MELBOURNE AND METROPOLITAN
BOARD OF WORKS

AESTHETIC TREATMENT OF CONCRETE LINED CHANNELS

MAIN DRAINAGE DIVISION

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1. INTRODUCTION

During recent months, several people have publicly criticised the Board for constructing concrete lined channels along such streams as the Moonee Ponds Creek and Gardiners Creek.

Most of the criticism has come from "conservationists" or "environmentalists". Articles have been published by Professor G. Seddon of the University of Melbourne's Centre of Environmental Studies, students of the University of Melbourne's Department of Architecture, students of the Swinburne Institute of Technology, Mr. Ronnfeldt-Holmes of Ashburton, the late Mr. Ellis Stones and others.

Strong verbal criticism has been made by leaders of the Merri Creek Action Group, and two of the Board's Commissioners.

Few, if any, of the critics live in properties affected by, or in close proximity to, the Board's concrete channels. Furthermore, no criticism has been received from the hundreds of people whose properties have been saved from flooding or erosion by these works. It should be noted that the Board has constructed drains of this type over the past twenty years and most of the criticism has been made only within the past twelve months.

On analysis, the criticism falls into two categories, namely —

(i) the effect of the works on the environment, and

(ii) the aesthetics of concrete lined channels.

It is not the purpose of this report to comment on the general environmental impact of drainage works along watercourses. This criticism must be answered in the light of the proposal and the circumstances associated with each section of each watercourse.

This report is devoted only to considering the reasons for adopting concrete lined channels, the alternative methods of lining, and possible methods of improving the aesthetics of the so-called "ugly" concrete lined channels which will need to be constructed in the future.

2. REASONS FOR ADOPTING CONCRETE LINING OF CHANNELS

Drainage works in the form of concrete lined channels are constructed for several reasons, as a solution to the following problems:

(a) **Control of flooding** from either natural runoff or increased runoff arising from urbanisation of catchments. Such projects usually require a substantial increase in the carrying capacity of the watercourse, at lower flood levels than occur when flood flows traverse the natural watercourse. This latter criterion can be satisfied by increasing the cross-sectional area of the stream by widening and/or deepening, or by decreasing the roughness characteristics of the bed and banks of the watercourse. Concrete lining greatly reduces the roughness factor and, therefore, the carrying capacity of the watercourse is enhanced.

(b) **Control of erosion** from either natural runoff or increased runoff arising from urbanisation of the catchment. Such projects often involve realigning tortuous bends in creeks, controlling the velocity of flows, protecting friable natural materials in the bed or banks, and establishing stable slopes to the banks of the watercourses. It is indeed unfortunate that most of the natural soils in the area under the Board's control for drainage purposes are easily eroded. Even the basaltic clays along the edge of a watercourse crumble under the action of very small flows of surface water. An adequate concrete lining permanently stabilises the bed and banks of the watercourses and can result in a minimum of maintenance works.

(c) **Control of siltation.** Several watercourses are subject to problems of flooding arising from siltation of the bed of the watercourse.

Siltation arises from general erosion of the catchment and erosion of the unlined bed and banks of the upstream section of the watercourse.

In nature, the section of Moonee Ponds Creek between Ormond Road and Mt. Alexander Road was always subject to siltation problems until the section was concrete lined. By so lining, the velocity of low flows as well as flood flows was increased to prevent siltation, and the bed load which was deposited along this section is now deposited immediately downstream of Mt. Alexander Road, from which point it can be more readily cleared. The concrete channel does not require any maintenance to clear debris after flood flows nor to maintain satisfactory conditions at times of low flow, and this work is typical of other concrete lined channels constructed throughout the Metropolis.

At the lower end of the Mordialloc Settlement Drain, the concrete lined channel has been designed so that sand and silt will be deposited rather than discharged into Mordialloc Creek. This section of the channel can be cleared by use of a rubber tyred front end loader and trucks working along the concrete bed of the channel.

(d) **Control of pollution.** The beds of most natural watercourses are uneven, and deep pools are common. At times of low flow, particularly along watercourses receiving urban runoff, organic material is deposited in the pools, which tend to become stagnant and set up anaerobic conditions in which decomposition of the organic material takes place in a similar fashion to the action of a septic tank.

Not only does the rough natural bed hold organic material which provides food for vermin such as rats and mice, the natural rough banks provide ideal protection for the vermin.

The natural banks generally are too rough to be maintained by mechanical means, such as slope mowers, and the cost of regular hand maintenance would be enormous.

Tests along the concrete lined channels have shown that even in the height of summer under drought conditions the dry weather flow is maintained in a highly aerated state, organic pollutants and bacteria are reduced without creating noxious conditions, and, provided that the grassed sloping banks and maintenance track are mown, vermin are not encouraged by the environment along the channels.

3. TYPES OF LINED CHANNELS USED

3.1 Factors to be considered

Experience has shown that in the urban enrivonment of Melbourne unlined earth channels are not a satisfactory long term solution to problems associated with the management and control of urban watercourses.

The type of lined channel adopted depends on the circumstances associated with each case.

In choosing the type of channel and the height of the banks to be hard lined, some of the factors to be considered are:

- the magnitude of the peak flood flow
- the magnitude of the normal dry weather flow
- the area of land available for the works
- the frequency and magnitude of "flushing" flows
- the gradient of the watercourse
- the velocity of both peak and dry weather flows
- the amount and type of bed load both under peak and dry weather flows
- the type and quantity of other pollutants
- the stability of the soil in the bed and banks
- the probability and problems of maintenance of the bed, sloping banks and adjacent land
- the type of materials available for the lining
- the length of time for which the channel is expected to provide a service
- the cost of the channel works both in construction and subsequent maintenance
- the question of safety of the public
- the inter-relationship of the use of the adjacent land with the type of drain and lining.

