so that scales could be serviced and operated from one building; any lanes greater than two would require an additional scale house with adjacent pit and scale, a costly input.

4) Each mechanical scale should require one attendant.

5) A scale house located between two approach ramps would be a hazardous location not only considering the errant vehicle, but the incidence of drivers and attendants having to walk across a lane of traffic.

6) While the selection of a lane could be left to the driver upstream of the scale, such decision, if delayed, could result in trucks crossing over to another lane at an undesirable point.

7) Merging lanes within the station area from multiple weigh lanes could be extensive and costly.

8) Cross-overs downstream of the scales leading to the parking area would be hazardous.

The Committee's attitude was that, while the back-ups in the approach lanes could be substantially reduced, the resulting system would not be as operationally safe as desired. In addition, the expenditures could be extensive; the money might better be invested in a system more simplified yet capable of handling high traffic volumes.

The third alternate and the one favored by the Committee was:

C. A double system utilizing both dynamic and static scales.

The dynamic system is one which should be capable of weighing trucks under motion. It would allow empties and those legally loaded to return to the highway, and sort out those where there is a question of possible overload and those that are definitely overloaded. This design concept is based on the recognition that the great majority of trucks traveling the State's highways are carrying legal loads. If these vehicles can be sorted out of the stream of truck traffic entering the station, they will experience only a slight delay - that being a reduction of speed to pass through a weigh station approach lane.

If it is determined by visual observation that a certain truck should be detained for inspection, even though not overloaded, it could be directed to an area designated for such purposes. Those vehicles requiring an accurate weight of the load would be directed to the static scale system, another set of scales, where axles would be weighed with vehicles at full stop. Citations would be written based only on the recordings of this latter weighing.

Basically this is the concept which was studied in a research and development program carried out by the Research Laboratory of the Michigan Department of State Highways and Transportation in cooperation with the Federal Highway Administration during the past two decades. Recognizing the limitations of mechanical equipment, the Department initiated a study in 1952 to sense and record, automatically, the physical characteristics (weight, dimension, type, etc.) of individual vehicles in a traffic stream. The study developed in 1960 into an electronic system for the automatic weighing of vehicles in motion with a prototype installation at the I 94 westbound weigh station at Grass Lake. This system was operated on an experimental basis through 1969, during which time considerable alterations were made to correct deficiencies, improve its accuracy, reliability, durability, and safety. Considerable refinements were made to the system by the Philco-Ford Corporation on a contract basis after the Department submitted a proposal to the electronics industry for modification of the existing installation.

Admittedly, the project did incur numerous problems; unfortunately the adverse publicity did the project an injustice. The publicity failed to recognize the total scope of the project, and focused attention on problems which the researchers either were able to resolve or were able to diagnose.

The Committee realized that such problems are characteristic of research or prototype systems. That is precisely why research projects are initiated; to discover, isolate, and eliminate the bugs, quirks, and weaknesses in the system. The final report on the research project pointedly cautions against misinterpreting through misunderstanding.

Following a period of operation of the system as improved by the Department's Research Laboratory personnel, and evaluation of the results, the researchers published their report in March 1974. The report indicates, quite optimistically, that electronic weigh-sorting systems will perform the task assigned to them. This same optimism was emphasized by two members of the Committee who had participated in the research project as well as representatives of Aeronutronics-Ford (formerly Philco-Ford) who have participated in electronic weigh systems in New York and Pennsylvania within the past few years, and who had actively been involved in Michigan's experimental project.

Available Scale Systems

Effective operation of any weigh station is totally dependent upon the scale system used: its capability, its condition, its location, the attendance thereof, plus many other factors. Whereas there are a few alternates one can consider for a design capable of handling high volumes of truck traffic in a more expeditious manner than our present single mechanical scale system, it is necessary first to examine the potential of the scales offered by the scale industry before making any selection.

Two scale systems were studied.

1) A completely mechanical system.

2) A totally electronic system. Electronic systems using platforms resting on load cells set in pits are being used or experimented with in some States. The systems addressed in this report are: a) platforms supported on load cells set below ground; and, b) low profile platforms resting in concrete pavement.

A. Mechanical System Advantages

1) Mechanical scales have been in use for many years. Under proper conditions they have proven to be accurate for static loads that are totally concentrated on their platforms.

2) The cost of a mechanical scale installation using a single 9 by 12-ft platform, even with its necessary pit and attendant scale house basement, appears to be less costly than a single platform electronic scale.

B. Mechanical System Disadvantages

1) The platform requires a pit which can best be serviced from a scale house having a basement. Such construction increases the cost of a building otherwise having no need for a basement.

2) A basement and/or pit requires drainage accommodations which usually can only be handled by a sump pump.

3) Power failure during time of heavy rain storms result in flooded basements causing costly damage to the heating unit, water heater, and other equipment stored there.

4) Effective seals around edges of the platform are virtually impossible to maintain.

5) Platform framing deteriorates from the salt-laden moisture environment of the pit.

6) Deteriorated platform framing advances concrete platform deterioration.

7) Deteriorated platform and/or framing flexes or induces impact loads causing erratic weight indications.

8) Replacement of platform and framing is costly.

9) Repair and/or replacement of platform and/or framing is time consuming, resulting in a lengthy closing of the station.

10) Due to the corrosive environment in the pit, the steel framing and scale require periodic maintenance, i.e., painting, greasing, etc. The frequency of such operations can only be ascertained by continual inspection. Such action, while prolonging the life of the platform and its supports will not totally eliminate deterioration.

11) Balance arms of the scale cannot be located such as to provide an unobstructed view of the platform for the operator and yet be convenient for operation.

12) Mechanical scales cannot be operated for dynamic loadings.

13) Weighing of a unit is restricted by the length of the platform; necessitating multiple wheel positionings to arrive at axle loads.

14) Manual computations are required to ascertain gross loads.

15) Additional platforms to lessen axle positioning would necessitate considerable expense in pit construction, additional scales, a larger building and more operators.

16) Single platform operation lends itself to load shifting by truck drivers having air axles.

17) The scale requires a small operational time during the weighing of a load rolled onto the platform for the scale levels to balance out and stop moving.

18) Hard wheel movements, and even normal scale use by heavy loads, wear the pivots and bearings, requiring frequent recalibration or replacement.

19) A print-out of the axle weights is difficult to obtain.

C. Electronic System Advantages

1) Deep pits required to house mechanical beam balances are eliminated.

2) The time required to weigh an axle is less than a mechanical scale.

3) Since there is little platform movement, the accuracy of the weighing operation is greater than a mechanical platform.

4) The weight reading is easily readable on a discrete numerical display. The operator is not required to adjust a beam balance weight.

5) The electronic scale platform requires a minimum of maintenance. Defective load cells can be easily and quickly replaced. Since the load cells are factory calibrated, scale platforms using load cells need not be recalibrated when a load cell is replaced.

6) Since pits and connecting balance beams are not required, more than one platform can be installed at a site in order to weigh more than one axle combination at a time.

7) The weight data can be automatically stored by electronic means for immediate print-out or permanently stored for subsequent analysis.

D. Electronic System Disadvantages

1) Initial costs are approximately twice that of mechanical scales. (Survey by State of Georgia.)

2) Load cells are subject to damage by moisture, fatigue, and lightning if not properly protected.

3) Repair of electronic scales can be slower than mechanical scales if trained technicians are not readily available.

4) The scales are not operational in the event of a power failure.

Legality of Electronic Scales

The dynamic sorting system, because of its demand for instant response to a moving load, precludes the use of mechanical scales. It can only function, in the manner contemplated, by using electronic scales. However, before reaching any decision involving electronic scales the Committee solicited an opinion from the State's Attorney General as to their legality. Would weights indicated by an electronic weighing process be legally acceptable in Michigan Courts for enforcement of weight limitations as stated in Michigan's Vehicle Code?

The opinion received pointed out that as the State's Department of Agriculture is charged with the responsibility of approving and sealing the scales used in the enforcement of Michigan's Vehicle Code. It should be consulted to determine if the proposed electronic devices can be sealed as legal weighing devices. In that Michigan law only requires a sealed legal weighing device, it does not expressly require that such be a mechanical one (Exhibit H).

The Department of Agriculture was, in turn, contacted. The Committee was informed that the electronic scales would present no problem to them. Such scales could be checked and sealed with an approval in a manner somewhat similar to that presently being done for the mechanical scales (Exhibit I).

In seeking the Attorney General's opinion, the Committee addressed itself only to a static weighing unit. Realizing that vehicle vibrations as well as liquid load shiftings would introduce weight indications quite different for a vehicle under motion than for one at rest, and interpreting the former conditions as ones which should be tolerated, no legal opinion on dynamic weighing was sought. The practice of not issuing citations for overloads registered on dynamic scales seems to be common for those states where such scales are installed.

One other area of concern which the Committee addressed was the cost of one system as contrasted to another. After considerable deliberation over the advantages and disadvantages of the alternates, and though cost estimates would be made, it was collectively agreed that the scale system recommended should not necessarily be dictated by what might appear as an initial cost saving. Costs would be evaluated at such time as a complete understanding of what is actually needed for an installation was reached.

Proposal Selected

In consideration of the knowledge and experience gained by the Department of Highways and Transportation during its research study, the assurance of industry's capability to produce a functional system, and the conviction that a sorting system would handle high volumes of traffic more expeditiously than any other system contemplated; the Committee selected the dynamic and static electronic weighing systems for what it proposed as a Class I or high traffic volume station.

RECOMMENDED PROPOSAL FOR DESIGN OF A HIGH VOLUME (CLASS I) STATION

Geometrics - Class I Station

Using the guidelines established earlier in this report, the recommendations made in the report on Michigan's electronic weighing-in-motion research project, and consultation with personnel engaged in that project, the Committee decided that the present geometric layout as detailed on Design Guide VII-510 (Fig. 2) cannot be used, nor be adapted for use with a dynamic weighing system.

The recommended layout of the proposed weigh station is shown in Figure 7. Due to a need to protect the weigh scale system against lightning, and the elimination of a separate enclosure to house electronic equipment, it was decided to place all electronic scales as close to the weigh house as possible; thereby reducing the length of cable required and preventing the generation of induced voltage. The Committee set this distance at 100 ft for the dynamic weigh scale and the installation would be in the approach lane. The sign locations at which a vehicle is directed to: a) proceed to the main highway, b) go to the static scales, or c) proceed to the parking area, would have to be downstream from the weigh house. Placing the gore in this location would provide the necessary distance for the signing required to give the driver appropriate instruction. It would also allow for the closest possible observation of the moving vehicle prefacing any necessary detaining instruction.

Legal vehicles, directed by electronically operated signing, would return to the highway. The vehicle being detained (needing a weigh check or otherwise) would be instructed, also by electronically actuated signals, to proceed via a loop ramp (to the drivers right) to the rear of the station area (Fig. 7). This ramp leads to the static scale area on the opposite side of the scale house (the side farthest from the highway). Immediately adjacent to the building in this second approach lane is the static scale. All vehicles proceeding to the rear of the station after passing over the dynamic scales would pass over the static scales. An attendant would determine whether the vehicle should proceed to the parking area for a safety inspection or be statically weighed.

After passing over the static scales, the vehicle would enter another loop ramp (to the drivers left) to the rear side of the station where, depending on instructions given, the driver would: a) park in the large parking area provided at this location, b) park in the inspection area (designed to accommodate the necessary inspection activities), or c) proceed via an exit

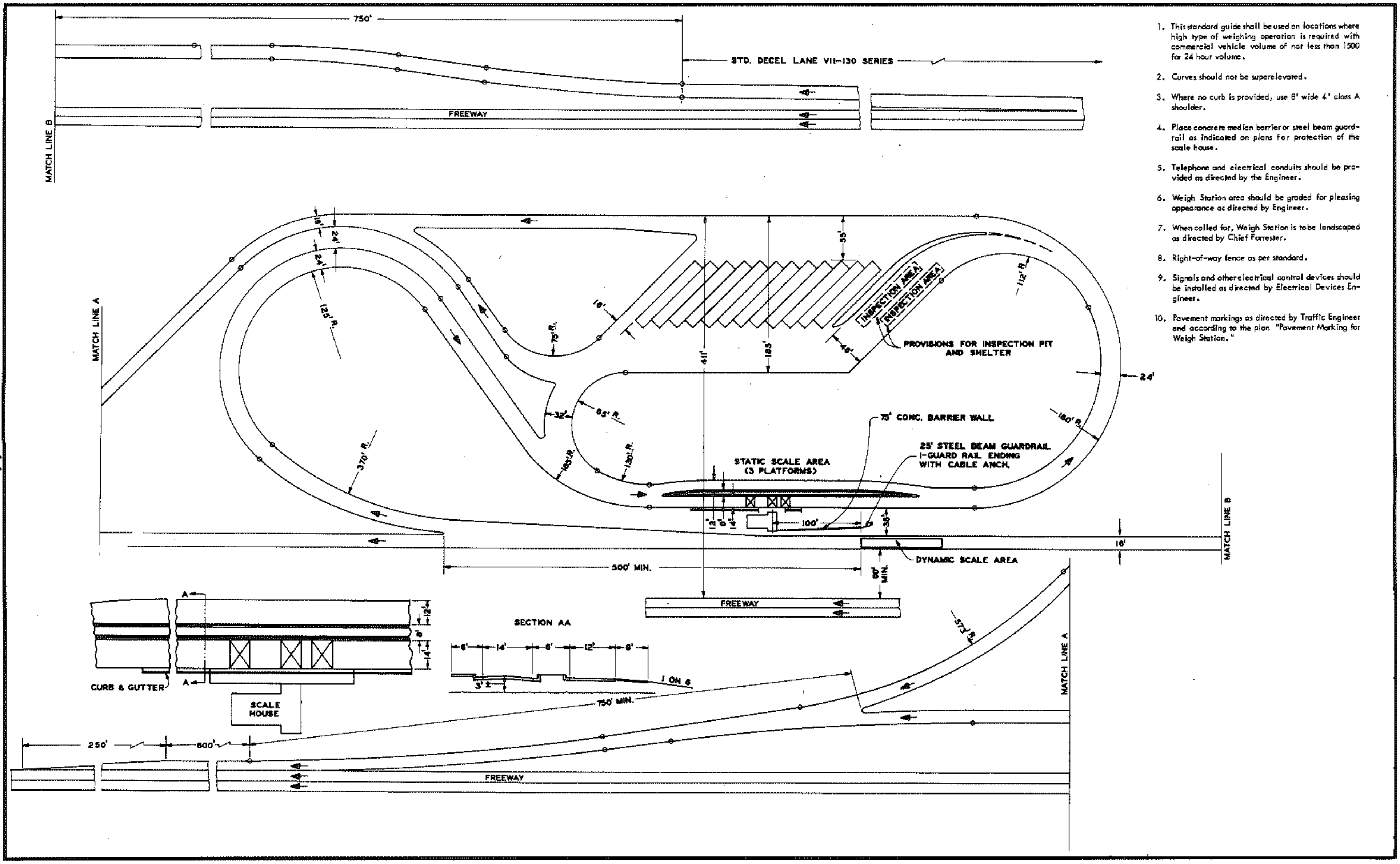


Figure 7. Proposed design for Class I weigh station.

ramp which joins the highway at the downstream end of the station. If a rechecking of weights is needed following adjustments of loads made in the parking areas, vehicles would be able to proceed directly from that area to the static scales via a connecting ramp.

Because the weigh scale house is in a vulnerable location (between two opposing directions of traffic), General Motors type concrete barrier walls would be provided on the approach lanes on the building side for the protection of the building and safety of its occupants.

Personnel of the Signing Section of the Traffic and Safety Division were consulted on the necessary signs, the most critical sign being the electric one controlled by electronic response to the dynamic scale loading. Signing personnel assured the Committee that the station should be able to function with a minimum of traffic problems as shown in Figure 8.

Weighing Systems - Class I Station

In general, the recommended scheme for weighing encompasses basic concepts, requirements, and performance characteristics for two totally independent systems for weighing vehicles at a fixed station site. It is a scheme primarily designed for those sites where high traffic volumes may exist.

As stated in Alternate C, in the previous Chapter, it relies on a sorting operation where partially loaded and empty vehicles are returned to the highway without delay. Vehicles loaded near maximum allowable limit would be directed to a set of scales for static weighing without detaining other trucks. It would also make possible a visual sorting of vehicles, detaining only those which need further inspection.

This sorting operation would be accomplished by a dynamic weigh-in-motion scale system installed in the approach lane. Trucks entering the weigh station site would decelerate to about 15 mph and pass over a series of weighing platforms embedded in the pavement. Sensors, actuated by wheel loads on the platforms, together with their electronic components, would calculate the weight of each axle, determine if the weigh limits are exceeded, and indicate vehicle status to the driver and weigh attendant. The system would also control signs to direct the driver back to the freeway or to the static scales.

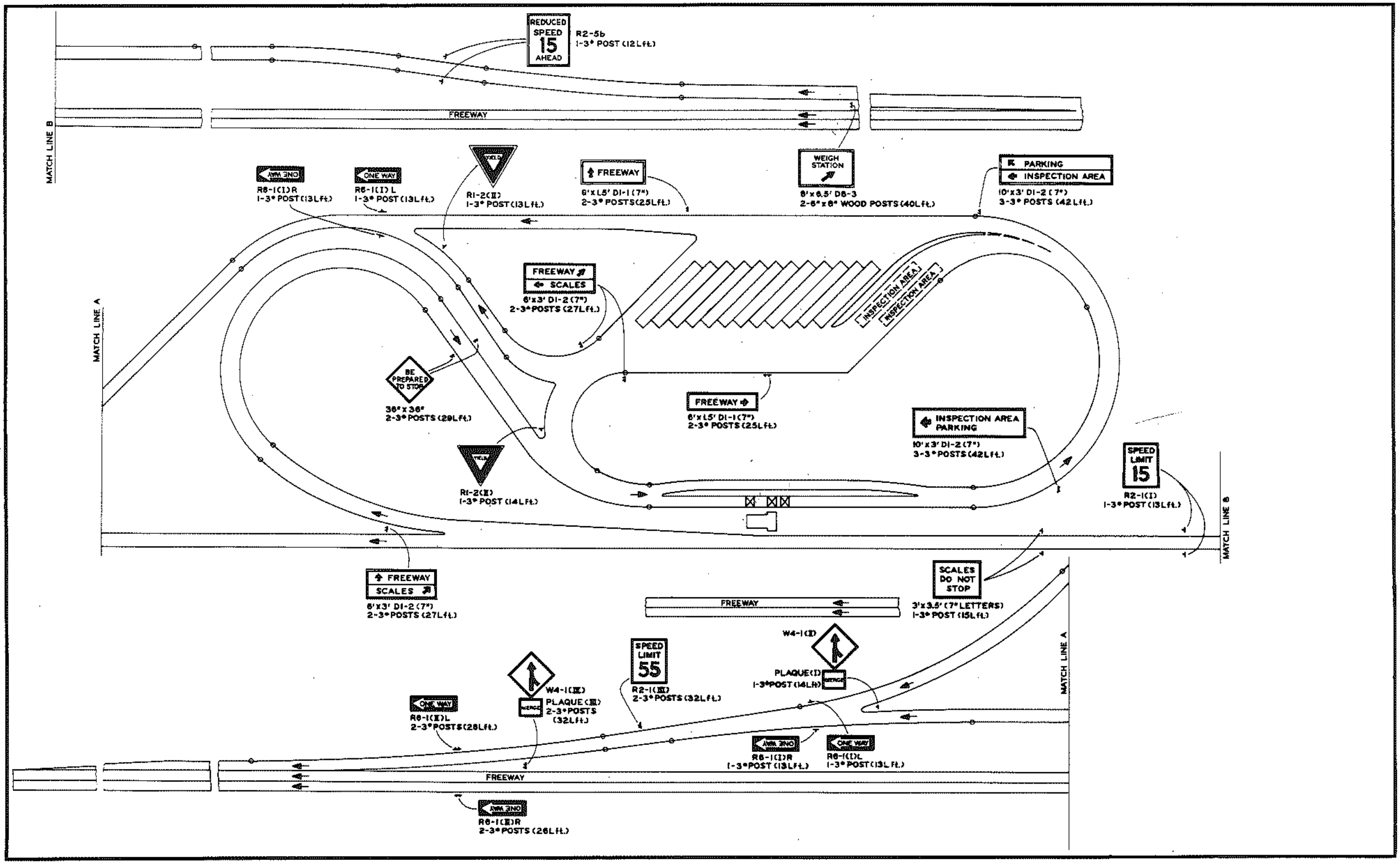


Figure 8. Proposed signing for Class I weigh station.

Static Scales

The static scale system consists of one or more low profile platforms. Each platform, supported by four load cells, would produce an electrical signal proportional to the weight of the axle load. In the scale house, the weight of each axle positioned on a platform would be visually displayed on a control console. A hard-copy record would be produced upon operator's request. Specific design considerations for this system follow.

A. Platform Design. The scales would be about 9 in. thick, made of structural steel encased in concrete or entirely of steel with subsequent galvanizing. Each platform would be 14 ft wide by 10 ft long. The foundation would be 12 in. thick with two layers of reinforcement and extend approximately 8 ft beyond each end of the scale gap. The platform, supported by four load cells, would be located within a curbed pavement, the curbing traversing just the scale area. Figure 9 illustrates the basic concepts of the platform design. Drainage would be accomplished by elevation of the pavement above the surrounding area allowing for transverse drainage of the foundation slab. The top surface of the platform would be treated to prevent slipperiness.

B. Number of Platforms and Location. Three platforms would be used at each site as shown in Figure 10. The platforms would be separated from each other by a distance of 5 ft and 15 ft. Platforms would be positioned such that additional scales could be placed if they are later determined necessary. The distances are based upon typical axle spacings of the most commonly used axle configurations.

C. Scale Accuracy. Scale installations must meet the requirements of the U.S. Department of Commerce, National Bureau of Standards, as stated in NBS Handbook 44. A tolerance of 0.1 percent of scale capacity is required. Platforms of a similar design installed by the Department at the Grass Lake scale site indicate that this precision is feasible and that the scale system components are reliable and durable. Sites having three platforms would also enjoy greater accuracy than existing one platform sites. Three platforms would reduce weighing inaccuracies caused by slight changes in grade, suspension system, and air axles. Ideally, having all axles on equally level platforms at the same time would produce a true axle load determination.

D. Weighing Speed. The electronic platform system proposed will provide the capability to weigh vehicles faster. Since there is little scale movement and no lever arm assembly, the time required for the platform to settle at a given weight reading is quicker than beam-balance scales.

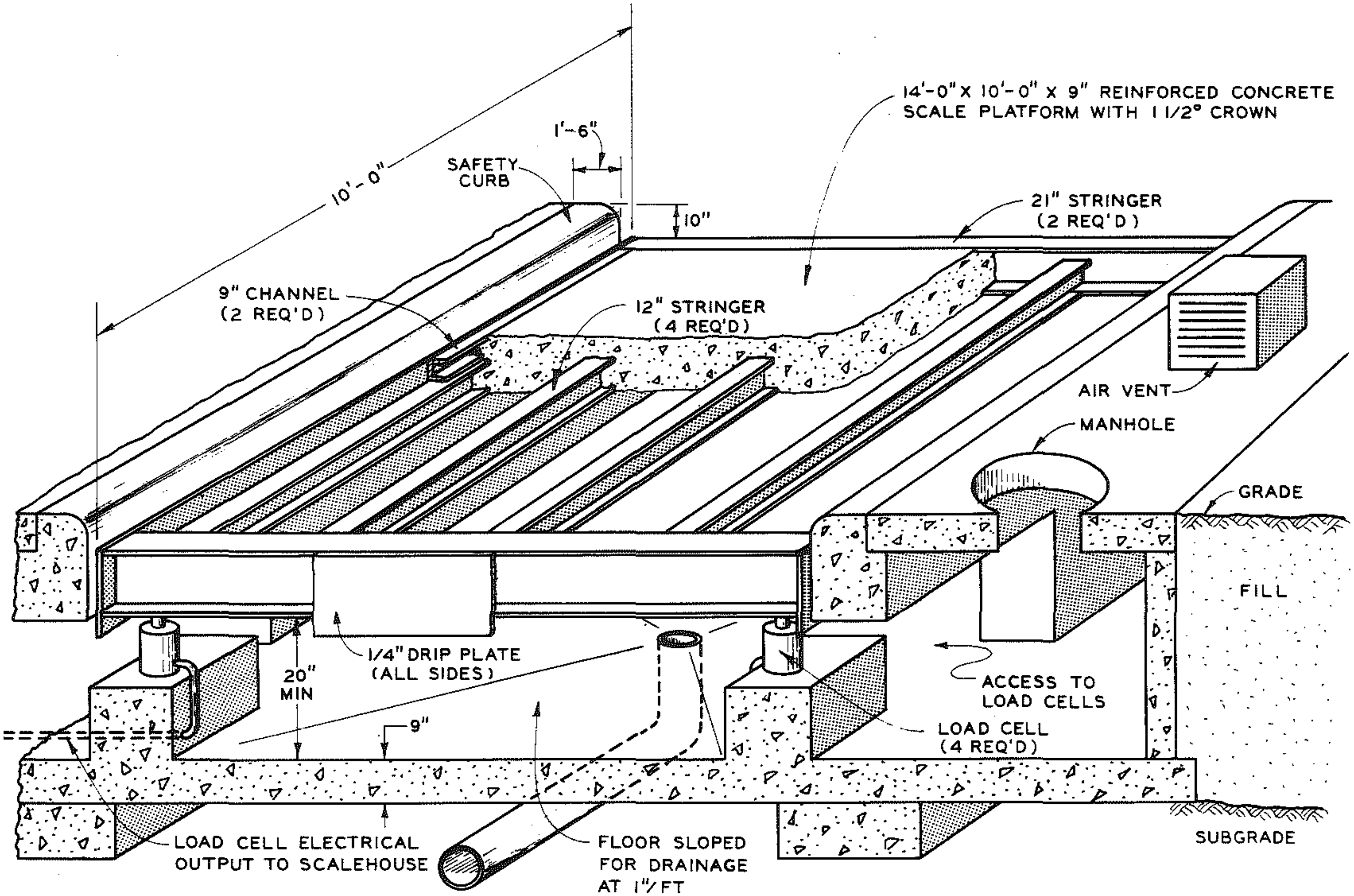


Figure 9. Conceptual design of static electronic scale platform.

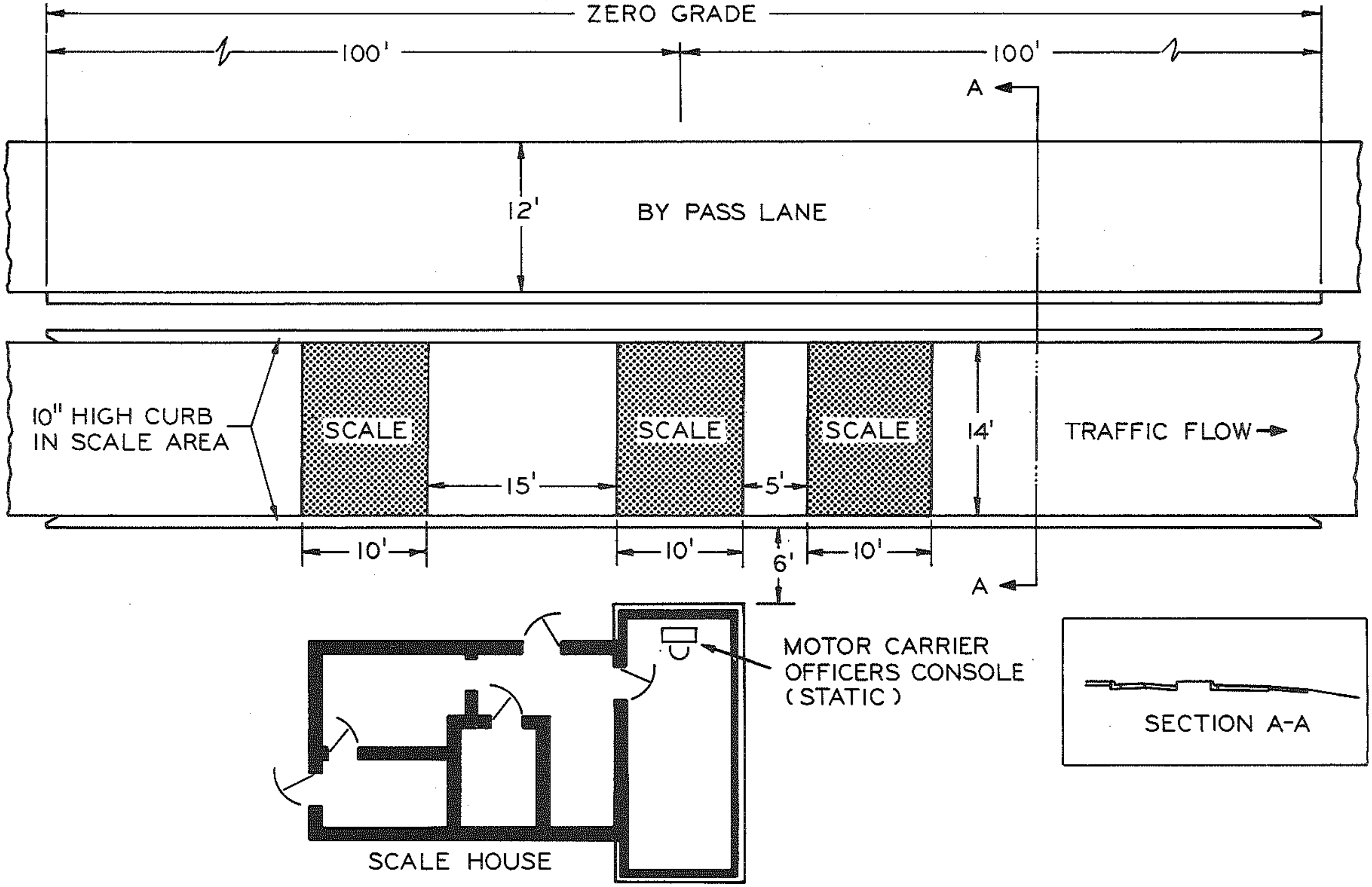


Figure 10. Proposed static scale area layout.

Also, by using more than one platform, adjacent axle groups can be weighed simultaneously; thus eliminating some time-consuming truck movements. A 1974 truck type survey showed that 60 percent of existing trucks using Michigan roadways have three axle groups. Therefore, if three scales were appropriately spaced, this high percentage of vehicles could be weighed in one operation. Figure 11 shows the axle group spacing of trucks and the frequency of occurrence. Figure 12 shows a distribution of truck types currently using our highways. Examination of the data indicates that three 10-ft platforms, spaced 5 ft and 15 ft apart, will accommodate over 90 percent of the trucks in one weighing operation.

