Shoulder Ballast Cleaning Guidelines

ETH-04-01

Introduction

These guidelines are intended to provide guidance on how to plan and use the Shoulder Ballast Cleaner effectively for ballast maintenance works, covering issues such as:

- What is a shoulder ballast cleaner?
- How does it work?
- Where does it work well?
- Does it fix everything?
- Scoping of works
- Field investigation
- Operational issues
- How to maximise productivity?
- What impacts on the cost?

What is a Shoulder Ballast Cleaner?

The Shoulder Ballast Cleaner (SBC) is a purpose-built machine that efficiently and cost effectively removes fines from the ballast shoulders. The major components of the SBC include:

- Digging Wheel – 760mm wide cut at either end of sleeper, depth of cut can be varied up to 400mm from top of sleeper
- Scarifier – hooks below each end of sleeper to remove mud plug
- Screening Car – removes fines from shoulder ballast; size and shape of screens can be varied to suit conditions.
- Ballast return - % return can vary depending on size of existing shoulder, age of ballast and screen size; generally 80-90% ballast return is achievable. Recovery of excess ballast will reduce top-up ballast required.
- Spoil disposal – to rail mounted car/tipper or directly onto cess

Shoulder Ballast Cleaner Consist

Typical SBC Consist

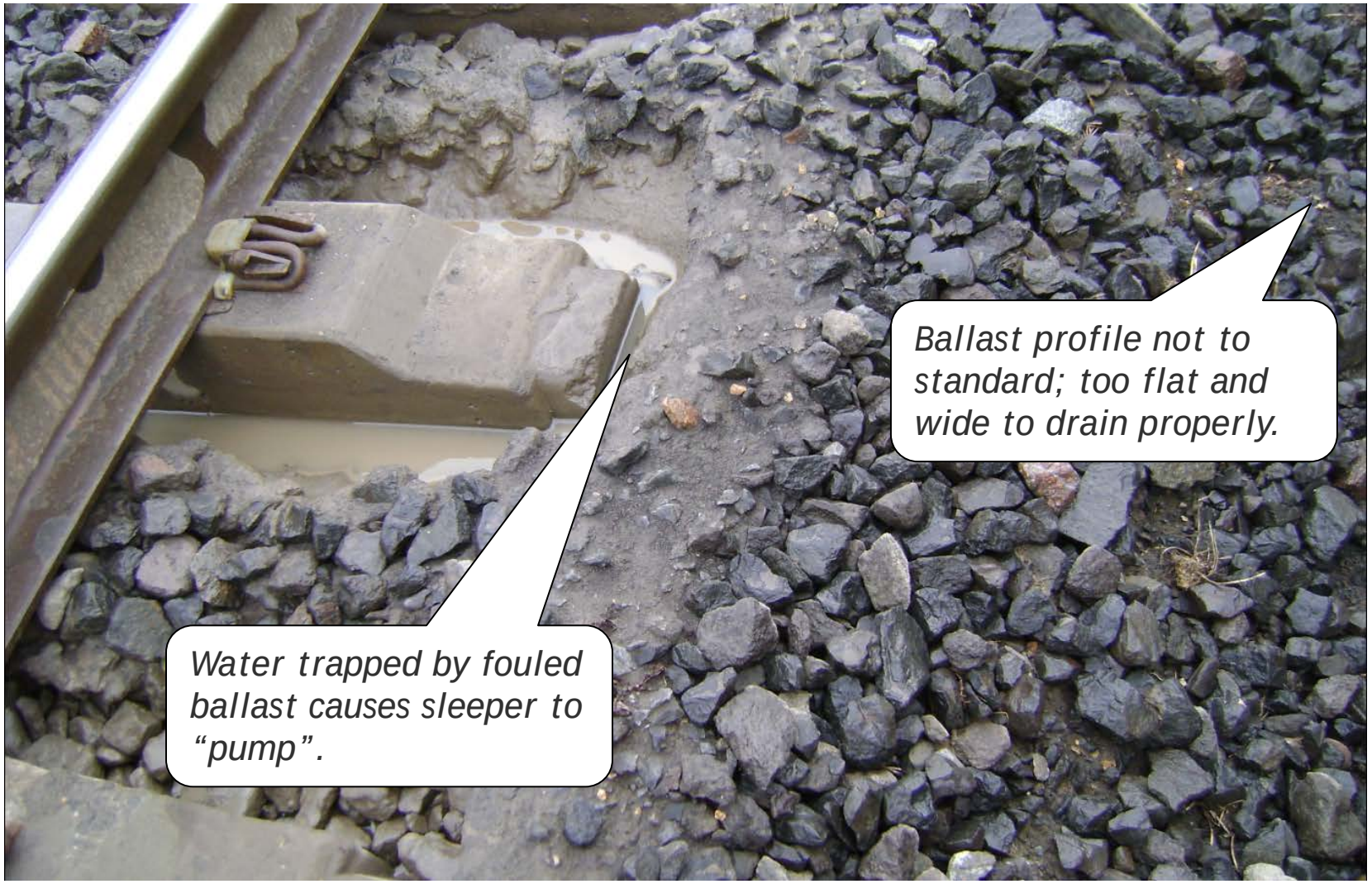
The SBC consist usually includes:

- Front Regulator – with long arms to reclaim ballast from shoulders and cess for screening to maximise ballast recovery.
- Water Truck – dust suppression during drier periods/near townships. Works best with time to infiltrate before cleaning.
- Signal Fitter – to remove track leads (only required part time).
- Track Worker – to remove track lubricators (when required).
- Shoulder Ballast Cleaner
- Tamper – absolute minimum 50mm lift to aid drainage and avoid centre-binding of sleepers.
- Rear Regulator – to box up following tamper.
- Grader – to remove any windrows of ballast left and level the cess.