3.2 Available Materials and their use for lining of channels

(a) Choice of materials

The matters to be taken into consideration in choosing a lining material for channels are:

- the availability of the material
- the durability of the material
- the ease of placing the material
- the stability of the lining under working conditions
- the effect of the material on the roughness characteristic of the channel
- the probability of the material in place complying with the criteria for the hydraulic design of the channel
- the cost of the material (including supply, delivery and handling into place)
- the difficulty of maintenance to retain the design criteria
- the susceptibility of the material to vandalism.

(b) Materials available in Melbourne

Materials available in the Melbourne region and suitable for the lining of open channels are very limited. Basalt is the only building stone in the region and the quality of the stone is variable and most of the stone is not suitable for cutting economically into durable building "blocks".

In the early days, some works were lined with timber or red building bricks, but most of the open channels were lined with bluestone (basalt) pitchers or larger beaching stones.

(c) Alternative Types of Lining

(i) Prior to 1952, pitchers were used extensively for the lining of open channels. The technique of pitcher cutting has been virtually lost since the Second World War due to a shortage of suitable skilled labour; also the availability of suitable stone is very limited. Likewise, the technique of pitcher setting has been lost and the cost of this labour intensive work has risen enormously.

Over the last 25 years virtually no new pitchers have been available to the Board, and only limited supplies of reclaimed pitchers have been available from municipal councils or demolition of buildings.

The pitcher lining of channels has not always been successful, as experience in Gardiners Creek downstream of Toorak Road has shown that the flat pitched berms cause deposition of silt and the pitchers are eroded by peak flood flows and are not capable of supporting rubber tyred mechanical equipment such as trucks.

(ii) The supply, cost of supply, delivery and laying has precluded the use of first class durable bricks as an alternative material for lining drains.

(iii) Various precast patented concrete products have been considered but have not been used in any quantity on the grounds of suitability to withstand flood flows, durability, economy, maintenance problems etc. Such products include crib walling, flat slabs, Humes bg slabs (waffle slabs).

(iv) In some cases, erosion has been controlled by large basalt boulders placed along eroding banks, but the general use of rocky banks of this type cannot be recommended. In the first place, the rocks present a very poor factor of roughness which is variable from one section to the next and cannot be defined with any degree of accuracy. Therefore, the depth of flow of water in the channel cannot be calculated with any degree of certainty and flooding may not be controlled. These rocky banks form the ideal habitat for snakes, rats and rabbits and grasses or noxious weeds grow in the silt accumulation between the stones. The uneven rocky banks cannot be mown by mechanical means and are costly to place.

(v) Another school of thought to which the late Ellis Stone subscribed, suggests that the bed of open watercourses should be covered with loose basalt boulders to simulate the rocky bed of a mountain stream or a babbling brook. This suggestion was discussed with Mr. Stone shortly before his death and he admitted that he had not considered that flood flows would move the rocks along the bed and would need to be replaced after each major flow.

Unless a stream has a natural supply of rock or gravel, it is considered that it is not possible to establish on a permanent basis an artificial rocky bed to simulate the mountain brook.

In the urban environment, the problems of collection of debris, and vandalism, must also be considered.

(vi) One interstate engineer has been advocating recently the use of small boulders, say 30 to 40 lb. weight, set in the sloping concrete banks of concrete lined channels. This recent suggestion is similar to the "rubble" concrete used in the past. Whilst it may improve the appearance of the drain, if properly constructed, the writer admitted that difficulty had been experienced in achieving his aim in the field. The disadvantage of this type of construction is that the coefficient of roughness is unknown and therefore the depth of flow is unknown. Also there would be a considerable increase in cost of supply and the labour in setting of suitable basalt boulders in the concrete.

(vii) In recent years, both the Board and overseas authorities have made limited use of rock-filled wire baskets, the trade name of which is "gabions", as a lining for eroding creeks. The wire baskets are made of heavy welded or woven wire mesh and filled with rock, preferably four inches to six inches in diameter.

The baskets, stacked one upon the other, present a rustic appearance and may be regarded as more aesthetically pleasing in appearance than a plain concrete drain. On the other hand, the baskets are more readily subject to vandalism, involve a high labour content, require much more quarry products and twice the quantity of steel mesh than does the concrete lining. The rougher surface of channels formed of gabions necessitates larger cross-sectional areas than equivalent concrete channels. Overseas experience has shown that some drains lined with gabions have serious problems with siltation and growth of vegetation resulting in difficult hand maintenance and increased costs.

The proper use of gabions seems to be as a means of controlling erosion in watercourses of relatively high velocity and where control of flooding and economics are not the prime criteria. Gabions have been found useful in situations where the natural ground is too soft to support a concrete lining.

3.3 Types of Concrete Lined Channels

Over the past twenty years the Board has constructed many concrete lined channels in various circumstances and has gained considerable experience in the design, operation and maintenance of such channels.

Whilst each channel has been designed to suit the local problem, the works can be categorised into three fundamentally different types of channel with variations of each type to suit differing circumstances —

(a) The wide flat bed channel

Where large discharges of the order of 3 000 to 10 000 cusecs have to be discharged along relatively flat graded channels such as the Moonee Ponds Creek at Mount Alexander Road, Flemington, and the Elsternwick Main Drain at New Street, Elwood, wide bed grass channels were used initially but quickly proved to be functionally unsatisfactory and unsightly. Maintenance of the weed growth on the saturated berms of these channels was not practical. As peak flows and consequent flooding increased it became necessary to adopt the type of construction illustrated in Figure 2.

The concentration of the dry weather flow into a relatively narrow central channel provides sufficient velocity to carry the daily sandy bed load to points where the sand can be readily collected. Both minor and major flood flows have sufficient velocity to wash the concrete beams and banks clean of any muck and debris carried by the floodwater.