E. Scale Operation. In operation, the motor carrier officer would sit before a console. As the truck approaches in clear view, the operator makes a cursory inspection of the vehicle, its driver, and license plates. As the truck rolls over the platforms, the attendant signals the driver to stop. Instantaneously, the weight of each axle would be displayed on the console. The operator monitors the readings until a stabilized reading is visible (this could take several minutes for liquid loads) and then examines the readings for an overweight condition. The operator would be able to obtain a hard copy print-out of each platform weight by push button control. If additional axles are to be weighed, the driver is instructed to move forward, otherwise the weighing operation would be complete. Optionally, an audible tone could be produced whenever the axle weight exceeded a value preset by the attendant. This provision at stations having only static scales would eliminate the attendant from constantly monitoring the displays and replaces the mechanical motion and "bang" of the weigh bar which is familiar to attendants. This system would require little operator training and the possibility of weight reading errors would be almost completely eliminated. A scale calibration mode would also be provided for the motor carrier officer to determine of all electronic components are functioning correctly.

F. Maintenance. System components exposed to the environment are the most susceptible to failure. Salt, moisture, and lightning caused the most damage at the Grass Lake site where the Department conducted its experimental project. This system design requires only the platforms and load cells to be exposed to the elements. However, the proposed construction will eliminate the need for deep pits and their associated problems.

The electronic components will be housed within the building and will be of solid-state semiconductor design. It will not be necessary to have a computer or other complex devices. It is estimated that a three-scale system, together with visual display and hard copy print-out, would occupy a space no larger than an office desk.

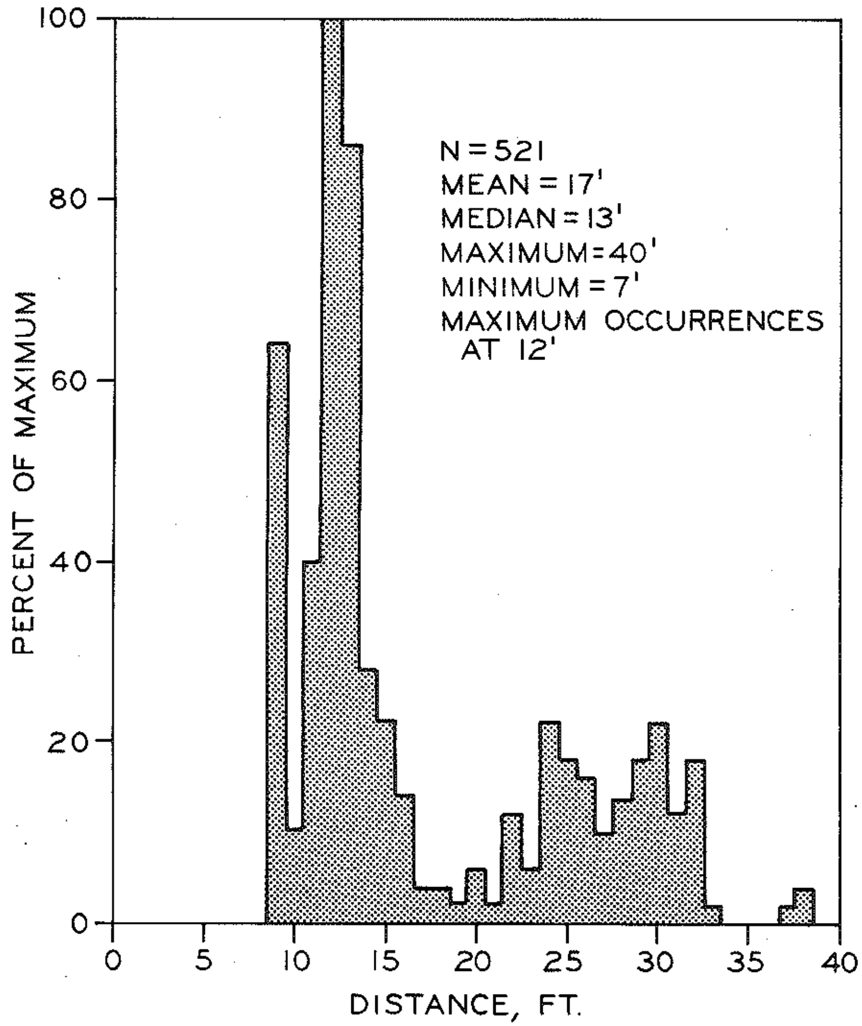


Figure 11. Truck axle spacing histogram, westbound I 94, 1972.

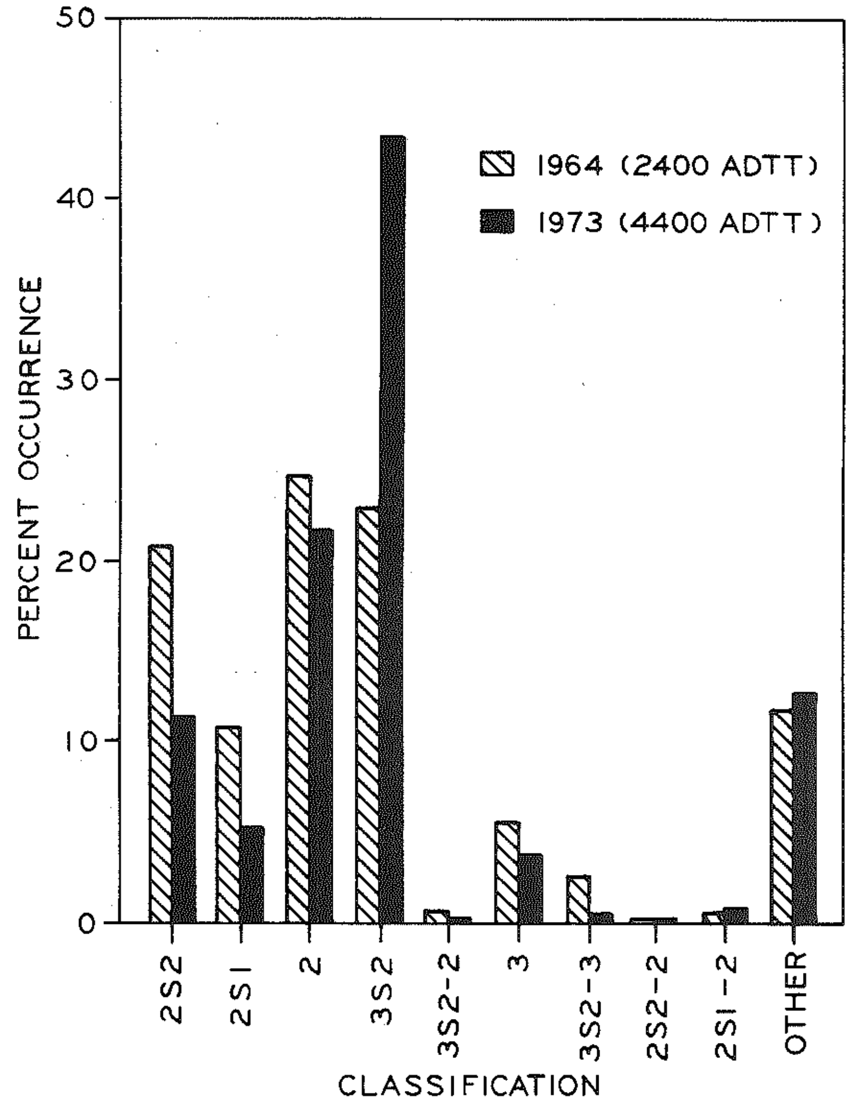


Figure 12. Distribution of truck types, westbound I 94 over Telegraph (US 24).

The system would be designed so that in the event of a component failure, the remaining one or two platforms would be operative. Since this system requires no pit for mechanical balance arms, a basement is not required. The periodic replacement, cleaning, and painting of scale appurtenances will be minimized.

G. Cost. The following is an estimate of costs for the component elements of the proposed static scale system. Data are estimates based upon previous experience at the Grass Lake site. Allowances have been made for increased cost of materials and labor and reductions in the cost of some electronic components. Since some mechanical and electrical design costs are one-time costs, they are listed as non-recurring. Estimates of construction costs assume these items to be distributed over two sites. Additional savings can be obtained through use of standard designs for each station classification.

1) Recurring Costs

Scale platform	
a. Installation of foundation and scale support structure for three platforms.	$17,000
b. Three scale platforms and miscellaneous hardware.	$18,900
c. Load cells, power supplies, amplifiers, miscellaneous including installation for each scale site.	$16,800
Site Installation	$10,000
System Design	$20,000
	$82,700

2) Non-Recurring Costs

Scale Platform Design	$10,000
Electronic and Hardware Design	$ 6,000
Operator Manuals and System Documentation	$ 5,000
	$21,000

3) Miscellaneous

Area Lighting at Scales	$ 8,000
Operator Controlled Signing	$ 1,000
Attendant-Driver Communication System	$ 1,000
	$10,000

Dynamic Scales

The dynamic weigh system consists of a series of low profile platforms embedded in the approach pavement to the scale house. These wheel load transducers, together with associated electronic components, will determine the approximate axle weights, axle spacings, and vehicle types. Loaded vehicles, detected as possible overload or misloads, would be directed to static scales for measurement. The dynamic weighing system would not be used for enforcement purposes. It would only function to sort out empty and legally loaded trucks and return them to the highway. Using the dual dynamic and static weighing systems at high volume stations, the motor carrier officer will be able to efficiently and accurately weigh potentially illegal trucks and minimize the delay in trucking operations.

A. Scale Operation. As drivers enter the weigh station, they would be directed to slow to 15 mph. When the vehicle is approximately 200 ft from the scale house, it would begin passing over the weigh platforms. Appropriate signing, which will be operator or system controlled, will inform the driver of action he should take.

B. Scale System. The dynamic system will consist of the following five major components.

1) Four pairs of low profile wheel load scales.

2) A detection system to determine:

a. When a vehicle is passing through a scale area
b. The weight of each axle
c. Distance between axles and determination of vehicle axle configuration.

3) An indication system to:

   a. Inform the motor carrier officer of truck status
   b. Print axle weights and spacings when requested
   c. Inform the driver of weight status and direct him to the static scales by controlling electrically operated signs.

4) Control console for the operator to:

   a. Indicate system status
   b. Provide for the testing of component failures
   c. Obtain a hard copy record of pertinent vehicle data.

5) Controlled signs for the routing of trucks to the static scales.

C. Scale Platforms. The scale platforms will be located as shown in Figure 13. Axle weights will be obtained by repeated weighings of each axle as it passes over each pair of scales. Each scale will produce an electrical signal proportional to the weight that it senses. The transducers, shown in Figure 14, together with other associated electronic components would be used to determine axle weights, spacings, and vehicle type required for enforcement.

D. Weighing Accuracy. The accuracy of in-motion weighing is affected by many variables which cannot be controlled. Vehicle roll, pitch, and vertical bounce cause its dynamic weight to oscillate about its static weight. Pavement profile can alter these vehicle characteristics to amplify or diminish these effects. The dynamic weighing system on Interstate I 94 at Grass Lake had a weighing precision of 682 lb; this being one standard error. Using small platforms, as proposed, with high resonant frequencies and uniform scale spacing, this standard error should be reduced. Weighing precision may be further increased through use of statistical techniques. Each of these optimization procedures will result in fewer legal vehicles being detained, providing a more efficient weigh station operation.

E. Maintenance. The scale platforms, being exposed to the weather, are that part of the installation most vulnerable to deterioration and failure. However, system design will provide for continual system operation when a scale fails. Under this condition, axle weight accuracy will be diminished, requiring the motor carrier officer to statically weigh a larger proportion of trucks. The remainder of the system components will be solid-state semiconductor devices located within the scale house. Therefore, they will be subject only to nominal failure rates.

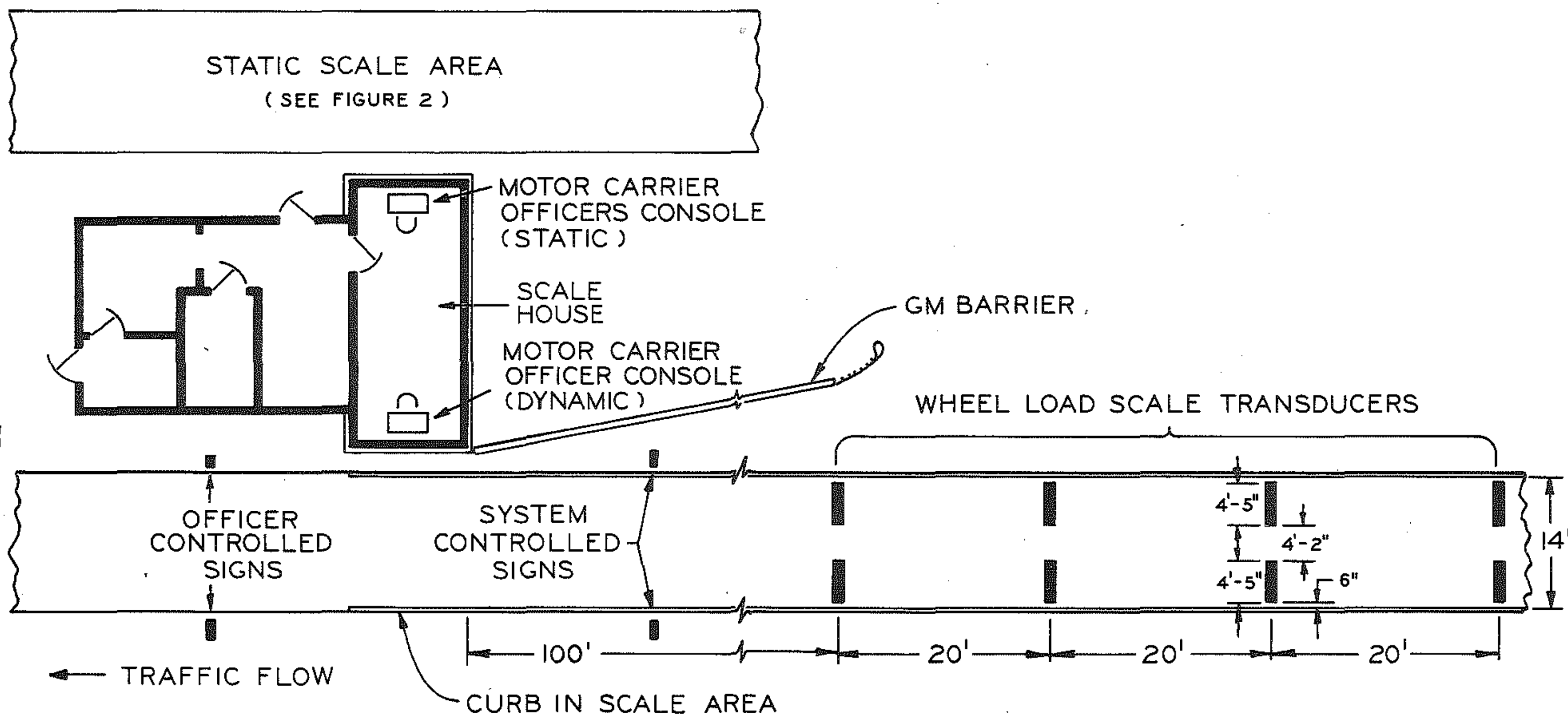


Figure 13. Proposed dynamic scale area layout.

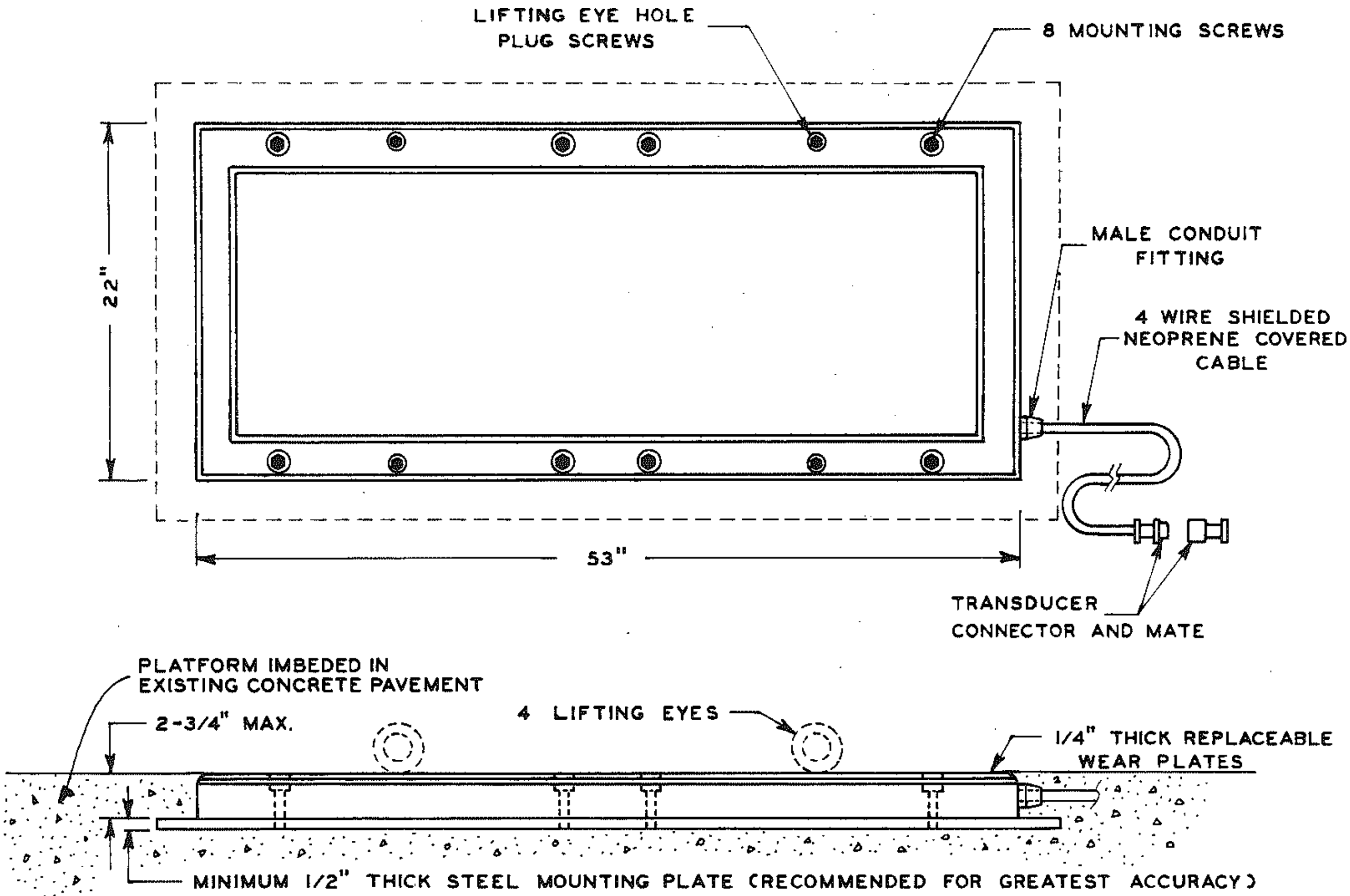


Figure 14. Dynamic wheel load transducer.

F. Cost. The following is an estimate of costs for the component elements of the proposed dynamic scale system.

1) Recurring Costs

Electronic Components	$ 24,000
Low Profile Scales (four pairs)	40,000
Scale System Installation	20,000
	$ 84,000

2) Non-Recurring Costs

Hardware Design	$ 35,000
Software Design	50,000
Operator and System Manuals	20,000
Procurement Specifications	15,000
	$120,000

3) Miscellaneous Costs

Lighting in Scale Area	$ 8,000
Electrically Operated Sign and Installation	5,000
Signing and Installation	3,000
	$ 16,000

Weigh House - Class I Station

With a new concept in weighing being recommended, it becomes necessary to consider a structure for operations, a weigh house, which not only would functionally serve the needs of the double scale system but would also embrace the desired modifications heretofore specified. Considerable alteration to the current building design would be desirable even were it to continue as the guide for future mechanical scale stations. Thus, the operational requirements of the Class I station, coupled with the desire for improvements, make a totally new building design necessary. The total proposal is outlined as follows:

1) Operational Orientation

A. Location. The weigh station building or scale house will be positioned between the high speed dynamic sorting lane and the static weighing lane about 200 ft downstream from the head end of the scale platform with the static scale directly opposite the building.

B. Visual Control. The scale room will be oriented toward the oncoming freeway traffic and will afford visual control of oncoming vehicles in the high speed sorting lane, as well as in the static weighing lane and the inspection and parking areas (Fig. 13).

C. Desirable Orientation. The direction of the related freeway will largely determine the compass orientation of the building. Where sites are to be selected, preference should be given to generally north-south route directions so that problems associated with glare from morning and evening sun will be minimized.

2) Building Layout

A. Functional Spaces. General layout of the scale house will encompass a scale room for the weighing operations with related work areas containing desks, counters, detection and communication equipment, etc., related to the weighing operation. A drivers area adjacent to the scale room will provide space for transacting business with the operators or waiting for results of inspections or other action by the attendants.

Adjacent to the driver area, and accessible to it, will be a single toilet facility. As the incidence of drivers using these facilities is minimal, the Committee did not feel it necessary to provide separate units for the sexes. A combined storage and utility room will provide space for maintenance equipment and supplies, water heater and furnace. Where necessitated by operations, space will be provided for the district supervisors office which will be accessible from the lobby area.

B. Sketch Plans. The sketches show general schematic plans for basic layouts both with (A), and without (B) supervisors office (Fig. 15).

C. Construction Recommendations. The basic plan is intended for slab-on-grade construction except for a crawl space under the scale room. The crawl space serves both as a plenum for circulation of air and as access for installation and connection of electrical wiring and related equipment. No components requiring regular service should be installed in the crawl space, which would be used only for original installation or major modification or replacement of signal cables. This configuration anticipates the installation of scale platforms without mechanical balances and their associated pits.

3) Equipment, Etc.

The operators consoles should be designed to incorporate all functions required in the operation, including scale and remote image readouts,

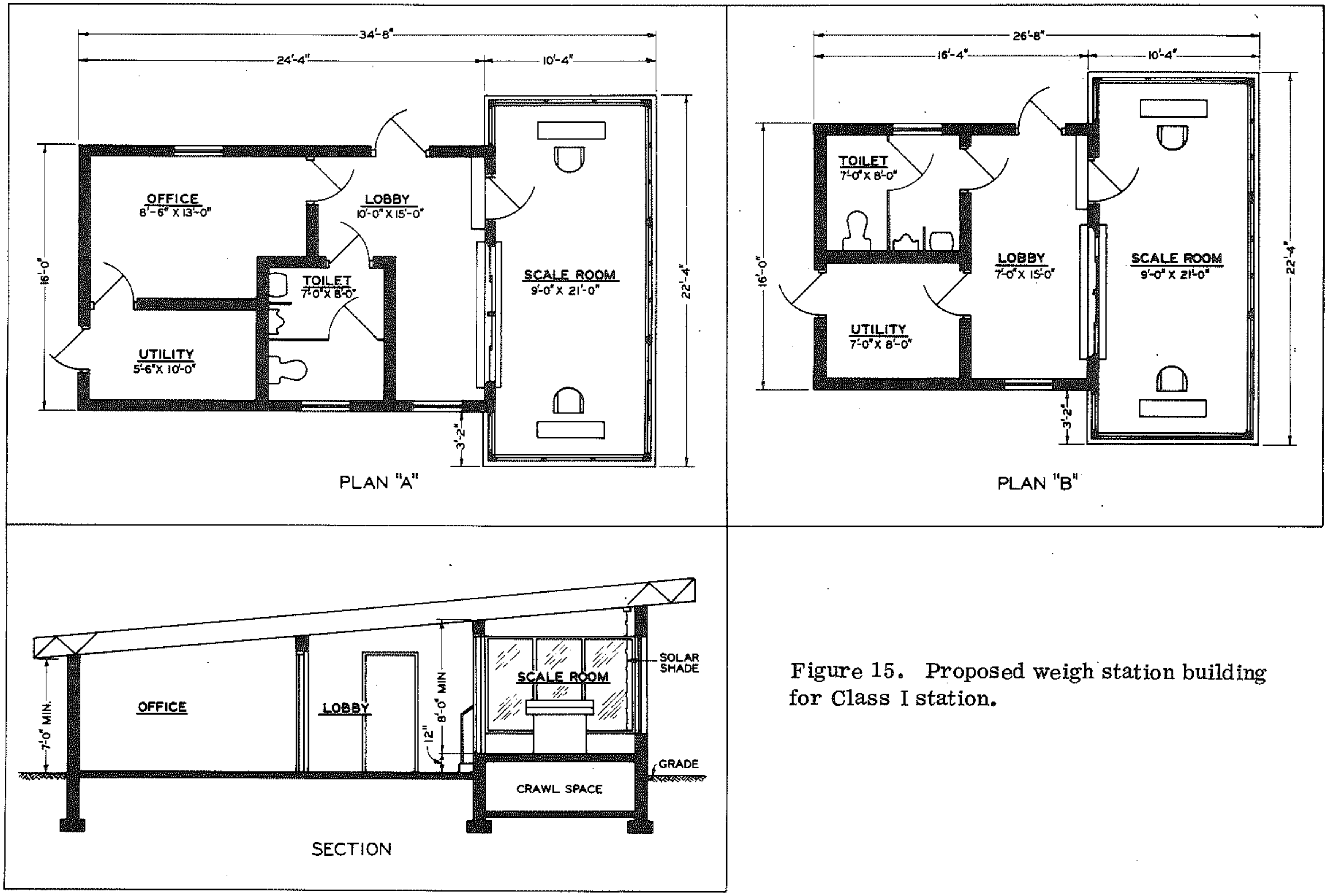


Figure 15. Proposed weigh station building for Class I station.

communications, control and recording operations. Additional equipment, telephone extension, cash drawer, form storage, etc., should be provided near the window serving the drivers area.

4) Heating, Windows, Security, Etc.

A. Heating can be accomplished along with cooling in a variety of systems with final choice being determined by location, availability of energy source, gas, electricity, oil, etc. To accommodate both heating and cooling, it is recommended that the structure include the basic air distribution system, using floor or roof mounted heating and cooling equipment.

B. Lighting. Normal lighting will be adequate throughout most of the building. Care should be taken in the drivers area to avoid spillover light into the operators area which would create problems of reflections. Level of light in the operator area should be controlled from the console positions with dimmer controls.

Exterior lighting should provide for normal access and security plus horizontal lighting at scale area for wheel location during nighttime weighing operations. In all exterior lighting, care should be taken to avoid creating glare or interference with drivers or operators vision.

C. Windows. In the final design state, the sightlines between the operators and the various vehicle locations should be carefully checked so that full, unobstructed visual control is obtained. Location and angle of sun at various seasons and times should be determined and provisions made for shielding from resulting glare through solar shades, etc.

It is recommended that two or more units of window in the operators area be installed in push out frames for emergency exit. For additional safety and conservation of energy, windows should be double glazed and all glazing materials be tempered or shatterproof glass.

E. Architecture. Selection of materials and development of exterior character should be determined coincidentally with the designing and detailing of the structure. Exterior material should be durable, fire safe, and maintenance free. Colors and textures should be selected with consideration for the roadside aesthetics prevalent in the area. The architectural style should be restrained and reflective of the utilitarian nature of the facility, while complementing the site insofar as possible.

PROPOSAL FOR ALTERNATE WEIGH STATION DESIGNS

System Classification

Having produced a design for a high traffic volume station, the Committee's attention was directed to the remaining stations; those where the volume and total activity is less. Referring again to the 15 station activity report, Exhibit D, the rate per hour for those stations other than Erie, Grass Lake, and New Buffalo ranges from approximately 50 to 7 trucks per hour. From this, one can obviously conclude that inasmuch as the operational activity varies, so also, to a degree, should the accommodating facility. It would not be prudent to install a station capable of handling volumes far in excess of what could be anticipated even 20 years hence. With this concern, and a knowledge of the existing stations, the Committee categorized all existing and future weigh stations into eight classifications. Such a breakdown not only assists in the planning of future stations, but also in the upgrading of existing ones (Fig. 16).

The present stations, all with mechanical scales, are of two classes. Most of them, the more recent ones, were constructed using, or patterned after, a geometrical layout somewhat similar to that shown on the State's Design Guide VII-510 (Fig. 2). These stations have been designated Class V. The remaining existing stations each have geometric layouts unique unto themselves, as they have been spotted at strategic locations where the design was adapted to fit a need; these have been denoted as Class VIII.

The Committee recognizes that at some future time, one or more of these latter stations may be upgraded with an electronic scale system and even a new building. Such upgrading would change the station classification to a VII or a VI. Although a Class VI might seem desirable for all new special installations, it is possible that in considering all the factors affecting the design of a particular station a mechanical scale might be acceptable.

Class V is the category which most of the present stations would be assigned. Hopefully, no new stations of this classification will be built. Upgrading the scale to an electronic one would move it into Class IV. Upgrading of both the scale, and construction of a building similar to that recommended for a Class I installation, would place it into Class III. It is conceivable that future stations, scheduled for divided highways where no large truck volumes would be anticipated in a 20-year forecast, should be placed in this category. The unfinished stations along I 69 south of Coldwater could well be completed as Class III stations with very little altera-

Figure 16
WEIGH STATION ALTERNATES

Station Class	Geometrical Layout	Scales		Building	Estimated Cost
		Dynamic	Static		
I	New design	Electronic - in approach ramp	Electronic - at rear side of building	New Design	$930,000
II	New-modified omit dynamic weigh ramp add cross-over to and from static scale ramp	None	Electronic - at rear side of building. - Traffic flow in reverse to Class I	New Design	$620,000
III	Current design Standard VII-510	None	Electronic - expressway side of building	New Design	$470,000
IV	Current design Standard VII-510	None	Electronic - expressway side of building	Present Design	$370,000
V	Current design Standard VII-510	None	Mechanical (w/pit) - expressway side of building	Present Design	$400,000
VI	Special design	None	Electronic	New Design	*
VII	Special design	None	Electronic	Present Design	*
VIII	Special design	None	Mechanical (w/pit)	Present Design	*

* Not determinable.

tion of already constructed portions. However, truck traffic predictions should be made.

As has previously been discussed in detail, Class I has been assigned to those stations where activity is heavy. It is an entirely new station embracing all the design features deemed desirable for the most functional operation.

Class II stations are those new stations which would be constructed as the first stage of a Class I design. Locations where current truck traffic may be light to moderate, but heavy traffic is predicted within 20 years, would be prime sites for Class II installations. With initial placing of the static scales and omitting portions needed for the dynamic weighing operations, the latter portion can be added quite simply at a later date with a second stage construction (Figs. 17 and 18).