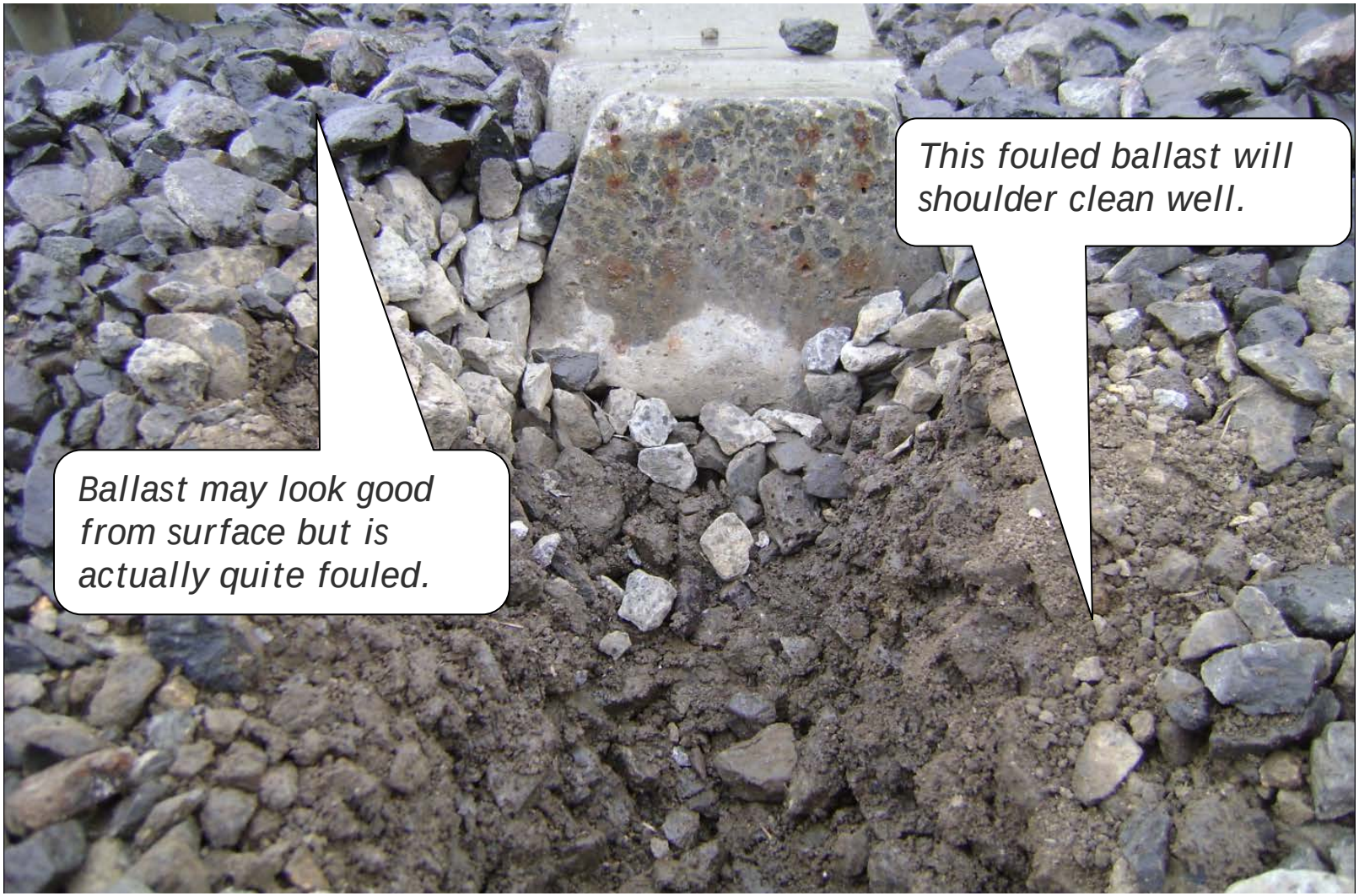
How does Shoulder Ballast Cleaning work?

- It removes fouled ballast or mud “plugs” at the ends of sleepers that hold water in the ballast profile.
- Mudholes form in wet, fouled ballast where there are impacts on the rail surface or weak spots in the underlying formation.
- The SBC cleans fine material from the ballast shoulders to allow water trapped in the ballast profile to escape and the track to dry.
- The SBC removes, cleans and returns the ballast, allowing the existing shoulder ballast to be re-used, rather than wasted.
- Under the repeated loading from trains, fines migrate from the centre of the track to the shoulders, requiring another SBC cycle.
- Rainfall, axle load, tonnage and local site factors such as windblown sand/coal dust will affect cycles achieved.
- For Interstate track with 10-15MGT pa and 13T average axle loads 7-8 year cycles proposed; HV plan adopts approach of US railways: 250MGT cycles for tracks with heavier axle loads and tonnage.

Mudhole in Fouled Ballast



Where does it work well?



What does it not fix?

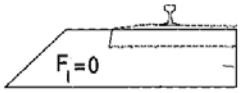
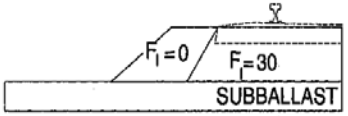
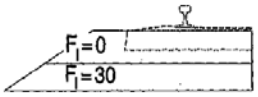
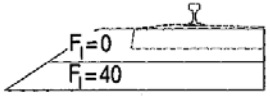
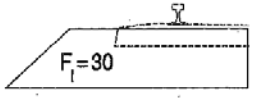
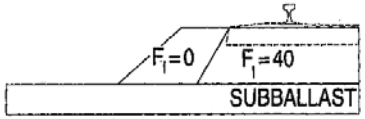
The SBC will not fix:

- Severely fouled ballast with voids totally filled with mud; where patches of very fouled ballast are found during cleaning there may be some benefit in turning these locations over without screening (like a rotary hoe) and cleaning once the track has dried out. Severely fouled ballast will need undercutting, sledding or full ballast cleaning (see next slide).
- Water trapped in ballast pockets in the formation causing it to heave; use ballast filled cross drains for these sites and locate using Top/Twist or Top Moving Sum (TMS) plots.
- Fouled ballast at fixed points where the SBC cannot access; these sites will need undercutting/cross drains and cutoff drains.
- Lack of ballast under the sleeper; although where the sleeper is sitting on mud/formation material it can be used to help address this by recovering excessive shoulder ballast to enable the track to be lifted and reduce the amount of top-up ballast required.

