1-1-1987

Water erosion survey in the Northam district after storms in June 1986

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Water Erosion Survey in the Northam District
After Storms in June 1986

D.J. McFarlane
A.T. Ryder

Resource Management Technical Report No. 57
Disclaimer

The contents of this report were based on the best available information at the time of publication. It is based in part on various assumptions and predictions. Conditions may change over time and conclusions should be interpreted in the light of the latest information available.

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Abstract

Water erosion occurred in June 1986 in the Irishtown-Wongamine area of Northam when heavy rain fell on cultivated land. Visits were made to the area by officers of the Soil Conservation Branch to estimate soil and crop losses and to provide recommendations for limiting future losses. As there have been few estimates of soil loss made in Western Australian agricultural areas, and as the findings from the investigation have applicability beyond their immediate area, this report was written.

The storm which caused the most erosion did not have a long return period, but the coincidence of the storm and bare cultivated soils resulted in large soil losses. There was an absence or neglect of soil conservation structures which are essential when sloping land is frequently cropped. Poor cultivation practices were evident, including the cultivation of natural waterways, a low adoption of minimum tillage, working up and down slope and cultivating corners which receive furrow runoff.

One small paddock measured lost about 60 per cent of its topsoil to the depth of cultivation. A larger paddock lost over ten per cent of its topsoil and accumulations on a fence line showed that at least 25mm of topsoil had been lost in previous years from this paddock.

Given that the soil formation rates in the area are practically negligible, the erosion represents mining of the soil profile. The most serious losses could have been significantly decreased by the adoption of soil conserving methods (e.g. minimum tillage on the contour between soil conservation structures and the non-cultivation of waterways). Many conservation practices are not expensive, particularly for highly productive farms such as occurs in the area. There is a need for the Northam office of the Department of Agriculture and the Northam Soil Conservation District Advisory Committee to increase the level of awareness of farmers in the area.
1. Introduction

An intense storm on freshly seeded soils in the Irishtown—Wongamine area caused widespread sheet and rill erosion on June 16, 1986. The approximate area affected by the storm is shown on Figure 1 to be about 125 km².

Soon after the storm, the area was visited by advisers from the Northam District Office and the Commissioner of Soil Conservation. It was decided that the area be visited by officers of the Soil Conservation Branch to see whether measurements of the amount of soil loss could be made to aid the extension of conservation practices.

This report gives:

A. observations on the causes of the water erosion,

B. estimates of soil and crop losses as a result of the storm,

C. estimates of the amount of soil contained in alluvial fans which have built up over several years in two areas.

D. recommendations on how water erosion could be lessened.
2. Rainfall

Figure 1 shows that a stream gauging station (Frenche's Crossing) is located within the area affected by the storm. A pluviometer at the station showed that on June 16, 40.2 mm of rainfall fell over a 6.5 hour period with a maximum intensity of 12.0 mm over 0.5 hours. The 6.5 hour storm intensity would be expected once every four years on average (i.e. has a 0.25 probability of occurring in any one year) while the 0.5 hour storm intensity would be expected once every two years on average (0.50 probability).

Some observations of storm intensity were also made by farmers in the area. Estimates ranged from 20 to 75 mm of rain in 0.5 hours. The lower figure in this range is a 1 in 15 year return period storm while the upper figure is several times the 1 in 100 year storm. It is considered that the intensity information from the pluviometer is a more reliable estimate of storm intensity, although it is quite possible that intensities were higher in some areas than was recorded at Frenche’s Crossing.

Farmers in the area observed that the storm was more typical of a summer event. Thus, while the storm intensity may have a relatively short return period, the erosion (which resulted from the storm occurring at a critical time) may have a much longer return period. One farmer observed that the same paddock had experienced similar erosion when in crop 17 years previously.