Required maintenance of these drains is minimal and is confined to mowing the access strips along the top of the banks and the grassed slopes above the sloping paved banks.

While some "conservationists" regard these channels as "ugly", other people have remarked on the tidyness of the channel as compared with the untidiness of the natural creek such as the Merri Creek and Plenty River, particularly after flood flows.

(b) **The wide trapezoidal channel**

Several watercourses which have needed improvement have been constructed as trapezoidal channels with bed widths in the range of 10 to 20 feet.

This type of channel has been chosen where peak flows are expected to reach 2000 to 8000 cusecs and the longitudinal grade is steep enough to guarantee a self-cleaning invert.

Typical construction is illustrated by the photographs of Moonee Ponds Creek at Albion Street and Waxman Parade, Cherrys Main Drain and Kayes Main Drain which are included in Figures 5 and 6.

The concrete bed has been designed to permit normal maintenance vehicles to traverse the bed. Concrete is carried up the slopes high enough to control erosion of the lower banks by normal flood flows, and the upper slopes and adjacent maintenance track is grassed. The only regular maintenance required is the mowing of grass by a tractor mounted mower.

Velocities along these channels at times of flood flows are relatively high and careful hydraulic design is necessary to control the flow, particularly around curves and at drop structures. In these circumstances it is necessary to adopt a lining of known hydraulic roughness characteristics.

The low flows are confined to the central section by sloping the invert slightly to the centre line of the channel, so that at low flows the velocity is still high enough to keep the sandy bed load moving. This design provides for a wide surface area for the flowing water, yet maintaining reasonable velocities at shallow depths. All these factors, together with the drop structures, provide the best conditions for re-aerating polluted waters and encourage aerobic conditions in the channel.

(c) **The narrow "V" channel**

In situations such as applied along the Clayton South Drain, see Figure 12, both peak and dry weather flows are comparatively small. There is a considerable bed load of sand, grades are not steep and the adjacent land is flat.

In these circumstances, it is necessary to construct a drain with a bed level and hydraulic grade line deep enough to drain the subsidiary municipal drainage system, to confine the low flows in order to prevent siltation along the drain, to control the velocity of flood flows to prevent erosion of the banks, and to occupy the minimum reasonable amount of land.

Along the Clayton South Drain it was considered desirable to concrete line a considerable proportion of the height of the sloping banks to prevent erosion of the sandy material by the regular "flushing" flows and erosion by surface runoff down the banks.

4. SURFACE TREATMENT OF CONCRETE CHANNELS

4.1 Present practice

The present specification for surface finish of concrete in channels requires that a hard durable surface be obtained by trowelling with a steel float. By so finishing the surface the smoothest finish is obtained initially and maintained during the service life of the channel.

Construction joints are permitted at intervals of eight feet three inches for ease of screening and economic use of reinforcing steel mesh. Alternate slabs are constructed as a means of maintaining accuracy of shape and reasonable progress of construction. These construction joints serve to control the tendency for shrinkage cracking and movement of the subgrade.

Expansion joints of patented compressed cork material are specified at intervals of approximately sixty feet.

This practice leads to the production of a white-grey concrete surface, particularly in the initial years, with little or no relief in colour or obvious pattern of jointing.

Whilst functionally the present practice produces the best hydraulic surface, and the most durable and most economic drain, together with simplicity of construction and maintenance, some people have expressed criticism of the appearance. Therefore a review has been made of alternative treatments of the concrete.

4.2 Alternative aesthetic treatment of Concrete-lined channels

The alternative treatments available for improving the appearance of concrete surfaces fall into three broad categories, viz. —

- treatment of the surface as a whole
- breaking of flat surfaces by a pattern of grooves or jointing, and
- colouring of the concrete surface.

(a) **Surface treatments of concrete**

Numerous treatments of concrete surfaces are in use to improve the appearance of footpaths, shopping malls, retaining walls and buildings.

Some are relatively simple to apply, whilst others are relatively costly. Some improve the appearance but greatly affect the durability of the concrete against wear and weather.

(i) Possibly the simplest surface finish to apply is that achieved by a wooden float or carpet float. Normally such finishes are applied with a circular motion to give a non-slip finish to footpaths but often the very fine surface shrinkage cracks are not sealed and the durability of the concrete surface is not as good as that achieved by the steel float. At a distance the difference in the finishes is not perceptible and it is considered that a wood-float finish would not satisfy the critics.

A rougher patterned surface can be obtained by the use of rollers, wire brushing or "combing" of a special surface layer of plastic facing mortar.

(ii) For many years use has been made of formwork to break the stark appearance of concrete walls. Of the various techniques used, perhaps the most applicable type of treatment to concrete drains would be that achieved by using rough sawn Douglas Fir planks as formwork for the sloping faces of concrete channels.

The surface of such timber, when sawn and weathered may show the grain clearly and, when used as formwork, the impression of the grain may be raised 1/8 in. to 1/4 in. above the general surface. The joints between boards also add to the pattern.

In general, this type of architectural treatment is best used when viewed from close range, rather than from long range, as is normally the case with drainage works.

(iii) Another current architectural trend is the use of exposed aggregates on the surface. This effect can be achieved in many ways.

"Sparrow" picking, that is, picking the surface with a diamond pointed pick, breaks 1/4 in. to 3/4 in. off the surface of the hardened concrete, splitting the aggregate and leaving a pitted surface.

Patented tools are now available for producing a "brushed" surface which again produces a rough surface and exposes the aggregate.

Washing a concrete surface with acid or blasting a surface that has just achieved the initial set with a jet of compressed air or high pressure water also produces a roughened surface and exposes the aggregate.