Ballast Fouling & Drainage Ability

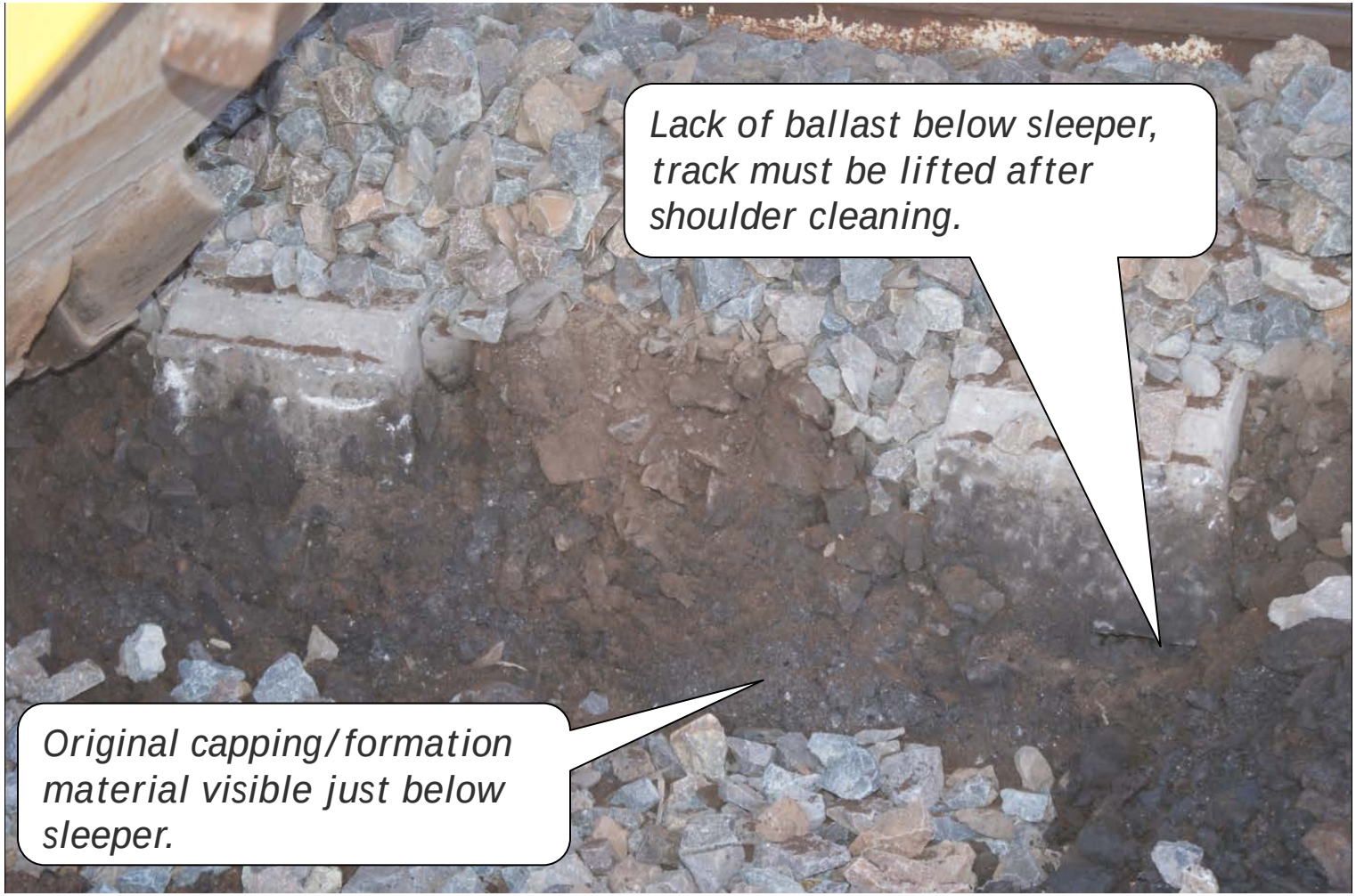
Refer to the diagrams below from Selig & Waters, 1994:

- Shoulder cleaning of fouled ballast gives a better result for drainage ability than undercutting (0.2 vs 0.05).
- However, for highly fouled ballast the opposite is true and undercutting results in better drainage ability (0.05 vs 0.003).

	R_{cr}, mm/hr (in./hr)	$R_{cr}/R_{cr}(a)$
 a) CLEAN BALLAST	150 (5.9)	1
 b) CLEAN SHOULDER WITH FOULED BALLAST	35 (1.4)	0.2
 c) UNDERCUT WITH FOULED BALLAST	8.3 (0.33)	0.05
 d) UNDERCUT WITH HIGHLY FOULED BALLAST	7.9 (0.31)	0.05
 e) FOULED BALLAST	1.5 (0.06)	0.01
 f) CLEAN SHOULDER WITH HIGHLY FOULED BALLAST	0.44 (0.02)	0.003