At Northam, 9 km south of Frenches Crossing, rainfall during January, March and April was below average. During February, 94 nun fell (decile 9), germinating weeds which required the early cultivation of cropping paddocks. Rainfall during May was slightly above average (65 mm, decile 7) which enable crops to be sown in many areas just prior to the June 16th storm.
Figure 1. Location of storm area in relation to roads and rivers
3. Observations

About 80 per cent of crop land in the 125 km² area showed evidence of erosion. Carder (1984) estimated that 36 per cent of the cleared land in the Northam Shire was cropped in 1982/83. The percentage during 1986/87 is likely to be similar. Some additional erosion had occurred in the ten day period between the storm and the visit to the area documented in this report. The most serious erosion occurred in the following situations:

3.1 Cropped areas below rocky outcrops

The area adjacent to the Mortlock River North Branch has had most of the lateritic profile removed, exposing basement outcrops of Archaean granites and gneisses (Jimperding Series). Soils are commonly duplex (D/r 2) over shallow rock. Numerous small to medium sized rock outcrops had shed water onto cultivated land resulting in ruling. In some cases, runoff from rock outcrops had travelled for 100 metres or more across pastured areas causing little obvious damage before entering cropping areas and removing soil to the depth of cultivation (often exposing the marks left behind by cultivation points). Disc ploughing around rock outcrops in the area has sometimes resulted in soil build—ups on one side of the outcrops and depleted areas on the other.

3.2 Cropped areas below lateritic breakaways

In the north east of the storm area, lateritic breakaways are more common and resulted in significant runoff and erosion of downslope cropped areas. Yellow earths (G/n 2.2) are common in this area. As in the previous case, runoff from the shedding area sometimes crossed pasture paddocks before causing erosion of the cropping land. Given the concentration of organic nitrogen in the top few millimetres of pasture land and the linear relationship between organic nitrogen loss and cereal yield decline (Marsh n.d.), it is possible that there has been economically—significant erosion of pasture paddocks, despite the lack of obvious soil loss.

3.3 Long slopes unprotected by any soil conservation structures

Some long slopes have evidence of continued erosion during cropping years resulting in alluvial fans being deposited against downslope fencelines. Rills above the fans are becoming broad depressions which are bordering on becoming gullies. Within these depressions, sub—soil clays are now close to the soil surface and are being incorporated during cultivation. In one case, sub—soil rock was being exposed (Plate 1). The fact that the continued erosion has sometimes resulted in broad depressions that can still be cropped over probably indicates a low erodibility for the kaolinitic subsoil clays in the area.

3.4 Cropping across natural waterways

Rilling of natural waterways was commonly observed in the area affected by the storm. Some landforms in the area result in numerous small natural waterways which it would
be difficult not to crop across.

Some large waterways had very narrow areas left uncultivated although there were few cases where this resulted in serious erosion. The deposition of silt in one flat waterway had resulted in flows either side of the waterway resulting in soil loss on the surrounding cultivated land. Trainer banks are required to better define the waterway in this case.

### 3.5 Inadequate banking

A case of severe erosion occurred on one hillslope where a level bank system had been installed using a grader (Plate 2). Six surveyed cross—sections across the banks showed they had channel capacities between 0.92 and 1.93 m³/m. On spacings of 70 to 95 m, these capacities represent 10 to 20 nun of runoff. The lower capacities would be exceeded by runoff events with a return period of about five years. Following the June 16 storm, three sets of level banks had overtopped in sequence resulting in severe erosion, despite the banks having been maintained in the summer prior to cropping. No runoff had occurred at the bank ends indicating an absence of any freeboard for the banks.

One or two cases were noticed where rilling resulted from banking systems not extending far enough uphill to prevent the initiation of runoff. However extensive rilling above one set of banks (Plate 2) was initiated by maintenance which left a sharp knick point on the upslope batter of the bank channel. Runoff waters entering the bank channel initiated rilling at the knick point and the rills subsequently advanced uphill by headward erosion. Care must be taken when carrying out bank maintenance not to create any sharp falls in level. There was some evidence that seepage forces may have exacerbated the nil initiation at the knick point. It was noticable in a number of shallow rills that wheat seedlings were still growing, although the ground surface had been lowered in the nil by five or more centimetres. In the fill itself, the row of seedlings were displaced downslope as if the soil in the rill area had flowed downslope (Plate 3).

### 3.6 Working corners downhill

A common cause of ruling was downhill corner workings (Plate 4). Some erosion resulted without corner working when runoff concentrated in cultivation furrows at a corner, exceeding the storage capacity of the furrows. This can even occur in paddocks containing contour banks as the lowest land is often not worked on the contour.