Surfaces of retaining walls and buildings have been roughened to expose the aggregate by dragging the teeth on the buckets of excavators across the surface or by setting thick manilla rope on to the formwork.

The ultimate in exposed aggregate surfaces is achieved by facing the concrete surfaces with precast slabs having a surface of exposed river gravel. The construction of in-situ exposed aggregate finishes of uniform quality would be an extremely difficult and costly operation.

All these various types of surfaces are more costly than the standard steel trowelled surface, less durable and with somewhat poor hydraulic characteristics and therefore are not considered to be desirable finishes for concrete drains.

(b) **Patterned Grooving**

A pattern of deep grooves in flat concrete surfaces can be used to break the flat appearance of large concrete slabs.

Figure 1 shows the effect achieved by the Country Roads Board on the abutments to a bridge on the Moe Bypass. Interest has been added to a large sloping surface by using concrete hexagonal slabs two feet in width across the flat sides. Whilst in this example precast slabs were used, the same effect could have been achieved by cutting grooves with a similar pattern into the surface of large cast-in-situ slabs at the time of final trowelling.

In order to achieve any effect at long distances, it is necessary that the grooves be deeper and wider than the 1/4 in. grooves normally used in footpath construction.

In buildings, architects have often used recesses one to two inches deep and one to three inches wide to establish definite breaks in the surface of flat walls.

It is considered that grooves approximately one inch deep and one inch wide would be adequate to establish a pattern which can be easily seen on the surface of concrete lined channels.

In order to illustrate the effects which could be achieved, ten perspective sketches have been prepared to show the effects on the three typical types of drains.

Whereas Figure 2 showed two photographs of the typical flat bed channel, Figures 3 and 4 show two possible treatments of the slabs by grooving, aimed at breaking the effect of the wide expanse of concrete.

Figures 7 to 11 show various possible patterns of grooving wide trapezoidal channels of the type shown in photographs included in Figures 5 and 6. Figures 7, 8 and 9 have been based on long straight lines along the drain, together with shorter transverse lines in an attempt to achieve an ashlar effect and, whilst the drawings show a regular pattern, the effect could be highlighted by a more irregular use of the transverse grooves.

Figure 10 illustrates an apparent irregular pattern which in fact is part of the hexagon pattern illustrated in Figure 11 and used so successfully by the Country Roads Board at Moe.

Possible treatment of the narrow "V" channels photographed in Figure 12 are shown in Figures 13 to 15. As the invert is normally only three feet wide and entirely covered with water, no grooving of the invert is suggested. Figures 13 and 14 show the effects of a simple and a more complex pattern of grooving whilst, in Figure 15, an attempt has been made to show the effect of using twelve inch planks of oregon or Douglas Fir timber to achieve a wood grain finish.

The adoption of a simple grooved pattern probably would require the use of one or two additional trowel hands to the normal concreting gang and add five per cent to the total cost of construction of a drain.

(c) **Colouring of Concrete**

(i) For reasons of economy and simplicity the Board has used concrete comprised of normal Portland cement, sand and basalt aggregate on all drainage work, and normally does not require any special hard wearing surface to be applied as is often the case with factory floors, petrol service stations, and similar areas subject to heavy traffic.

The appearance of the natural grey surface of concrete can be improved by colouring and several methods are used to achieve this result.

(ii) Existing concrete can be painted, but this method is costly, needs to be repeated at regular intervals and is unlikely to be successful because of the normal dampness of the concrete in drains from capillary action of the ground water beneath the concrete and flood flows along the drain.

(iii) A new patented German process is available in Melbourne from Bomanite Australasia Pty. Ltd. in which the surface of freshly placed concrete is treated with a pigment impregnated wax. The process is usually associated with the production of a patterned surface to simulate cobblestone, tiling, basket-weave brickwork etc. Photographs of this type of finish are included in Figure 16.

(iv) Pigments added at the time of mixing have been available for many years for colouring concrete.

Initially, naturally occurring pigments were used and later carbon black and other organic pigments were tried, but all these earlier pigments were subject to relatively quick deterioration by weathering or leaching from the concrete. Some proved unstable in the presence of cement or lime.

Today, the German Bayer chemical company produces a range of inorganic pigments for colouring concrete which is imported to Australia by Bayer Australia Limited and distributed in Melbourne by five main distributors.

Four of the pigments, namely black, red, yellow and brown, are based on iron oxide, whilst the green pigment is a chrome oxide, the light blue pigment is a compound of cobalt, aluminium and chrome oxides, and the light yellow pigment is a mixture of compounds of nickel, antimony and titanium.

These pigments are claimed to be chemically stable, non toxic and corrosion resistant. No loss of strength in the concrete is experienced up to a pigment-cement ratio of 10%.

Normally pigment is added to the concrete mix in the ratio of 8% pigment to cement and, allowing for 300 kg of cement per cubic metre, approximately 25 kg of pigment is added to one cubic metre of concrete.

There are two ways in which to produce a coloured surface to a concrete lined channel. The simplest method is to add the pigment to all the concrete used at the time of mixing, and the only additional cost is in the supply and handling of pigment and the additional washing of the mixer and trucks to remove all traces of the pigment. However, this method is an extravagant use of pigment in a situation where most of it will not be seen.

The alternative method is to place normal concrete to the level of the finished surface, to mix on site a surface layer of pigment, cement and stone dust, to dust this pigmented mixture over the surface of the concrete, and steel trowel the mixture into the surface. This process is specified by the oil companies for the construction of coloured pavements at service stations, but is understood to give patchy colouring if not properly finished.

It is the current practice on the construction of drainage channels to purchase all concrete premixed from one or more of the several suppliers and the addition of pigment at the premix plant would be the simplest process and would not involve any additional on-site labour. Mixing of a surface layer at the site of the works would save substantially on the cost of the supply of pigments, but add to the labour cost of the work.