Severely Fouled Ballast

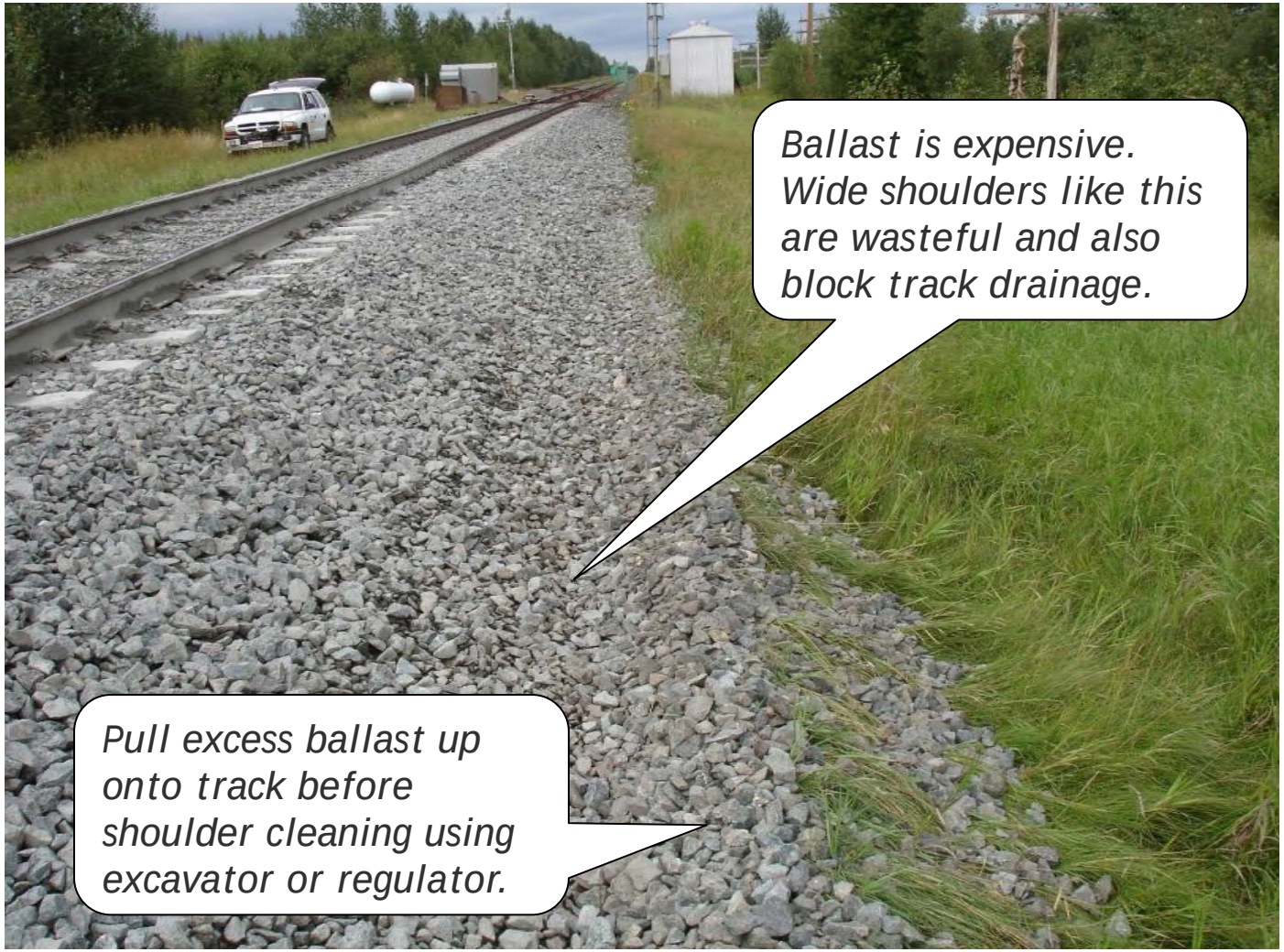
Lack of Ballast



Why would you Shoulder Ballast Clean?

- Cost effective way of improving shoulder ballast condition.
- Recovers and recycles “waste” ballast on shoulders/cess allowing significant cost saving on ballast.
- Allows water to drain freely from the ballast profile.
- Improves track geometry and reduces formation instability.
- Prevents the formation and spread of mudholes as well as rehabilitating the shoulder ballast.
- Prolongs costly major ballast renewal activities and improves effectiveness of tamping.
- Minimal track disturbance; track quickly returned to normal operations.

Extremely Wide Ballast Shoulder

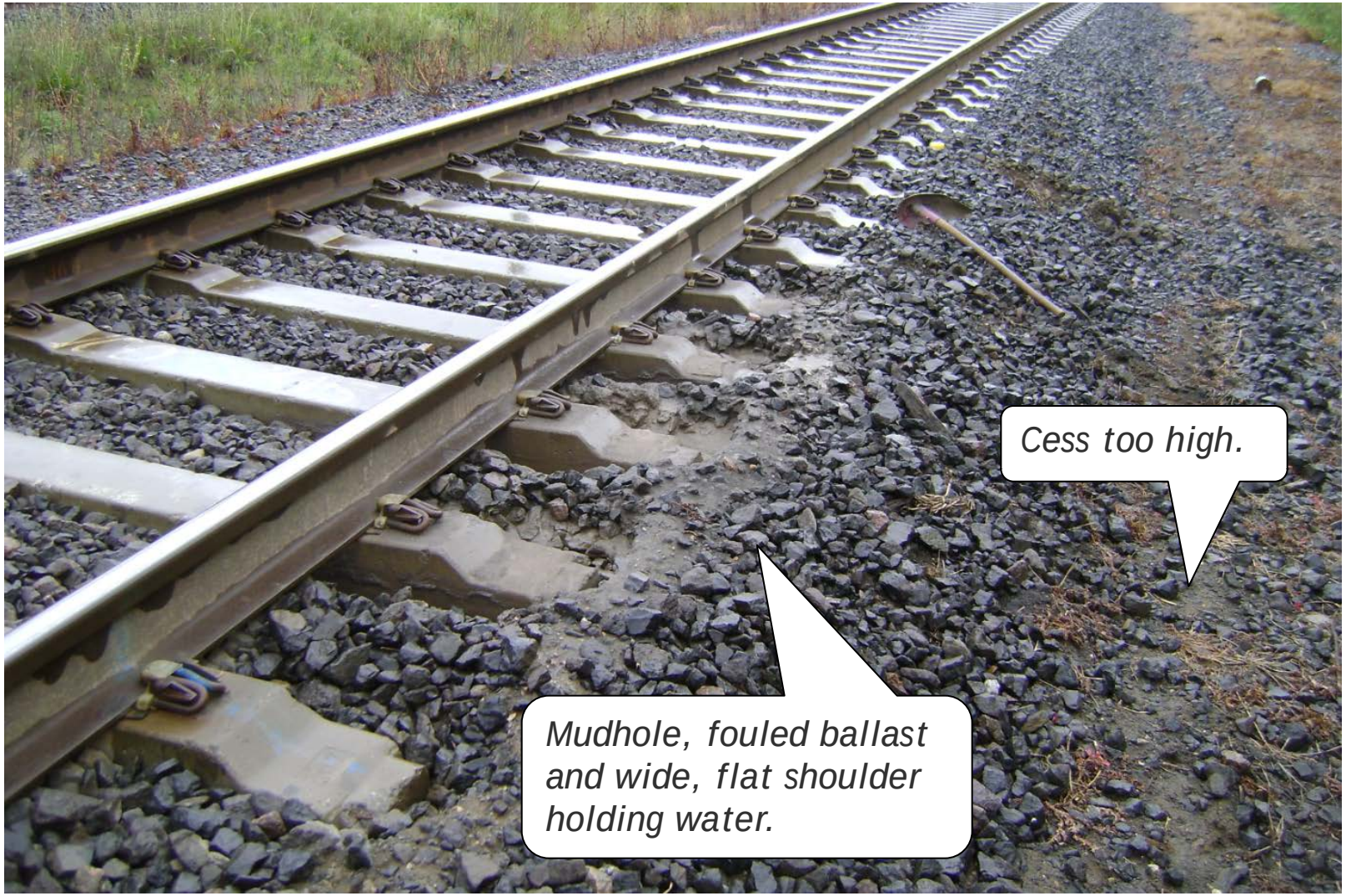


Issues for consideration when scoping SBC works:

- Need for additional regulator/excavator in front of the SBC to recover excess/waste ballast from the cess/shoulders.
- Control of scarifer and depth of cut; do not use scarifier if cutting only to the base of sleeper due to lack of ballast below sleeper (ie if sleeper is sitting on formation/mud).
- Need to scope depth of SBC cut required by investigation of ballast depth and shoulder condition in the field.
- Screen size; smaller screens (25mm) will produce greater ballast return but will need drier ballast conditions.
- Management of spoil in constrained areas such as cuttings or adjacent plant reserves or waterways may require tippers/wagons.
- Off track drainage works may be required to lower the cess and avoid cutting a trench.