### 3.7 Runoff from road verges

Some roadside drains had inadequate capacities and spilt water onto cultivated paddocks, particularly in low lying areas.
**Plate 1:** Two stages of soil removed. Ruling removes the cultivated layer while gullying exposes sub—soil rock.

**Plate 2:** Inadequate capacity of a level bank system has resulted in sequential failure and gullying. Note the numerous rills above each bank channel due to the creation of a knick point during maintenance.
3.8  Erosion of waterlogged areas

It was noticeable that a number of low-lying areas were already waterlogged and susceptible to erosion. Some waterlogging occurred immediately below grade banks.
4. Soil and crop losses as a result of the storm

Four weeks after the storm, two hours were spent flying over the area taking aerial photographs of the damage. Colour enlargements of two eroded areas were made to estimate soil and crop losses. The method used was:

A. Using point counting planimetry, determine the proportion of rills, soil deposits and non—rilled crop land.

B. As ruling of crop land is commonly to the depth of cultivation, estimate the soil loss.

C. As crop is completely lost in rills and deposits, estimate the proportion of crop lost.

The first area for which the method was used is shown in Plates 5 and 6. Plate 5 shows a triangular paddock in the left foreground which had been extensively ruled to the depth of cultivation (Plate 6). This paddock had received multiple cultivations. Runoff had been initiated from gravel hills in the centre background of the photograph (Plate 5) and crossed a cropped and a pasture paddock before entering the triangular paddock. From counting 3,500 points in the paddock it was estimated that 58.2 per cent of the paddock had been ruled. If the average depth of ruling was 5cm, this represents 291 m³.ha⁻¹ or 350 t.ha⁻¹ or 29 mm of soil lost over the whole paddock (assuming a bulk density for the cultivated land of 1.2 t.m⁻³). The area of crop lost was the same as that ruled (i.e. 58 per cent). The farmer recalled a similar erosion event on the paddock 17 years previously.

The second area for which estimates were made was an extensively ruled paddock with large alluvial fan deposits resulting from a number of years erosion against a fence line. This paddock had been direct drilled. Point counting (ca. 28,000 points) indicated that the rills occupied about 3.4 per cent of the area and the alluvial fans a further 7.8 per cent. Thus about 11.2 per cent of the crop was lost during the storm and subsequent erosion. Assuming an average depth of ruling on this area of 8 cm (the rills were often deeper than those in the first case), soil losses are estimated to have been 27 m³.ha⁻¹ or 32 t.ha⁻¹ or about 3 mm. As will be seen in the next section, this represents only about one tenth of the soil contained within the largest alluvial fan on the paddock, indicating the erosion from the June storm was not an uncommon occurrence at this site.
5. Soil accumulations in alluvial fans

Two sites (designated A and B on Figure 1) had triangular alluvial fan deposits against a downslope fenceline. Upslope of the deposits were rills bordering on becoming gullies as described in situation 3.3 of Section 3. As the deposits showed up as convex rises above the natural land surface, surveyed cross—sections were made across the fans in an attempt to estimate the volume of soil contained within them. The method used was

Plate 3: Wheat seedlings growing in a rill and showing downslope displacement of the sowing line.
Plate 4: Erosion of corners worked down hill. Note that the cultivation furrows feed water into the downhill workings, adding to the erosion.

A. A centre line was surveyed up the fans determining the fan slope and establishing points at 10 or 20 metre intervals.

B. The level was set up at each 10 or 20 metre point and cross-sections surveyed, estimating distances by stadia.

C. The cross-sections were then plotted (Figure 2 (a) and (b)) with a vertical exaggeration of 20. From field observations of where the fans began and the cross-sections, estimates were made of the natural ground surface beneath the fans. In one case these estimates were checked against the depth of burial of a fenceline and found to be conservative.

D. From the cross-sections, the thickness of the fans at ten metre intervals were estimated and averaged to determine the cross-sectional area of the fan at each section. These areas were then averaged and multiplied by the distance between sections to calculate the volumes.

