Stream Rehabilitation Workshop and Field Walk

30 November 2018

IECA and SCS

Participants

LB experience:

- **Erosion / Sediment Control**
- **Rivers**
- **Works Design**
- **Implementation / Construction**

Your Turn……… Show of Hands

Lyall Bogie

Senior Environmental Officer, Nowra/SC
13 years experience in River Rehab with:
SR-CMA Shoalhaven / Illawarra
SE-LLS Berry
SCS Nowra/SC
ALL MAINLY **RURAL** EXPERIENCE

AIMS

Share knowledge and experience
Promote **awareness** and **confidence**
Look at **practical** examples

Major Change in Approach

- Traditional / Engineered solutions:
  - **Reductionist**
  - **Isolationist**
  - **Hydraulic** scale (generally)
  - **Short** sighted / reactionary
  - Caused many **side-effects** and damage to rivers.
  - **Simplified** modelling; reliance on **restricted** data
- OK in fully engineered systems eg Dams
- Lots of Urban design relies on engineering

Major Change in Approach

- BUT Rivers are **Complex**
- **Geomorphic** solutions:
  - **Inclusive** of processes, "external" factors
  - **Scale**: reach, multi-reach, catchment
  - Based on river **evolution** and **trajectory**
  - Address **multiple** issues
  - Complexity addressed through **observation**
- From **RESISTING** to **ASSISTING**

So we……

- **LOOK** for signs in rivers of change / process
- **APPLY** Fluvial Geomorph principles and scales
- **FIND** opportunities for the river to work for us
- **DESIGN** integrated interventions
- **IMPLEMENT** through broader strategies
- **MONITOR** for effectiveness and improvement
- (REPAIR and ADJUST if things go wrong)

Same whether small- or catchment-scale program

Today we will look at

- 1. Hydrology
- 2. Landscape setting
- 3. Channel types
- 4. Sediment transport
- 5. Channel change
- 6. Erosion / Sedimentation
- 7. Trajectory
- 8. Works in the field

"Let the River do the Work"

- Incorporating **Fluvial Geomorphology**
- Investigation of earth **form** and **process** to **understand systems** operating at **varying scales**, and inform **integrative** design
- **INVESTIGATIVE**
- **OBSERVATIONAL**
- Complexity matches river systems
- Modelling replaced by observation

What we will NOT look at

- Calculations (hydrology, sediment, flow etc)
- Hydraulics (details). [NEH ch6]
- River classification. [Brierly]
- Measurements
- Biophysical considerations on their own.

This is a **complex** area with lots of info, so I have focused on understanding what is **different about rivers**, and some of the things you really **need to know**, to compliment your knowledge in erosion / works / design etc.

1. Hydrology

- NEH ch5
- **Catchment** hydrology factors:
  - Rainfall (intensity, duration, frequency)
  - Interception. Infiltration. Runoff.
  - Catchment size and shape / branching
- **Most** catchments have undergone hydrological **change** since 1788.
- **Most** channels have **responded** to this – many are still **responding**

1. Hydrology

- Stream **Power** / Energy
  - Parameters can be **calculated**
  - Factors in discharge, slope, depth, width etc.
  - Related to stream **competence** and **erosivity**
  - Best "estimated" from **field** observation
  - High / Medium / Low
    - Different **structures** / interventions in each
    - Different channel **responses** to disturbance
    - Different channel **types** for each

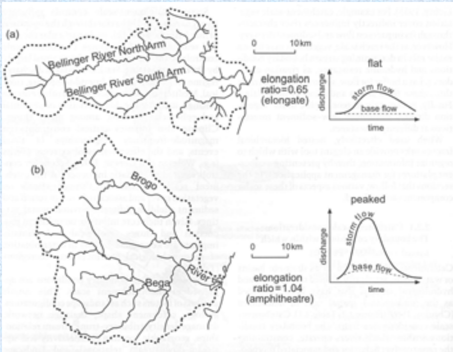
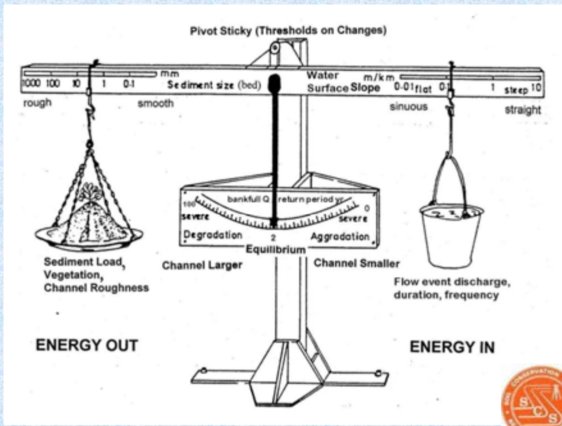