Investigation of Ballast Condition

Field Observations

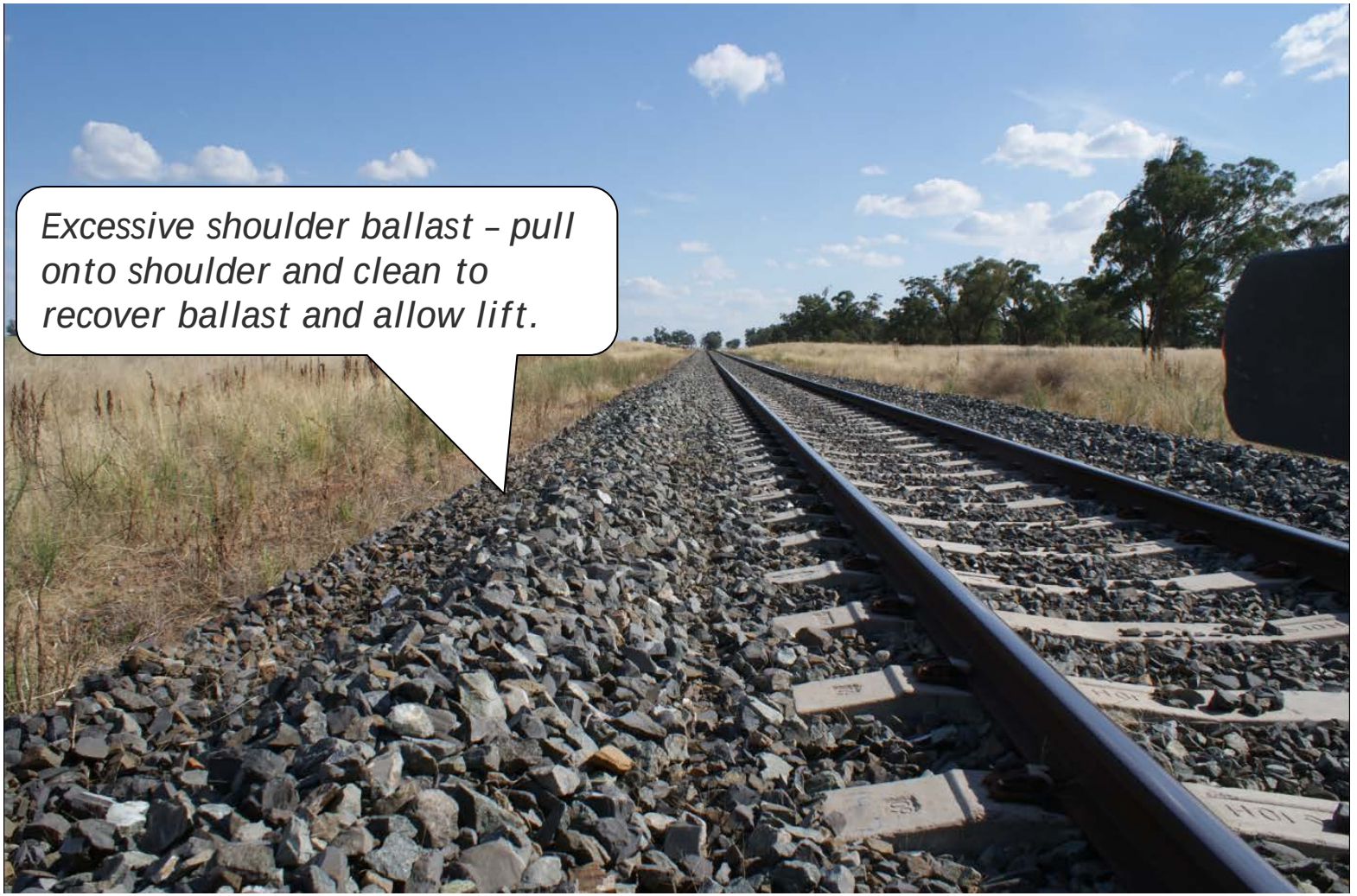


Cess Too High

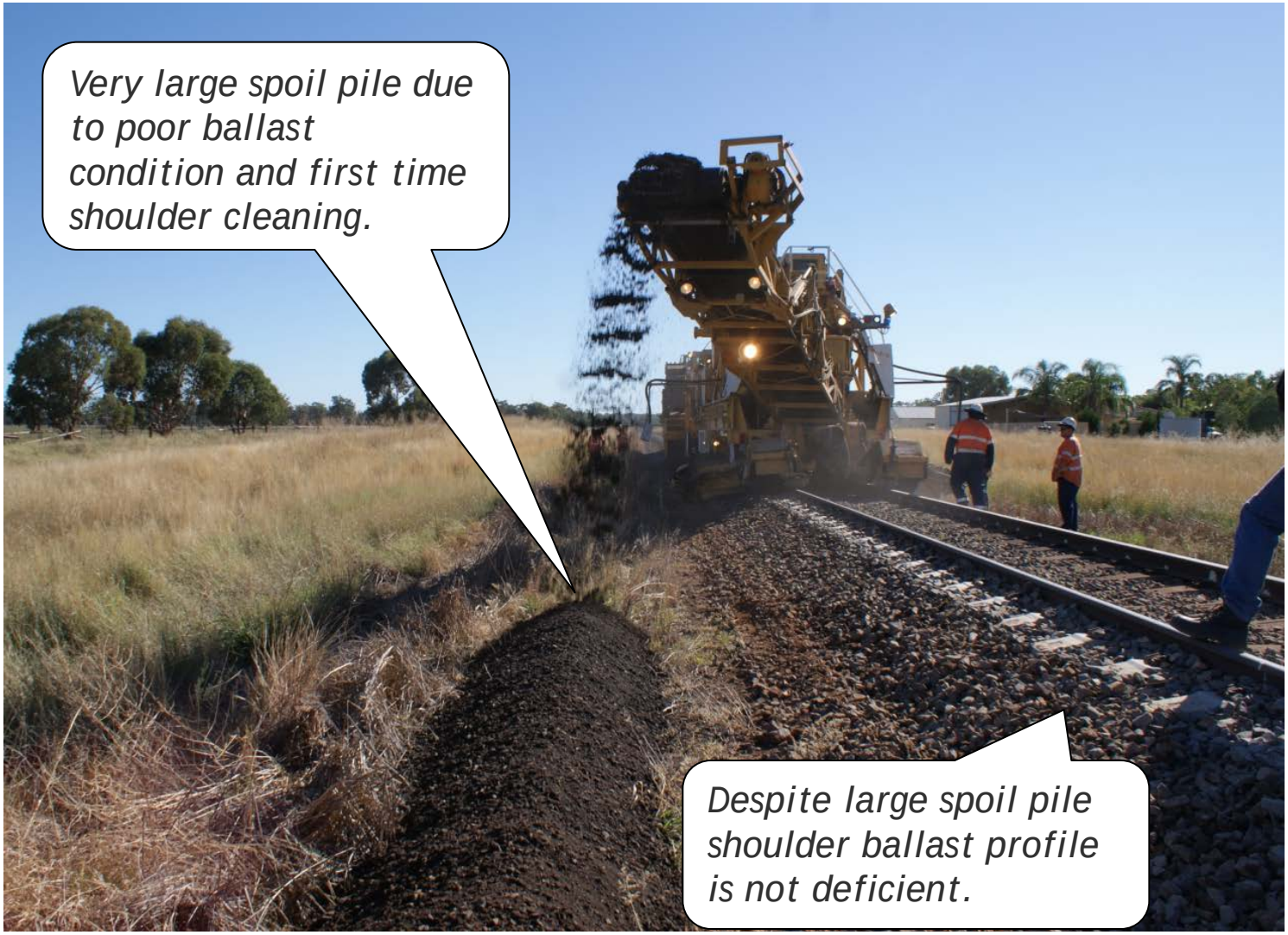
Selection of where SBC works are required:

- Top/twist values exceeding 4mm line on Top/Twist Plots indicate fouled ballast is present.
- Confirmation of fouled ballast conditions in field using pelican pick; dig into ballast profile to assess depth and condition.
- Prioritise sites and group where possible.
- Minimum length of clean normally around 0.5km.
- Assess top-up ballast; only need to achieve a standard ballast profile of 250-300mm wide at end of sleeper but must achieve 50mm lift (unless 100mm of clean ballast below sleeper already).
- If shoulders are 250mm wider than standard enough ballast should be recovered to give at least 50mm lift without needing top-up ballast.

Excessive Shoulder Ballast



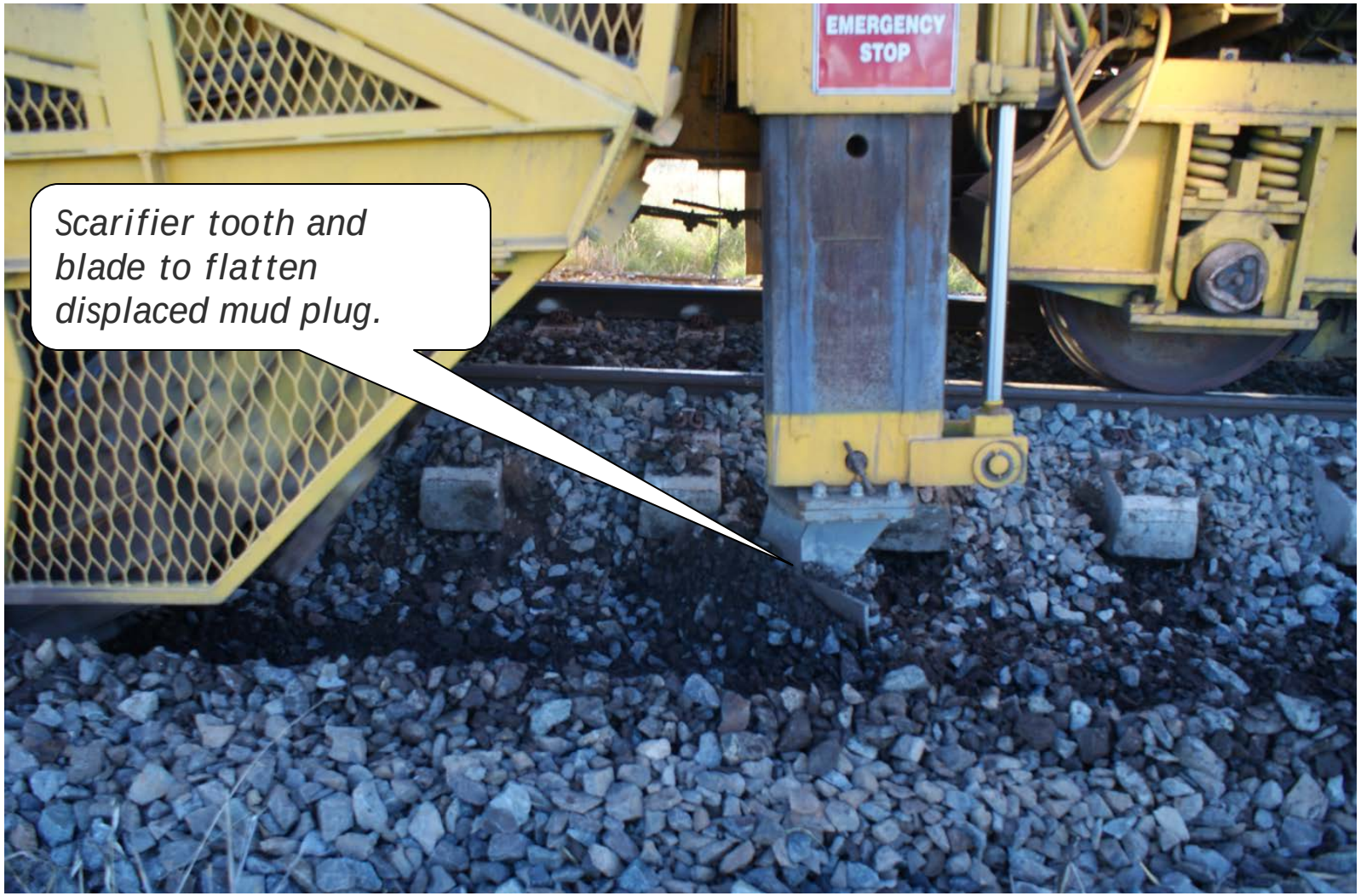
Spoil Disposal and Ballast Profile



Use of Scarifier

- It is important that the scarifier is set correctly and not too deep.
- It only has to break the mud plug at the end of the sleeper and not dig way under the sleeper plate.
- The scarifier tooth moves mud from under the sleeper down into the trench formed by the cutting wheel.
- This mud must be graded flat using a blade attached to the SBC to avoid trapping water in the cleaned shoulder (see photo on following page).
- Where there is limited/no ballast under the sleeper before cleaning and it is sitting on formation/mud, avoid cutting deeper than the base of the sleeper and do not use the scarifier.
- It is important that works are well supervised to monitor this.
- Where the cess is too high, care must be taken not to cut a trench with the SBC by lowering and widening the cess.