The question of possible damage to the surface by vandalism or heavy equipment needs consideration. Damage to a dusted pigmented surface would reveal the underlying grey concrete and would detract far more from the appearance than damage to normal grey concrete or to totally coloured concrete.

It is considered that field trials would be necessary to determine the relative economy and effectiveness of each method.

Examples of each technique are shown in Figure 17. Brown Bayer iron oxide pigment was used throughout the concrete in the road at Upwey. The slate grey concrete at the Essendon Private Hospital was produced by a surface layer of "Cementone" black pigment.

The price of each pigment varies considerably, depending on the type of raw material, and complexity of manufacture. It is also dependent on the quantity ordered and considerable reductions are available on large direct shipments. For example, direct shipments of lots of 18 tonnes could cost $347 per tonne for black pigment and $498 per tonne for brown pigment, that is approximately $8.5 and $12.5 per cubic metre of concrete respectively. Apart from the yellow oxide, other pigments are dearer.

One large supplier of premixed concrete has tentatively quoted to supply black pigmented concrete at an extra $18 per cubic metre, such cost to allow for costs of supply, handling, storage, additional cleaning out of mixers, trucks etc. This amount represents an addition of about 60% to the normal cost of supply of concrete.

Applying these figures to the current work being undertaken on Moonee Ponds Creek near Pascoe Vale Road at Broadmeadows, where the estimated value of the project is $895 000, the use of black pigmented concrete would increase the cost by $80 000 or 9%. Bulk buying of pigment could possibly reduce the extra cost to $70 000; however, delivery periods in excess of three months can be expected after placing an order.

On the grounds of economy and appearance in drainage channels, the black pigment appears most suitable. It provides a dark slate grey surface but, if the concrete is not properly placed and efflorescence occurs, the dark pigmentation has been known to make more obvious any such damp patches in the concrete.

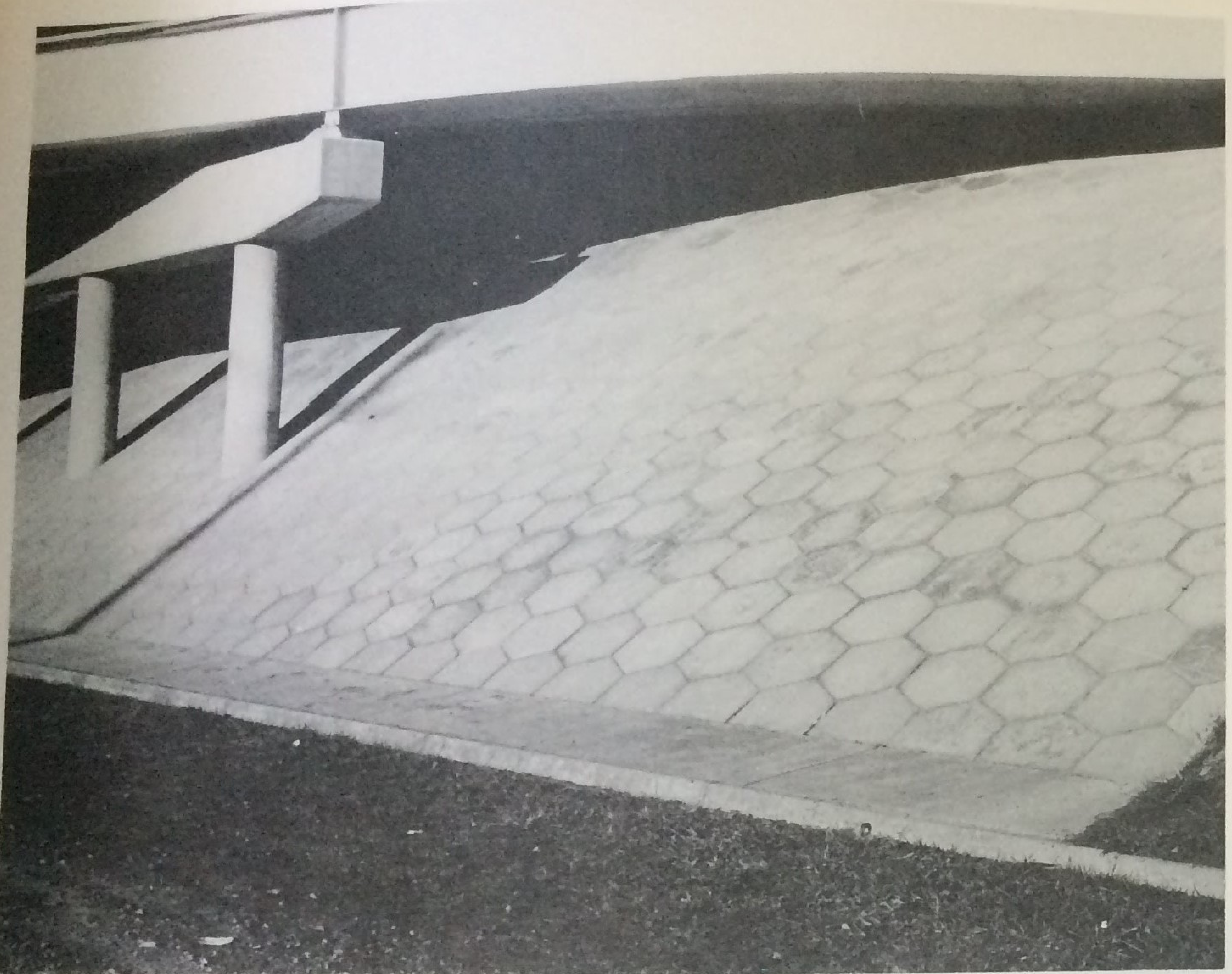
5. CONCLUSIONS

5.1 The aesthetics of concrete lined drains could be improved by additional expenditure on pigments and/or surface finishes, including deep jointing patterns which could be seen at reasonable distances.