System Costs

The costs which are shown in Figure 16 represent the estimated cost of construction for each of the classes of stations listed. These costs are broken down by units of construction to allow for more understandable comparison. It should be pointed out that the cost of any class employing static electronic scales is based on the number of platforms proposed; this number, being dependent upon the amount of traffic for which the station is being designed. Another cost factor subject to design is the building type; the large (A) or the smaller (B). Although right-of-way costs are an extremely important part of the total cost, no estimate of value can be made without knowing the specific area being contemplated for a particular station. However, the areas of land required for those classes which are determinate, is given. For Classes VI, VII, and VIII, requiring geometrics to fit special situations, neither a cost nor an area estimate can be made. Cost estimates for static and dynamic electronic scales reflect savings incurred in non-recurring costs for two sites.

Class V Station (present design for interstate)

	Estimated Cost
Building w/basement and scale pit	$ 48,000
Scales - mechanical	2,400
Grading, drainage structures, and paving	338,200
Lighting	8,000
Signing (as in Fig. 19)	3,400
(R-O-W 11 Acres)	$400,000

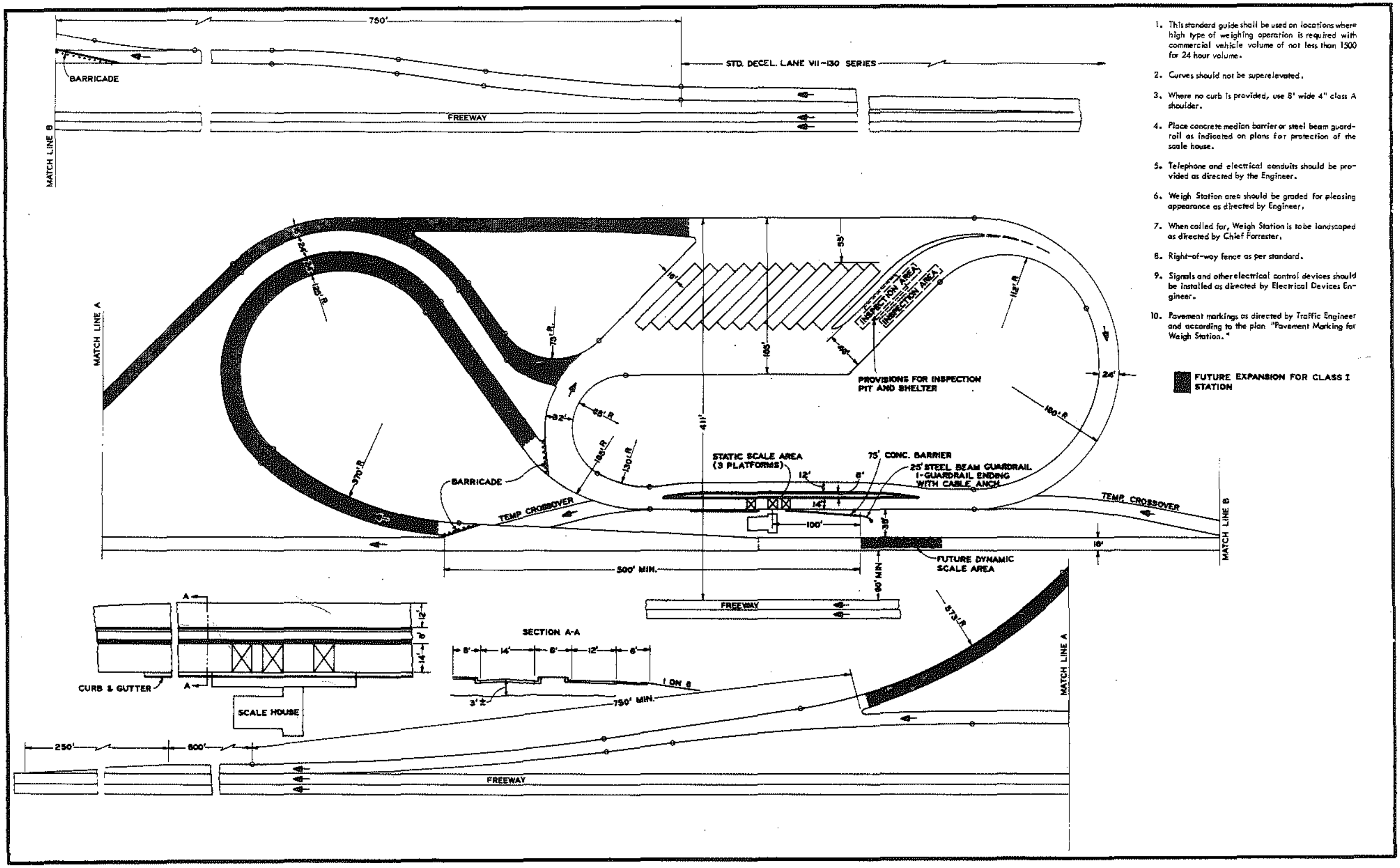


Figure 17. Proposed design for Class II weigh station.

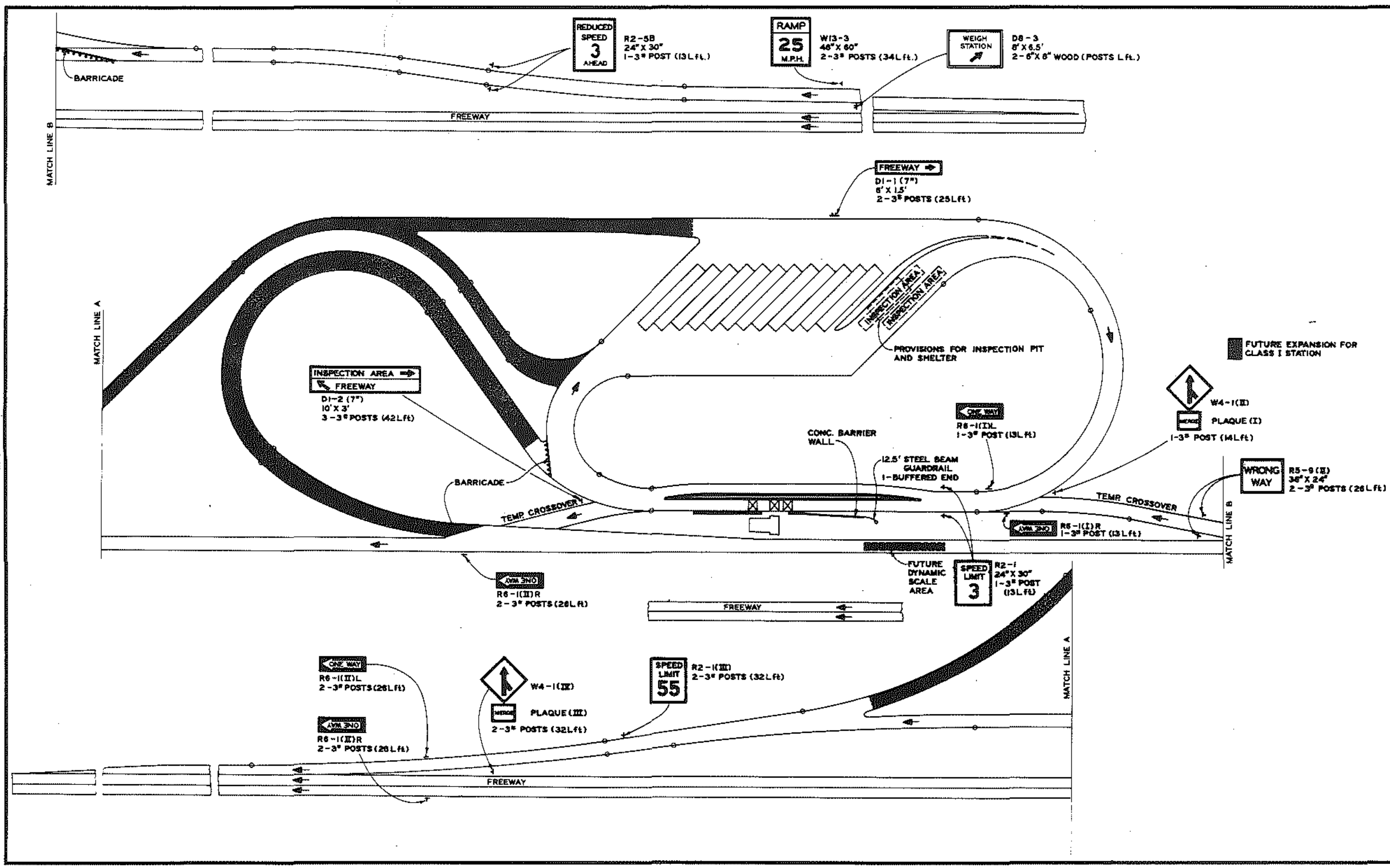


Figure 18. Proposed signing for Class II station.

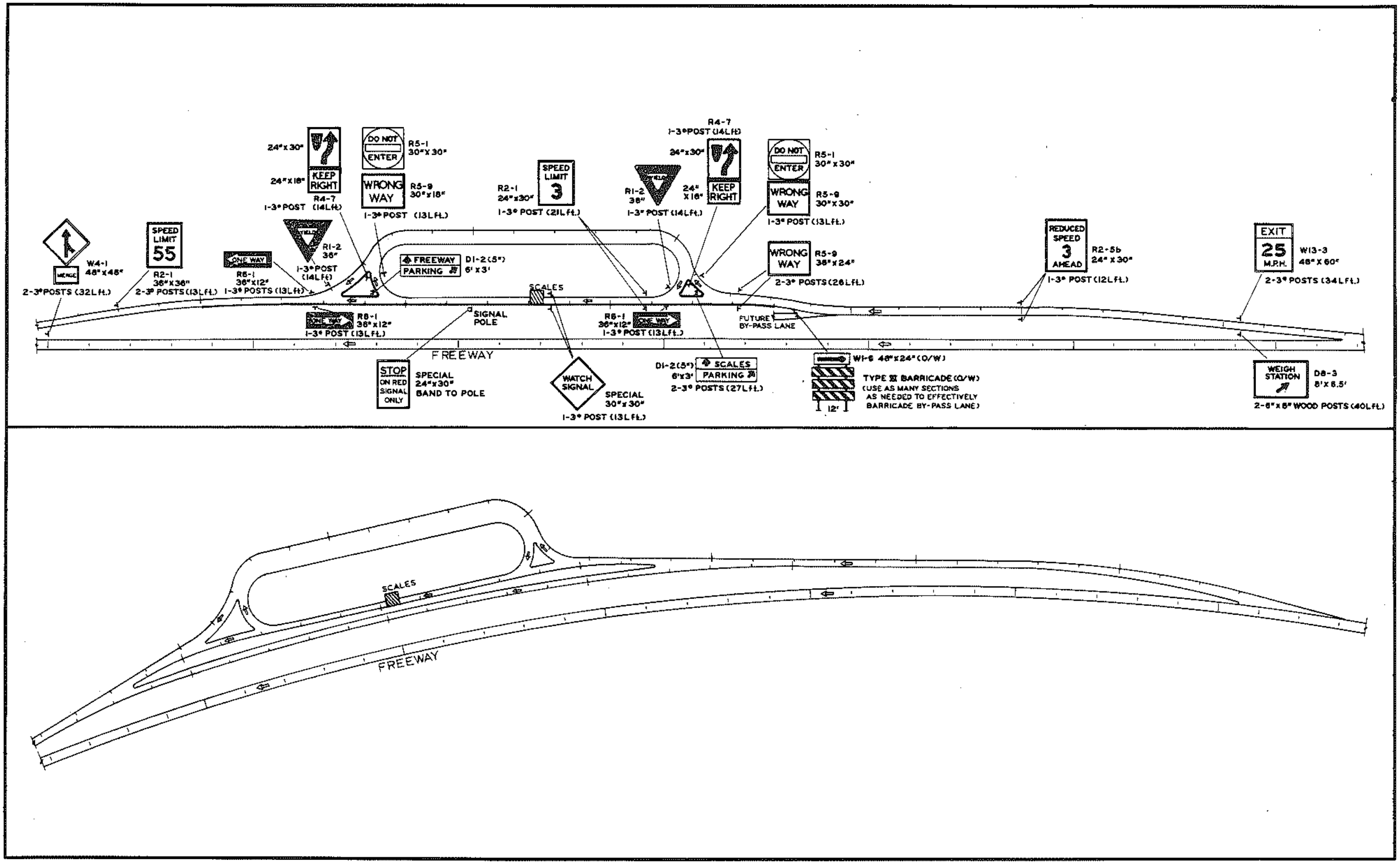


Figure 19. Proposed signing for Class V station.

Class I Station (Dynamic Sorting)

Building (Type A = $25,000, Type B = $22,000)	$ 25,000
Scales, static - electronic	93,200
Grading, drainage structures, and paving	627,800
Lighting	15,000
Signing	3,000
Special electrical signing	6,000
Concrete barrier	3,800
Scales, dynamic - electronic	154,000
(R-O-W 19 Acres)	$927,800

Class II Station (Stage Construction - Class I)

Building (Type A)	$ 25,000
Scales, static - electronic	93,200
Grading, drainage structures, and paving	486,400
Lighting	8,000
Signing	3,000
Concrete barrier	3,800
(R-O-W 19 Acres)	$619,400

Class III Station

Building (Type A)	$ 25,000
Scales, static - electronic	93,200
Grading, drainage structures, and paving	338,200
Lighting	8,000
Signing	3,000
(R-O-W 11 Acres)	$467,400

Class IV Station

An upgrading of a Class V by replacing mechanical scale with an electronic static scale.

Scales, static - electronic	$ 25,000
Grading, drainage structures, and paving	338,200
(R-O-W 11 Acres)	$363,200

Note: Grading costs are dependent upon the site selected. When Class IV or III are being considered for upgrading existing Class V stations, estimated costs of removing existing building and/or scale should be added.

SUPPLEMENTARY WEIGH SYSTEMS

Industry today is manufacturing or has the ability to manufacture electronic weigh systems with capabilities almost defying imagination. They range from very basic units which accomplish little more than wheel or axle weighing, to more sophisticated ones which, in addition to weighing individual wheels and axles, calculate gross load of the vehicle, record its axle spacings, its length, its speed, date, plus many other elements of information. Using rectangular platforms, called transducers, along with magnetic loop detectors buried in highway pavements, they are capable of gathering miscellaneous data almost instantaneously as vehicles pass by at expressway speeds. The units used in the dynamic sorting system as described for the Class I station make use of such transducers.

There are areas, other than at weigh stations, where these transducers can be used. These would be locations along highways where the traffic volumes would not justify even a Class V or lesser station. Transducers can be embedded and sealed into a concrete pavement together with wiring connections which would be buried to the shoulder point enabling a mobile van to connect thereto while parked off the road. A motor carrier officer, upon detecting a violator, can, through radio communication, describe the violator to another officer located a distance down the highway who would signal the driver to stop for a static weighing and/or a closer inspection.

The advantage of this system is the small investment, with flexibility of operation. A van could drive from one such dynamic installation to another at a different site on a roving basis, thereby obtaining a much more effective coverage for enforcement.

Since these dynamic systems in the pavement function only as screening or sorting detectors, final weighing would need to be accomplished either by portable scales, similar to those presently in use, or by some other weighing devices at the check point. The latter may be a series of transducers embedded in a special weighing lane or inspection area similar to that used for the dynamic sorting, except that it is operated statically. Or, they may be shallow portable electronic platform scales with platforms either resting on the pavement or in recesses in the pavement so as to provide a flush condition.

A big advantage of the embedded transducer is its permanency, as it remains at the site embedded ready for service any time a mobile unit is connected. The disadvantage is the need for the mobile unit.

Major advantages of the platform scales are that they can be easily trailored to another site and handled by two men, maintenance would be minimal, and the electronic gear does not require special enclosure. Its disadvantage, a minor one, is that it does require a little more set-up time as well as some physical effort in so doing.

Whereas these various weighing devices or systems are available from industry, collectively or individually they can be incorporated into a demonstrably capable system. The following options are available:

Scheme A

Dynamic:	Transducer platforms embedded in trunkline pavement (two sets)	$22,000*
	Platform installation and materials	3,000**
		$25,000
Static:	Transducer platform embedded in inspection area pavement (two sets)	$22,000*
	Platform installation and materials	3,000**
		$25,000
	TOTAL	$50,000

Cost of two vans, and inspection area not included.
* Add $12,000 if magnetic storage desired.
** Deduct $3,000 if unit installed at time of initial pavement construction.

Scheme B

Dynamic:	Same as Scheme A	$25,000* and **
Static:	Portable scales at an inspection area	equipment on hand
	TOTAL	$25,000

Cost of one van and inspection area not included.

Scheme C

Dynamic:	Same as Scheme A	$25,000* and **
Static:	Platforms above inspection area pavement, or in recesses	10,000
	TOTAL	$35,000

Cost of one van and inspection area not included.

Scheme D

Static:	Transducer platforms embedded in inspection area pavement (two sets)	$22,000* and **

Cost of one van and inspection area not included.

Scheme E

Static:	Platforms above inspection area pavement or in recesses	$10,000

Cost of inspection area not included.

Obviously Scheme E is the most economical; Scheme A is the most expensive. This is not to intimate that Scheme E should therefore be adopted. Selectivity could become arbitrary. However, while the Committee strongly believes that there are numerous areas in Michigan where serious consideration should be given to installing inspection areas utilizing these schemes, it defers such selection to others as recommended later in the report.

WEIGH STATION FINANCING

One of the earliest concerns of the Committee, which was addressed in the letter of appointment, was that of financing new weigh stations. The stations scheduled for I 75 near Erie, had been proposed in a 1965 Highway Department Engineering Report for the widening of I 75. At that date, weighing responsibilities rested on the Highway Department. Therefore, following necessary reviews, the report was accepted as a basis for plan development. The Federal Highway Administration gave their preliminary approval and indicated it would participate in the costs of the right-of-way and portions of construction other than the scale house and the scales.

It is obvious that the Federal Highway Administration has a devoted interest in the safety and maintenance of the nation's highways. However, though recognizing that control of vehicle loads and inspection of vehicles are a necessary facet, its input in this area is somewhat conditional. This limitation, it is explained, is due to the lack of a privilege of control or enforcement of vehicle weight laws. Therefore, its policy has been to not participate in those portions of a weigh station necessary to perform the actual weighing. An exception, as stated previously, is in cases where the scales and the house are accepted as a Highway Planning and Research project.

On January 4, 1975, U. S. Public Law 93-643 became effective. Section 106 deals with vehicle sizes and weights amending Section 127 of Title 23 U. S. Code by increasing certain axle loads on Federal highways. Section 107, a new added section, paragraph 141 introduces what heretofore had been the missing element - "Enforcement of requirements." This section requires each state to certify, yearly, that it is enforcing all of its state laws respecting maximum vehicle size and weights permitted on the Federal-Aid Primary, the Federal-Aid Urban, and the Federal-Aid Secondary systems, including the Interstate system. Federal approval of future projects is now contingent on a state's compliance (Exhibits J and K).

While this new law seemingly gives the Federal government, through its Federal Highway Administration, a very effective control of vehicle weights, as of this date there has not been any change in its weigh station participation policy. We are informed, however, that the policy is being reviewed; hopefully Federal participation in the complete station will be forthcoming.

While the degree of participation by FHWA still is questionable, the State's financing, itself, is not clear as pertains to all new stations. This is attributable to the change in assignment of weighing responsibilities as instituted by Act 77 Michigan Public Acts of 1968 as described early in this report (Exhibit L). In those paragraphs the question of construction of new stations on the Interstate system only was addressed in an opinion dated February 14, 1974, handed down by the State's Attorney General's office. The issue dominant in the opinion appears to be that if Federal Highway funds are available, as they would be on the Interstate system, it would be permissible to use matching monies from the State's motor vehicle highway funds for purposes of design and construction of weigh stations on that system (Exhibit M).

Whereas the Department of State Highways and Transportation financial involvement in the construction of weigh stations on the Interstate system has been somewhat resolved, a question as to the funding of the scales and the scale house conceivably might not be construed as a legal use of motor vehicle funds insofar as there is no Federal matching funding for these portions. While the Committee believes, that although there would not be any Federal assistance for the building and the scales, this should not be interpreted as a diminishing of interest on their part to have the total facility constructed. Likewise, we believe the Bureau of Highways attitude would be the desire to have the complete station constructed. To isolate certain portions of an initial station construction, and assign their costs to state departments other than the MDSHT could, because of budgetary problems, materialize into a situation where for the lack of a building and the scales render the partial facility unusable. Although no problem would exist if the Federal Highway Administration decided to participate in the costs of these two necessary units, it might be prudent to seek a legal opinion on this aspect of financing for Interstate highway weigh stations.

This leads to a question of the financing of stations on highways other than Interstate. The February 14, 1974 opinion of the Attorney General's office specifically addressed financing of proposed stations on the Interstate system; it made no reference to any which would be desired for other highways in the state. Since Federal financing participation for non-interstate differs from that for Interstate highways, the Committee felt that a legal opinion should be sought by the Department which is addressed specifically to these situations. In a discussion with Louis J. Caruso, Assistant Attorney General involved in the February 1974 opinion, this concern was recognized as a worthy one.

RESPONSIBILITY FOR WEIGH STATION DESIGN

Since the July 1, 1968 date of transfer of weighing responsibilities from the Department of Highways to the Department of Commerce, only one weigh station has been constructed in the State. That station is at the intersection of US 12 and M 50 at Cambridge Junction, and was constructed in 1973. It would be designated as a Class VIII station, using the Committee's classification system.

Intersection upgrading plans for the two highways mentioned, required relocation of the existing weigh station located adjacent thereto. Highway design forces were actively engaged in the preparation of contract plans for the station, including the scale house at the time of transfer of weighing facilities to the Commerce Department. Thus, the design of the intersection expanded to embrace the new station.

While concern was expressed at that time regarding responsibility of acquiring right-of-way for the new station leading to an Attorney General's opinion, no question was raised as to the legality of the highway forces performing the design work. (It is interesting to note that the opinion as rendered on October 15, 1968 states that "if the proposed widening and reconstruction of . . . intersection . . . necessitates relocating the existing weigh station, then it appears that the Department of Commerce has the responsibility for moving the weigh station. If the particular weigh station at the intersection . . . cannot be relocated on the existing right-of-way, then it becomes the responsibility of the Department of Commerce to acquire another right-of-way for constructing a new weigh station and to move the weighing equipment." (Exhibit N).)

In November 1968, following several months of effort by both the MDSHT and the Department of Commerce to reach accord on the handling of maintenance duties at the stations, the State's Attorney General pointed out, in another opinion, that the two departments could not legally agree to assume the maintenance responsibilities in a contractural manner (Exhibit O). While both departments could manifest their understanding in writing, they each should be cognizant that a written agreement would not constitute a valid and enforceable contract.

Subsequently, a letter of understanding April 21, 1969 between the Directors of the two departments was written. In it, the maintenance assignments were spelled out (Exhibits P and Q). While there have been miscellaneous maintenance problems, ones which have been addressed early in the report, the mechanics have been established to resolve them. In all probability the best explanation of there being any difficulty in their resolution is that everyone in a position either affected or obligated to perform was not thoroughly acquainted with the maintenance assignments.

As to design of new stations, although the Bureau of Highways might not necessarily be involved in design work of an adjacent highway to a proposed weigh station site, such should not rule out using the design forces of said Department. The building might be considered in a different light.

According to Act 77 P.A. 1968 all existing weigh stations are the property of the Department of Commerce, which is responsible for their operation and maintenance. Funding for regular and special maintenance, remodeling and additions is obtained through the Department of Management and Budget Capital Outlay process. Briefly the process which is fully described in the Capital Outlay Manual provides that regular maintenance (projects costing less than $15,000), are provided for in the operating budget of the agency and special maintenance ($15,000 to $100,000) and remodeling and additions projects under $100,000 are requested and allocated from lump sum appropriations to the Department of Management and Budget for this purpose. New construction and special maintenance and remodeling projects in excess of $100,000, are provided for in line item requests in the agency's Capital Outlay Budget.

Plans and specifications for authorized projects may, upon the request of the agency, and the approval of the Bureau of Facilities, be prepared by the agency itself, by the Bureau of Facilities Design Division, or by a Professional Services Contractor. Costs of these services unless provided by the agency must be accounted for in the authorizing work order.

Projects involving labor and materials other than force account work completed by the agencies own personnel are accomplished through the competitive bidding process administered by the Bureau of Facilities.

At this time, while all existing scale houses are the property of the Department of Commerce, any minor or even major maintenance or reconstruction of the building is handled by the State's Department of Management and Budget as delegated by the Department of Commerce. Whereas the Bureau of Highways did in the past prepare the architectural plans for the scale houses, such involvement now is subject to question, especially in consideration of the above. The Department of Management and Budget does have a qualified staff for preparation of such plans; when overloaded with work assignments it would be given to consultants. On the other hand, the Bureau of Highways presently has an individual capable of preparing the desired building plans; however does it intend to continue with architectural involvements? The Committee tends to favor assigning preparation of scale house plans to the Department of Management and Budget subject to Commerce's approval. In any event, an agreement should be reached and a letter of understanding worked out. Presumably this arrangement will also be legally acceptable.

CONTINUING WEIGH STATION PLANNING

Having categorized all weigh stations into eight classifications - each characteristically different from the others, having addressed the issue of financing new and reconstructed stations, and having presented recommendations for design of new stations, the Committee sought a plan or program of action for the future. It would have to be one capable of discovering needs, establishing priorities, and setting up programs whereby existing stations could be upgraded and new stations constructed. The need for correcting and improving conditions at existing stations, alone is a motivating factor for upgrading; the knowledge that trucks can travel the full length and breadth of the State without encountering any weigh station gives impetus to a desire for construction of new ones (Exhibit F).

Using current construction costs it has been estimated that the cost of a new weigh station built to the present design guide VII-510 or which has previously been classified as a Class V station would cost $400,000. Discounting depreciation, and not considering any right-of-way, this amount represents the approximate investment the State has in each of the more recent weigh stations. In view of this cost, it would not be prudent to suggest that all of the existing weigh stations be upgraded to the standards that the Committee is recommending for its Class I weigh station. The total investment in stations precludes a wholesale discarding for the sake of a better system. The cost for such an undertaking would be prohibitive. However, consideration should be given to some upgrading in one form or another. The above figure becomes significant where there may be a desire to upgrade parts of the older stations, or even the complete station to present design standards. Such treatment, however, should not be considered without thorough assessment of the need as it pertains to each specific site.

In order to assure that the weigh station needs within the State are provided for in a logical and comprehensive manner, it will be necessary to establish this assignment as a full-time unrestricted responsibility. At present, the manpower requirements for determining needs, priorities, and programs, along with coordination and monitoring, are not known. Initial efforts may require several staff members with a gradual reduction in staff as the time consuming inventory and needs elements of the programs are completed. Of utmost importance is that the responsibility for weigh stations be clearly defined as the primary work assignment of the engineer in charge.

Several sequential steps or functions can readily be defined as basic requirements in providing for a comprehensive weigh station program. The following outlines these functions:

Inventory

a. Structures

When constructed
Upgraded
Maintenance costs

b. Scale Platform

Type
When installed

c. Geometric Layout

d. Traffic Volumes

Average daily traffic
Percent trucks
Peak truck volume

Classification

a. Classify into categories I through VIII based on existing criteria

b. Classify into desired categories I through VIII based on:

Truck traffic volume
Peak traffic periods

Needs

a. Determine deficiencies in the existing weigh stations based on an analysis of:

Structure deficiencies
Platform deficiencies
Geometric deficiencies
Structural deficiencies
Capacity deficiencies

b. Determine new areas of need where gaps in the network may presently exist.

Priorities

Based on the analysis of needs, establish a listing of priorities for improvements. It may be necessary to assign values to the various categories of needs and by station classification.

Funding

Based on the analysis of needs and the established priorities, review the financial aspects with management and establish a financial program.

Improvement Program

Based on a combination of needs, priorities and approved level of funding, develop a construction program.

Monitor and Update

As an ongoing function, monitor the weigh station system. This would include:

Update inventories upon completion of specific construction programs.

Maintain a close surveillance of the weigh station system in terms of service function.

Major highway construction program, whereby highway relocations may alter weigh station requirements.

Liaison with the Public Service Commission and the Federal Highway Administration.

RECOMMENDED DESIGN FOR I 75 WEIGH STATIONS AT ERIE

A foremost concern of the Committee from the date of its appointment has been a design for new stations on the divided Interstate highway at Erie. Two stations are presently located on I 75 seven miles north of the Ohio border. They are the busiest in the State, handling exceedingly large interstate truck movements between Detroit and Ohio and/or points south and east. Unfortunately they are incapable of handling existing truck volumes because of inadequate facilities and being located too close to an interchange. The Bureau of Highways recognized this at the time it prepared an Engineering Report for third lane widening of I 75 for this section of the highway. It called for constructing new stations at a more appropriate location, and discontinuing the existing ones.

Topographical Controls

Between the time of the Engineering Report's acceptance and that of acquiring rights-of-way for the stations, several electrical transmission lines on large steel towers were installed in a land corridor immediately adjacent to and west of the highway. The utility company owns the corridor. Two other utility companies also have transmission lines on the same towers.

Moving the towers to take the lines around a proposed weigh station would be extremely costly and difficult, as there is no time the power can be even temporarily turned off concurrently for the three companies.

The challenge has been to design a station, which would leave the towers and the lines untouched. The utility company indicates it would be agreeable to such a design, providing that certain vertical and horizontal clearances were observed for any structure that we would desire to construct.

Resolution of Problem

Design Guide VII-510 definitely will not fit the southbound roadway without extensive pavement removal and replacement. Also, insufficient land is available to provide for future dynamic weighing. Thus, in the course of developing a Class I station, thought was directed, to a great extent, to the problem at Erie, although it was not the determining factor in the ultimate geometrics.

The Committee discovered that the final geometrics of the Class I station, as recommended, will accommodate the utility companies facilities with no alterations. Therefore, the Committee strongly recommends that a Class I station be constructed along southbound I 75 at Erie. And, in concern for consistency and regard of the need of a dynamic sorting installation for both roadways, it recommends that a Class I station also be constructed along northbound I 75 directly opposite the other. The expected cost reduction for the second station, if constructed by the same contractor as the first, adds incentive to the desire to place two Class I stations at these locations.

In the course of its study, the Committee was approached by representatives of Aeronutronics-Ford of Willow Grove, Pennsylvania, a company engaged in the design and installation of electronic communications and other specialized technical systems. It is a division of Philco-Ford, an affiliate of Ford Motor Company, and was responsible for completing the MDSHT's electronic research project at the Grass Lake site in 1965 and 1966. The Highway Department's Testing and Research personnel involved in the project worked extensively with the contracted organization, and are fully cognizant both of the company's understanding of the type of electronic system the Committee is pursuing and of the company's capabilities.

With the Committee's approval, the company prepared a proposal for an electronic dynamic and static weigh system as contemplated for a Class I station for the Erie locations. The proposal is based on the Committee's Proposal for Design of a High Volume Station as found earlier in this report. Aeronutronics-Ford's technically detailed proposal is found in Exhibit R.