Figure 2.2 The influence of catchment shape on tributary–trunk stream relationships and storm hydrographs Catchment shape and regional geology influence the pattern of tributary–trunk stream relationships. This exerts a secondary influence on biophysical fluxes such as the peakedness of flow during flood events. An elongate catchment (with a low elongation ratio) (Figure 2.2a) has a relatively suppressed flow duration curve (Bellinger catchment, New South Wales, Australia). In contrast, an amphitheatre, almost circular catchment (Figure 2.2b) is characterized by the convergence of several tributaries within a short distance along the trunk stream resulting in more peaked flood events (Bega catchment, New South Wales, Australia).



1. Hydrology

- Stream / **Channel** hydrology (reach)
  - Width/depth, slope, roughness, planform, length, branching, bedforms
  - Manning relationship

$$v = \frac{R^{2/3} S^{1/2}}{n}$$

  - **Bankfull** flow assumed to be **channel forming** flow
  - **Overbank** flow **drops** velocity appreciably and **floodplain** flow factors in (natural 2-5y ARI)

1. Hydrology

Energy / Power	Bank Protection	Flow Realignment
HIGH	Large Rock >1m. Anchored LWD on banks. Vegetation long term.	Large rock >1m in groynes. Anchored LWD.
MEDIUM	Smaller rock if needed. All except unprotected vegetation / brush.	All except unprotected vegetation / brush. Rock structures. Log structures.
LOW	Unprotected brush / debris. Rock not required. Bank vegetation.	Brush / timber retards. Channel vegetation. No rock required.

1. Hydrology

- River **flow**:
  - **Low** flows (& flow diversity) very **important** for **biological** function. Structures must account for it
  - BKF used for calcs of max. scour, velocity etc
  - After BKF reached, flow **slows** in channel and erosion **stops** – floodplains take flow
  - Accelerating flow can occur on floodplains and cause stripping and avulsion
  - **Duration** of flow is important for flood as well as base flows
  - **Medium** floods shape channel. **Large** floods damage channel. **Smaller** floods recover in stream structures

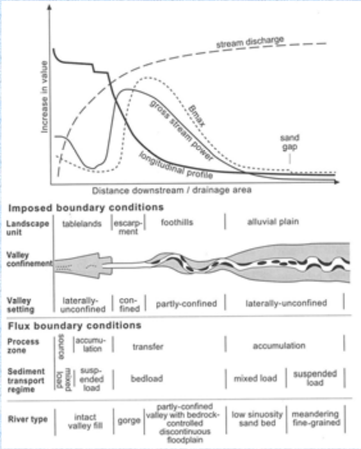


Figure 3.6 Typical longitudinal profile in a tectonically stable, escarpment-dominated setting

2. Landscape Setting

Source	**Transport**	**Accumulation**	**ZONES**
Erosion	Transfer	Sedimentation	PROCESS
High	Medium	Low	POWER

- Material removed from hillslopes and steep channel in upper catchment…… (E>S)
- Moved through middle slopes….. (E=S)
- Accumulated on flatter valley bottoms (E<S)

3. Channel Types

- **52** Different River Styles !!! Can't cover here.
- Channels are a product of **hydrological** and **landscape** history, as well as underlying **geology** and the sequence of past **events**
- Local **setting** and **hydrology** dictates channel **morphology**
- **Natural channels** have evolved over centuries (with vegetation!) through climatic history. They are **adapted** to this history and landscape setting
- **Downstream Sequence** (typical):

  HW - VF[ChF] – G – BC – PC - UC[TG] - T

2. Landscape Setting

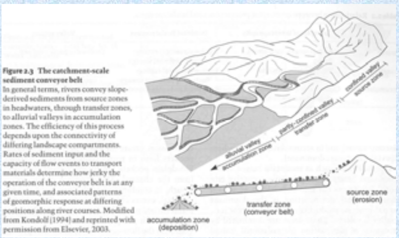


Figure 2.3 The catchment-scale sediment conveyor belt

- **Different** floods affect (mainly) the **transfer** zone depending on **discharge**: erosion / transport
- **Larger** floods carry **greater** volumes of sediment **further** (look around after flood events)