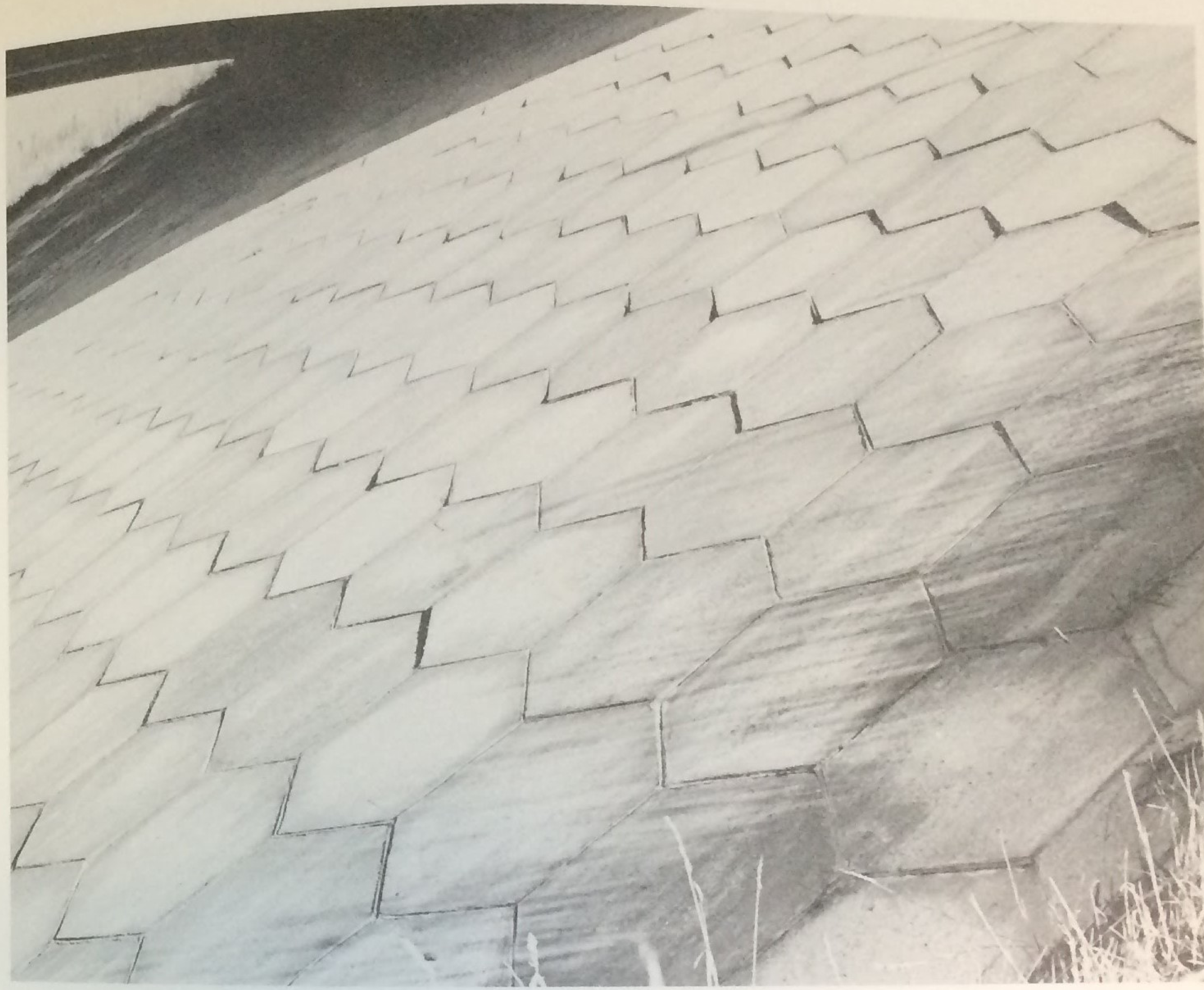
5.2 Because of the additional cost, such treatments should only be considered where environmental considerations warrant; however, the question is raised as to whether the mass of the ratepayers is prepared to pay the cost of the additional aesthetic treatments of concrete channels, when there is such a back-log of drainage works awaiting finance.

5.3 If it is decided that a better appearance to concrete lined channels is warranted, it is considered that it could be achieved by the use of black pigments to produce a slate-grey surface and/or by using simple grooved patterns moulded into the surface of the concrete, such as those shown in the various drawings supporting this report.

C. T. EARL
Chief Engineer Main Drainage
30th June, 1975.



PRECAST CONCRETE SLAB REVETMENT



REVETMENT SLABS DETAIL
(2 ft. across flats)

C.R.B. BRIDGE ABUTMENT, MOE

APPROACH TO MT. ALEXANDER ROAD BRIDGE

LOOKING UPSTREAM

MOONEE PONDS CREEK
UPSTREAM OF MT. ALEXANDER ROAD: BED WIDTH 80'-0"