E. Using an estimated bulk density of 1.2 t.m$^{-3}$, the weight of sediment in each fan was estimated.

Using the above method the volume of sediment in fans A and B were estimated to be
1190 and 127 m³ respectively, which is 1430 and 152 tonnes when converted using a bulk density of 1.2 t.m⁻³. The estimates are likely to be conservative due to:

A. A check of depth of burial of a fenceline at site B showed the fan thickness along the fenceline to be between 22 and 24 cm. The maximum depth estimated from surveying was 15 cm.

B. There was abundant evidence that there was erosion of the fans, particularly along their outer edges (Plate 6), which has resulted in the movement of sediment through the fences and across a road.

C. Erosion is known to be a sorting process and the deposited material in the fans was predominantly sandy. Clay and organic matter are likely to have been carried away in suspension in the runoff waters.

D. While the bulk density of cultivated soil may be only 1.2 t.m⁻³, the alluvium may have a higher density.

To convert the fan volumes to equivalent depths of soil, the area contributing to each fan was measured using a measuring wheel (Plate 7). The area contributing to fans A and B were about 4.66 and 1.14 ha respectively. This represents an average depth of soil over the contributing area of 28 and 11 mm for the two fans. About 3 mm of soil was contributed by the June storm to fan A, if the volume of rills is used as a guide (Section 4).
6. Rate of soil formation

The measurements of soil loss in sections 4 and 5 need to be related to rough estimates of the rate of soil formation to put the loss into perspective. Three aspects of soil formation can be considered:

Plate 5: Runoff from a gravel hill (center background) and roadway crosses pasture paddocks (causing little obvious erosion) and cropped paddocks (causing extensive riling – left foreground).

Plate 6: Extensive rilling removes cultivated soil and crop. Paddock is located at centre left of above photograph.
6.1 The rate of rock (crystal) weathering

The slow rate of rock weathering can be seen by the resistance of building stones and tombstones. Rahn (1986) notes that granite is a particularly resistant rock and records cases of only minute changes along hairline cracks in granites 10,000 years old although granite boulders have been reported to have decomposed within 100,000 years. This represents weathering rates of about 1 mm in 1,000 years. In Western Australia, the lateritic profile (Ca. 35 m thick) is thought to have formed during the Tertiary (70 million years). This represents about 1mm every 2,000 years. Rock weathering rates are likely to be greatest in warm, wet environments.

6.2 The rate of soil profile formation

In deeply weathered lateritic profiles, the depth of rocky basement is considerable and the rate of rock weathering is not as critical as the rate of soil profile formation (ie. topsoil replacement). Plate 9 shows a deeply gullied and sheet eroded lateritic soil in the York—Beverley area. The erosion is thought to have taken place in the 1920’s or 30’s and has changed little since that time. There is no evidence of new topsoil accumulating on the exposed clay subsoil.

Some estimates of soil profile formation rates have been made for the Quindalup dunes on the coast near Perth (Woods, 1983). Despite being in a high rainfall environment and being easily leached, these soils have shown little profile development after 6,000 years. It is likely that duplex (sand over clay) soils in the agricultural areas will take much longer to develop. In the eastern states, red brown earth and podzolic (duplex) soils have developed within the last 30,000 years (Walker 1980) in alluvium which consisted of pre—weathered minerals. For a one metre profile, this represents 30 years to form one millimetre of the profile.

6.3 The rate of organic matter replacement

The selective removal of organic nitrogen in runoff waters is thought to be the mechanism whereby short term yield declines occur in Western Australian soils as a result of erosion (Marsh, n.d.). Organic matter plays an important role in soil structure, cation exchange and water retention as well as supplying nutrients following mineralisation. It is likely that organic matter replacement can be relatively rapid under favourable conditions. Fresh organic matter is also though to be richer in organic nitrogen, has a higher exchange capacity and may be more active in holding large aggregates together (with polysaccharides).

The conclusions that can be made from the above is that it may take a thousand years to form a millimetre of soil from soil granite, up to a hundred years to form a millimetre of mature profile and perhaps only a few years to replace organic matter. Given these rates, soil can be considered to be effectively non—renewable and the losses reported in this report represent mining of the soil resource. Chemical fertility can be replaced by
fertilizers in most cases but the long term effects of erosion will be decreased physical fertility.

**Plate 7:** Measuring the dimensions of an alluvial fan and its contributing area. Note the reworking of the fan deposit in the foreground.