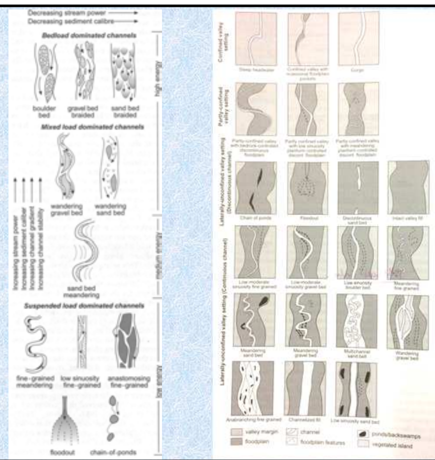


Figure 9.8 Examples of

3. Channel Types

- **Changing** hydrology results sometimes in situations the channel and sediments can't handle and **instability** occurs
- They respond **immediately** in flooding events, and over multiple floods (bankfull) begin to **change character** to the new regime
- This is the concept of **trajectory** (bit later)
- Ask if instability is **transient** (look for clues in landscape and history) or from **changed process**

3. Channel Types

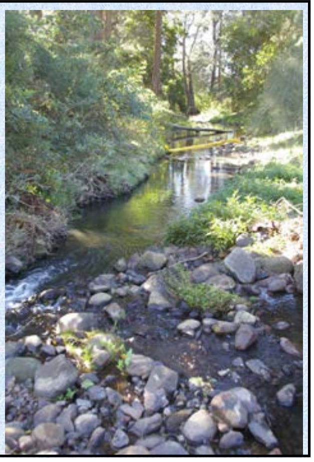
- **Threshold** [NEH ch8]
  - Bed and banks **stable** under normal floods
  - Forces to move bdy materials < threshold of movt
  - **Suspended** load dominated. Sediments **cohesive**
  - Bed/banks not transported by current river
  - Includes very coarse sed., bedrock, sev incised fine
  - **Can't readily adapt** geometry to adjust to change
  - Can become **unstable** at high flows – change generally occurs in extreme events or instabilities
  - **Problems**: incision and widening, sediment slugs, severe bank erosion, local scour, flooding, avulsion

3. Channel Types

- **Alluvial** [NEH ch 9]
  - Bed and banks **mobile** in, and formed by normal floods under current conditions
  - **Bedload** dominated. Sediments **uncohesive**.
  - Bed/banks are material river has transported under current conditions
  - Includes sand / gravel/ cobble beds (typ. **coarser**)
  - Appears as "typical" alluvial stream
  - Can **readily** adapt to **change** and remain stable
  - Problems: outside bend erosion, excessive deposition (point bars etc), obstruction, avulsion, degradation (desnagging trigger), conversion, sed. slugs

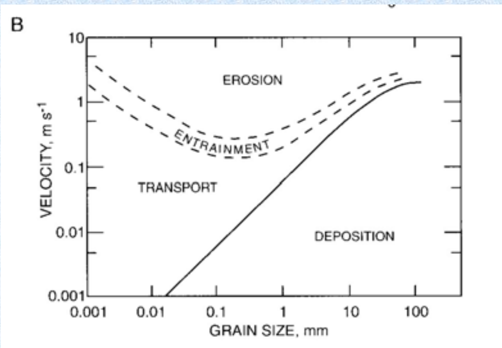

Threshold channels

Alluvial streams

4. Sediment Transport

- [Hickin Ch4]
- **Wash** Load
  - Clays etc NOT dependent on turbulence
  - Stay in suspension until chemical change (sea)
- **Suspended** Load
  - Mainly silt and sand DEPENDENT on turbulence
  - Faster water = larger particles
  - Stay in suspension until flow slows to threshold



(Suspended sediment)

Sediment Slug

4. Sediment Transport

- **Saltation** load:
  - Intermittently suspended, at threshold of motion
  - Bounce along bottom by turbulent and tractive forces
  - Partially supported by bed, and by water column
  - Small floods may not mobilise, or may act as bed load, but may move long distances under larger floods in suspension