Alternative

At the present time right-of-way has been acquired for the two weigh stations, one on each side of the highway, based on what the Committee has classified as a Class V station (present Standard Guide VII-510). While such a station could be constructed within this right-of-way for the northbound roadway, one could only be placed along the southbound roadway by moving the complete station approximately 80 ft further away from the highway than the Design Guide specifies. This shift is needed to satisfy the power company's clearance requirements for its transmission lines. The new geometrics would necessitate acquiring considerably more right-of-way both laterally as well as longitudinally, than what is already acquired.

Urgency for Action

With a need for rights-of-way greater than already acquired, it is imperative that steps be initiated immediately to purchase the needed extra amount. The I 75 widening contract is presently underway. While temporary provisions have been made for continuing weighing operations at the existing sites, the need for the new stations is even more important than before the widening was begun.

SPECIFIC RECOMMENDATIONS REQUIRING EARLY ATTENTION

Addressing the Problem

As has previously been mentioned, the Bureau of Highway's more recent concern in the State's truck weighing program was revived in the spring of 1973 following receipt of a letter from the Department of Commerce's Executive Motor Carrier Officer. The letter cited difficulty in obtaining acceptably accurate weighings for certain truck types at certain stations, and indicated that irregularities in the scale approach pavements may be at fault. Subsequent thereto the Bureau of Highways ran profile surveys and conducted an in-depth study, ultimately leading to the creation of this Committee.

Inasmuch as the problem should, of necessity, be addressed to each specific location, the Committee conducted its own study, making follow-up site inspections in October 1975.

It was obvious that a positive attempt has been made to correct some of the deficiencies noted in earlier inspections and discussed in this report. Traffic signals have been, or are being moved further from the scales, scale platform as well as inspection area lighting is being implemented. In at least two locations, platforms and their support frameworks have been rebuilt. Many of the problems can only be completely resolved by abandonment of the present design and installing a more functional layout with new weighing techniques (as described for a Class I station). The alternative is to reconstruct or improve within the constraints of the present facilities.

Manpower

The manpower problem is one which needs to be considered in light of the real purpose of the weigh station. Is the intent to provide a positive and expedient means of checking and controlling the commercial vehicles traversing the state's highways, or is it no more than a device for spot checking by random selection and unpredictable hours of operation to keep the truckers honest? It is the Committee's opinion that the former should definitely be the objective; certainly, the investment in the physical plant at each site mandates that the station be operated in such manner as to realize its maximum potential.

A recommendation for staffing the various stations as presently designed was submitted to the Committee for its review by the State's Executive Motor Carrier Officer. With the knowledge gained through its two years of study, having observed the number of personnel actually working at a weigh station in another state (three persons inspecting vehicles, one working the scales, and one handling the remaining miscellaneous station duties such as, citations, radio, telephone, household, etc.) and the recognition that a job only partially performed misses its objective by a substantial margin, the Committee considered itself qualified to pass judgment. The Committee reasons that the mission of each weigh station has definitely changed from that of a decade or even five years ago. Where basically the only concern once was weighing, it has broadened to include vehicle safety inspection, driver qualification checking, reciprocal agreement compliance checking, and emergency aid and Civil Defense communications operations plus several other miscellaneous assignments. To expect a weigh attendant to perform all of these assignments effectively as well as maintain an effective scale operation, is unreasonable.

It is therefore recommended that serious consideration be given to staffing the existing stations classed as V and VIII as suggested by the Executive Motor Carrier Officer in Exhibit G. This recommendation is, however, conditioned on periodic review of the operations at each station to verify a continuance of need, or to assess additional needs.

The Committee does wish to point out that it has not studied the manpower needs, as stated in Exhibit G pertaining to road patrols. However, it does recognize the necessity for an active organization capable of covering the many highways which have no weigh stations. The present station system leaves numerous areas controllable only by road patrol. With the knowledge that it takes a force of two officers of a patrol unit approximately one hour to set up and weigh just one of Michigan's 11-axle truck-trailer combinations, one can see that a vast number of patrols could easily be put to effective use throughout the State.

While by letter of understanding, the MDSHT has agreed to take care of all the routine maintenance of the stations in conjunction with its regular trunkline maintenance; heavy maintenance such as pavement resurfacing, base correction, pavement widening, etc., also becomes its responsibility when such work is requested by the Department of Commerce. After months of probing and studying the many facets of weigh station operations, and with a more comprehensive appreciation of weighing requisites, the Committee directed special attention to the condition of the approach pavement for those stations experiencing weighing difficulty. Any repair or replacement of pavement, which in the Committee's judgment would eliminate part or all of the problems affecting weighing, would be the MDSHT's responsibility.

Most of the weigh stations inspected have a 10-ft long concrete slab in the approach pavement immediately adjacent to both the upstream and downstream ends of the scale pit. Apparently, designers considered this construction necessary to introduce joints to accommodate expansion of the approach pavements. Unfortunately, this slab is difficult to maintain at the absolute level condition necessary for proper weighing, and at all sites irregularities were observed. With an understanding of how the platform has to accommodate vehicles with 9-ft spread axles some of these irregularities, even though seemingly tolerable, cannot be accepted for a weigh system dependent on a single platform scale.

Ideally, the platform concrete of a scale should be flush with its perimeter frame angle, the top of the backwall and the top of the approach slab. Where the approach slab is lower than the other two, the only correction available, other than correcting the elevation of the approach slab is to lower the scale platform. This is done at some stations to make weighing of 9-ft axle spacing units possible. Unfortunately the backwall is left high, resulting in impact loadings, as well as introducing weighing difficulty with units having closely spaced axles.

The present design specifies 100-ft tangents at 0.0 percent grade extending both directions from the scale. This length is not unreasonable, as the concern is for a truck-tractor to be able to ease its full length over the scales with a minimum of tractive effort. While the degree of tolerance of variation from this profile may be very little near the scales, it can be less restrictive at the zone's outer limits.

Having ascertained that the joint materials designed to take expansion are not suffering any distress, it appears that other than at the juncture of the slab and the pit backwall, no joint is needed for expansion closer than the points of vertical tangency, i.e., 100-ft upstream and downstream of the scale.

In general, where pavement cracking is severe within 100-ft of the scales, the Committee is recommending complete pavement removal and replacement within those limits. Although attention may be required for repair beyond those limits, unless the condition of the slab is very bad or profile correction is needed, such work extension can be handled as joint repairs, and programmed by the MDSHT as it deems appropriate. In any event, the amount of pavement replacement is confined to that portion which has a direct or indirect effect on the weighing. The criteria used in determining the extent of removal and replacement of pavement have been the severity of the cracks, the irregularity of the profiles and the desire to avoid introducing extra joints and short pavement lengths near the scales.

Condition statements together with recommendations for each site follow.

Portland Weigh Station - I 96 Westbound

This station was built in June 1961. The scale platform with its structural steel support system was rebuilt in January 1974. The steel floor plate, or stay-in-place form, was eliminated from the design and the concrete platform was placed directly on the steel stringers and floor beams. This conforms with a recommendation of the investigative team following their inspection in the summer of 1973.

The Committee now notes that the new concrete platform has incurred several bad cracks. The cracking could be attributable to one or more reasons, the location of one crack strongly indicates the possibility of an inadequately tightened floor beam-to-stringer connection. As neither the replacement construction plans showing the amount of reinforcing steel as well as its location in the slab, nor the inspection and testing reports were available to the Committee, it was not possible to draw a positive conclusion as to the full cause of its present condition.

The Committee recommends that the Department involved in the scale reconstruction work, presumably the Department of Commerce, examine its records of the contract as performed and, if legally possible, seek damages from the Contractor. Certainly, with adequate design, proper supervision, and controlled testing, the work should be performed such as to render a job that would be maintenance free for more than a year or two.

It was also noted that the tops of the concrete foundation walls, both at the approach as well as the exit end of the scale, need reconstruction due to cracking. This work should have been done at the time the platform was removed. The walls need early attention as their deterioration will accelerate with water, salt, and grit leaching into the cracks.

The ramp through the scale area is bounded by 10-in. curbs; no provisions for drainage was provided in the approach design other than two curb cuts which serve no function, as all sod behind the curb is flush with the top of the curb for its full length. The ramp profile invites surface water to drain to the scale pit rather than away from it. The outside curb extends continuously adjacent to the side of the pit prohibiting any drainage away from it.

There are numerous cracks in the approaches, many inducing vehicle vibrations. The 10-ft approach slabs are tilted. The curbs and the pavement are monolithic.

Both drainage and pavement correction can be attained by removing and replacing 100 ft of pavement and curb on the approach end of the scale and 60 ft on the leaving end, and constructing a flush paved shoulder section for this length. Curb should definitely be removed from the outside of the pit, and a flush shoulder installed here as well. Pavement striping should channel the traffic through the area.

Other than the work of repairing the platform and the pit walls, the estimated cost of remedial approach work is $8,500.

Portland Weigh Station - I 96 Eastbound

This station was built at the same time as the westbound station (June 1961). The platform with its support system has also been replaced since the summer of 1973. The present condition of this platform is much worse than that of the westbound scale, having many bad transverse cracks plus two spalled areas patched with asphalt. The screeding was poorly done with the concrete not flush with the perimeter frame. No plans or reports were available here either; however, the Committee was informed that the platform concrete was placed during the winter of 1973-74, and that heating and housing were not provided during the concrete curing. The overall condition of the concrete is suspect. The same recommendation concerning the platform reconstruction is made for this scale as for the westbound one.

Although the backwall condition is better than at the westbound station, a separation or opening has developed between the WF beam embedded in the backwall and the backwall concrete on the downstream end. It is possible that sealing this joint may be all that is needed; however, the sealant should not protrude above the top of the backwall at any location. In any case, some corrective action is warranted to prevent water, etc., from getting into the opening.

The ramp through the scale area is similar to the weigh site across the highway. The drainage problem is more acute at this location. A fair amount of area alongside the building drains across an unpaved shoulder area used for attendants' car parking. This drainage washes a considerable amount of sand and loose gravel onto the approach pavement and into the pit. The 10-ft approach slabs, like the ones at the westbound station present identical problems. As considerable cracking is prevalent in the approaches, correction can only be attained by removal and replacement, simultaneously correcting the drainage which presently flows into the pit.

The Committee recommends removal and replacement of 100 ft of pavement and curb upstream, and 60 ft downstream of the scale, and construction of a flush shoulder cross-section for the area being corrected. Curb on the outside of the scale should also be removed and flush shoulders constructed to slope away from the ramp.

Recommendations and Cost Estimates - Portland

At each scale remove 100 ft of approach pavement and replace to 0.0 percent grade. Remove 60 ft of leaving pavement and replace at 0.0 percent grade. Grade areas around scale to drain away from scales. Place a 4-ft bituminous aggregate shoulder adjacent to the new concrete pavement. Remove and replace approach guardrail. Resurface bituminous parking area in back of scales.

Quantities

Item	Unit	Amount	Unit Cost	Total
Pavement removal	sq yd	284	$ 3	$ 852
Sidewalk removal	sq yd	4	3	12
10-in. concrete pavement reinforced	sq yd	284	12	3,408
7-in. concrete, southwest	sq ft	36	2	72
Earth excavation	cu yd	70	2	140
Fertilizer	lb	40	3	120
Seed	lb	20	5	100
Mulch	ton	1	200	200
Bituminous concrete 4.12	ton	45	25	1,125
Bituminous aggregate shoulder	ton	12	25	300
Class AA shoulder	ton	55	5	275
Guardrail	lin ft	103.5	8	828
		Sub-Total		$ 7,432
		E&C		1,068
		Each Scale Total		$ 8,500
		Total (both scales)		$17,000

New Buffalo Weigh Station - I 94 Eastbound

This station was built in 1964. The scales and platform were rebuilt in May 1971.

In February 1975 an inebriated truck driver attempted to pass a truck stopped on the scales. There was no guardrail adjacent to the scale approach ramp to offer some protection for the building and the truck crashed through the building. Since that date, while the station remains open, it functions only as a check point where very brief inspections are conducted in the parking area where all trucks are routed. Occasionally a unit is checked for weight using portable scales when the attendants believe a certain unit may be overloaded. This operation is time consuming.

This station experiences the third highest truck volume in the State, rating closely behind the two stations on I 75 at Erie. It was constructed using bituminous paving. After several years use, the approach ramps experienced distress to such an extent, that approximately 85 ft of pavement, upstream and downstream of the scale was removed and replaced with heavy reinforced concrete slab. Here too, 10-ft approach slabs were placed immediately adjacent to the scales. Since this reconstruction these short slabs have been noticed to rock under loads and to pump water following extended rainy periods. Although the scale has not been used since February, its platform is adjusted to match the average elevation of the 10-ft approach slabs which are slightly lower than the tops of the backwalls.

Aside from this, the condition of the platform is good; the portions of the approach pavement which are concrete are very good. Unfortunately, the major portion of the approach ramp (from where it leaves the highway to where it rejoins) has suffered base failure and requires extensive repair. Though an asphalt surface treatment would put the parking area in good condition, long service can still be expected before extensive resurfacing would be needed.

On October 23, the Department of Management and Budget took bids on replacing the scale house. Subject to acceptance of the bids, reconstruction can be anticipated to begin in the near future. In a sense, the Committee is a bit disappointed that it was not able to have its report completed prior to the time of reconstruction of the house. It would much rather see all monies scheduled for this station's repair diverted into a fund for constructing a new station, one which can process the units at a rate, and in a manner much more expeditious than that of the present system, when operating again. Periodic traffic lineups on eastbound I 94 as far back as LaPorte Rd, will continue to interfere with the interchange "on" ramp unless the system is changed.

The Committee acknowledges that the building should be constructed, and recommends that protective guardrail and adequate lighting be installed. No pavement correction need be done. (There is no surface drainage problem. The approaches have a flush shoulder cross-section.) It also recommends that planning be initiated to expand and reconstruct this site into a Class I station. As the new type station requires additional right-of-way, it would seem prudent to acquire this as soon as possible. At the present time, the adjacent land is undeveloped. With the building restored to its designed function, and a minimum investment in corrective construction, the existing station could probably operate without any heavy maintenance until such time as a new station can be constructed, provided action is not delayed.

It is interesting to note that concrete pavement was used to replace the asphalt in the critical weighing zone at this station. Upon observing the breaking action of some of the axles of the multi-axle units decelerating at the scale, it is not difficult to understand the problem in keeping an asphalt pavement profile free from distortion.

Recommendations and Cost Estimates - New Buffalo

Work toward future reconstruction as a Class I station. Place 150 ft of beam guardrail, Type C, with cable anchorage for building protection.

Quantities

Item	Unit	Amount	Unit Cost	Total
Guardrail, Type C	lin ft	150	$ 16	$2,400
Cable anchorage	each	1	650	650
			Sub-Total	$3,050
			Cont.	450
			Total	$3,500

Grass Lake Weigh Station - I 94 Eastbound

This station was built in August 1962. The scales were rebuilt in 1967, 1969, and 1973. Although this station was one listed in the letter as a problem area, the condition seems to have been corrected somewhat by the reconstruction of the platform and framing in the late spring of 1973. The investigative team, following its midsummer 1973 investigation, did indicate an objection to the way that access manholes were placed in the platform. This objection is repeated in this report, as structural integrity of the supporting steel framework was diminished by its placement. Furthermore, no appreciable advantage is gained by installing manholes in the platform when access is provided through the scale house basement.

While some minor cracks exist in the platform concrete, they are not so severe as to warrant any corrective action at this time. They should, however, be observed periodically to determine if any progressive failure has taken place.

The electric sign located on I 94 about 3/4 of a mile upstream from the station operates as designed; its performance is appreciated by both truckers and attendants alike. At present, the I 94 westbound station requires a manual sign operation, requiring some agility in climbing.

Existing curbing of the approaches at eastbound I 94 contains the water in a manner quite similar to all other stations using the standard Class V station design. However, the profile is somewhat better than the others and though some drainage does flow to the pit, the amount is less than experienced at the Portland sites. But here, too, a curb on the outer side of the scale platform contains the water, and some early stage of deterioration in the top of the pit foundation wall is evidenced where this ponding occurs. Again, curbing should not be positioned at the outer side of the scale. A flush shoulder, properly maintained, would carry the water away from the pit.

New area lighting has been installed. Unfortunately, the two poles alongside the approach ramp as well as the pole by the parking area are placed on the wrong side of the traveled way. They should be placed on the scale house side of the ramp, and the far side of the parking lot to be most effective. The latter location is for personnel safety. Possibly three additional lights, properly located, might be worth the investment by providing even better total lighting; however, if no lights are added the newly installed ones should be relocated.

It was noted that the approach pavement was striped by a luminous painted white line. Station personnel consider this to be very effective.

The approach pavement does have sufficient cracks to warrant attention, considering the length of the cracked pavement and the improper drainage involved.

Recommendations and Cost Estimates - Grass Lake (Eastbound)

Remove 150 ft of approach pavement and 125 ft of leaving pavement and replace at 0.0 percent grade. Grade to drain away from scale. Do not replace curb where pavement is removed, place 4-ft bituminous aggregate shoulder instead. Remove and replace guardrail.

Quantities

Item	Unit	Amount	Unit Cost	Total
Pavement removal	sq yd	490	$ 3	$ 1,470
10-in. concrete pavement reinforced	sq yd	490	12	5,800
Curb removal	lin ft	10	2	20
Earth excavation	cu yd	100	2	200
Fertilizer	lb	40	3	120
Seed	lb	20	5	100
Mulch	ton	1	200	200
Bituminous aggregate shoulder	ton	10	25	250
Guardrail	lin ft	103.5	8	828
		Sub-Total		$ 9,068
		Cont.		1,332
		Total		$10,400

Grass Lake Weigh Station - I 94 Westbound

Like its twin, this facility was built in August 1972. The scales were rebuilt in 1965, 1969, and 1973. This station was the site of the State's Electronic Weighing in Motion research project referred to in other sections of this report. Other than for the special accommodations made for that project (some remnants still in place, none of which affect the mechanical scale operation) the stations are alike. The approach ramp is of concrete with monolithic curbs. The curb also is continuous on the outside of the scale. There is no short (10-ft) scale approach slab.

Drainage is not as severe a problem at this station as at some of the others visited. However, the curb on the outside of the scale does prevent a runoff; thus a considerable amount still drains into the pit.

The pavement condition on the approach end of the scale is in fair condition; that on the leaving end requires repair. It is recommended that pavement and curb be removed for a distance of 150 ft downstream from the scale, and replaced with a pavement with flush paved shoulder design. Curb at the outside of the scales should also be removed and replaced with a flush paved shoulder. Pavement edge striping should be provided.

The platform has a manhole in it, the same comments made for the eastbound station apply here. The top of the pit backwall on the approach end is cracked, and should be attended to before too long.

The new area lighting is improperly located. The electric "open" - "closed" sign is not connected to electric source. The speaker for the sound system needs attention.

Recommendations and Cost Estimates - Grass Lake (Westbound)

Leave approach pavement; remove 150 ft of leaving pavement and replace at 0.0 percent grade. Replace concrete curb; make necessary drainage corrections; repair bad pavement cracks.

Quantities

Item	Unit	Amount	Unit Cost	Total
Pavement removal	sq yd	270	$ 3	$ 810
10-in. concrete pavement reinforced	sq yd	270	12	3,240
Concrete curb	lin ft	150	7	1,050
Earth excavation	cu yd	50	2	100
Fertilizer	lb	20	3	60
Seed	lb	10	5	50
Mulch	ton	1	200	200
Repair pavement joints	lin ft	32	10	320
		Sub-Total		$5,830
		Cont.		870
		Total		$6,700

Birch Run Weigh Station - I 75 Northbound

This station was built in June 1961. It is still operating with its original scales.

Although its design is Class V, and it is similar to the Portland and Grass Lake stations, it has very short lengths of curbs near the scales. Pavement with flush paved shoulder design predominates, and in those areas the ramp is clean of grit. In the area where there is curbing, due to high ground behind the curb in one location, runoff is causing sand to run over the curb onto the ramp. This can be corrected quite easily by trimming this area and resodding. The shoulder on the outside of the platform should also be graded to better encourage water to drain away from the pit.

The platform appears to be in fair condition with only minor cracks. The leading edge is lower than the pit frame; however, there does not seem to be any weighing difficulty. There seems to be more than average longitudinal movement of the platform. The backwall is in good shape.

While there are some minor cracks in the pavement both directions from the scale, the profile is good, and the cracks can be endured for a time. They should, however, be periodically checked.

It is interesting to learn that this scale is used to check weight of loads which are questioned during weighings on the southbound scale across the highway, or the I 75 northbound Pontiac scale.

Recommendations and Cost Estimates - Birch Run (Northbound)

Grade to drain away from scales and grade to drain away from curb.

Quantities				
Item	Unit	Amount	Unit Cost	Total
Earth excavation	cu yd	90	$ 2	$180
Fertilizer	lb	40	3	120
Seed	lb	20	5	100
Mulch	ton	1	200	200
		Sub-Total		$600
		Cont.		100
		Total		$700

Birch Run Weigh Station - I 75 Southbound

This station was built in June 1961. The scales and platform were rebuilt in the winter of 1972-73.

This station experiences considerable weighing difficulties. This can be determined by visual inspection of the pavement profile and is verified by the plotted survey. There is a definite convex vertical curve in the profile of the approach ramp. This was accentuated with an additional curve on the platform when it was rebuilt in 1973. There is no way that reasonable scale readings can be obtained for the spread axle vehicle types.

At the present time the concrete platform is badly deteriorated with spalling and cracking. One might conjecture that this concrete was placed during the winter months and possibly froze during the curing. It should definitely be removed and replaced. As the top of the backwall concrete shows deterioration on both the leading and trailing ends, it should be repaired at the time of the platform reconstruction.

Recommendations and Cost Estimates - Birch Run (Southbound)

Remove 125 ft of approach pavement and 100 ft of leaving pavement and replace at 0.0 percent grade. Grade to drain away from scales and away from curb. Replace curb and adjust catch basins as required. Remove and replace guardrail. Pavement edge striping should be done.

Quantities

Item	Unit	Amount	Unit Cost	Total
Pavement removal	sq yd	400	$ 3	$ 1,200
10-in. concrete pavement reinforced	sq yd	400	12	4,800
Earth excavation	cu yd	90	2	180
Fertilizer	lb	40	3	120
Seed	lb	20	5	100
Mulch	ton	1	200	200
Concrete curb	lin ft	300	7	2,100
Adjust dr. strs.	each	6	100	600
Guardrail	lin ft	103.5	8	828
		Sub-Total		$10,128
		Cont.		1,372
		Total		$11,500

Pontiac Weigh Station - I 75 Southbound

This station was built in 1962, and is using its original scale. It is a Class V station. However, it has even less curbing on the scale approach ramp than the Birch Run stations. The only curb is a 60-ft length located on the inside, or right side, at the upstream end of the scale. Flush shoulder treatment prevails elsewhere. The shoulder is paved except for approximately 100 ft on the outside at the scale. Drainage is excellent, except at the curbed portion where some sand and grit collects. This, however, is no real problem as most of the water drains away from the pit.

The attendant was not aware of any weighing problem at this site; certainly, the outward appearances did not show any obvious fault. There are a few minor transverse cracks in the platform concrete, however they are tight. There is some scaling of the top of the backwall; it, too, is minor and at present is no problem. There is a longitudinal crack or opening in the top of the downstream backwall at the juncture of the concrete and the embedded steel beam. This should be sealed to prevent any drainage into the opening, as this area is not accessible to any form of maintenance. The sealant should not protrude above the top of the wall.

There are some minor pavement cracks, but they too are tight, and few in number.

Recommendations and Cost Estimates - Pontiac (Southbound)

Leave existing pavement; pave 4-ft shoulder approximately 50 ft each side of scale. Repair bad pavement cracks.

Quantities

Item	Unit	Amount	Unit Cost	Total
Bituminous aggregate shoulder	ton	5	$25	$125
Repairing pavement joints	lin ft	32	10	320
		Sub-Total		$445
		Cont.		55
		Total		$500

Pontiac Weigh Station - I 75 Northbound

This station was also built in 1962; it, too, has its original scale. There are weighing problems at this location. The platform concrete has numerous transverse cracks. The tops of backwalls, both upstream and downstream, have deteriorated areas which have been patched with asphalt. These patches have dished and piled-up causing impact loadings as well as uneven axle-load distribution.

The same condition prevails at some of the more serious cracks in the pavement where asphalt patching has only temporarily solved the problem, only to later reestablish it with equal, if not greater, negative effect on the weighing. Approximately 150 ft upstream and 70 ft downstream pavement, including the short length of curb, should be removed and replaced with new concrete pavement with flush paved shoulders. The shoulder should also be paved on the outside of the scale.

Drainage does not appear to be any problem, although the confined area created by the curb does not direct water away from the scale as desired. This would be corrected by the flush shoulder design.

Recommendations and Cost Estimates - Pontiac (Northbound)

Remove 150 ft of approach pavement and 70 ft of leaving pavement and replace at 0.0 percent grade; pave 4-ft shoulder 50 ft each side of scale and along approach pavement in place of curb and gutter; remove and replace guardrail. Repair bad pavement crack.

Quantities

Item	Unit	Amount	Unit Cost	Total
Pavement removal	sq yd	390	$ 3	$1,170
Earth excavation	cu yd	30	3	90
10-in. concrete pavement reinforced	sq yd	390	12	4,680
Bituminous aggregate shoulder	ton	10	25	250
Repair pavement joints	lin ft	16	10	160
Guardrail	lin ft	103.5	8	828
		Sub-Total		$7,178
		Cont.		1,022
		Total		$8,200

Summary of Improvement Costs

Weigh Station	Total Cost
Portland - Eastbound	$ 8,500
Portland - Westbound	8,500
Pontiac - Southbound	500
Pontiac - Northbound	8,200
Birch Run - Northbound	700
Birch Run - Southbound	11,500
Grass Lake - Eastbound	10,400
Grass Lake - Westbound	6,700
New Buffalo	3,500
Total (All Stations)	$58,500

Erie Stations - I 75 Northbound and Southbound

Hopefully the many weighing problems experienced at these stations will be resolved with construction of the new Class I stations in the near future. The Committee's recommendation for these new stations is included earlier in this report.

General Observations

In its October 16, 1973 report, the investigative team addressed numerous areas of concern at each weigh station inspected and made specific recommendations. Although this Committee report focuses primarily, in this portion, on the needed corrective approach work, it does indicate additional necessary work which could be the responsibility of departments other than MDSHT.

Area lighting, traffic signal relocation, energizing of the "open" - "closed" electric sign, repair of loud speakers, and platform lighting, as well as other items listed in the 1973 report should be implemented for all stations. A cautionary note is made. Rigid specifications for any pit foundation wall and platform reconstruction should be established for any future work of such nature. Inspection of the work as being performed, and testing of the materials used should also be required. Inasmuch as the finished product has to accommodate the same vehicles which use highway facilities, it is fundamental that these controls be at least equal to those which the

Michigan Department of State Highways and Transportation institutes for its construction contracts.

A final suggestion: whereas the approach work which has been described as necessary for correcting the problems at these stations does involve appreciable expenditures, the work may be classed as reconstruction and conceivably qualify for Federal aid.

CONCLUSIONS AND RECOMMENDATIONS

Ten to 15 years ago, when most of Michigan's currently active weigh stations were built, the primary concern was the weighing of vehicles. While it is recognized that weighing is still the major function at each station, new responsibilities have been added. In addition, the weighing itself has become more complex. Assignments, other than weighing, to name a few, are determining the safe condition of vehicles and their loads, checking on proper vehicle warning devices, driver qualifications, required permits, compliance with reciprocal agreements with other states, compliance with U. S. Department of Transportation Bureau of Motor Carrier Safety regulations, and compliance with Interstate Commerce Commission economic regulations. Various Federal Departments as well as motor carrier organizations periodically use the facilities to perform some of their independent checks.

While shouldering the added responsibilities, station attendants have had to cope with changing vehicle types - many of which defy a practical and effective weighing by the State's present system. The varied axle arrangements, now legally permitted in Michigan, the air axle springing of individual axles, the relatively small single scale platform, and the necessity for ideal pavement conditions adjacent to the scales have collectively made the weighing, as presently performed, a dubious operation.

The time involved in effectively weighing some of the multi-axle units statically can amount to several minutes, depending on the driver's ability to position axles properly on the scales. Where trunkline truck traffic volumes are exceedingly large, the weighing of a few units arriving within a short time span could create traffic backups extending onto the trunkline creating a hazardous condition.

As the intent is not to delay, unnecessarily, shipping movements on the State's highways, storage lanes off the traveled way are not desirable solutions to the problem. More effective would be to provide a station facility which could efficiently accommodate the traffic. This is possible through the employment of new and more sophisticated techniques and systems.

Recognizing that the great majority of trucks are operating within legal weigh limits, a system is designed in the report using two electronic weigh scales. One would be operated dynamically to sort out vehicles which are legal, from those having axle loads exceeding or approximating the maximum allowable. This system would not only expedite the movements of all trucks but would provide a more accurate weighing through the introduction of additional platforms. The geometric layout of the facility would also accommodate the many inspection facets of its operation via its specially designed parking-inspection area. The system, to be totally functional, is dependent upon adequate staffing.

Currently, the Bureau of Highways is awaiting design recommendations for two weigh stations on I 75 at Erie, Michigan. The two existing facilities are inadequate, and create hazardous traffic situations on I 75 due to traffic backups. They are scheduled for relocation. Although right-of-way has been acquired for the new stations based on the current design guide, electric power transmission lines and towers within the area of one demand a substantial change from the present standard design. This change, in turn, necessitates considerably more right-of-way.

The recommendation is made to construct two Class I stations using both the electronic dynamic and electronic static scale systems. Although the cost of this Class I station exceeds the cost of one using the present design by $327,800 the cost differential per station where two Class I stations are built by a single contract would be reduced to $186,000. As the existing standard design could not be used for one of the locations, the differential would be even less. However, to construct a new station at a critical location such as Erie based on the current design guide, one which is totally inadequate for high volume stations, would be to relegate it to a "spot checking status," with no assurance of its ability to perform effective weighing.

As an extension of this analysis, a recommendation is made also to reconstruct the eastbound I 94 station at New Buffalo into a Class I station. This station, like the Erie stations, is subjected to traffic volumes which it is incapable of effectively handling. In the next two years this station will require extensive reconstruction just to keep it operable. At the present time the land adjacent to the existing site is undeveloped; additional right-of-way acquisition should be initiated as soon as possible.

While a dynamic and static electronic system is recommended for high traffic volume stations, the design is flexible in that a stage construction is possible whereby static scales would be constructed initially; the dynamic scales would be added at a future date. With this plan of development, certain other stations could be upgraded or new ones constructed in part. At such time as traffic volumes indicate, the dynamic sorting system can be added.