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**Plate 8:** Numerous rills both along and across cultivation furrows. The rills will be covered by subsequent cultivation. Large amounts of soil will then have been lost without any visible signs remaining (e.g. gullies).
Plate 9: Sheet and gully erosion in the York—Beverley area. The network of gullies has prevented cropping of about three-quarters of the area. The exposed white subsoil has apparently remained without plant cover or noticable topsoil accumulation in the 50 to 60 years since the erosion occurred.
7. Discussion

With relatively small effort, the amount of soil in alluvial fans can be adequately estimated. The field time to survey each fan in this study was about one hour. To estimate the soil loss in rills and gullies using photographs, levels and/or profilometers takes considerably more time.

The time spent measuring soil loss must be in proportion to the usefulness of the information. Unless the soil loss is measured in relation to causative and management practices (as discussed in Section 3), then it has limited usefulness apart from extension purposes.

The main problem in the Northam area appears to be the adoption of established soil conservation techniques and the use of common sense when cultivating erosion—prone areas. Long term neglect of an area (e.g. Fan A) can result in minimum tillage techniques being inadequate to prevent further erosion as gullies are already beginning to form. It is ironic that interest in soil conservation was so high in the Irishtown area in 1952 that it was chosen as the second site for a soil conservation school (run by the Soil Conservation Service and the Irishtown Pasture and Soil Conservation Group). A revival in interest in soil conservation is evidenced by the formation of the Northam Soil Conservation District. The slow rate of soil formation and the shallow depth of many of the soils in the area needs to be emphasised in any extension programme, along with information on the best methods of mitigating the erosion in each situation.
8. Conclusions

Some of the soil loss during the Irishtown—Wongamine storm was probably inevitable given the intensity and timing of the rainfall. However the damage could have been limited by adopting more soil conserving practices while cropping and by preventing excessive runoff from shedding areas (rock outcrops, lateritic breakaways and roads). Extension more than additional research information is required to limit future serious soil loss. Improved soil conservation is essential if the shallow soils in the area are to be prevented from permanent loss from production.
9. Recommendations

The following recommendations are made to mitigate erosion during future storms on each erosional situation identified in Section 3.

9.1 Cropped areas below rocky outcrops

When numerous rock outcrops occur in a cropped paddock, it is difficult to make recommendations for the mitigation of water erosion. Installing contour banks in such areas often results in small irregular areas which are difficult to cultivate. Ted Rowley (Northam District Office) has suggested the economics of cropping small lands be investigated so that farmers may be discouraged from attempting to crop non-economic areas. Such areas would be classified as non-arable on a land capability map. Minimum tillage in rocky areas would lessen the time when the soil is bare and detached and perhaps increase soil infiltration capacities. However it has been noted in other areas in the “zone of rejuvenated drainage” (i.e. west of the Meckering Line) that some soils around granite outcrops have limited storage capacities and are susceptible to waterlogging and severe erosion during high rainfall years. Under such conditions, increasing soil infiltration capacities will not limit erosion. If areas below large rock outcrops are to be cropped, absorption banks should be installed below the outcrops with a capacity for at least a ten year return period runoff event. In some areas, seepage interceptors are recommended to drain the duplex soil profiles.

9.2 Cropped areas below lateritic breakaways

As lateritic breakaways are more compact than most rock outcrops, it is possible to recommend absorption banks to contain a large proportion of storm runoffs. The natural vegetation of some breakaway areas has been degraded by stock or been cleared. This will have increased their shedding potential. Re-establishment of perennials on breakaways may require contour ridging (or pasture furrows) to retain water. Such ridging will also decrease their shedding ability.

9.3 Long slopes unprotected by any soil conservation structures

These areas require a bank system (either graded or level depending upon the availability of a waterway). The continued cropping of long slopes without adequate protection should not be tolerated in the area and active extension is recommended. If no response results from such extension, peer group pressure should be exerted (through the Northam Soil Conservation District Advisory Committee if possible). Failing such action, Soil Conservation Notices should be served on the most serious offenders.

9.4 Cropping across natural waterways

In some cases a banking system would protect small waterways, although in rocky areas this may result in unacceptably small and irregular working areas. Minimum tillage
may be effective in limiting the runoff occurring on small natural waterways.