4. Sediment Transport

- Very different characteristics for different channel types eg.
  - CoP: slow / fine / suspended / local scour;
  - BCG: fast / coarse / bed load / bend erosion
- For many structures to work (including vegetation) in restoring channels from degradation, a sediment **supply** is required
- This should be factored into projects
- What works in one place may be a disaster in another – channels are **DIFFERENT**

4. Sediment Transport

- **Bed** Load (aka **Traction** Load):
  - Mostly sand and gravel, kept in motion (rolling and sliding) by shear stress
  - Particles moving through channel fully supported by the channel itself
  - Generally capacity limited (stream competence)
  - Bed load incompetence results in sediment slugs

Eg. Sediment oversupply

4. Sediment Transport

- Sediment entrainment / movement very complex physics, so…..
- …..we **go with what we know** in river rehab.
- What do you know?... Have a **LOOK**
- …..look for sediment inputs/outputs, particle sizes moving at what stage, material being removed/eroded, sediment response to obstructions, bends, other features etc etc
- **Bed** load can be trapped by subtle changes in bed form and obstructions; **suspended** load needs the flow to slow markedly (small-scale roughness) to drop out

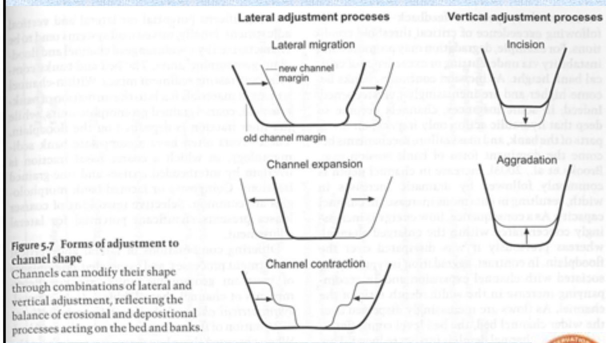
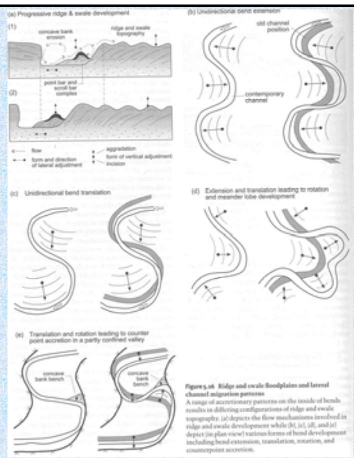


Figure 5.7 Forms of adjustment to channel shape
Channels can modify their shape through combinations of lateral and vertical adjustment, reflecting the balance of erosional and depositional processes acting on the bed and banks.

Suspended sediment around rough obstruction



5. Channel Change

- [Brierly]
- **Natural** processes – bend migration, expansion, etc
- **Degradation** (erosion)
- **Aggradation** (slugs/sand)
- **Scour**
- VERY **different** in different channel types
- **Eastern seaboard** mainly degradation seen because of landscape context (ag land on floodplains) and increasing catchment hydrology (clearing)
- Other causes straightening (ie steepening), drainage, avulsion, channelization (culverts etc), gravel extraction
- **Tablelands** mainly incision into inactive alluvium ie channelization, increased hydrology in larger systems overall as on coast.

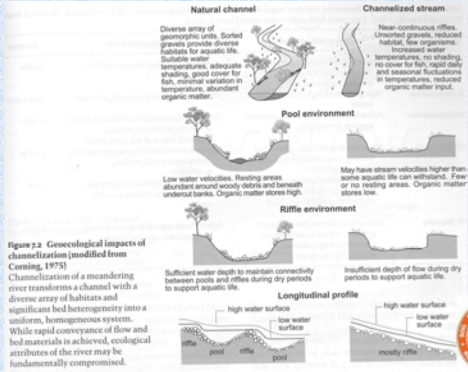
5. Channel Change

- **Structural problems** can **destroy** everything in channel – get these **fixed** if possible, using cover and roughness, and structures where needed
- **Channel** response:
  - short term (power variation flood to flood – benches, bars etc in stream) to
  - medium term (hydrological change – channel dimensions, planform, stream type)
- **Natural** channels BKF 2-5y ARI
  - <2y ARI **aggraded**; >5y ARI **degraded**
- Features built in 1-10y floods (high freq.) and removed in 20-100y floods (low freq.)