FIGURE

ALBION STREET BRIDGE

WAXMAN PARADE

MOONEE PONDS CREEK

FIGURE 5

UPSTREAM FROM PRINCES HIGHWAY
Friable bank material eroding by surface runoff

CHERRYS MAIN DRAIN

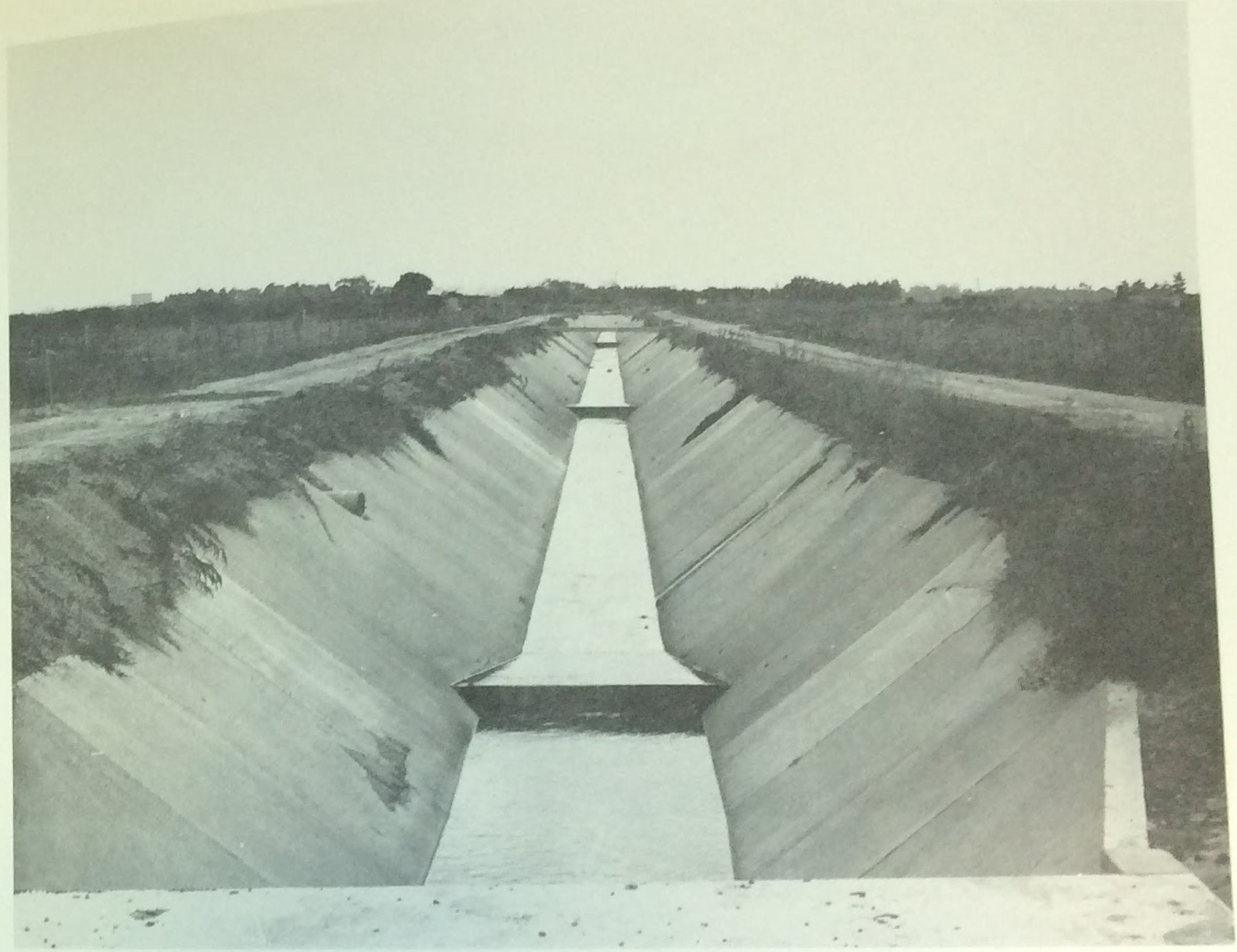
KOROROIT CREEK ROAD TO PRINCES HIGHWAY
Works nearing completion