Currently there are several areas in the state where trucks can operate free of any weight, size, etc., surveillance other than that performed by mobile enforcement units with portable scales. There is a definite need for new weigh stations, as well as for upgrading existing ones. Since three Departments, i.e., Highways and Transportation, Commerce, and Management and Budget are involved, a suggestion is made wherein a job position is created for a person to: collect truck traffic volume data for various sections of the State's trunklines, study the effect of newly planned highways on commercial movements on existing ones, monitor existing weigh station and road patrol operations, keep posted on latest weighing techniques and equipment as offered by industry and utilized by various states, plan new stations, and program updating or major maintenance at existing stations. It is further suggested that such position be assigned to the Michigan Department of State Highways and Transportation. This individual could operate independently or work with a small committee having representation from Commerce and Management and Budget. In any event, it is necessary that some person or committee or organization of some type assume a responsibility directed toward effective planning and coordinating of input from the three separate State Departments.

One of the original concerns of the Committee, and an influencing factor in its creation, was the question regarding the cause of weighing problems at several weigh stations. The conclusion was reached that, whereas several factors were involved, each negatively contributing to the cause, some corrective action was in order. Numerous general recommendations are made for making scale building and area improvements of the existing facilities. Some are not easily attainable within the present system. However, a certain amount of pavement and drainage correction in the vicinity of the scales is recognized as necessary for nine stations amounting to $58,000 total. This work should be programmed as soon as feasible.

The Committee was also concerned about the increased use of air suspension axles. These devices are usually controlled from within the vehicle and are commonly raised when the truck is negotiating a turn. Evidence also indicates that some drivers lower the air axles only when passing over the scales. It is recommended that legislation be enacted to require controls to be located only on the exterior of the tractor. It is further recommended that trailers having covered loads be required to always have axles lowered.

REFERENCES

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"Weigh Station Designs - A Comparative Cost Analysis," Michigan State Highway Department, May 1959.

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"Fairbanks-Morse Electronic and Levetronic Axle Load Weighing Scales," Bulletin ED-10, Fairbanks-Morse Corp., Chicago, Illinois.

"WIM-1A Moving Vehicle Weighing System," Unitech, Inc., Austin, Texas.

"ELDEC The Only Weigh Scales," Eldec Corp., Lynnwood, Washington.

"Series 50 Wheelload Transducers," Toroid Corporation, Huntsville, Alabama.

APPENDICES

STATE OF MICHIGAN
DEPARTMENT OF STATE HIGHWAYS
UTILITIES – PERMITS DIVISION
TRANSPORT PERMIT SECTION

ALLOWABLE TRUCK LOADINGS AND DIMENSIONS

Destroy previous editions

T-1 (1/75)

REGULATIONS PERTAINING TO THE OPERATION OF TRUCKS AND TRAILERS ACCORDING TO ACT 300, P.A. 1949 AS AMENDED.

MAXIMUM OVERALL DIMENSIONS

Width . . . . . 96 inches
Height . . . . . 13 feet, 6 inches
Length of semi-trailer or trailer . . . . . No Restriction
Length of any other vehicle with or without load . . **(excluding impact absorbing bumpers)** . . . . . 40 feet
Units permitted in train . . . . . Truck, or tractor with semi-trailer, and 1 trailer
Length of any combination with or without load . . . . . 55 feet
Projection beyond front of vehicles . . . . . 3 feet
Overhang beyond rear of vehicles . . . Any amount is permissible if the legal overall length is not exceeded. But if this overhang is 4 feet or more, there shall be displayed on the extreme rear of such load a 12 inch red square flag in the daytime and a red light or lantern at night.
Axle Limitation . . . . . A combination of vehicles shall not have in excess of 11 axles.

EXCEPTIONS:

WIDTH: **Unprocessed Logs, Pulpwood, Wood Bolts and Concrete Pipe,** 104 inches for load only; **Busses,** 102 inches within incorporated cities or municipalities; **Farm Equipment,** if self propelled or towed along the highway, 186 inches between the hours of sunrise and sundown and 108 inches between the hours of sundown and sunrise, providing it does not extend across the center line of the highway.

LENGTH: **Truck-Tractor, Semitrailer and Trailer or Truck and Semitrailer or Trailer:** Any such combination of vehicles may exceed a total length of 55 feet, but shall not exceed a total length of 65 feet including load. Any such combination, except as herein described with regard to assembled motor vehicles or bodies or boats, may be operated only on such highways and routes as designated by the appropriate authorities.

Truck-Tractor and Trailer or Semitrailer, designed and used exclusively to transport assembled motor vehicles or bodies or boats: Any such combination of vehicles not to exceed a total length of 60 feet. The load on any such combination of vehicles may extend an additional 3 feet beyond the front and 4 feet beyond the rear thereof; total length of vehicles and load not to exceed 67 feet. Any combination exceeding 60 feet in length may be operated only on such highways and routes as designated by the appropriate authorities.

Truck-Tractor, Semitrailer and Trailer or Truck and Semitrailer or Trailer, designed and used exclusively to transport assembled motor vehicles or bodies or boats: Any such combination of vehicles not to exceed a total length of 65 feet. The load on any such combination of vehicles may extend an additional 3 feet beyond the front and 4 feet beyond the rear thereof; total length of vehicles and load not to exceed 72 feet. Any combination exceeding 60 feet in length may be operated only on such highways and routes as designated by the appropriate authorities.

Motor vehicles wholly or partially assembled transported by utilizing 1 tow bar or 3 saddle mounts with full mount mechanisms and using the motive power of 1 vehicle: Any such combination of vehicles may not exceed the maximum length of 65 feet. Any combination exceeding 55 feet in length may be operated only on such highways and routes as designated by appropriate authorities.

The total gross weight of any 65 foot combination of vehicles shall not exceed a ratio of 400 lbs. per engine net horsepower delivered to clutch or its' equivalent specified in the SAE test code.

MOBILE HOMES: 45 feet in body length, 60 feet when in combination with a towing unitl 8 feet, 4 inches in width, 12 feet, 6 inches in height.

TABLE OF MAXIMUM ALLOWABLE GROSS AXLE LOADINGS

Spacings Between Axles	Normal Loading When Limitations Are Not in Force (Speed Limit 50 MPH) (Freeway 60 MPH) †	Seasonal Load Limitations (Speed Limit 35 MPH)	
		Rigid	Flexible
9 feet or over	18,000 lbs.	13,500 lbs.	11,700 lbs.
More than 3½ feet but less than 9 feet	13,000 lbs.	9,750 lbs.	8,450 lbs.
When part of a tandem axle assembly	* 16,000 lbs.	** 12,000 lbs.	*** 10,400 lbs.
When less than 3½ feet the combined weight shall not exceed	18,000 lbs.	13,500 lbs.	11,700 lbs.
Maximum load on any wheel shall not exceed: (pounds per inch of tire width)	700 lbs.	525 lbs.	450 lbs.

† 'Freeway' defined: A divided arterial highway for through traffic with full control of access and with all crossroads separated in grade from pavements for through traffic.

* On any legal combination of vehicles, only one (1) tandem axle assembly shall be permitted at the gross weight of 16,000 lbs. per axle and no other tandem axle assembly in such combination of vehicles shall exceed a gross weight of 13,000 lbs. per axle. When the gross weight of a combination of vehicles with load, does not exceed 73,280 lbs., two (2) tandem axle assemblies shall be permitted at a gross weight of 16,000 lbs. per axle.

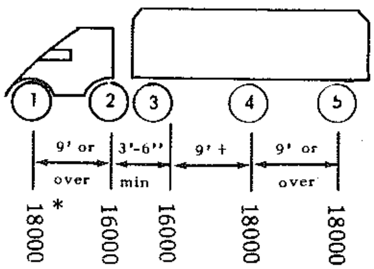
** On any legal combination of vehicles, only one (1) tandem axle assembly shall be permitted at the gross weight of 12,000 lbs. per axle and no other tandem axle assembly in such combination of vehicles shall exceed a gross weight of 9,750 lbs. per axle. When the gross weight of a combination of vehicles with load does not exceed 73,280 lbs., two (2) tandem axle assemblies shall be permitted at a gross weight of 12,000 lbs. per axle.

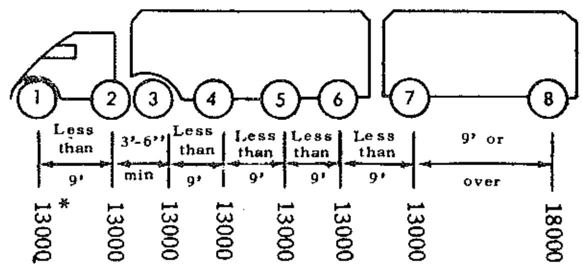
*** On any legal combination of vehicles, only one (1) tandem axle assembly shall be permitted at the gross weight of 10,400 lbs. per axle and no other tandem axle assembly in such combination of vehicles shall exceed a gross weight of 8,450 lbs. per axle. When the gross weight of a combination of vehicles with load does not exceed 73,280 lbs., two (2) tandem axle assemblies shall be permitted at a gross weight of 10,400 lbs. per axle.

The following examples are shown as a guide for figuring the maximum allowable gross axle loads on all State Trunklines during all periods of the year.

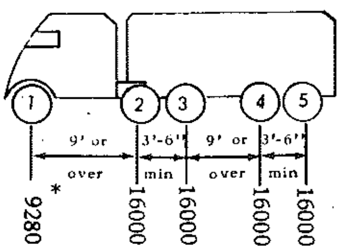
* MINIMUM TIRE REQUIREMENTS: The maximum load on any wheel shall not exceed 700 pounds per inch of tire width.

Illustrations of axle spacings:





Public Act #36, 1965



"When the maximum gross weight of a combination of vehicles with load does not exceed 73,280 pounds, 2 tandem axle assemblies shall be permitted at a gross permissible weight of 16,000 pounds for any such individual axle."

Other Tandem axles and Multi-axles

On any other combination of vehicles exceeding a gross weight of 73.280 lbs., only one (1) tandem axle assembly shall be permitted at this weight (16,000 pounds per axle). No other tandem axle assembly shall exceed 13,000 pounds per axle.

NOTE: When restricted loadings are in effect, the normal maximum axle weights allowable on rigid pavements shall be reduced 25%, and the maximum wheel load shall not exceed 525 pounds per inch width of tire.

When restricted loadings are in effect, the normal maximum axle weights allowable on flexible pavements shall be reduced 35%, and the maximum wheel load shall not exceed 450 pounds per inch width of tire.

SPECIAL PERMIT INFORMATION

Vehicles or the loads thereon which exceed the legal dimensions or weights as listed, require a Special Transportation Permit for travel. Special Transportation Permits are issued only for the occasional movement of oversize or overweight vehicles or loads which cannot be dismantled, reduced or otherwise rearranged to come within the legal limits. Application for Permits to be made on regular Department Application Form No. 2258 or by making application via Teletype, Telex or Western Union. No Overweight Permits are issued when weight restrictions are in effect.

NOTE: Vehicles exceeding legal size or weight when using the Mackinac Bridge, must contact the Bridge Authority in advance. Any load in excess of 72 tons requires certification of the Bridge Authority approval before a permit will be issued.

MAXIMUM TRUCK SPEED

No truck, tractor or tractor with trailer, or any combination of such vehicles with a gross weight, loaded or unloaded, in excess of 5,000 pounds, shall exceed a speed of 50 miles per hour on highways or streets or 60 miles per hour on freeways. Speed shall be reduced to 35 miles per hour where reduced loadings are being enforced during the period of seasonal weight restrictions.

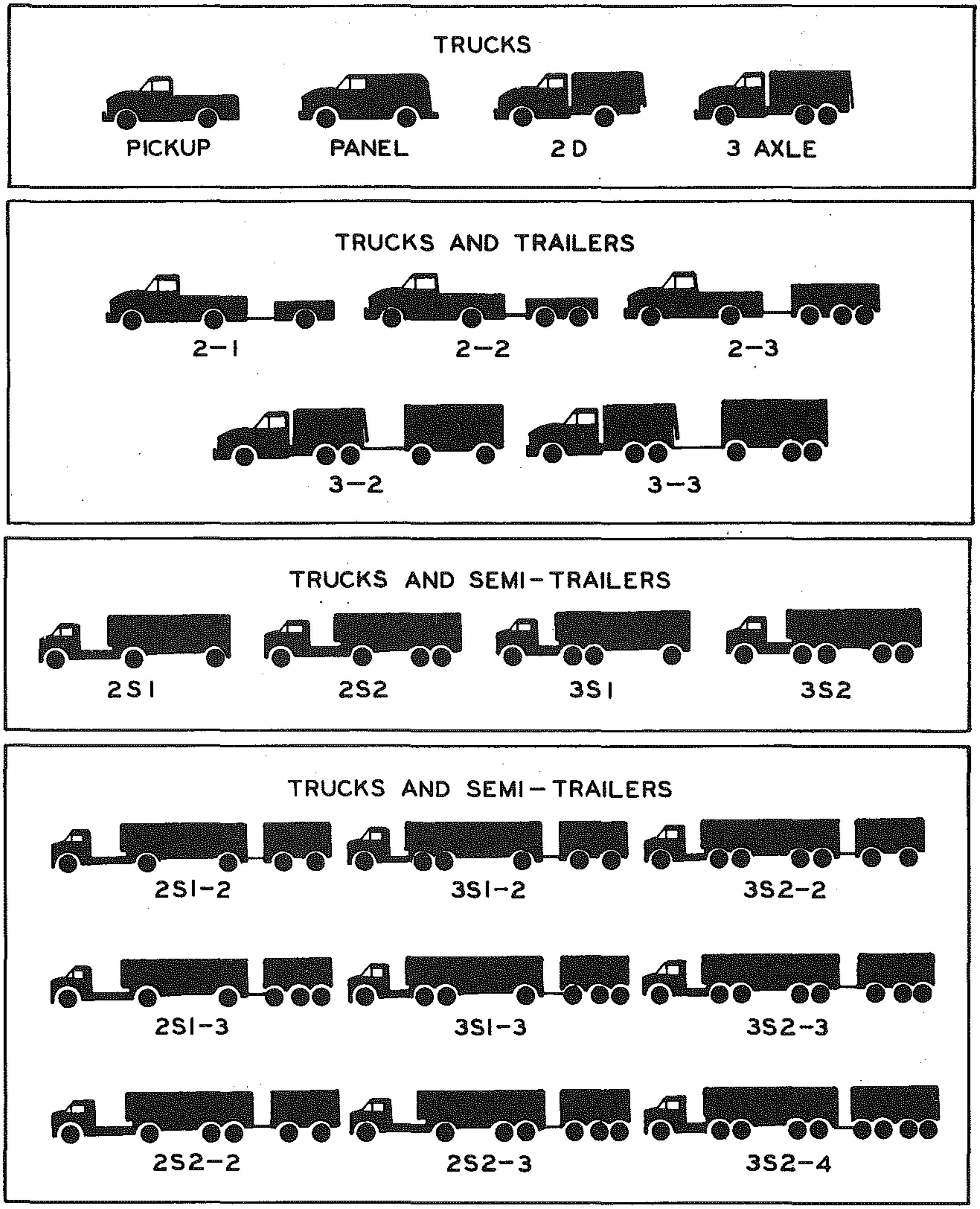


EXHIBIT B
TYPICAL COMMERCIAL VEHICLE TYPES IN MICHIGAN

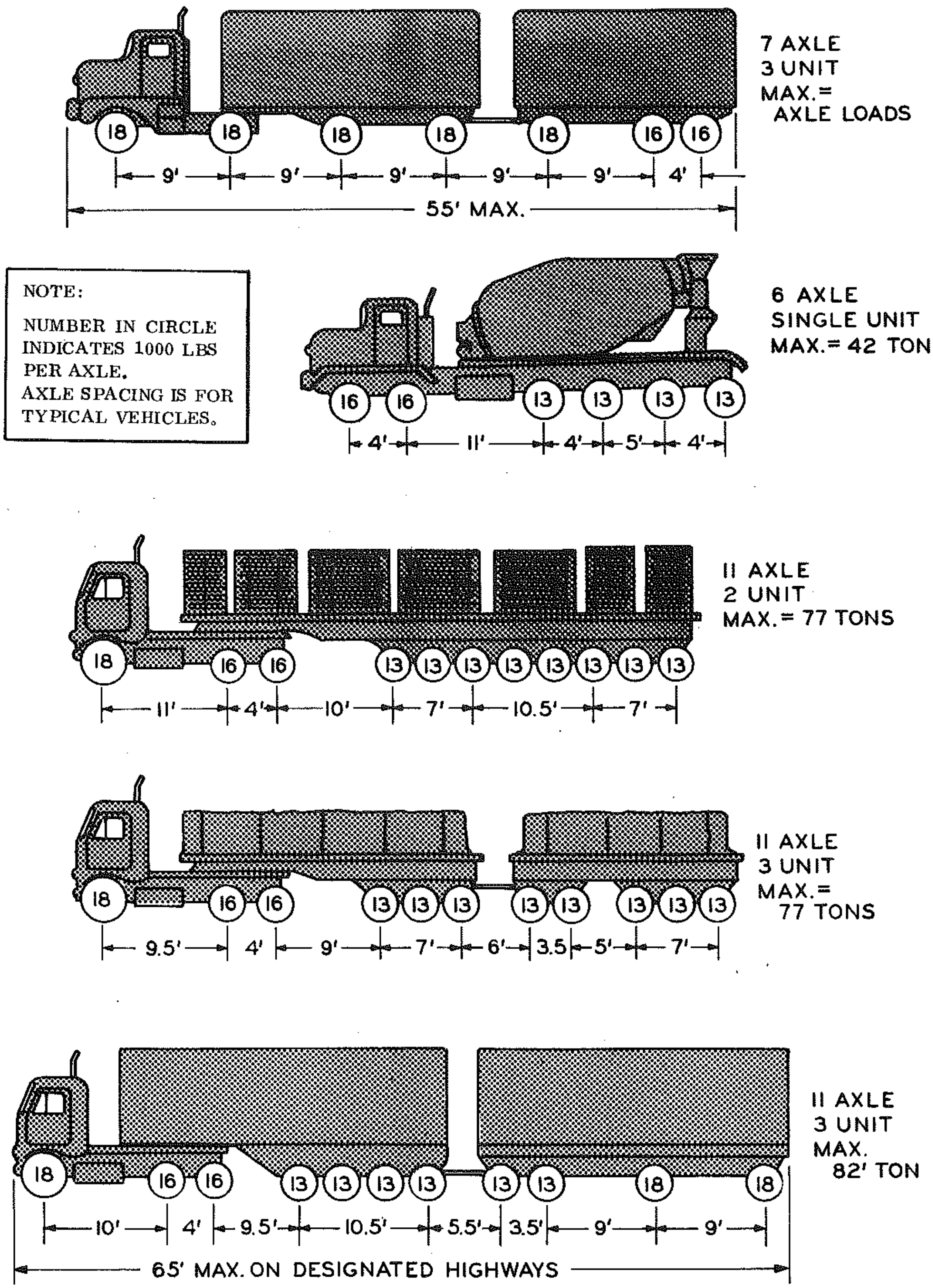


EXHIBIT B
MAXIMUM GROSS VEHICLE WEIGHTS IN MICHIGAN IN 1970

- C-1 -

STATE OF MICHIGAN
78TH LEGISLATURE
REGULAR SESSION OF 1975

Introduced by Reps. Maynard, Novak, Stevens, Keith, Holmes, Brown, Legel, Thaddeus C. Stopczynski and Spaniola

ENROLLED HOUSE BILL No. 5368

AN ACT to amend section 722 of Act No. 300 of the Public Acts of 1949, entitled as amended "An act to provide for the registration, titling, sale and transfer, and regulation of vehicles operated upon the public highways of this state; to provide for the licensing of vehicle dealers and wreckers; to provide for the examination, licensing and control of operators and chauffeurs; to provide for the giving of proof of financial responsibility and security by owners and operators of vehicles; to provide for the imposition, levy and collection of specific taxes on vehicles, and the levy and collection of sales and use taxes, license fees and permit fees; to provide for the regulation and use of streets and highways; to provide penalties for violation of any of the provisions of this act; to provide for civil liability of owners and operators of vehicles and service of process on nonresidents; and to repeal all other acts or parts of acts inconsistent herewith or contrary hereto," as amended by Act No. 348 of the Public Acts of 1974, being section 257.722 of the Compiled Laws of 1970.

The People of the State of Michigan enact:

Section 1. Section 722 of Act No. 300 of the Public Acts of 1949, as amended by Act No. 348 of the Public Acts of 1974, being section 257.722 of the Compiled Laws of 1970, is amended to read as follows:

Sec. 722. (a) The maximum axle load shall not exceed the number of pounds designated in the following provisions which prescribe the distance between axles:

(1) When the axle spacing is 9 feet or more between axles, the maximum axle load shall not exceed 18,000 pounds for vehicles equipped with high pressure pneumatic or balloon tires.

(2) When the axle spacing is less than 9 feet between 2 axles but more than 3-1/2 feet, the maximum axle load shall not exceed 13,000 pounds for high pressure pneumatic or balloon tires.

(3) When 2 axles are spaced less than 3-1/2 feet apart the combined weight thereof shall not exceed the maximum weights as specified for a single axle when spaced 9 feet or more apart.

(4) Subdivisions (1), (2), and (3) shall be known as the normal loading maximum.

(b) When normal loading is in effect the state highway commission and local authorities with respect to highways under their jurisdiction shall have the authority to designate certain highways, or sections thereof where bridges and road surfaces are adequate for heavier loading, which designation may be revised as needed, on which the maximum tandem axle assembly loading shall not exceed 16,000 pounds for any axle of the assembly.

(c) Except as provided in subsection (h), on any legal combination of vehicles, only 1 tandem axle assembly shall be permitted on such designated highways at the gross permissible weight of 16,000 pounds for any such axle and no other tandem axle assembly in such combination of vehicles shall exceed a gross weight of 13,000 pounds for any such axle. When the maximum gross weight of a combination of vehicles with load does not exceed 73,280 pounds, 2 tandem axle assemblies shall be permitted on such designated highways at a gross permissible weight of 16,000 pounds for any such axle.

(d) The normal size of tires shall be the rated size as published by the manufacturers and the maximum wheel load permissible for any wheel shall not exceed 700 pounds per inch of width of tire.

(e) During the months of March, April, and May in each year, the maximum axle load allowable on concrete pavements, or pavements with a concrete base, shall be reduced by 25% from the maximum axle loads as specified heretofore in this chapter, and the maximum axle loads allowable on all other types of roads during these months shall be reduced by 35% from the maximum axle loads as herein specified. The maximum wheel load shall not exceed 525 pounds per inch of tire width on concrete and concrete base or 450 pounds per inch of tire width on all other roads during the period the seasonal road restrictions are in effect.

(f) The state highway commission or county road commission, with respect to highways under their jurisdiction, may suspend the restrictions imposed by this section when and where in their discretion conditions of the highways or the public health, safety, and welfare so warrant and may impose the restricted loading requirements of this section on designated highways at any other time that the conditions of the highway may require.

(g) For the purpose of enforcement of this act, the gross vehicle weight of a single vehicle and load or a combination of vehicles and loads, shall be determined by weighing individual axles or groups of axles and the total weight on all the axles shall be the gross vehicle weight.

(h) The state highway commission, or a local authority with respect to highways under its jurisdiction, may designate a highway, or a section thereof, for the operation of vehicles which do not exceed any of the following:

(i) Twenty thousand pounds on any 1 axle.

(ii) A tandem axle weight of 34,000 pounds including all enforcement tolerances.

(iii) An overall gross weight on a group of 2 or more consecutive axles equaling:

$$W = 500 \left(\frac{LN}{N-1} + 12N + 36 \right)$$

where W = overall gross weight on a group of 2 or more consecutive axles to the nearest 500 pounds, L = distance in feet between the extreme of a group of 2 or more consecutive axles, and N = number of axles in the group under consideration; except that 2 consecutive sets of tandem axles may carry a gross load of 34,000 pounds each if the first and last axles of the consecutive sets of tandem axles are not less than 36 feet apart, and the gross vehicle weight does not exceed 80,000 pounds including all enforcement tolerances.

This act is ordered to take immediate effect.

Thos. Thatcher
Clerk of the House of Representatives.

Billie S. Farnum
Secretary of the Senate.

Approved ....

....
Governor.

EXHIBIT C
ACT 270 OF P.A. 1975 FOR MAXIMUM LEGAL AXLE LOADINGS

EXHIBIT D
5 DAY ACTIVITY RECORD - 15 WEIGH STATIONS
May 24-31, 1973

District	Scale - Location	Rate Units Per Hour	In Operation		Number Personnel Utilized	Total Units					Commercial Plate Inspection	Log Book Inspection	Driver License Inspection	Unauthorized Transportation	Total Units Vehicle Inspection	$20-10 Day Permits/Sold
			Days	Hours		Crossing Scales*	Actually Weighed	Overweight	Over Dimension	Sp. Trans. Permit						
1	Fowlerville - EB	41.1	4	32	1	1315	8	6	23	23	20	8	20	0	5	0
	Citations							1	3		0	0	0	0	0	
	Warning Notices							2	0		0	0	0	0	0	
	Verbal Warnings							3	3		0	0	0	0	1	
1	Fowlerville - WB	27.1	5	78	2	2110	81	32	51	52	30	35	45	2	36	2
	Citations							11	1		1	2	0	1	1	
	Warning Notices							7	0		1	0	0	0	2	
	Verbal Warnings							14	0		1	1	0	0	33	
2a	Erie - US 24	7.3	5	38	1	277	7	5	0	0	5	8	9	8	9	2
	Citations							3	0		2	0	0	0	0	
	Warning Notices							1	0		1	0	0	0	3	
	Verbal Warnings							1	0		1	1	0	0	4	
2a	Erie - I 75 NB	48.4	5	108	3	5226	31	16	16	16	12	39	56	29	20	17
	Citations							3	0		2	0	0	0	0	
	Warning Notices							6	0		0	2	0	0	2	
	Verbal Warnings							6	0		1	1	0	0	18	
2a	Erie - I 75 SB	85.1	5	44	2	3745	32	19	22	20	19	18	20	2	11	7
	Citations							2	0		1	0	1	0	0	
	Warning Notices							5	0		1	1	0	0	0	
	Verbal Warnings							5	0		0	1	0	0	0	
2b	New Baltimore - I 94 NB	17.8	5	72	2	1285	74	48	14	14	68	49	66	23	72	5
	Citations							3	1		1	0	0	1	0	
	Warning Notices							4	0		4	1	1	0	4	
	Verbal Warnings							40	3		8	10	0	0	68	
2b	Pontiac - I 75 SB	9.0	5	80	2	721	58	10	8	7	25	15	35	3	15	1
	Citations							1	1		0	1	0	0	0	
	Warning Notices							6	1		0	1	0	0	3	
	Verbal Warnings							3	0		1	0	0	0	5	
3	Birch Run - I 75 NB	55.9	5	59	2	3296	74	15	58	57	46	44	47	30	0	2
	Citations							6	2		5	0	1	0	0	
	Warning Notices							5	1		1	0	0	0	0	
	Verbal Warnings							4	1		15	2	0	0	0	
3	Birch Run - I 75 SB	41.3	5	53	2	2190	86	30	12	12	22	32	41	32	38	1
	Citations							4	0		0	1	1	0	2	
	Warning Notices							4	0		0	0	0	0	0	
	Verbal Warnings							10	0		0	3	0	0	36	
4	Cambridge Jct	17.7	5	80	2	1412	14	8	6	6	13	19	20	5	16	5
	Citations							1	1		0	0	1	1	0	
	Warning Notices							3	0		1	0	0	1	0	
	Verbal Warnings							0	0		0	0	0	0	11	
4	Grass Lake - I 94 EB	60.5	5	117	3	7079	47	18	67	60	77	80	81	4	65	14
	Citations							7	1		0	1	0	2	0	
	Warning Notices							6	2		1	6	0	0	9	
	Verbal Warnings							5	8		10	10	0	2	40	
4	Grass Lake - I 94 WB	71.5	5	62	2	4431	36	25	49	45	63	44	48	10	37	21
	Citations							5	2		0	0	0	3	2	
	Warning Notices							12	3		2	0	1	1	4	
	Verbal Warnings							8	3		9	15	0	4	30	
5	New Buffalo - I 94 NB	77.1	5	102	3	7862	23	21	28	28	79	61	76	3	60	30
	Citations							4	2		3	0	0	3	4	
	Warning Notices							7	0		4	3	1	0	27	
	Verbal Warnings							10	0		0	0	0	0	18	
6	Portland - I 96 WB	27.2	5	56	2	1524	27	7	16	15	12	14	35	6	30	1
	Citations							5	1		4	0	0	0	1	
	Warning Notices							1	1		1	0	0	0	0	
	Verbal Warnings							1	0		1	5	0	0	21	
6	Portland - I 96 EB	31.3	5	72	2	2251	21	16	15	10	39	34	46	1	26	2
	Citations							5	3		2	0	0	0	0	
	Warning Notices							5	0		0	0	0	0	2	
	Verbal Warnings							6	0		0	1	0	0	19	
	TOTAL			1053	31	44724	619	277	385	365	529	500	685	158	440	110
	Citations							61	18		21	5	4	11	10	
	Warning Notices							74	8		17	14	3	2	56	
	Verbal Warnings							116	18		47	50	0	6	304	

* Truck count taken only when motor carrier officer was not issuing citations or making inspections.

EXHIBIT E
QUESTIONNAIRE RESULTS OF MOTOR CARRIER OFFICERS

SCALE HOUSE BUILDING

1. Do you experience any trouble with:
   headlight glare? 51 yes; 18 no
   sun glare? 50 yes; 26 no
   light reflections? 40 yes; 29 no

   Comments: *inadequate lighting, signs instructing trucks to turn off lights, *slanted glass *heavier glass tint

2. Considering the attendant's work area:
   A. Is the size adequate? 67 yes; 8 no
   B. Is the general layout good for conducting necessary operations? 59 yes; 14 no

   Comments: Separate area for truck drivers *not enough office space in station; all office controls should be put in one space, would also solve space shortage.

   C. Is the counter and furniture adequate: 51 yes; 18 no

   Comments: Need newer and lower furniture

   D. Does the scale beam interfere with the operator's view of weighing operations? 42 yes; 34 no

      Explain: *scale beam needs to be lower

   E. Is the general layout of this area considering all the appurtenances installed within functional? 55 yes; 9 no
      Do you have any suggestions for improving it? longer & wider scale platforms for newer trucks with quad axles and wide spaced triple axle combs. Interior light dimmer switch.