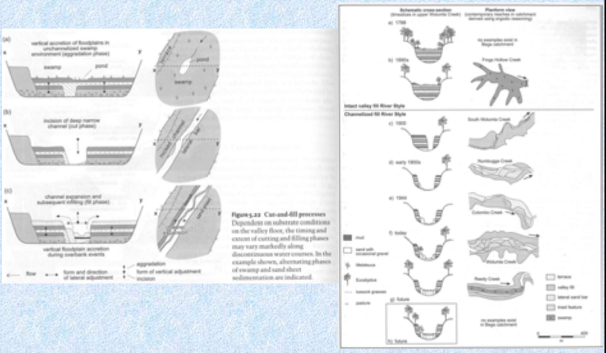
Focus on Incision

- Very **common** on coast **AND** tablelands
- Channelisation of valley fills, entrenchment of channels **disconnecting** them from floodplains
- PROCESS basically:
  - 1. **instability** (sediment starvation, increased flow)
  - 2. **downcutting** (for capacity until limited)
  - 3. **widening** (for capacity above resistant material)
  - 4. **recovery** (sediment fills trench)
  - 5. new **equilibrium** (new river inset in trench)

Focus on Incision



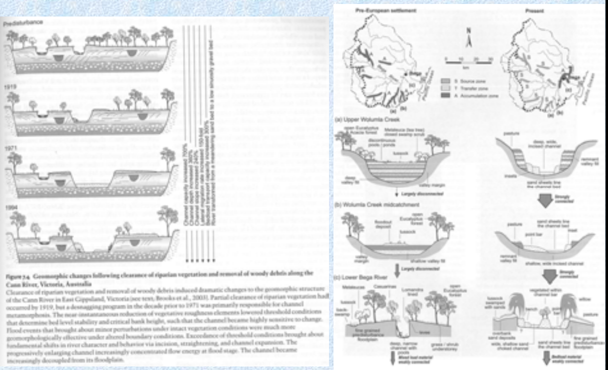
Focus on Incision

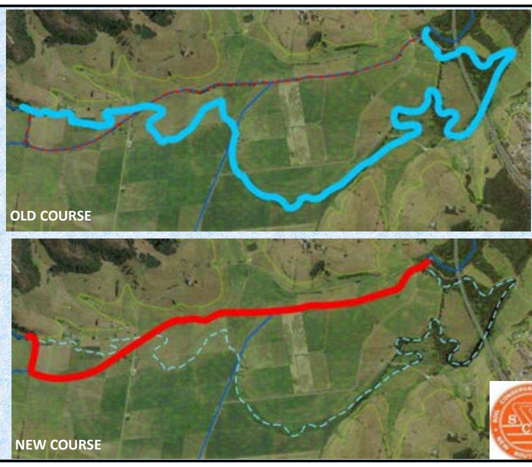


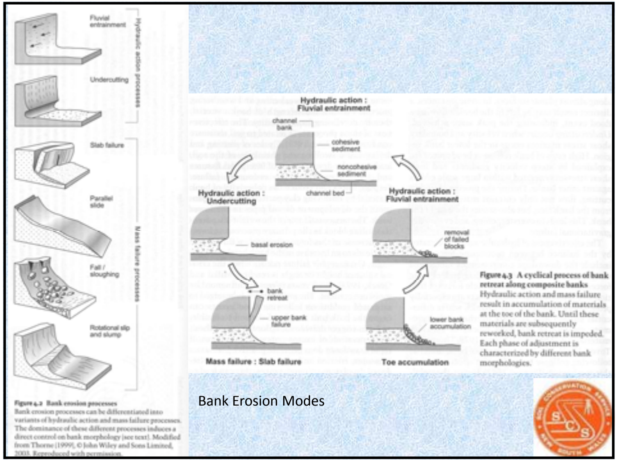
6. Erosion / Sedimentation

- **Erosion**: Sediment IN < OUT of a reach.
  - Changes in **bed slope**: straightening / shortening, excavation (very common)
  - Changes in **supply**: headcuts↑; dams↓; obstructions↓; mining↓; upstream degradation↑.
  - Increase in **stream power** through hydrology (climate change↑?; clearing↑).
  - Large event; long duration; peaky hydrograph; events in succession.
  - Desnagging, past works eg flood mitigation