Scarifier Tooth



View behind Digging Wheel

Associated Drainage Works

- The SBC clears only one component of the drainage path.
- Plan drainage works in conjunction with SBC, including:
  - Cess drains, top drains in cuttings, etc
  - Clearing of blocked cuttings and culverts
- Install ballast filled slot/trench drains at soft spots in the formation where indicated on Top/Twist or TMS plots.
- See ARTC guidelines for installing trench drains on Intranet under "Engineering/Track & Civil/Guidelines/Earthworks & Drainage".
- Shoulder cleaning will not work well if you fail to remove mud at the toe of ballast and water is trapped in a trench.
- Water trapped in the ballast results in soft formation and ballast pockets may form. Trench drains then are required through the formation to drain the ballast pockets.
- Review Top/Twist plots following works to identify locations requiring follow up drainage works such as trench drains.

Cess Too High

Wide Shoulder

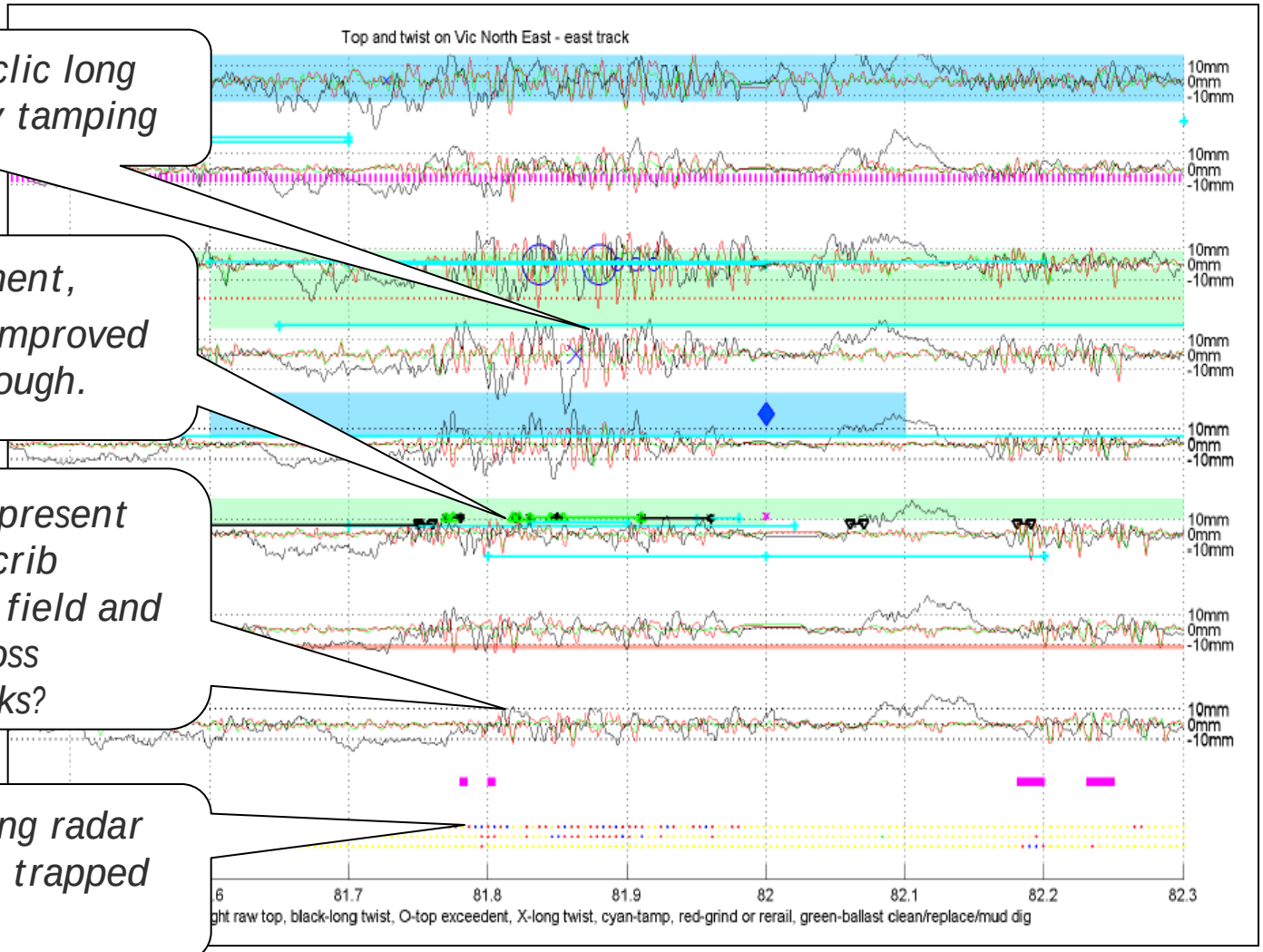
Monitor Effectiveness of Works

Rough top and cyclic long twist not fixed by tamping

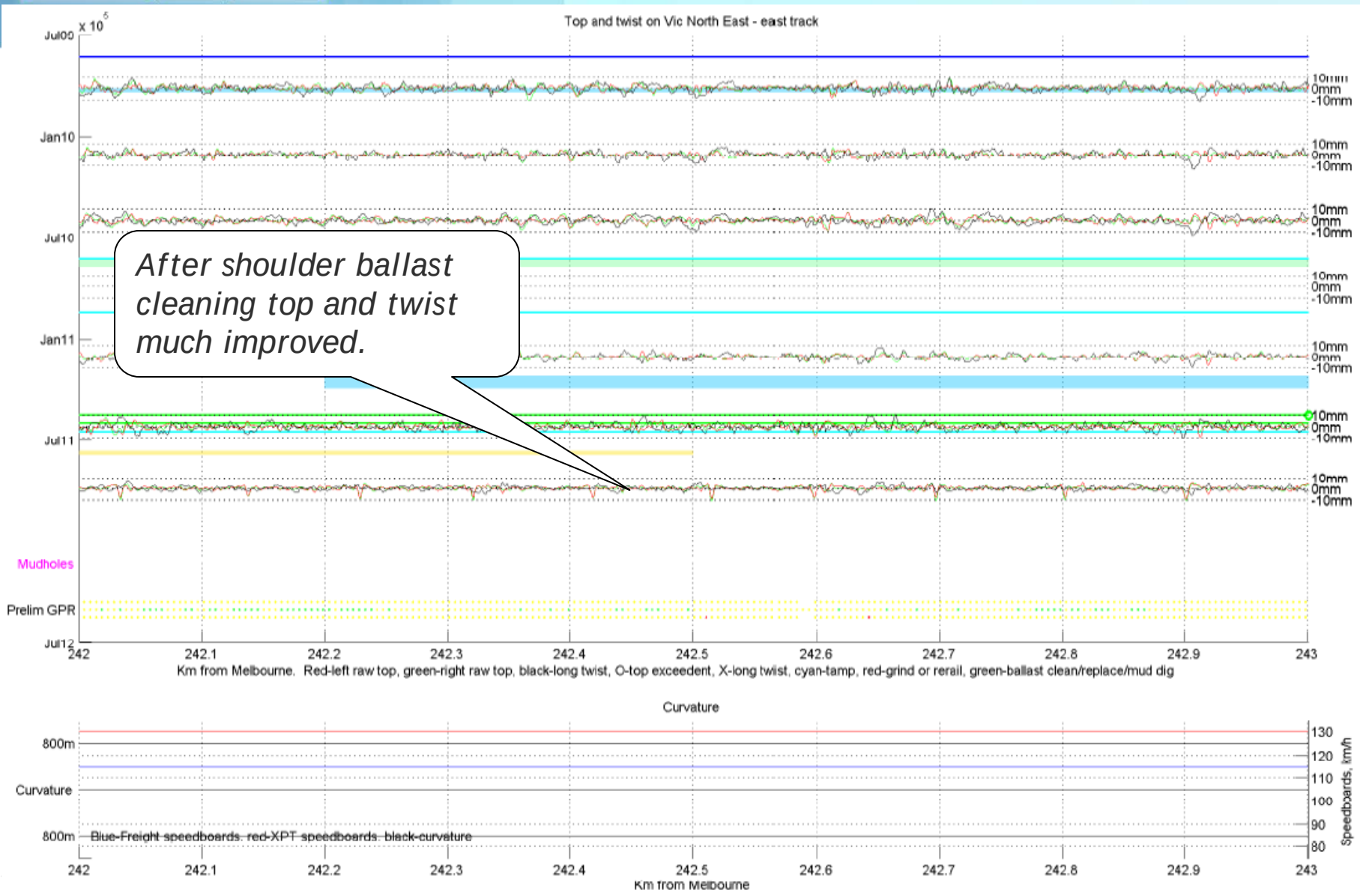
Shoulder replacement, crib out & tamp; improved results, but still rough.

Undulations still present after tamping & crib works. Review in field and scope for SBC/cross drains/other works?

Ground penetrating radar data shows water trapped in fouled ballast.



Monitor Effectiveness: Top Twist Plot



Operational and WHS issues to consider:

- JHG machine not designed for NSW structure gauge & Victorian platforms; narrow bucket machine may be a solution.
- JHG machine is out of gauge rolling stock when operating.
- Noise sensitive locations, e.g. cleaning at night time in residential areas should be avoided.
- Dust control; use of water cart operating with machine in dry conditions. Allow water to infiltrate ahead of machine.
- Speed restrictions may be required in warmer weather on timber sleepered track or where there are concerns about track stability.
- Disposal of spoil to meet EPA conditions; may remain in corridor to cap and seal access tracks, but not within 40m of waterways.

Spoil Disposal near Waterway

Productivity can be improved by:

- Turning over ballast without screening or increasing screen size if ballast is initially too heavy to clean (say from 25mm to 32mm).
- Generally plan for sites greater than 0.5-1km but can do smaller sites if warranted.
- Work windows of 60 minutes or more preferred – depends on location of sidings.
- Undertaking possession planning with Operational Planners to maximise productivity.
- Discuss prioritisation with Train Control to improve time on track.
- Removing old sleeper plates and other objects likely to block screens from the ballast profile.

Screens Clogged with Mud

Production Rates of the Hollands SBC Machine:

- Approximately 700-800m/hour.
- Average of 2500-3000m/day working as trains permit and in possessions (4 hours on track cleaning time).