   F. Please comment on the desirability, the suitability and the location of the following:
      Short wave radio Majority ok; 6 inadequate; 3 have none
      Operator's telephone *need longer cord; 3 have none
      Loud speaker system *not loud enough; cannot hear
      Traffic signal light *should be further from scales
      Pay telephone *needed outside; 9 needed
      Drinking fountain *unsafe water source; 14 needed
      Soft drink vending machine *30 desired

Coffee vending machine *would like one
Other Vendor machines discouraged because truckers may begin using weigh station as rest stop

3. Toilet-storage room:
   A. What items are being stored in this room? 45 cleaning supplies and misc. such as gasoline; 13 have none
   B. Considering the present dual purpose of this room, do you favor this room arrangement or do you think a separate toilet-lavatory room and a storage closet would be more functional: *desire separate rooms but have none

4. Should the building provide storage with outside access for such things as lawn mower, shovel, rake, hose? Yes-63; No-11 With larger scale house this wouldn't be required.

5. Office ??? room:
   A. What is this room used for? Supervise office 34 *have no office room
   B. Would such use be characteristic of all weigh stations, or only certain ones? Consider, especially, weigh houses being across the highway from each other? 10 yes; 5 no certain ones with only one weigh station

6. Basement:
   A. Assuming the heating unit is located here, what type of system is installed in your station: 71 oil, forced air; 2 natural gas
   B. Is the system adequate? 12 no; all others yes
   C. If an oil fired system is used, is the oil storage tank located in the basement? 3 no basement; all others yes
   D. Do you have water drainage problems in the basement? 54 yes; 13 no
   E. Is there a sump pump: 67 yes; 3 no
   F. In future weigh house design, if the scale platform (pit and basement floor) were placed at a higher elevation to lessen basement flooding possibility, do you think trucks would have any difficulty in negotiating a slight grade during the winter? Yes - 43; No - 32
   G. What is your water supply? Well - 69; Other - 5
   H. If pump, where is it located? Basement
   I. Is there a need for or is there a water softener at your station? Yes - 31; No - 31
   J. What sewage system is employed: Septic Tank - 66; City - 2; Cesspool - 2
   K. Is the basement used for purposes other than for access to scale pit, location of heating plant, water pump, fuel tank and sump pump? Is the basement used for any other purpose? Storage - sometimes floods

7. Stairway to basement:
   A. Is location good: Yes - 60; No - 13

   Comment: Outside entrance needed - Interior entrance needed Rear window should be included

   B. Is width adequate? Yes - 74; No - 0

   Comment: Too steep and narrow

8. Building general:
   A. Housekeeping chores are performed by? Attendant
      How much time is spent on such chores each day? 1/2 hour - 1-1/2 hour
   B. Building maintenance (i.e. painting, roofing, tuck pointing, etc.) is done by Bid Contractor - 39; Attendant - 9; Unknown - 31
   C. Repair work (i.e. plumbing, heating, electrical, radio, etc.) is done by Bid Contractor - 51; Attendant - 4; Unknown - 24
   D. Any comments regarding door locks for all doors and security in general? Not OK - 26; OK - 15; Unknown - 38; Better lighting needed - Possible steel door similar to State Police - Master keys needed for all scale houses.
   E. Any comments regarding ventilation or air conditions of building? Not OK - 38; OK - 13; Unknown - 28; Should be central air conditioning rather than window units - Air conditioning maintained annually
   F. Any comments regarding safety of the attendant? Not OK - 35; OK - 8; Unknown - 36; Heavier guardrails - escape door away from traffic - Shatter proof glass
   G. Any comments regarding unsatisfactory materials used in construction of the building, or of materials or design which you think should be considered in new designs? Not OK - 50; OK - 3; Unknown - 26; Should have rear window - All single design - tinted glass in main window - Larger building including a Driver's Room. Materials should be such as to require minimal maintenance.

Supervisor's Comments:

The officers in the building should have console-type work counters, both the weighing side and the visual inspection side. The P.A. microphone, radio microphone, typewriter, control switches for traffic signals, electronic digital read-outs for weights, light switches, and typewriter should be within easy reach of the duty officer.

The counter separating the drivers from the officers, should be designed similar to bank teller counters. Installed with dividers with a window-type opening for officers to do business with drivers, thereby dealing with only one driver at a time. This will expedite the processing of violations and limit confusion by having several drivers talking at one time.

SCALES

1. Scale platform:
   Do you think a manhole through the platform providing access to the scale pit is advantageous? Yes - 41; No - 26
   If so, why? Would be easier to clean and better access to scale pit
2. Scale pit:
   A. Is drainage satisfactory? Yes - 54; No - 10
   B. Does sump pump work satisfactorily? Yes - 45; No - 19
   C. Is size (vertical clearance) adequate for maintaining scale mechanism and platform support system as well as pit? Yes - 41; No - 26

   Comment: Should be deeper and larger for cleaning purposes and repair

   D. Would some kind of lighting be desirable in the pit area. Yes - 22; No - 52; Other - 36
   E. Who maintains the scale? Attendant - 17; Unknown - 27; Other - 14
   F. Who maintains the platform and its support system? Private Contractor - 38; Unknown - 27; Other - 14

Supervisor's Comments:

Electronic scale to separate loaded or near capacity loaded vehicles from empties or lightly loaded vehicles. Located immediately after entering lane leading to weigh station.

An electronic scale platform approximately 10' x 30', divided in 8 panels, capable of weighing separately and/or adding the weights for an accumulation as a gross weight.

A platform scale with eight panels would handle the maximum number of axles coupled together in tandem attached to a semi-trailer now traveling the highways in Michigan. This will enable each axle to be weighed separately, so that the weight of each individual axle is obtained. Thus there will be no dispute regarding the gross weight of a multi-axle unit as it is presently being done, due to the weighing of the axles in pairs, adding the pairs, and averaging out the weight as individual axle weight. The dispute comes about because the gross weight is obtained by adding the total weight obtained by adding the known weight of the equipment and load. The accumulation of weight is due to the coupling of the axles. The weight of the axles immediately prior to and after the axles on the platform is being transferred and added to the weight of the axles being weighed. The greater number of axles in the combination, the greater the difference in the gross weight.

The steering axle (#1 axle) and the two axles of the tandem assembly (#2 and #3 axles) could be weighed separately on three of the panels, thereby getting the individual axle weights on this combination of axles.

The 8 remaining axles on the semi-trailer could be placed on the 8 panels, thereby getting the individual axle weights on this combination of axles.

The axle spacing between the tractor's tandem axle assembly and the 8 axle combination on the semi-trailer is a great enough distance as not to cause a coupling problem.

All individual axle weights could be obtained on this type of scale and the gross weight could also be computed at the same time.

The combination described above (a truck-tractor and semi-trailer) with 11 axles is the unit with the maximum number of axles allowed (11), with the greatest number of axles (8) in one grouping. A scale with 8 panels that would accommodate this unit would suffice for all others.

APPROACHES

1. Is entrance lane of sufficient length for deceleration and storage? Yes - 52; No - 23
2. Is exit lane from the scale of sufficient length to permit needed acceleration? Yes - 66; No - 10
3. Do you think a "by-pass" lane, controllable by a traffic signal operated by the attendant would be desirable in handling traffic "line-ups?" Yes - 46; No - 30
4. In event a "by-pass" lane was available, from an operational standpoint do you think the "cut-over" connection should be located relatively close to the scale or several hundred feet "upstream" of the scale? Upstream - 38; Close - 16

Supervisor's Comments:

Both sides of weigh station to have several sections of pavement strongly anchored and firmly constructed as to remain level with the volume of heavy truck traffic. Pavement must be level on either side of scale platform for weighing purposes.

WEIGH STATION LAYOUT

1. From an operation standpoint, do you think the scale house is positioned in the best location relative to:
   the highway? Yes - 59; No - 13
   the approaches? Yes - 56; No - 16
   the parking area? Yes - 53; No - 18

   Comments: Approaches too short and too sharp of turns (probably older stations); Location visable more in advance by truckers; Layout in general too small (probably older stations)

2. Are the presently designed scale houses oriented such as to afford the attendant the best view of his total operations? Yes - 23; No - 45

   Comments: No views of parking areas from scales; Very badly wanted by all officers

3. Should provision be made in the overall layout of the complex to allow a driver who "overshot" the entrance ramp to double back via a secondary low speed turn-off and proceed to the approach lane, for example, through the parking area? Yes - 49; No - 25

   Comments: If properly designed and signed this is not needed and possible emergency exit further downstream would eliminate dangerous backing on freeway; Would only confuse truckers and other vehicles.

Supervisor's Comments:

Two ribbons of pavement at location of overhead signs, one leading to scale side, the other leading to opposite side to conduct other visual inspections.

An inspection pit should be provided to allow easier inspection of the underbody of the vehicles.

PARKING AREA

1. Is parking area so located as to provide the most convenient work operation? Yes - 67; No - 8

   Comments: Scalehouse should have rear window to observe parking area, possible area to park impounded vehicles

2. Is size of area adequate? Yes - 55; No - 18
3. Is access to and from the area adequate? Yes - 66; No - 8 Larger radius needed for easier access to and from area
4. As an average, how many units are safety inspected each day? Approximately 6 - 10 per shift
5. Do vehicles, following a safety check, leave the parking area by way of the approach ramp and again pass over the scales? Yes - 67; No - 4
6. If answer to 5 is yes, do you think that provisions should be made to allow them to exit without being further delayed?

   Comments: Yes - 16; No - 51 Delay is generally minimal and many units must be reweighed. Original design should be such as to provide NO delay

7. Is lighting of parking area adequate? Yes - 23; No - 54
8. Is drainage of parking area adequate? Yes - 68; No - 3
9. Would it be advantageous to the operation for the attendant to have a parking space for his car located off the exit ramp and near the weigh house? Yes - 63; No - 2

TRAFFIC CONTROL & SIGNING

1. What type of traffic control sign do you suggest for indicating scales are open and trucks should pass over?
   A. Electric lights behind block lettering. 34
   B. Neon lettering. 14
   C. Painted lettering, manually changed. 0
   D. Painted lettering, electronically changed. 18
2. What lettering should be on the sign?
   "Pass Over" and "By-Pass" 10
   "Open" and "Closed" 59
3. Should there be an announcement sign at some point considerably in advance of the Pass Over sign that will advise truckers of the scale they are approaching? Yes - 67; No - 3
4. Are the approaches including the turns to and from the parking area adequately signed? Yes - 54; No - 17
   Suggest: Additional signs needed
5. Is the traffic signal for the tractor-unit being weighed positioned at the most effective location? Yes - 14; No - 59

Comments: Should be moved further back to facilitate viewing todays longer units

6. Is the loud speaker a satisfactory means of "talking" to the drivers? Yes - 49; No -22
7. Is the loud speaker positioned at the most effective location? Yes - 11; No - 56

Comments: Should be series of speakers to accommodate movement of vehicles.

Supervisor's Comments:

Sufficient signs on highway in advance of weigh stations directing trucks to truck traffic lane. To channel truck traffic away from passenger vehicle traffic. To avoid trucks crossing lanes to enter scale area.

A sign installed prior to weigh station and prior to "Open" and "Closed" sign, directing all trucks to cross scales, X amount of feet ahead. Needed to back up 'By-Passing Scale" violations.

Electrically operated and lighted "Open" and "Closed" sign prior to scale entrance.

A lighted entrance sign at entrance lane leading from highway to weigh station. Entrances are rather dark at nighttime and trucks do unintentionally by-pass the entrance.

Overhead signs directing loaded vehicles to scale side of inspection or weigh station. Empties or lightly loaded vehicles to opposite side of station for visual inspection.

On each side of station should be traffic control signals operated by officers in the building. They should be located to accommodate the view of drivers of 65' units.

Loud speakers of the P.A. System should be the marine weather-proof type. At least two on each side of building. One close to building to accommodate the shorter vehicles and one some distance beyond the scale platform to accommodate the 65' long combinations. Also, one back to summon drivers.

LIGHTING

1. Are the approaches adequately lighted? Yes - 21; No - 55

2. Should there be special lighting near the weigh house illuminating the axles of the approaching unit? Yes - 72; No - 1

Supervisor's Comments:

The pavement immediately prior to and after the scale platform, as well as the scale platform should be lighted in a manner to cast light on the axles as well as the body of the unit crossing the scale. This would enable the officers to readily determine the axle spacing during hours of darkness.

The parking area should be well lighted.

GENERAL

1. Who performs the seasonal maintenance of the area? (grass mowing, snow plowing, light bulb replacement, etc.) Officer, County Road Commission; Department of State Highways
2. A standard design guide for Weigh Stations VII-510 as presently used by the Department of State Highways and Transportation is attached for your information. Considering this guide and your familiarity with the actual operation of a weigh station, do you have any additional comments regarding the effectiveness of the present system or recommendations for change? Additional lighting - better drainage in scale pit area - longer and straighter approaches - scale house further from roadway - larger scale house - more protection of scale house from vehicles
3. Please comment on the desirability of maintaining a 24-hour daily operation of the weigh stations. Not OK - 25; OK - 42; Unknown - 12 Depends on the amount of truck traffic - Occasional spot checking in "light" shifts. Would eliminate much of the present vandalism - Would require additional personnel.
4. Please comment on the desirability of having two operators on duty full time: OK - 37; Not OK - 31; Unknown - 11 Two men would provide additional security - Depends on location - Would aid in inspection and weighing - Certain shifts require it.

OTHER COMMENTS:

Other than the public rest area, the State Scale Houses represent the only other governmental agency the traveling public comes in contact with on the road. Thus an attractive, clean and efficient operation should be on display (i.e. landscaped area, flag poles for Federal and State flags, Department of Commerce identification signs, outside pay phones). Outside Mercury lighting would make a safer, brighter area for anyone stopping for any reason.

EXHIBIT F

PROPOSED BUILDING OF WEIGH STATIONS

MICHIGAN

PUBLIC SERVICE COMMISSION

INTEROFFICE COMMUNICATION

To: Donald C. Rush - Programing Section
Department of State Highways

From: Paschal Turner, Chief
Enforcement Section

Subject: Proposed Building of Weigh Stations

With reference to my meeting with Mr. Brunke on January 23, 1974, concerning the proposed building of weigh stations north and southbound I-69 and southbound I-94, the following comments are submitted for your consideration.

It is my understanding that no problem exists to justify the north (inbound) weigh station but the south (outbound) weigh stations must have more justification than that of the enforcement on size and weight requirements. Before getting into the other purposes for which such facilities are utilized, it is believed that if the south (outbound) scales were used only to enforce size and weight requirements, this alone would be justification enough to support the building of a weigh station.

A quick look at the state map, one can readily come to the conclusion that a vehicle may overload, and leave the state from any point without passing over an inspection station, thereby encouraging the overloading of vehicles. An overloaded vehicle, or combination of vehicles, is unsafe, as well as damaging to the highway. Because the vehicle is outbound, this does not change the fact that it is unsafe and damaging to the highway system.

I suppose the logic used is that such vehicle is leaving the state so let someone else have the problem. This logic, however, is unreasonable. For example, a vehicle could overload in the Upper Peninsula resulting in an unsafe operation, as well as, damaging to the highways, and travel approximately 500 miles on Michigan highways before leaving the state without being subject to inspection.

If a driver, or company, knew that the vehicle would have to pass over a weigh or inspection station, this would be a deterent to properly load the vehicle, thereby resulting in a safer operation and longer highway life with less maintenance. Weigh stations in Michigan are used for other than size and weight enforcement. They are inspection points used by Federal agencies because of the safety factor involved. It is much safer to check vehicles at the weigh stations rather than on the highway which is always a dangerous situation.

This department checks vehicles at scale locations for (1) to determine the safe condition of vehicles and load; (2) that vehicles are equipped with proper warning devices; (3) driver qualifications, etc.; (4) that the carriers have the required permits; (5) that the vehicles are in compliance with, and operating according to various reciprocal agreements; (6) vehicles are checked for compliance with the U.S. Department of Transportation, Bureau of Motor Carrier Safety regulations; (7) vehicles are checked for compliance with the Interstate Commerce Commission economic regulations; (this department has entered into a cooperative agreement with both the DOT and ICC); (8) weigh stations are equipped with two-way radios and are oftentimes used to summon aid in case of accidents and to aid stranded motorists; (9) used to check vehicles for compliance with the requirements of the Michigan Vehicle Code, including commercial registration plates; and (10) the facilities are included as part of our Civil Defense program.

Federal departments using our facilities are the U.S. Department of Transportation, Bureau of Motor Carrier Safety (checking compliance of vehicle and driver safety requirements); the Interstate Commerce Commission (checking compliance of economic regulations); U.S. and state agriculture departments (livestock, food and horticultural product inspections); various motor carrier organizations (Michigan Trucking Association, National Automobile Transporters Association, insurance agencies, etc.); and the National Guard (re-fueling convoy units and break stops).

If this information is not sufficient or if you have any questions, please feel free to call me.

PT/mw

EXHIBIT G

WEIGH STATION MANPOWER NEEDS

MICHIGAN
PUBLIC SERVICE COMMISSION

To: Cornell Beukema - Design Division
Department of State Highways

Date: 2-10-75

From: Paschal Turner - Chief of Enforcement
Michigan Public Service Commission

Subject: MANPOWER NEEDS FOR 24-HOUR, 7-DAY OPERATION

The number of officers required for all districts for a 24-hour, 7-day operation would be determined by the following criteria:

1. At scale locations where vehicles passing over the scales exceeds 500 per 24 hours, two officers per scale location.

2. Road Patrol - 1 officer per shift for day shift, 2 for afternoon, and 2 for midnights.

   If a district requires more than 1 patrol per shift, the number of road patrols would be increased by the number of areas within the district times the number of required officers.

3. One officer or more, depending on complaint requirements.

4. Relief personnel to fill in on vacation and sick leave.

5. Other positions necessary for 24-hour, 7-day operations.

6. Scale locations and area covered by road patrol units.

PT/kw

DEPARTMENT OF

ATTORNEY GENERAL

MEMORANDUM

September 4, 1974

TO John P. Woodford
Director

FROM Louis J. Caruso
Assistant Attorney General

Our File #74-36-2

Re: Electronic Weighing Devices

In response to your inquiry of August 26, 1974, concerning the captioned matter, we advise as follows:

MCLA 257.724(a), provides in pertinent part:

> ". . . may require the driver to stop and submit to a weighing of the same by means of either portable or stationary scales approved and sealed by the state department of agriculture as a legal weighing device. . ." (emphasis added)

Based upon this statutory language the question then becomes, what is a legal weighing device?

MCLA 290.602, § 2(a), defines weights and measures as follows:

> "(a) 'Weights and measures' mean weights and measures of every kind, instruments and devices for weighing and measuring, . . ."

Therefore it would be my opinion that the Department of Agriculture should be consulted to determine if the proposed devices can be sealed as legal weighing devices. In that MCLA 257.724(a) only requires a sealed legal weighing device, I can find no statutory language expressly requiring mechanical weighing devices.

Louis J. Caruso

EXHIBIT H
LEGALITY OF ELECTRONIC WEIGHING DEVICES

OFFICE MEMORANDUM

DATE: December 19, 1974

TO: Ad Hoc Committee on Construction and Reconstruction of Weigh Stations

FROM: P. Milliman

SUBJECT: Application of "Approved and Sealed" by Department of Agriculture in Compliance with MCLA 257.724(a).

The following information was obtained from Mr. John F. Hartzell, General Supervisor, Food Inspection Division, Department of Agriculture. (This is the Agriculture Division which deals with weights and measures.)

Approval and sealing of our electronic scales will consist of:

1. Application of test weights to appropriate maximums, in 2,000 lb increments.

2. Certification of each 2,000 lb increment.

3. Mounting of the Department's standard gold colored seal (paper) at some conspicuous location on the system's controls. This seal certifies the scales accuracy and gives the inspectors name, and the date (this is not a security seal).

Mr. Hartzell assured me that they would not apply any type of security seal which might inhibit the use of electronic balance or sensitivity controls. Application of this type of certification, however, places full responsibility on our Department for the maintenance and continuing accuracy of the system.

It appears therefore, that neither inspection, certification or sealing should be a problem in the operation of electronic scales.

TESTING AND RESEARCH DIVISION

Supervising Engineer of Physical
Research Unit

PM:bf

EXHIBIT I
DEPARTMENT OF AGRICULTURE APPROVAL OF ELECTRONIC WEIGHING

EXHIBIT J

U. S. Public Law 93-643
(Sections 106 and 107; January 4, 1975)

VEHICLE SIZES AND WEIGHTS

SEC. 106. (a) Section 127 of title 23, United States Code, is amended by striking out "eighteen thousand pounds carried on any one axle, or with a tandem-axle weight in excess of thirty-two thousand pounds, or with an overall gross weight in excess of seventy-three thousand two hundred and eighty pounds," and inserting in lieu thereof the following: "twenty thousand pounds carried on any one axle, including all enforcement tolerances; or with a tandem axle weight in excess of thirty-four thousand pounds, including all enforcement tolerances; or with an overall gross weight on a group of two or more consecutive axles produced by application of the following formula:

$$W = 500 \left(\frac{LN}{N - 1} + 12N + 36\right)$$

where W = overall gross weight on any group of two or more consecutive axles to the nearest 500 pounds, L = distance in feet between the extreme of any group of two or more consecutive axles, and N = number of axles in group under consideration, except that two consecutive sets of tandem axles may carry a gross load of 34,000 pounds each providing the overall distance between the first and last axles of such consecutive sets of tandem axles is thirty-six feet or more: Provided, That such overall gross weight may not exceed eighty thousand pounds, including all enforcement tolerances,".

(b) The first sentence of section 127 of title 23, United States Code, is amended by inserting immediately after "July 1, 1956," the following: "except in the case of the overall gross weight of any group of two or more consecutive axles, on the date of enactment of the Federal-Aid Highway Amendments of 1974,". The third sentence of such section is amended by striking out the period at the end thereof and inserting in lieu thereof a comma and the following: "except in the case of the overall gross weight of any group of two or more consecutive axles, on the date of enactment of the Federal-Aid Highway Amendments of 1974.".

ENFORCEMENT

SEC. 107. (a) Chapter 1 of title 23 of the United States Code is amended by inserting after section 140 the following new section:

" §141. Enforcement of requirements

"Each State shall certify to the Secretary before January 1 of each year that it is enforcing all State laws respecting maximum vehicle size and weights permitted on the Federal-aid primary, the Federal-aid urban system and the Federal-aid secondary system, including the Interstate System in accordance with section 127 of this title, and all speed limits on public highways in accordance with section 154 of this title. The Secretary shall not approve any project under section 106 of this title in any State which has failed to certify in accordance with this section.".

U. S. DEPARTMENT OF TRANSPORTATION

FEDERAL HIGHWAY ADMINISTRATION

FEDERAL-AID HIGHWAY PROGRAM MANUAL

VOLUME	4	PLANNING
CHAPTER	1	PROGRAM MANAGEMENT AND COORDINATION
SECTION	4	TRUCK WEIGHING STATIONS

Transmittal 131
April 21, 1975
HHP-11

1. PURPOSE

* *The purpose of this directive is to set forth policies and procedures for Federal-aid participation in the cost of providing truck weighing stations on the Federal-aid highway systems.*

2. AUTHORITY

23 U.S.C. 307(c).

3. GENERAL CONSIDERATIONS

a. When determining the number and location of weighing stations, consideration should be given to those that will be needed on a statewide basis for planning and research purposes, for enforcement purposes, and for combined planning, research and enforcement purposes. For planning and research purposes, data are needed for traffic in both directions; therefore, on expressways or freeways the number of weighing stations should be based on complete stations, i.e., a pair of one-way weighing stations. These need not necessarily be opposite each other but the two one-way weighing stations should be located at favorable sites sufficiently close to each other to provide two-way data.

b. When determining the location of weighing stations every effort should be made to achieve coordination between States in the location and operation of weighing stations at or near their common borders to avoid possible duplication of effort and unnecessary delay and inconvenience to truck operations. In approving Federal participation in any such installation,

*Regulatory material is italicized

the Federal Highway Administration (FHWA) Division Engineer should ascertain that such coordination has been effected to the maximum extent feasible.

c. The scale house and facilities of a weighing station should be in keeping with the design standards of the highway system upon which it is located. The scale house should be neat, attractive, and should be constructed of material that can be maintained in such manner that the building will not constitute an "eyesore" to the traveling public.

4. DETERMINATION OF FEDERAL-AID PARTICIPATION

a. Use of Federal-aid Construction Funds

(1) *Federal-aid highway construction funds may participate in the components of weighing stations which can be classed as falling within the definition of the terms "highway" and "construction" as established in 23 U.S.C. 101.* Such components include: reasonable additional right-of-way width for the weighing stations; access lanes (including deceleration and acceleration lanes); vehicle standing and storage areas; and the surfacing and lighting of these access lanes and storage areas. *Federal-aid highway construction funds may not participate in the cost of the components of truck weighing stations provided for State enforcement purposes only, except for a minimum number of such stations on the Interstate System. Since the scale housing and its service facilities, scale pit and scale, and the installation of these components cannot be classed as falling within the definition of the terms "highway" and "construction," their cost is not eligible for participation from Federal-aid highway construction funds.*

(2) *Federal-aid highway construction funds may participate in the cost of the highway construction portion of a truck weighing station provided for enforcement purposes on the Interstate System under the following conditions:*

(a) *The number of complete weighing stations either for enforcement purposes, for planning and research purposes, or both, should not exceed an average of one complete station per 100 miles of Interstate highway (exclusive of toll highways), except that there may be at least three but not more than 15 complete stations in any one State. A greater number of stations may be allowed by the FHWA if the State presents sufficient justification.*

(b) *Each weighing station must be justified as to necessity at that location and agreement made as to an annual operating schedule to warrant its construction.*

(c) *If requested by the State, data obtained must be made available as supplementary research information.*

(3) *Additional weighing stations for enforcement purposes may be approved as nonparticipating work provided the location and design of each are acceptable to the FHWA Division Engineer.*

b. Use of Highway Planning and Research Funds

(1) *Federal-aid highway planning and research funds may not participate in any component of a scale or scale house needed for enforcement only. For those stations which will be operated for planning and research or for combined planning, research and enforcement, the highway planning and research funds authorized by 23 U.S.C. 307(c) may participate in the cost of the purchase and installation of the scale, scale pit, and scale house.*

(2) *As a minimum, a scale with a platform capable of accommodating dual axles is required for planning and research purposes. However, this does not preclude the use of a scale having a larger platform or a combination of*

platforms if the State prefers such types. The manufacture and installation of the scale must conform to appropriate specifications, performance requirements, tolerances, and structural requirements. Reference to those specifications is contained in Appendices A, B, and C to Volume 4, Chapter III of the Highway Planning Program Manual.

(3) *A State planning to utilize highway planning and research funds in the installation or construction of components of weighing stations should submit a map or other description, showing the location of all weighing stations intended to be used for obtaining weight data for highway planning and research purposes, together with an outline of the planned schedule of operations of these stations for such purposes.*

c. Limits of Highway Planning and Research Fund Participation

(1) *The maximum facility in which Federal-aid highway planning and research funds may participate is a one-story building, providing not more than 300 square feet of space, housing the scale dials and other weight recording equipment, and providing sufficient space for operating personnel to function properly.*

(2) *The following supplement facilities are eligible for highway planning and research fund participation:*

(a) *Proper electrical supply connections.*

(b) *Lavatory and toilet facilities within the scale house, together with necessary septic system (or connection to available sewer line).*

(c) *Space heater.*

(d) *Air conditioning facilities which are needed and customarily used in local area business.*

(e) *Well and home type electric water supply pump and tank for places not having other adequate sources of water supply. Where two weighing installations are directly opposite each other, a single well and pump installation with a supply line connecting the two is considered adequate for the two installations.*

(f) *Landscaping as necessary to fit into the surroundings.*

(g) *Adequate drainage for the scale pit. While gravity tile is preferred, an automatically controlled electric sump pump may be used where necessary.*

(3) *When the State intends to construct a scale house that is larger or has more facilities than are reasonable and appropriate for conducting planning and research operations, Federal highway planning and research funds may participate in a pro-rata share of providing the facilities specified in subparagraphs 4c(1) and (2). The Federal share shall be determined by the FHWA Division Engineer on the basis of the pro-rata cost of the limited facility to the total cost of the proposed facility.* The FHWA Division Engineer shall make his determination before he authorizes the State to proceed with construction of the scale house.

EXHIBIT L

TRANSFER OF WEIGH STATION RESPONSIBILITIES TO DEPARTMENT OF COMMERCE
(Michigan P.A. 77, 1968)

SEC. 238. THE POWERS, DUTIES AND FUNCTIONS OF THE DEPARTMENT OF STATE HIGHWAYS ADMINISTERED BY THE WEIGH-MASTER SECTION, RELATING TO THE ADMINISTRATION AND ENFORCEMENT OF THE SIZE, WEIGHT AND LOAD OF VEHICLES PROVISIONS OF ACT NO. 300 OF THE PUBLIC ACTS OF 1949, AS AMENDED, BEING SECTIONS 257.1 TO 257.923 OF THE COMPILED LAWS OF 1948, WITH THE EXCEPTION OF SECTIONS 719A, 722F, 725 AND 725A, ARE TRANSFERRED TO THE PUBLIC SERVICE COMMISSION OF THE DEPARTMENT OF COMMERCE.

SEC. 239. THE POWERS, DUTIES AND FUNCTIONS OF THE SECRETARY OF STATE AND THE DEPARTMENT OF STATE RELATING TO THE REGULATION OF COMMERCIAL VEHICLES, OTHER THAN TITLING AND REGISTRATION, UNDER THE PROVISIONS OF ACT NO. 300 OF THE PUBLIC ACTS OF 1949, AS AMENDED, ARE TRANSFERRED TO THE PUBLIC SERVICE COMMISSION OF THE DEPARTMENT OF COMMERCE.

SEC. 240. THE POWERS, DUTIES AND FUNCTIONS TRANSFERRED TO THE DEPARTMENT OF COMMERCE IN SECTIONS 238 AND 239 OF THIS ACT SHALL BE TRANSFERRED EFFECTIVE JULY 1, 1968. ALL RECORDS, PROPERTY, PERSONNEL AND APPROPRIATIONS USED, HELD, EMPLOYED, AVAILABLE OR TO BE MADE AVAILABLE IN CONNECTION WITH SUCH POWERS, DUTIES AND FUNCTIONS SHALL BE TRANSFERRED TO THE DEPARTMENT OF COMMERCE.

DEPARTMENT OF

ATTORNEY GENERAL

MEMORANDUM

February 14, 1974

TO: John P. Woodford
Director

FROM: Louis J. Caruso
Assistant Attorney General

Our File #74-36-1

Re: Weigh Stations

By memorandum dated February 8, 1974, you state that the Department of State Highways and Transportation is currently planning construction of weigh stations at several strategic locations on the interstate highway system.

You also indicate in your memorandum your awareness of 1968 PA 77, MCLA 16.338, which transferred the functions of the then Department of State Highways concerning the administration and enforcement of the size, weight and load of motor vehicle restrictions under 1949 PA 300, MCLA 257.1, to the Michigan Department of Commerce, Public Service Commission.