Focus on Incision







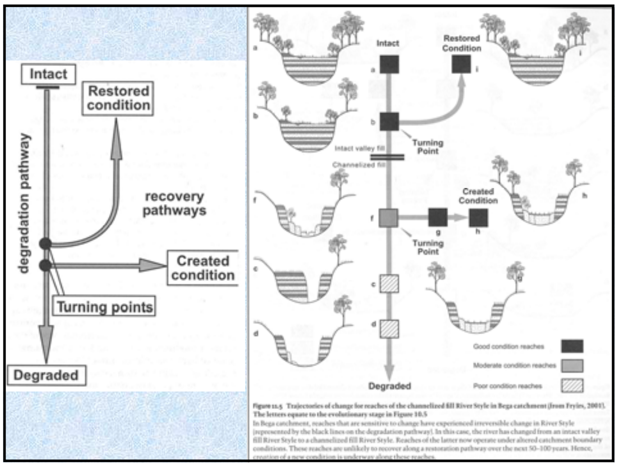
Bank Erosion Modes

7. Trajectory

- Put together a mental **reconstruction** based on what you **see** in the reach and **history** from maps, photos, landholders (whatever you can)
- Need to determine where **system** is **heading**
- Requires good understanding of **process** of **change** and **thresholds** (in the field) as indicators of current state and future
- Sometimes systems recover naturally if no threshold breached, sometimes recovery not possible
- Projects can focus on restoration, recovery, creation etc – all points on degradation "map"

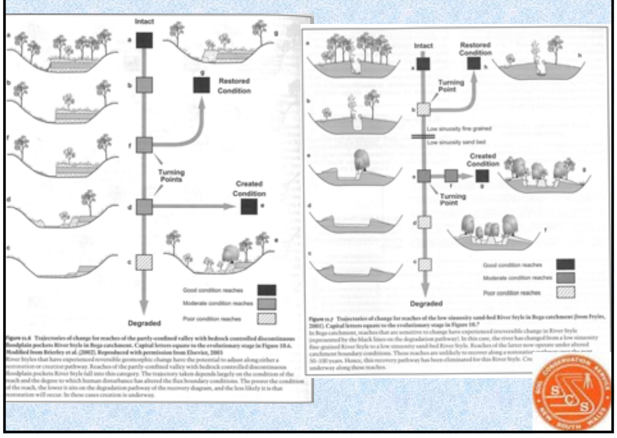
6. Erosion / Sedimentation

- **Sedimentation**: Sediment IN > OUT of a reach.
  - Stream **incompetent** to transport calibre of sediment (widening phase of incision, widening of channel)
  - **Sediment slug** from upstream erosion (bed load) – incompetent
  - **Valley** contributing sediment eg forestry, roads and tracks
  - Water slowing by **afflux** (dam, confluence)
  - Change in pH / chemical composition of receiving waters precipitates out clay fraction (estuaries)



6. Erosion / Sedimentation

- Problem may **not** be what everyone thinks, or what landholders expect
- Solution may be **very different** from ideas in first inspection
- River may be **VERY** far from "**natural**" before current problem occurred
- LOOK for **CAUSES**
- THINK about the **SYSTEM**



8. Works/Structures

- Field walk will look at structures / works
- **Before** structures are placed (esp in high energy or degraded environments) designs should be checked through collaboration with experts in the field.
- **Severe damage** can result from inappropriate or incorrectly placed structures.

8. Works / Structures

Vanes / hooks / weirs	Footings / anchors
Sills / Ramps	Piers
Flume design	Barbs / retards
Revetments – log/rock	Bed controls
Veg for roughness	Scour around structures
Pins	Battering
Cages	Grade control
LWD deflectors	LWD realignment
Tidal structures	Can anyone think of more?

References

- Brierly & Fryirs. *Geomorphology and River Management.*
- North Carolina Stream Restoration Institute. *A Natural Channel Design Handbook.*
- National Engineering Handbook (US) Part 654. *Stream Restoration Design*. Chapters 5, 6, 7, 8, 9, 11 and Tech Supp's
- Hickin. *River Geomorphology*. Ch4 Sediment Transport.
- Heaps of resources on the Internet.

- Lyall Bogie 0437 112 604. lyall.bogie@scs.nsw.gov.au