9.5 **Inadequate banking**

Failure to properly construct banks surveyed by the Department is the responsibility of the landholder. The recording system that has been adopted by the Soil Conservation Branch now provides a record of the recommendations that were made at the time of surveying. The Earthworks Design Manual enables the risk of installing banks with low capacities to be calculated.

9.6 **Working corners downhill**

Bill Smart (Merredin Ag Memo, 1985) made a strong case for not working corners or at least doing it before sowing the rest of the paddock. The text of this case is included as an Appendix to this report. This case may need more active extension if it is to change the cultivation habits of some farmers in the area affected by the storm.

9.7 **Runoff from road verges**

As roadmaking authorities have little area to control road runoff, it is usually up to the landholder to accept the runoff. Where the water enters a natural waterway, an uncultivated strip must be left. It is often possible for a landholder to use banks to divert runoff from road verges to a safe disposal area.

9.8 **Erosion of waterlogged areas**

If seepage forces help initiate ruling in duplex soils, drainage of these areas is the only method of stopping the erosion. The accelerated adoption of seepage interceptors is recommended for such areas.

The erosion that occurred in the above eight situations was almost certainly exacerbated by the continued use of multiple cultivations and disc ploughs to control weeds. Most farmers reported at least three workings of their paddocks. Some of this working may have been necessary following the growth of weeds after February rainfall. However there is more scope for the use of herbicides in the area.

Between 10 and 20 farm plans are drawn up for farmers in the Northam district each year. Farm plans are particularly relevant in areas with a significant stock component, variable soils and abundant natural hazards for cropping. However there was little evidence of the adoption of the farm plans in the areas inspected. The enthusiasm of Ted Rowley for land capability mapping should accelerate the production and adoption of farm plans in the area.
10. Acknowledgments

The advice and help of Tan Sweeney during this brief reconnaissance of the area affected by the storm is gratefully acknowledged. Simon Eyres took the photographs shown in this report (except Plate 3).
11. References


12. Appendix

The case for and against working corners (adapted from Merredin Ag Memo, 1985 by W. Smart).

Consider a square 400 ha paddock (sides 2 km long). The area sown in the corners pulling double 28 run combines is 10.9 ha or 2.7% of the crop. If a 12 m airseeder is used, 13.6 ha or 3.4% of the area is sown.

For a paddock twice as long as it is wide (still 400 ha) the sides are 1.414 km and 2.828 km long. The area sown in the corners pulling double 28 run combines is 7.7 ha or 2% of the cropped area. If a 12 m airseeder is used, 9.6 ha are sown in the corners, 2.4% of the crop.

It seems fair to assume that less than 25% of the area sown in the corners are unsown, so over 75% of the corner is double sowing.

This amounts to:

Square paddock, combines 8.2 ha (2% of crop)  
air seeder 10.2 ha (2.5% of crop)

Rectangular paddock, combines 5.8 ha (1.5% of crop)  
air seeder 7.2 ha (1.8% of crop).

The case for sowing corners:

1. Weed control — the combine kills weeds and the area left (1/2 to 1% of total area) will grow weeds.
2. Productivity — bare land does not grow a crop.
3. Aesthetics — it does not look good to have unsown patches in the crops.
4. Tradition — its always been done this way.

The case against sowing corners:

1. Erosion — workings concentrate water into corners, some of which must run down the slope.
2. Weed control — boom sprays leave much smaller untreated areas on corners and these will rarely coincide with the unsown areas. Do not forget that weeds also grow along fence lines, in rock heaps, creek lines and under trees to re-infest crops.
3. Productivity — the double sown area (1.5 — 2.5%) of the crop is the first to burn off in a dry spell. Up to 2.5% of the crop is put at risk to add less than 1% to the cropped area. By double sowing corners, seeding costs are increased by up to 2.5%. These include fuel for the tractor, wear and tear and depreciation on tractor and seeder, cost of fertiliser and seed, time taken to sow.

4. Aesthetics — after 6 weeks or so you do not see whether the corners have been sown or not from the ground, but you can from the header cab.

5. Tradition — the people who have suffered the slings and arrows of the doubters and left corners out have observed benefits from cost and time savings and no loss of returns.

Compromise:

If you still want to work out corners, how about doing it before sowing the rest of the paddock.