Section 240 of 1968 PA 77, MCLA 16.340, set July 1, 1968, as the effective date for the transfer of such powers and duties. It is also provided therein that the records, property, personnel and appropriations used, held or employed be available to the Department of Commerce for use in connection with the weighmaster activities.

You indicate in your memorandum that the Department of Commerce does not have any moneys available in its budget to match federal aid funds for the construction of the proposed new weigh stations on the interstate system. You ask whether it is proper for the Michigan Department of State Highways and Transportation to use motor vehicle highway funds to match available federal aid highway funds for the purposes of constructing such weigh stations.

Title 23 USC, §116, mandates the various department of state highways to have a maintenance program with respect to interstate highways. Section 127 of Title 23 USC expresses

EXHIBIT M

CONSTRUCTION OF NEW WEIGH STATIONS ON INTERSTATE HIGHWAYS certain limitations with respect to weight and width of motor vehicles using the interstate system. These are conditions to be met to obtain federal funds for highway projects.

The Michigan Federal Aid Highway Act, 1917 PA 99, MCLA 249.1, provides for legislative assent to federal aid for federal highway construction projects. Reference is made to the federal aid act of 1916, being 39 Stat 355. The Michigan act provides that the State Treasurer is authorized to receive moneys from the Federal Government and disburse same under orders of the Auditor General issued upon orders of the state highway commissioner.

> "'The legislature of the state of Michigan hereby assents to the provisions of the act of congress approved July 11, 1916, (39 Statutes laws 355), entitled "An act to provide that the United States shall aid the states in the construction of rural post roads, and for other purposes," and the good faith of the state is hereby pledged under the provisions of this act to make available from time to time sufficient funds to pay the state's portion of the cost of constructing and maintaining federal aided roads. The state highway department of Michigan through the state highway commissioner is hereby authorized to make surveys, prepare plans and specifications and take charge of the building and maintaining of federal aided roads in accordance with the provisions of the aforesaid act of congress and rules and regulations of the secretary of agriculture made thereunder and such amendments thereto as may from time to time be made. The state highway commissioner is further authorized to enter into all contracts and agreements with the United States government relating to the construction and maintenance of rural post roads under the provisions of the said act of congress, to submit such scheme or program of construction and maintenance as may be required by the secretary of agriculture, and do all other things necessary fully to carry out the cooperation contemplated and provided for by the said act. The state treasurer

> is hereby authorized to receive any and all moneys due the state of Michigan under the provisions of this act, and shall pay out the same under the orders of the auditor general which shall be issued by said auditor general upon orders of the state highway commissioner.'"

The powers, duties and functions of the Auditor General have been transferred to the Department of Treasury by the Executive Organization Act, Act 380 of 1965, as amended, MCLA 16.182.

The present-day federal highway act consists of amendments and supplements to the Federal Aid Act of 1916. The Attorney General by OAG No. 2947, 1957, concluded that the Michigan legislature by assent to provisions of the act of Congress of July 11, 1916, authorized the state highway commissioner to perform all acts necessary to receive federal funds for construction, maintenance and construction of federal aid roads.

The Michigan legislature by Act 286 of 1964, Section 7(m), MCLA 247.807(m), has authorized the Michigan State Highway Commission

> "to do anything necessary and proper to comply fully with the provisions of present or future federal aid acts."

In view of these provisions of law, it is patent that the legislature did not intend by the enactment of 1968 PA 77 to impede the Department of State Highways and Transportation from complying with federal aid acts necessary for the construction, reconstruction and maintenance of the interstate highway system, There being nothing contained in 1968 PA 77, supra, prohibiting the expenditures of motor vehicle highway funds for the purposes of matching federal aid highway funds for the construction of weigh stations, you are advised that the Michigan Department of State Highways and Transportation is authorized to construct such weigh stations on the interstate system for the purposes of complying with federal aid requirements. However, 1968 PA 77, supra, places the use of such weigh stations for the purposes of the administration and enforcement of the size, weight and load of motor vehicle provisions of 1949 PA 300, supra, under the control of the Department of Commerce, Michigan Public Service Commission.

Louis J. Caruso

LJC:sk

EXHIBIT N

RESPONSIBILITY FOR RELOCATING WEIGH STATIONS

October 15, 1968

To: J. P. Woodford
Deputy Director

From: Louis J. Caruso
Assistant Attorney General

Re: Weigh Stations

In determining whether the Department of Commerce or the Department of State Highways has the responsibility of relocating the weigh station at the intersection of U.S. 12 and M-50, Act 77, Public Acts of 1968 is relevant.

Section 238, of Act 77 reads:

> "The powers, duties and functions of the department of state highways administered by the weighmaster section, relating to the administration and enforcement of the size, weight and load of vehicles provisions of Act No. 300 of the Public Acts of 1949, as amended, being sections 257.1 to 257.923 of the Compiled Laws of 1948, with the exception of sections 719a, 722f, 725 and 725a, are transferred to the public service commission of the department of commerce."

None of these excepted sections pertain directly to this question.

Section 240 of Act 77 states:

> "The powers, duties and functions transferred to the department of commerce in sections 238 and 239 of this act shall be transferred effective July 1, 1968. All records, property, personnel and appropriations used, held, employed, available or to be made available in connection with such powers, duties and functions shall be transferred to the department of commerce." (emphasis supplied)

Also, pertinent to this question is the last paragraph of Section 10 of Act 228, Public Acts of 1968, and reads:

> "To enable the public service commission of the department of commerce to administer enrolled senate bill 833 of the 1968 session (Act 77, Public Acts of 1968) there shall be transferred from the state trunkline fund to the general fund the sum of $887,000.00." (parenthetical note supplied)

It is evident that the underlined word "property" must include weigh stations. Since Act 77 became effective June 4, 1968, the Department of Commerce already should be exercising its control and jurisdiction over the weigh stations. This control and jurisdiction must also include any future relocation of weigh stations necessitated by highway reconstruction. Therefore, if the proposed widening and reconstruction of U.S.-12 and M-50 intersection at Cambridge Junction necessitates relocating the existing weigh station, then it appears that the Department of Commerce has the responsibility for moving the weigh station.

If the particular weigh station at the intersection of U.S.-12 and M-50 cannot be relocated on the existing right of way, then, it becomes the responsibility of the Department of Commerce to acquire another right or way for constructing a new weigh station and to move the weighing equipment. This acquisition of a new right of way may be accomplished pursuant to the authority granted under Act 149, Public Acts 1911 as last amended, an act to provide for the condemnation by state agencies and public corporations of private property for the use or benefit of the public.

LJC:GEM:bd

EXHIBIT O

CONTRACTUAL AGREEMENT - DEPARTMENT OF COMMERCE AND MDSHT

DEPARTMENT OF

ATTORNEY GENERAL

MEMORANDUM

November 8, 1968

To: C. L. Blake
Contract Officer

From: Louis J. Caruso
Assistant Attorney General

Re: Michigan Department of Commerce Agreement No. 68-0943

In reviewing the proposed contractual agreement between the Michigan State Highway Commission and the Michigan Department of Commerce several problems manifest themselves, casting considerable doubt on its legality and practicality. The proposed agreement seemingly thwarts the legislative intent of Act 77, Public Acts of 1968, transferring the powers, duties and functions of the Department of State Highways administered by the Weighmaster Section, relating to the administration and enforcement of the size, weight and load of vehicles to the Public Service Commission of the Department of Commerce. Implementing this transferral, Section 240 of Act 77 reads in part:

> " . . . All records, property, personnel and appropriations used, held, employed, available or to be made available in connection with such powers, duties and functions shall be transferred to the department of commerce."

From this language it is logical to infer that the responsibility of maintaining the transferred property now rests with the Department of Commerce. Yet, the proposed agreement places the maintenance responsibility upon the Department of State Highways.

While a mutual understanding between the State Highway Commission and the Department of Commerce is desirable, neither the Department of Commerce, created by Section 225 of Act 380, Public Acts of 1965, nor the Public Service Commission, transferred to the Department of Commerce by Section 231 of that act, has any express statutory authority to make contracts of this nature. Although Act 286, Public Acts of 1964, confers upon the State Highway Commission broad powers including authority to enter into contracts concerning matters under its jurisdiction, the powers, duties and functions of Weighmasters no longer are under Highway Commission jurisdiction. Therefore, it must be inferred that the Commission does not have any contractural authority relating to this matter. Even if the State Highway Commission and the Department of Commerce had the authority to contract separately, the enforceability of the proposed agreement still would be questionable because the Commission and the Department are divisions of the State government, and the proposed contract would be analogous to an individual attempting to contract with himself.

Apparently the primary concern of both the Department of Commerce and the State Highway Commission is having the Weighmaster's stations operated in the most practical and efficient manner as possible with the minimum of confusion, and while complying with and implementing the legislative intent of Act 77, Public Acts of 1968, may cause some difficulties, perhaps a better way to cope with any problems existing now or arising in the future would be to bring them to the attention of the legislature which may have to enact additional legislation. However, some, if not all, difficulties possibly can be alleviated by requesting Civil Service to effectuate the transferral of personnel so that the same people who previously performed the work will continue in the future, thereby assuring the smooth and efficient execution of the powers, duties and functions administered by the Weighmasters.

If the Department of Commerce and the State Highway Commission still want to manifest their understanding in writing, this is permissible, but both agencies should be cognizant that a written agreement would not constitute a valid and enforceable contract.

The Bureau of Federal Roads has informed my office that although it is desirous to have the weigh stations operated smoothly and efficiently, it has no preference for the way in which this objective is achieved.

For your personal information I am attaching a copy of my recent memorandum to John P. Woodford, Deputy Director, on a related matter.

LJC:GEM:mm
Attachment

STATE OF MICHIGAN

WILLIAM G. MILLIKEN, GOVERNOR

DEPARTMENT OF STATE HIGHWAYS

STATE HIGHWAYS BUILDING - POST OFFICE DRAWER K - LANSING, MICHIGAN 48904
HENRIK E. STAFSETH, Director

April 21, 1969

Mr. Herbert C. DeJonge, Director
Department of Commerce
Stevens T. Mason Building
Lansing, Michigan

Dear Mr. DeJonge:

The Department of State Highways agrees that all weigh stations should be maintained in a practical and efficient manner. On this basis, we are submitting the following procedure for your approval.

ROUTINE MAINTENANCE OF WEIGH STATIONS - It is economical to perform certain maintenance activities on an integrated basis with the maintenance of adjacent trunklines. Therefore, the Department of State Highways will continue to perform routine maintenance services in weigh station areas in conjunction with our regular trunkline maintenance. These activities will consist of maintenance of weigh station driveways, parking areas, signs and signals, and grounds. Also included in this category will be snow and ice control and mowing. Mowing is interpreted to mean machine mowing as performed along the roadsides and does not include any hand mowing.

HEAVY MAINTENANCE FOR WEIGH STATIONS - Heavy maintenance requests for work such as pavement resurfacing, base correction, pavement widening, etc., will be directed to the Department of State Highways through regular channels.

SPECIAL MAINTENANCE FOR WEIGH STATIONS - Special maintenance, such as scale house repairs, scale repairs, etc., will be performed, or arranged for, by the Department of Commerce.

The Bureau of Public Roads requires proper maintenance of weigh station facilities on interstate routes and they will perform periodic maintenance inspections.

Sincerely,

HENRIK E. STAFSETH
State Highway Director

MICHIGAN THE GREAT LAKE STATE

EXHIBIT P
LETTER OF UNDERSTANDING WEIGH STATION MAINTENANCE

STATE OF MICHIGAN

GEORGE ROMNEY, Governor

DEPARTMENT OF COMMERCE

STEVENS T. MASON BUILDING, LANSING, MICHIGAN 48926

HERBERT C. DEJONGE, Director

FILE COPY MAINTENANCE DIVISION

April 25, 1969

Mr. Henrik E. Stafseth, Director
Department of State Highways
Post Office Drawer K
Lansing, Michigan 48904

Dear Mr. Stafseth:

The procedure suggested in your letter of April 21, 1969 for the maintenance of weigh stations has the approval of this Department.

Your consideration of the problem is greatly appreciated and we will make every effort to retain the past high standards of maintenance.

Very truly yours,

Herbert C. De Jonge,
Director

MICHIGAN THE GREAT LAKE STATE

EXHIBIT Q

DEPARTMENT OF COMMERCE APPROVAL OF MAINTENANCE PROCEDURE

EXHIBIT R

AERONUTRONIC FORD PROPRIETARY

D R A F T

A TECHNICAL PROPOSAL FOR A BASELINE SYSTEM FOR THE DYNAMIC SORTING OF TRUCKS BY ELECTRONIC MEANS

PROPRIETARY

September 1975

SECTION 1

Introduction

Aeronutronic Ford is pleased to submit this proposal to implement the first pair of baseline weighing stations for the dynamic sorting of trucks by weight. Having installed and operated the prototype system at Grass Lake, we fully appreciate the significance of the modifications indicated by the 'weighing committee' that are necessary to provide a standardized baseline system that can be repeated throughout the state to satisfy Michigan's needs for the efficient enforcement of the applicable section of the Michigan vehicle code (re: House Bill #5368).

All of the basic functions related to vehicle weighing accomplished at Grass Lake by the prototype system will be accomplished by this system without the use or dependence on tape switches and with a minimal use of preprocessing. In addition, we propose an independent electronic subsystem at this installation to interface with the static scales to provide the weighmaster with a read-out and print-out, as desired. Functions in the prototype system related to dimensioning, survey, site surveillance, and vehicle classification are deleted from the baseline weighing station to be implemented on this program.

The configuration presented herein represents our considered recommendations on the most cost-effective approach to satisfy the total requirements of the State of Michigan, with an admitted accent on system reliability and availability. In those instances where a relatively small increase in system cost provides a decided advantage in reliability, maintainability or warranty, we have used the higher cost item in our estimates.

SECTION 2

System Description

2.1 General Characteristics

The proposed system, with the basic elements shown in Figure 1, provides for the automatic detection, computation, recording, and display of:

- Axle weights
- Axle spacings
- Axle counts
- Total weight of all axles or of pre-selected subsets
- Alarm and print-out for weight violations
- Static scale measurements
- Speed
- System status, including variable signing

The system provides for two additional optional inputs: one from a detector indicating a height violation, and another from an 'end of vehicle detector'. In addition, the system is configured to operate in an unattended mode to monitor the number, type, and time of occurrence of violations that may occur when the weighmaster is off-duty. The design is such that the special equipments used in this configuration for 'monitoring only' purposes need not be duplicated at other stations, but may be moved and used at any other station as desired.

The major subsystems of the proposed system are:

- 16 wheel load transducers
- 2 pre-processors and self-testing
- 2 mini-computers
- 1 software package
- 2 teleprinters
- 2 weighmaster consoles
- 2 static scale read-out display units
- 1 complete set of documentation

The actual hardware implementation involves a duplicate installation at the out-going and in-coming sites of the selected weighing station.

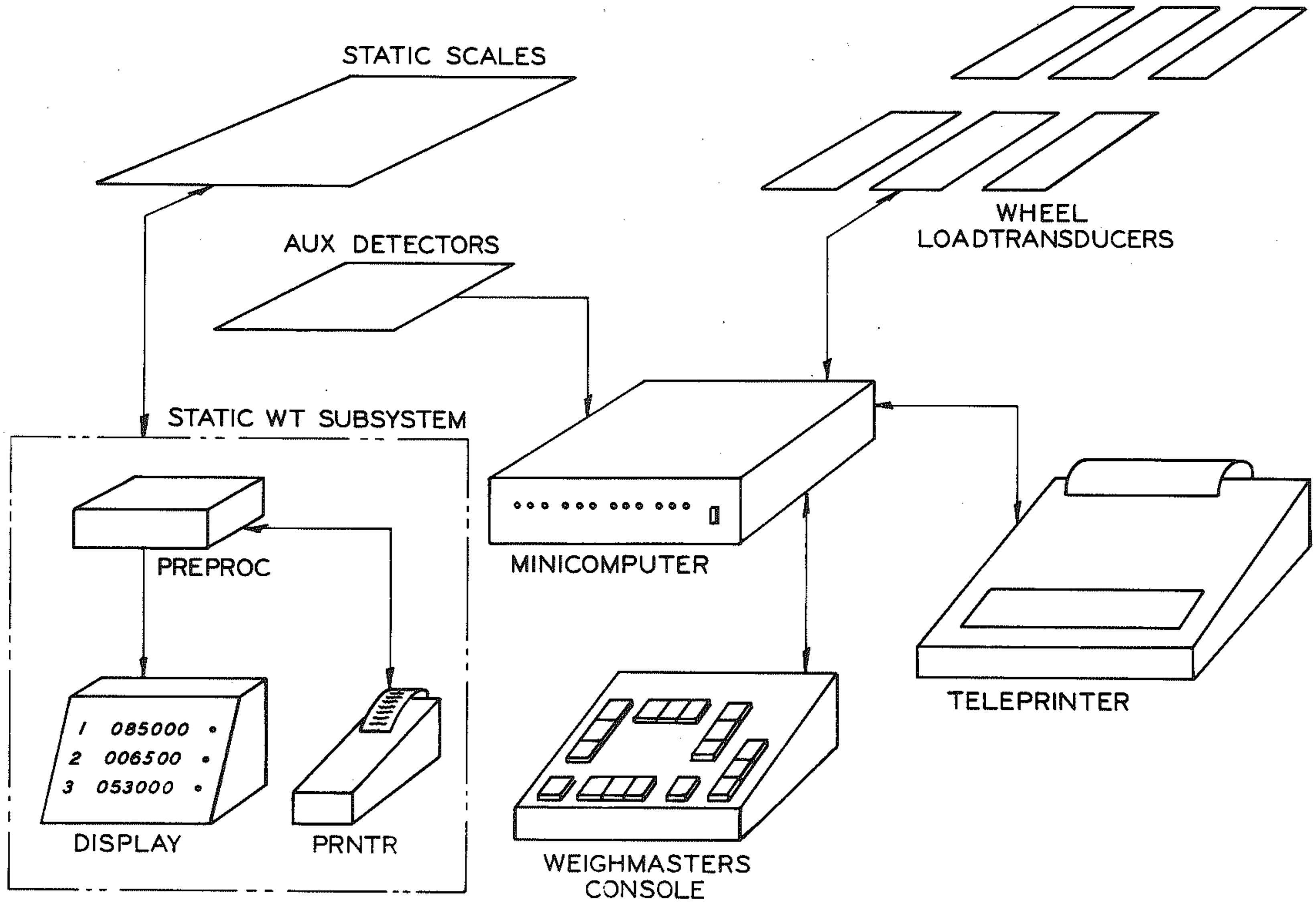


Figure 1. Elements of baseline weighing system.

The system is designed to provide an all electronic dynamic (in motion) sorting system for weight restrictions as specified by 'House Bill No. 5368' of the Michigan Vehicle Code. In addition, it provides for visual and computational assistance to the weighmaster in the use and operation of the static weighing system. Another facet of the design is its relatively cost-free capability for collecting unattended off-hour data on a station selective basis to permit an evaluation of the liberties truckers may take when the weigh station is scheduled to be closed.

The following paragraphs describe the funcational characteristics of each of the subsystems, as well as the alternative modes of operation of the total system.

2.2 Major Subsystems Descriptions

2.2.1 Wheel Load Transducers Subsystem

The individual wheel load transducers are electronic, and are designed to withstand 40,000 pound loads without damage. Each transducer is approximately four feet wide, two feet long (direction of travel), and two and three-quarter inches deep. Typically, the transducer is bolted to a larger steel plate levelly imbedded in the roadway, covered with the roadway surface to the dimensions of the transducer or its dummy replacement. The reaction time and reciprocal natural resonance frequency of the electronic transducer is on the order of 200 to 400 Hertz, and will permit 14 to 16 msecs of sampling time for a 16 inch tire foot print. The transducers are compensated to operate over the range of minus 30 F to plus 140 F, and provide the best known resistance to rain, ice, snow, salt and dirt of any other transducer for this application.

The proposed system for the weighing station will utilize four pairs of wheel load transducers in each direction (e.g., four pairs North bound and four pairs South bound).

2.3.2 Pre-Processors and Self-Testing Subsystem

The pre-processor subassembly provides the interface between the digital processing subassembly and the wheel load transducers, variable signing, weighmaster console, etc. This subsystem is designed to handle as optional inputs, an external signal (e.g., an infra-red or sonic) indicating 'end of vehicle' or 'height violation'. An integral part of this subsystem is the external (to the computer) hardware required for system self-testing and fault diagnosis.

2.2.3 Weighmaster's Console

The 'weighmaster's console' is a light weight desk top unit designed to facilitate the weighmaster's operation and control of the system. Control switches, indicators, and displays are located on the console 'face panel'. A power on/off switch for the dynamic weight sorting system is provided. Computer linked switches on the console permit override and independent control of variable signing, hard copy output, audible alarm, and system operating mode selection (normal, unattended, and test modes). Console switches permit the selection of the computer input mode, i.e., keyboard or paper tape. Provisions are made to incorporate computer independent weighmaster aids and control of the static weighing system which can also be used in stations which do not include a dynamic sorting system. These functions include a six digit display of the weight for each static scale, with a print-out as required. A conceptual version of the total capability weighmaster's console is depicted in Figure 2. The electronic subsystem to support static weighing operations is characterized in Figure 3.

2.2.4 Teleprinter

The teleprinter will be any of the reliable commercial grade equipments on the market, with a paper tape punch and reader option.

2.2.5 Mini-Computer Subsystem

We propose that a general purpose mini-computer is best suited for this station as opposed to a micro-processor with insufficient speed, limited flexibility and lower cost or as opposed to a pipeline processor with higher speed, higher cost and limited flexibility. We have provided examples of each item required in terms of the equivalent Digital Equipment Corporation (DEC) products. DEC products are used as examples because they are reliable and competitively priced, and are backed up with extensive software and servicing support.

2.2.5.1 The Central Processing Unit

For this application, we propose a 16-bit mini-computer with 8K of core memory, a read-only memory, auto-loader and a power failure auto-start capability. All programming will be done in machine language in order to obtain maximum throughput and memory efficiency from the processor. All computations will be done with 2's complement, fixed point arithmetic. By applying straightforward sealing techniques in the arithmetic processes, more than adequate precision can be obtained for this application without requiring expensive and relatively slow floating point processing. The Digital Equipment Corporation PDP-11/05 with 8K

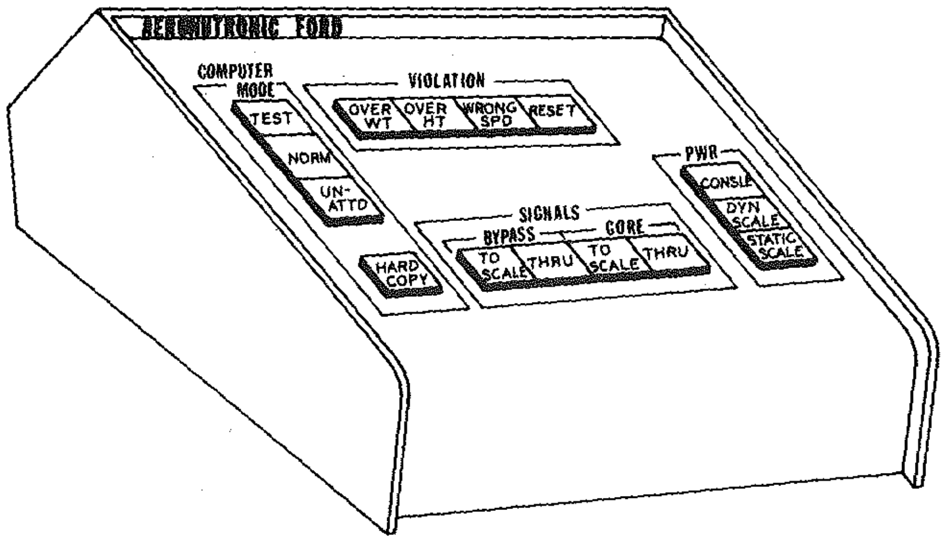


Figure 2. Proposed weighmasters console.

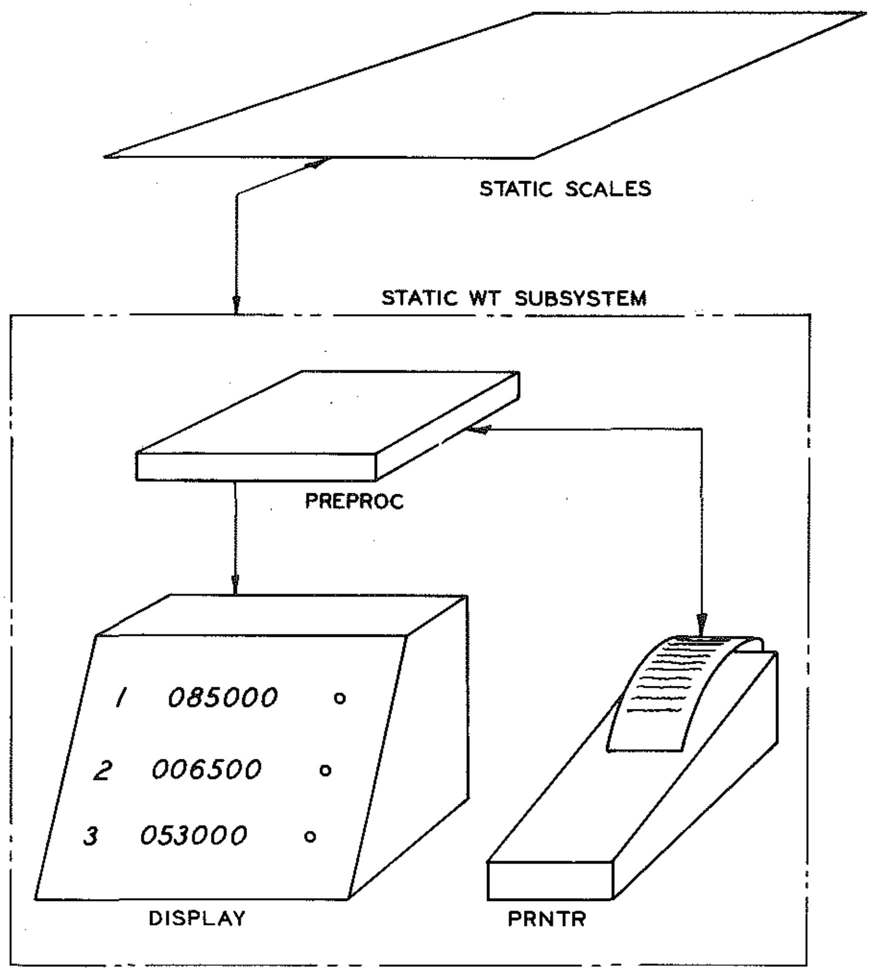


Figure 3. Static weighing electronic subsystem.

memory and optional RDM bootstrap loader or equivalent provides all of the required capabilities.

2.2.5.2 Hardcopy and Manual I/O Interface Unit

A hardcopy and manual I/O interface unit such as the Teletype ASR-35 will be required. The DEC equivalent is the DECWRITER-II. The DEC machine has the advantage of higher speed, quieter operation, and fewer moving parts, but is more expensive.

2.2.5.3 Analog to Digital Converter Subsystem

An analog to digital converter with a capability for independently sampling eight or more channels is required. A sample and hold unit will also be included in order to reduce the aperture time. This will reduce time uncertainty in the samples so that accurate timing information will be available for measuring vehicle speed and axle spacings. For the dynamic weighing system, a unipolar resolution of 10 bits will be adequate. This will provide 0.1 percent of full scale resolution.

The DEC model AD01 A/D converter, with optional sample and hold and one extra multiplexer board will satisfy the system requirements.

2.2.5.4 Real-Time Clock

A programmable real-time clock capable of providing interrupts at a preprogrammed rate is required for controlling the sampling and the A/D conversion process. This same clock will also provide a time reference from which speed and axle spacing measurements can be made, and from which time of day can be computed for printing on the hard copy and magnetic tape records.

The applicable DEC unit is the KW-11-P.

2.2.5.5 Digital Interfaces

Digital I/O interface units are required for providing communications between the computer and the weighmaster's console, and for indicating the status of the vehicle height and end of vehicle sensors. Parallel I/O interface units will be used which have independent 16-bit input and 16-bit output capabilities. Two such interfaces will provide adequate capabilities for the system.

The applicable DEC interface is the DR-11-C.

2.3 Weighing and Measurement Algorithms

The weighing and measurement algorithms used in the prototype system were based on the use of tape switches to establish 'event times' for the computer. Poor performance of these switches has dictated the use of alternate methods, based on the signal outputs from the scales (wheel load transducers) if a reliable baseline system is to be achieved. To accomplish this objective has required a modification of computational algorithms with the resultant need for establishing new flow diagrams and essentially developing a completely new software package.

As a result of analysis of data from the prototype system by the Michigan Department of State Highways and Transportation, and by an independent evaluation by Aeronutronic Ford of data collected on the Michigan Test Track, alternative methods for detecting 'peak average weights' have been derived consistent with the recommendations and conclusions of the final report on 'Automatic Weighing of Vehicles in Motion and Collection of Traffic Data by Electronic Means' by the Testing and Research Division dated March, 1974. The most promising alternative is described below in Paragraph 2.4.3, entitled 'Measurement of Dynamic Weight".

2.3.1 Determination of Axle On/Off Times

In order to measure vehicle speed and axle spacings for moving vehicles, it is necessary to obtain accurate indications of axle arrival times at several fixed points in the measurement path. It is also necessary to have a reliable indication of axle on and off times in order to associate the weight samples from the scales with particular axles.

Since there will be no binary tape switch to provide an indication of when to start sampling, we will use the scales themselves as the sensors for detecting the on and off times of the axles. To do this, the computer will continuously sample the scale output signals, and on and off times will be determined by comparing the sampled scale signals to fixed thresholds. The thresholds will correspond to some nominal weight value such as 3,000 lbs., which will be certain to be exceeded by vehicles which are potential weight violators. The on time will be the sample time for the first sample to exceed the threshold after a period of generally low sample values. The off time will be the sample time in the first sample to drop below the threshold value after a period of generally high sample values.

2.3.2 Measurement of Vehicle Speed and Axle Spacing

Vehicle speed and axle spacing will be measured as they were at the Grass Lake weigh station.

The computer program will calculate the speed of each axle by the formula:

$$S_i = \frac{D4 - D3}{T4_i - T3_i}$$

where:

S_i = speed of axle i

D3 = location of leading edge of scale No. 3

D4 = location of leading edge of scale No. 4

$T3_i$ = event time of axle i arriving at scale No. 3

$T4_i$ = event time of axle i arriving at scale No. 4

After the last axle of a vehicle crosses scale No. 4, the computer determines the vehicle speed, S_i, by averaging the individual axle speeds.