KAYES MAIN DRAIN

FIGURE 6

FIGURE 7

UPSTREAM FROM BOURKE ROAD



UPSTREAM FROM PEACE ROAD

CLAYTON SOUTH DRAIN

FIGURE 12

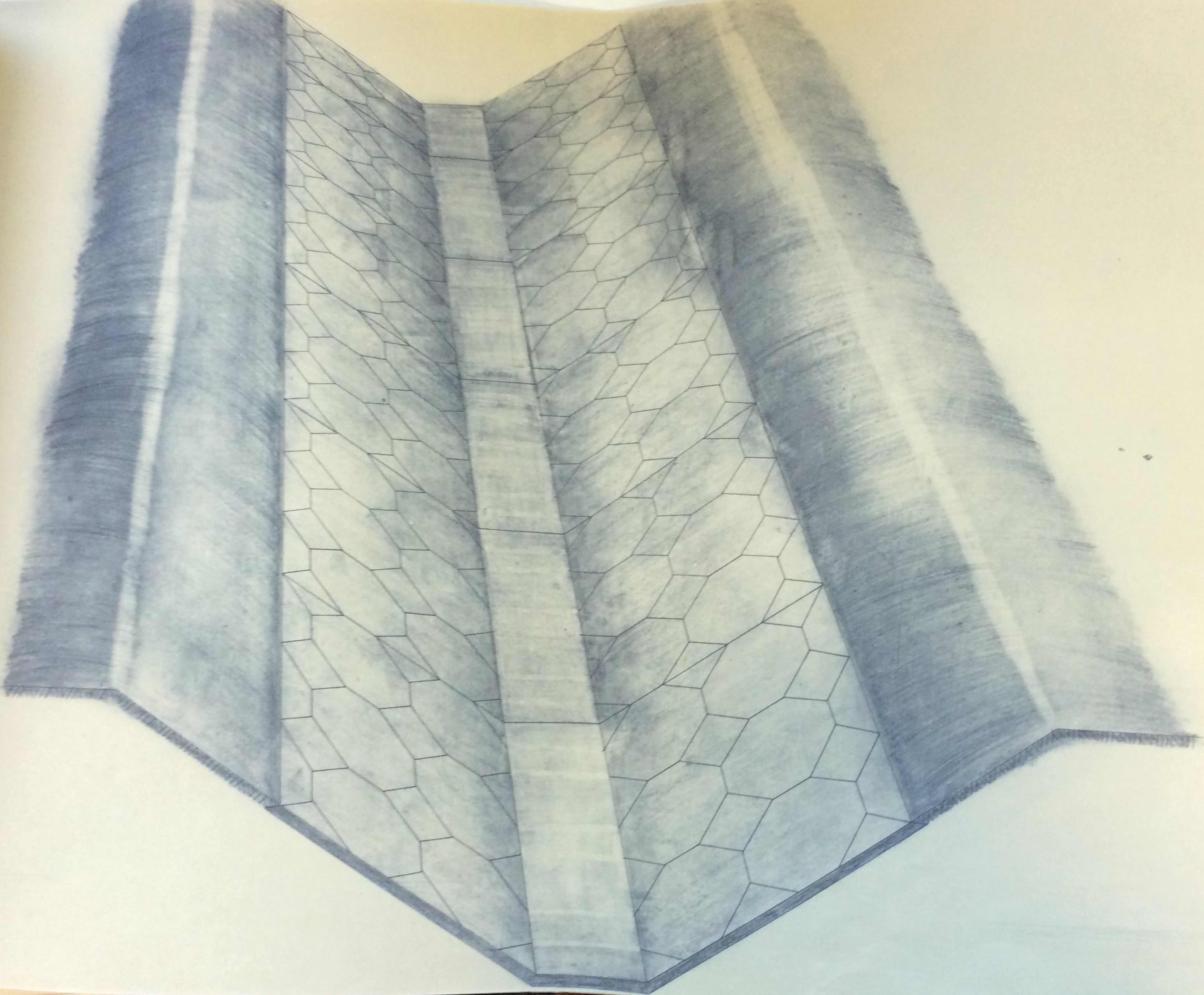


FIGURE 14

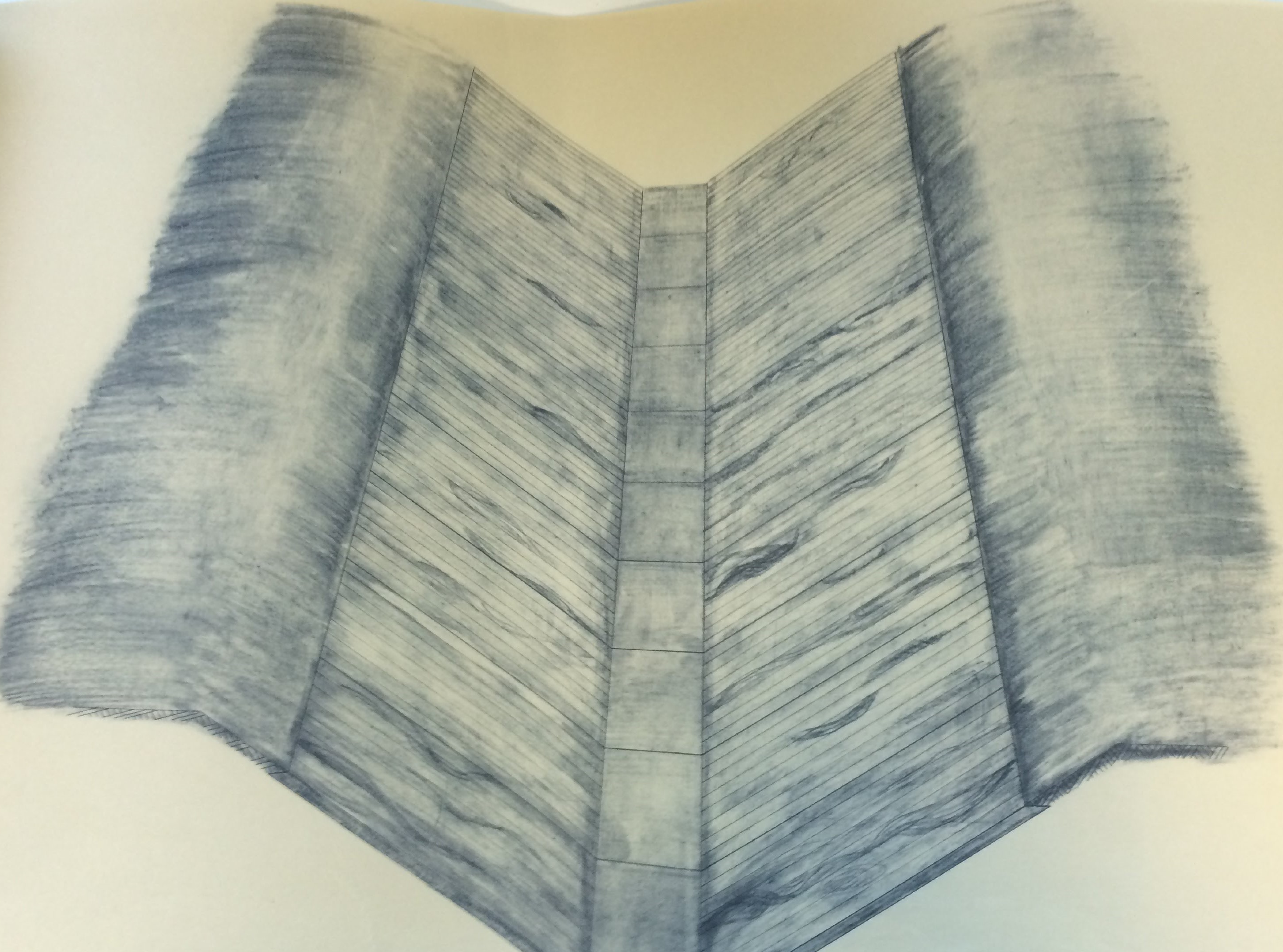


FIGURE 15