- Longer shifts and good working conditions can significantly improve output (up to 8km/day has been achieved).
- Ensure that sufficient time is allowed for machine maintenance or breakdowns will affect utilisation of available track time.
- Work needs to be scoped and planned to get best productivity.
- Consider use of full-time project manager to fully scope and plan works in advance, manage production and effectiveness, and ensure work outcomes are properly captured.

What impacts the cost?

Costs below are in 2013 dollars

- Aim to achieve basic cost of around $13,000-$15,000/km including tamping, regulating to recover ballast, and top-up ballast.
- Factors influencing cost/km include the following:
  - Safeworking in NSW/Victoria. Will increase above cost/km depending on how works are planned and managed; prepare a site specific safeworking plan.
  - Track access time available for cleaning. Track access windows of 5-6 hours allow around 3km/day to be cleaned generally.
  - Machine hire rate for SBC. Machine hire rate of $5000/km for SBC assumed above. (Based on 3km/day cleaned).
  - Tamping and regulating cost. Cost of $6000/km assumed, based on 3km/day.
  - Amount of top-up ballast required. Cost of $2,000-$4,000/km used above assumes recovery of excess ballast. Assess need for top-up ballast against standard (tangent track and concrete sleepers need less). Aim to recover excess ballast and clean it to minimise wastage and top-up ballast. (250mm excess shoulder ballast will allow a 50mm lift).
- EW Productivity works cost around $12,000/km with little top-up ballast required and good track windows.

Comparison of Typical Unit Rates

Comparison of costs (in 2013 dollars) with other ballast cleaning methods:

- **1km Sledding**
  - **Approximately $300,000 including ballast**
- **1km Undercut Ballast Cleaning**
  - **Approximately $350,000***
- **1km Shoulder Ballast Cleaning**
  - **Approximately $13,000***

*** Includes expected associated works**

Conclusions

- Ballast is expensive; recover and rehabilitate ballast using SBC. Wide shoulders impede drainage; do not “flood” track with ballast.
- The SBC removes fines from the shoulder ballast, but does not completely remove the shoulder. Do not overestimate top-up ballast; only a standard ballast shoulder width is required.
- Target underlying geometry problems and weak spots in formation using the Top/Twist plots and install cross/slot drains only where needed; monitor settlement as track drains.
- Do field investigation and prepare drainage plan for the corridor in association with SBC; clean out cess & top drains, install cross/slot drains. Scope and control the depth of SBC cut.
- Try using the cheapest methods first for mudholes (SBC plus small drainage crews to install cross/slot drains).
- Use shoulder ballast cleaning to reduce spread of mudholes and associated deterioration of track geometry.
- Tamping behind SBC is mandatory and must achieve 50mm lift (unless 100mm clean ballast present). Measure track lift obtained.