Axle spacing is calculated for each axle after the first by the formula:

$$d_i = S_V (T1_i - T1_i + 1)$$

where:

d_i = axle spacing between axle i and axle i + 1

S_V = vehicle speed

$T1_i$ = event time of axle i arriving at scale No. 1

$T1_i + 1$ = event time of axle i + 1 arriving at scale No. 1

The axle spacing computations will be repeated, based on the arrival times at all four scales. These four calculations will then be averaged to improve the accuracy of the axle spacing measurements.

2.3.3 Measurement of Dynamic Weight

The outputs of the electronic scales will be sampled and converted to digital form for input to the computer.

The eight scales will be sampled in rotation at approximately 1,000 samples per second rate so that the computer will actually be processing data at an 8,000 sample per second rate (assuming four pairs of wheel load transducers). Sampling will continue at all times that the dynamic scales are in operation, but extraction of a weight estimate will not be attempted until the threshold detection described in Section 2.4.1 indicates that an axle has rolled onto the scale.

Starting with the first sample that exceeds the threshold, in a particular scale, the computer will begin to store the scale samples and will also begin to accumulate a sum of the samples. This storage and accumulations will continue for N samples. When sample N + 1 occurs, it will be added to the sum. Sample 1 will be subtracted from the sum, and sample N + 1 will be stored in place of sample 1.

For each subsequent sample, this procedure will be repeated. Sample k will be added to the sum, sample k-N will be subtracted from the sum, and sample k will be stored in place of sample k-N. The sum that is generated at the k^{th} sample will then be N times the average weight measured over the last N samples. The weight measurement for a particular axle on a particular scale will be defined as the highest value of the N sample running average that is measured between the axle on and off times for that particular scale.

The averaging window length, N, will be a variable which will increase with decreasing vehicle speed. When the first axle arrives at the first scale, there is no way of knowing the vehicle speed. Therefore, for this axle scale combination, N will be set at the value corresponding to the maximum expected speed. Subsequent axle scale combinations will use a value of N which is computed from a speed estimate based on the axle on-off times for the first axle crossing the first scale.

The value of N will be determined by the number of samples for which the wheel is expected to be fully on a two foot long scale at the given vehicle speed.

With a sampling rate of 1,000 samples per second, a velocity of 44 feet per second and a 16 inch footprint, the tire will be fully on the scale for approximately 15 samples. For this speed, N will be 15 samples.

A flow chart for this weight measurement process is given in Figure 4. The routine must be repeated for each set of eight input samples. At a sampling rate of 1,000 samples per second, there are 1,000 usec available for processing the data. On the PDP-11/05, the maximum running time for this routine is about 700 usec, and this is by far the dominant factor in consuming computer time. All other processes in the weight measuring system occur at much lower rates, and can easily be performed in the background during the remaining computer time.

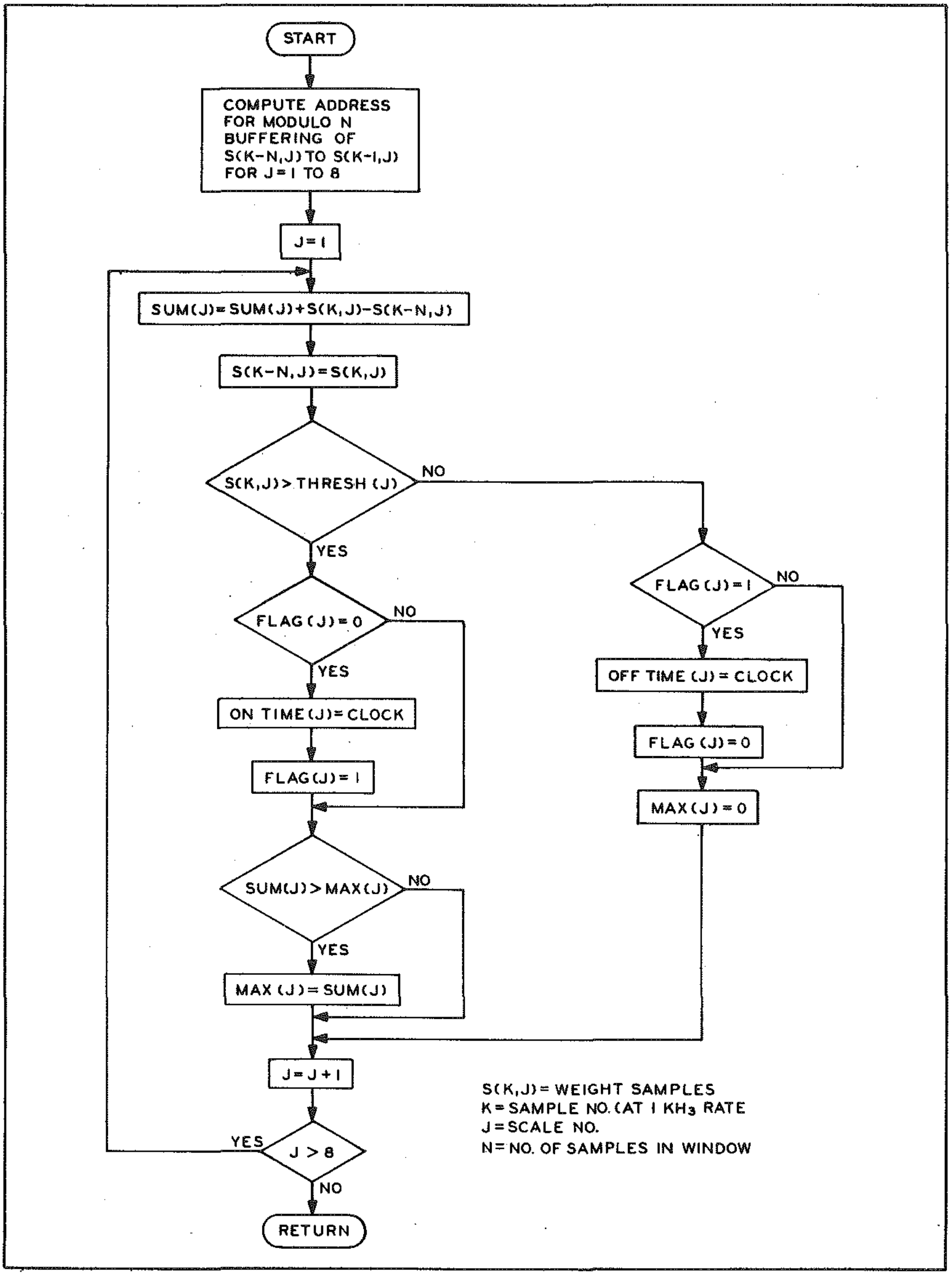


Figure 4. Flow chart - weight measurement process.

2.4 System Operation

In this section, the proposed functions of the computer controlled weighing system in its various modes of operation, are described. We also discuss the hard copy reports that the system will generate, and the operator responses that will be required.

2.4.1 Startup

The following procedure should be followed when turning the system on for the first time, or after a period of inoperation.

(a) Turn on power at the operator's console for the console itself, and for the dynamic and static weighing subsystems.

(b) Select the computer mode on the operator's console (either; TEST, NORMAL, or UNATTENDED).

(c) Turn the teletype power switch to the AUTO mode.

(d) Start the computer program by turning on the power at the computer front panel.

(e) If there is reason to believe that the program may have been erased from core memory, mount the system tape on the magnetic tape unit and load the system programs into the computer. Start the program by hitting the CONTINUE switch on the computer front panel.

(f) The system will request and the operator will enter in the teletype.

- o Serial No. update
- o Clock update
- o System start character

(g) If system is in the normal mode, activate the BYPASS-TO-SCALE signal and release the gore signal switches so that the gore signal is under computer control.

(h) If operating in the unattended mode, mount a tape for data collection, and activate the BYPASS-TO-SCALE and GORE-THRU signals.

(i) Before selecting the TEST mode, activate the BYPASS-THRU signal.

2.4.2 Normal Mode

The normal mode of operation provides for automatic dynamic weighing on a continuous basis, and also provides a means of independently making static weight measurements.

2.4.2.1 Dynamic Weighing

Dynamic weighing is performed continuously when in the normal mode. The computer will sample the scale signals continuously and periodically. The presence of a vehicle on a scale will be indicated when the weight sample for that scale exceeds a preset threshold. Hence, exceeding the weight threshold serves the same function as the tape switches in the prototype system at Grass Lake.

Sample averaging will start when the threshold is exceeded, and will continue until the sensor output drops below the threshold again. Weight measurement will be extracted for each wheel passing over the dynamic scales. The measurements for adjacent scales will be averaged to produce four sets of measurements for each axle.

A threshold time will also be recorded for each wheel for all four scales. End of vehicle will be detected by combining the end of vehicle sensor output with a "time lapse without axle detection" measurement.

From these weight and time measurements, averaged axle weights and axle spacings will be computed. Combined axle weights for tandem axles will be computed and then all measurements will be compared to the legal limits to determine whether violation exists. If either a weight violation or a height violation is detected:

(a) The audible alarm will sound,

(b) The oversize (if provided) and/or overweight light will come on,

(c) The gore signal will switch to direct the violator to the scale house lane, and

(d) The typewriter will begin printing out a hard copy record for the vehicle, containing the gross load, single axle weights and spacings, tandem weights, and date and time of occurrence.

To correctly respond to these outputs, the weighmaster should turn off the audible alarm by pushing the SIG-OFF/RESUME Button. The gore signal will be automatically returned to the THRU position by the computer. The timing of this signal will be automatically computed, using the speed and distance estimations for the truck which is in violation, and for a following truck if one exists.

An example of the dynamic weighing hard copy is given in Figure 5.

2.4.2.2 Hard Copy Request

Normally, the hard copy will be printed only when there is a violation detected. Alternatively, hard copy can be obtained for vehicles which are not in violation by pressing the hard copy button on the weighmaster's console. Pressing the button will result in a hard copy for the vehicle under process. If no vehicle is currently on the scales, it will result in a hard copy for the next vehicle processed.

This hard copy capability provides a convenient method for checking that the system is actually making weight and axle spacing measurements. It does not in and of itself check the accuracy of those measurements.

2.4.2.3 Static Weighing

Static Weighing is accomplished in the normal mode simultaneously with dynamic weighing, using the electronic subsystem depicted in Figure 3. After the truck is positioned on the scales, weight readings are visually displayed to the weighmaster and a hard copy print-out is provided as required.

Axle spacing data available during static weighing is expected to be obtained by manual means.

2.4.3 Unattended Mode

The unattended weighing mode performs dynamic weighing exactly as in the normal mode except that:

(a) The gore signal always routes the vehicle back to the highway.

(b) All weight violation readings are recorded on the teleprinter with the date and time of occurrence.

2.4.4 Test Mode

The test mode provides a method for checking the accuracy and proper functioning of the measurement subsystems. This mode should only be selected when there are no vehicles on or approaching the scales.

EXAMPLE

Time: 13:30:16

Date: 7/8/75

Truck No.: 127

Speed: 27 mph (alt. message "out of range")

Axle	Spacing	Weight	Violation
1		7.22	
2	12.4	12.22	
3	6.2	16.47	
4	32.9	21.29	***
5	7.6	18.47	

Tandem	Weight	Violation
2-3	28.69	***
4-5	39.76	***

Overweight	Gross Weight	Violation
No (YES)	75.67	***

Figure 5. Dynamic weighing hard copy.

Known quiescent voltages will be measured on all dynamic scales in the system. These measurements will be compared to standard measurement values at each stage of the weight measurement calculations. Diagnostic messages will be printed if at any stage in the calculations the measured values fall outside of allowable limits. These diagnostic measurements can be used for rapid detection and isolation of faulty input signals to the computer, or of faulty subroutines within the computer. Isolation of faults to subroutines can be used to indicate bad memory elements, or faulty arithmetic functions within the computer.

An independent test on the static scales using known quiescent values will provide the operator with a 'scale operational' indication for each scale, unless a static scale component has failed.

SECTION 3

Installation

Total system installation involves a dual responsibility and close cooperation between cognizant Michigan Government personnel and assigned contractor personnel.

Appreciating the fact that the overall program management will be performed by the Commerce Department or their designates, it is anticipated that the Highway Department will play a major role in the actual system implementation and installation.

In addition to the functional requirements and systems specifications already developed by the 'ad hoc committee on weighing systems', it is expected that this body will evaluate and delineate the detailed and documented specifications for the remaining twenty stations necessary to meet Michigan's commitment to the truck weighing problem.

For this particular installation, the contractor will provide:

- All electronic subsystems, including wheel load transducers for the dynamic weighing system as described in Paragraph 2.2 of this proposal.
- All cabling and connectors associated with the indicated electronic subsystem.
- All related electronic subsystem racks, mountings, and fixtures.
- Specifications, wiring diagrams, and pertinent installation procedures.
- Installation and interconnection of all electronic subsystems, including the electronic interface and display equipments for the variable signing and static weighing subsystem.
- Debugging, testing, and validation of entire electronic subsystem.

We anticipate that the Highway Department will provide:

- The static electronic scales and their installation.
- The site and site preparation (including levelled mounting plates), and installation of the dynamic wheel load transducers.

- Variable signing and installation as required.
- The necessary space and housing for all electronic subsystems.
- Supervision of the installation and testing of the total system.
- A detailed review and validation of the explicit design specifications for modification of each of the remaining twenty stations for presentation to the 'weighing committee' for their consideration.

The total electronic installation will be in accordance with best commercial practices, with a special consideration for reliability and system availability.

SECTION 4

Documentation

As part of the proposed program, a complete set of documentation will be provided, including:

- o Instruction manuals.
- o Operator's manual.
- o Detailed procurement specifications.
- o Estimated production unit costs for each element of the system.
- o Interim status reports covering design, installation, testing, and operational phases of Weighing Station implementation.

Except for status reports, twenty copies and one reproducible of each of the documents will be delivered at the conclusion of the program.

Note that the procurement specifications will include:

- o Software specifications.
- o Console specifications.
- o Computer specifications.
- o Wheel load transducer specifications.

SECTION 5

Budgetary Costs

Budgetary estimates associated with each subsystem are included in two parts; one representing the one-time non-recurring costs associated with making the necessary design modifications to the prototype system to provide a final design for the baseline weighing station, and the second representing the recurring costs for additional implementations to the same specifications.

The indicated costs do not take into account savings that can accrue from multi-unit discounts, projected lower manufacturing costs, or clever and efficient engineering effort. For this reason, the listed costs can be considered to be "maximum anticipated/allowable costs."

TABLE 1

ELECTRONIC SUBSYSTEM - BUDGETARY COSTS

Non-Recurring Costs	
Engineer Mods. to Prototype	
Hardware Redesign	$35K
Software Redesign	50K
Common Equipment	--
	$85K
Additional First System Costs	
Install, Test and Debug	$20K
Operator & Systems Manuals	20K
Procurement Specifications	15K
	$55K
Recurring Costs Per Station	
Electronic Subsystems	$24K
Wheel Load Transducers	40K
Engineering Labor	20K
	$84K

Since Baseline System Costs = $140K + $84K = $224K

Two Station Baseline System Costs = $140K + $168K = $308K

APPENDIX

AERONUTRONIC FORD CORPORATION

The Communication Systems Division of the Aeronutronic Ford Corporation has its headquarters at Plant 35, Willow Grove, Pennsylvania. This fully equipped engineering facility houses over 300 engineers and scientists and approximately 100 technicians and support personnel. Support functions available at the Willow Grove facility include drafting, technical writing, parts provisioning, print reproduction, a fully equipped photographic darkroom, a model shop, and a technical library.

5.1 COMPUTER FACILITY

The Aeronutronic Ford engineer has at his disposal, in addition to desk-top computers, two major computer facilities for simulations and calculations. These facilities are:

a. The Honeywell 635 System located at the Willow Grove facility.

b. Time-shared terminals using FORTRAN IV, BASIC, ALGOL, COBAL, and ECAP. These terminals are connected to both the Honeywell 635 System and to a Burroughs 5500 computer located at a nearby Philco-Ford plant.

The Honeywell 635 Information Processing System is shown in Figure 5-1. The present system is equipped with three disc storage devices, each device containing four modules, giving the system a total capacity of 180 million characters. The Detroit 355 communications processor accepts inputs from 10 communications lines: two high-speed (4800 baud) lines are connected directly with Ford Motor Headquarters in Dearborn, Michigan, and 8 low-speed lines are available for local time sharing. Of these 8 lines one is a 300 baud line and 7 are 110 baud lines, connected to a rotary switch.

The magnetic tape unit has 7 nine-track tapes and 1 seven-track tape. Two printers, 10 card readers and a card puncher complete the system.

Both of the time sharing systems permit users to converse with the center in a natural language from their deskside, using remote terminals and regular telephone lines on a dial-up basis. Each user has his own programs stored in the computer's disc file. These programs are not available to other users of the Time Sharing System. In addition to his own programs, each user has access to several hundred programs stored on the Common Library.

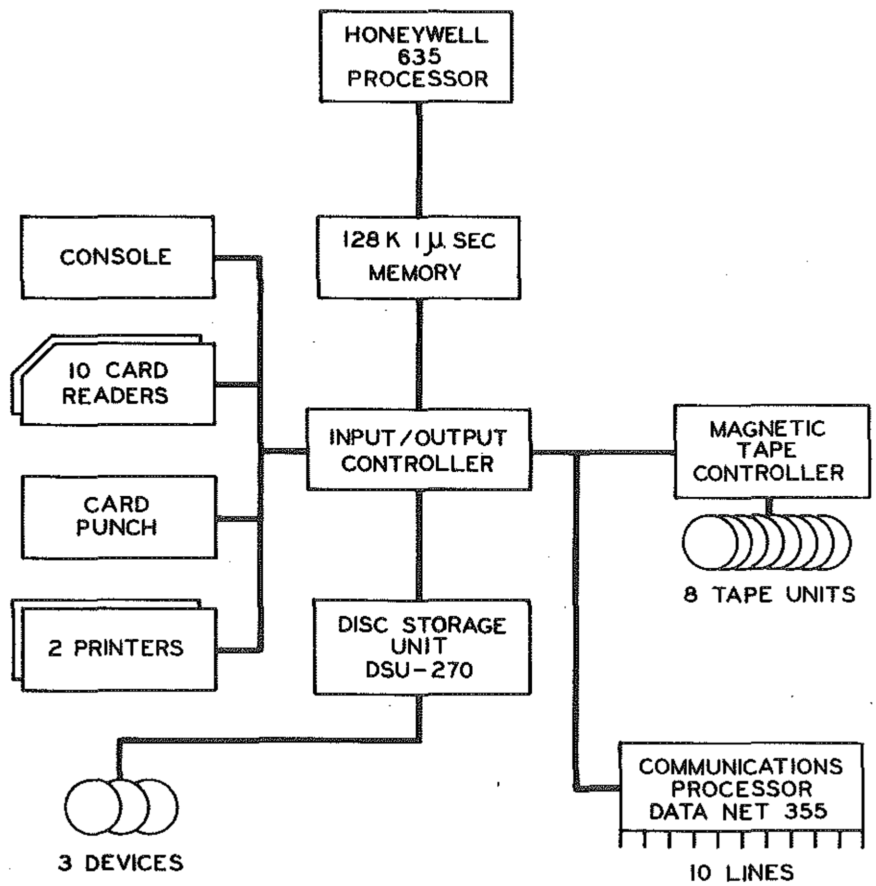


Figure 5-1. Honeywell 635 information processing system.

5.2 REAL-TIME SIGNAL PROCESSING FACILITY

The Communication Systems Division has the capability to perform real-time simulation of speech and data transmission equipment through the use of a Computer Signal Processor-30 (CSP-30) (see Figure 5-2). This computer is a 16-bit digital machine with a basic cycle time of 100 nanoseconds. It is the fastest computer of its type in existence except for machines in the behemoth class of CDC-7600 and IBM 360/195. Its inherent speed, coupled with an extremely sophisticated instruction repertoire, rapid and easy input/output, and flexibility make it ideal for use in speech processing, vocoding, speech recognition, and data communication simulation. Some features of the CSP-30 are:

- 8,192 words of 900 nanosecond core.
- 512 words of 100 nanosecond IC memory.
- 32 word accumulator file.
- two A/D converters plus two D/A converters with programmable frequency source.
- CRT display via Tektronix oscilloscope.
- three high-speed I/O channels.
- 8 channel partyline I/O.
- KSR 35 teletypewriter.
- Dual-cartridge magnietic tape unit.
- Extensive software for signal processing.
- Assembler and utility software.
- Special features which permit IC memory speed even when using core memory.

The CSP-30 is linked via a magnetic tape interface with Philco-Ford's large-scale general-purpose computing system which contains a Honeywell 635 computer and associated peripherals including disc and magnetic tape storage, card reader and punch, plotter, and high-speed printer. This link permits the usage of the large computer system for FORTRAN IV simulations using the Aeronutronic Ford signal processing program library as well as for auxiliary operations such as bulk data storage, plotting, printing, and off-line assembly using a FORTRAN IV-based assembler for the CSP-30

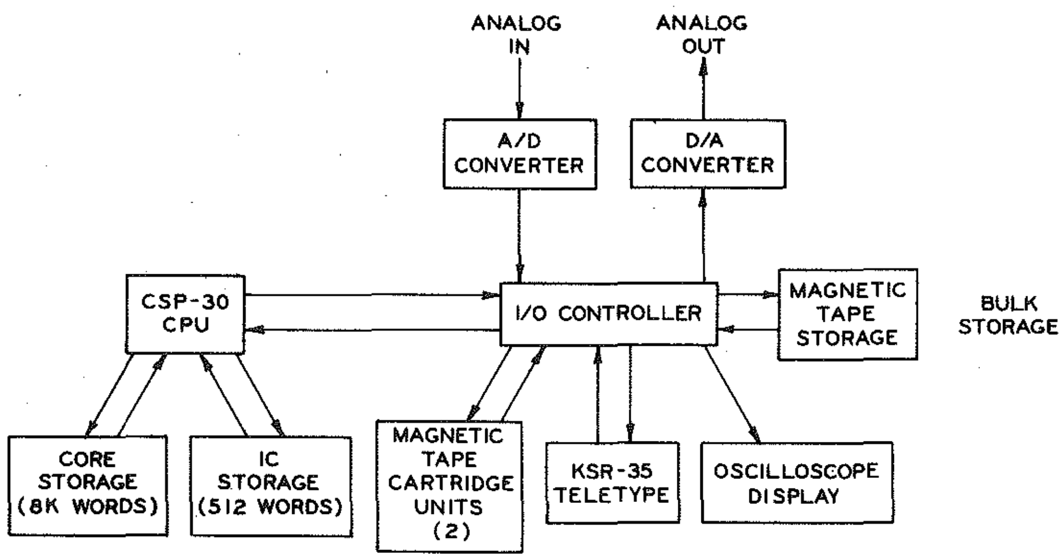


Figure 5-2. Real-time signal - processing facility, block diagram.

supplied by its manufacturer. The Honeywell 635 computer can service many remote terminal devices such as teletypes, graphics terminals, and satellite processors through its related Honeywell 355 front-end processor. It provides the CSP-30 with expanded computational facilities for maximum speed, economy, and freedom from human errors by virtue of its capability for automatic data interchange without manual intervention.

5.3 LIBRARY

Important among the facilities available at the Plant 35 facility is the Central Technical Library, which provides a reference collection of over 10,000 volumes in the fields of physics, chemistry, engineering, mathematics and related disciplines. In fulfilling the function as a central source for the compilation and the dissemination of the most up-to-date technical information, the Library subscribes to 150 scientific journals, and various technical and trade journals, including the official transactions and proceedings of professional groups and institutes here and abroad. Also, some 15,000 technical documents are now on file. As a member of the Union Catalog Service, the Inter-Library Loan Service, Franklin Institute, the Technical Library has access to all other reference collections throughout the country. Especially convenient are the libraries of the University of Pennsylvania, the Franklin Institute, and Temple University; in the area surrounding the center are the libraries of Princeton University, Lehigh University, Villanova University, Swarthmore College, and Bryn Mawr College. The Technical Library also subscribes to the National Technical Information Service (NTIS).

5.4 MANUFACTURING FACILITIES

The Communication Systems Division has recently constructed a new building at Willow Grove which provides 225,000 square feet of most modern electronic equipment manufacturing facility. Included are a fully-automated Gardner-Denver wiring facility, a printed wiring and multilayer board fabrication facility, LSI mask generation facilities, and design automation software and hardware.

5.4.1 Automated Wiring Facilities

In order to provide rapid turn around and accuracy in wiring, fully-automated Gardner-Denver wirewrap equipment, capable of wrapping 24-26 gage wire on .045 square posts and 29-30 gage wire on .025 square posts, is available. Grid patterns of .100 x .200 are currently being attained in production.

The punched cards which control the Gardner-Denver wirewrap machine are generated from a computer program, and changes can be incorporated easily by replacing or augmenting the punched cards. The machine has the distinct advantage of providing identical wiring from unit to unit as well as obvious cost-effectiveness.

In addition, a number of magnetic tape controlled semiautomatic wiring machines are available for a short-run engineering orders, wiring twisted pairs and providing for later wiring changes. These machines are designed such that a wrap cannot be completed if the operator attempts to place a wire on a post not identified by the magnetic tape and indicated on a digital display.

An automated, tape-controlled network analyzer is normally utilized to verify continuity on completed backpans or complex wired assemblies. Printed readouts identify fault location.

5.4.2 Multilayer Board Facility

The process and equipment used for printed wiring fabrication have been developed to produce quality boards, and manufacturing feedback is maintained to assure that the parameters for printed wiring and multilayer board fabrication are achieved and the established schedules met. Dimensional fidelity of circuit images, drilling uniformity and accuracy, temperature and pressure control in lamination, plating consistency, etchback controls and material cleanliness are continually monitored during the fabrication process.

Equipment acquisition on a continuing basis since the facility was established has assured that only the most modern and technically advanced equipment is available. The facilities and processes have been qualified to NSA specifications.

The major elements include facilities such as a Gerber automated drafting machine, photographic and dark room, coordinate measuring and step-and-repeat equipment, silk screening, photoexposing and film resist capability, conveyorized photo-resist developers, etchers and resist removers, optical scanning and microsectioning, multiple platen laminating presses, N.C. drilling machines, semiautomated etchback, and automated thru-hole plating machine.

It is important that proper assembly of component parts, fluxings, wave soldering, flux removal and test be accomplished with technical competence and precise process controls; therefore, equipment in these areas is of advanced design and inprocess controls are emphasized.

5.5 LSI SYSTEM DEVELOPMENT CAPABILITIES

The Communication Systems Division of Aeronutronic Ford Corporation has the capability for Large Scale Integrated circuit design, fabrication, assembly and test in its LSI Development Laboratory. This laboratory is dedicated to the support of those contractual activities requiring relatively small quantities of high reliability LSI components.

The LSI Development Laboratory, when fully operational in mid-1975, will provide LSI components in the three MOS technologies selected for a large part of the digital communications equipment for 1975-1978.

- P-Channel Metal Gate MOS
- P-Channel Silicon Gate MOS
- High Density, Single Guard Band CMOS

The LSI facility has state of the art 3" fabrication equipment designed for minimum handling and maximum reproducibility and control. Engineering personnel in the Laboratory have extensive (150 cumulative man years) experience in the design, fabrication, test and analysis of high yield, high reliability components. Special expertise centers on process and device design for maximum reproducibility and development of techniques for rapid feedback of defects and failure analysis data.

5.5.1 Automated MOS Chip Layout System

When the production volume of a custom MOS/LSI circuit is in the low or medium range, computer-aided layout of the MOS chip is usually more economical than the more costly and time consuming manual chip layout techniques.

Aeronutronic Ford has available MOSAIC, a set of proven MOS chip layout computer programs, and an extensive standard cell circuit library which offer fast, low cost, and error free MOS/LSI mask layouts, The MOS chip layout designed by the MOSAIC system is formed of MOS transistors with one-layer-metal and P-tunnel crossunder interconnections. The devices are grouped into manually designed circuit functions called standard cells, and each group is given a cell type code. Each cell has bus connection channels near its top edge and logic connection points along its bottom edge known as pins. Presently, each cell may have up to four bus connection channels and up to nine logic pins.

5.5.2 MOS Circuit Analysis Program (MOSCAP)

MOSCAP is a Aeronutronic Ford Developed MOS circuit analysis computer program which is an accurate and efficient tool for basic MOS circuit or standard cell design/performance analysis. The Communications Systems and former Microelectronic Divisions of Aeronutronic Ford have made extensive use of MOSCAP. The MOSCAP program obtains a D.C. analysis solution by use of a Newton-Raphson iteration. Transient analysis is performed by using the Nodal State Space Analysis. The numerical integration for the transient analysis is performed by an exponential technique.

The data inputs to MOSCAP are the circuit topology, the width and length of the channel in mils after adjustment for lateral diffusion, the process gain parameter K', threshold voltage, body effect coefficient, supply voltages, capacities, and input pulse train specifications. Tolerances of these parameters are determined by photographic, mask alignment, and process controls. Having established the above input parameters a worse-case analysis of the MOS circuit can be performed. The circuit designer familiar with MOS devices knows the effect of the main parameters that would maximize or minimize required performance characteristics. Those parameters where the performance effect is now known may be varied while running the MOSCAP program and observing the effect on circuit output characteristics as computed by the program.

5.5.3 Logic Simulation

Logic simulation is performed by a functional logic simulator which is written as a compiler for use on the GE 635 computer. It is designed to assemble and execute a computer program that simulates MOS digital logic as designed by the user. The design may contain as few as 10 or as many as 5000 interconnected two-phase, clocked MOS standard logic cells.

5.6 AUTOGRAPHICS FACILITIES

The Aeronutronic Ford Willow Grove plant is well equipped with modern autographics and photographic facilities which are utilized to produce precision artwork for printed circuit boards and LSI circuit masks. Included in this system are the following:

Gerber 2032 Automated Plotter

This computer controlled precision plotter is made up of the Model 32 table and series 2000 controller with magnetic tape drive. Drawing tools for inking, scribing, and optical exposure of light-sensitive material are available. Artwork is made on a 4-foot by 5-foot table with accuracy of $\pm$ 0.0008 inch with repeatability to $\pm$ 0.0004 inch. The series 2000 controller is a stored program control which can be changed to meet user requirements. It includes a punched paper tape reader and I/O teletypewriter with paper tape punch. The optical exposure head for the Gerber is equipped with a replaceable 24-position aperture wheel. Apertures are selected automatically by series 2000 controller. Precision MOS/LSI mask artwork is produced by optically exposing photographic film at 100X final size.

Autotrol Digitizer

The Autotrol Digitizer is a high-speed x-y coordinate measuring and recording system designed to operate with a card punch, paper tape punch, and typewriter. An IBM 870 Document Writer System is used as an input.output device for the Autotrol Digitizer.

5.7 OTHER FACILITIES

To complement the engineering laboratory, automated design, autographics, and data processing capability, the Willow Grove facility has all normal engineering services including drafting, technical writing, a components laboratory, test equipment calibration and repair and reproduction facilities.