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Waiting for the grey rhino to charge: closure liability and cognitive dissonance

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Abstract

Effective and realistic understanding of closure liabilities that exist and will be incurred, inclusive of risk and uncertainty, is crucial for informed decision-making and the efficient closure of mining operations. Accurate financial planning allows legal, environmental and social responsibilities to be met while also safeguarding the financial stability of the mining company.

There is a history of closure liabilities increasing significantly towards the end of operational life, creating 'surprises' for boards, investors and regulators. Have these increases occurred often enough for the industry to consider material closure liability increases at the end of operational life a 'grey rhino event', given the repeatability of this 'surprise', regardless of commodity, geography or size of company? Grey rhino events, a term introduced by policy analyst Michele Wucker, represent a highly probable, high impact yet neglected threat. Grey rhino events are not random surprises; rather, they occur after a series of warnings and visible evidence. The risk is evident and the event foreseeable.

These closure liability increases occur for a multitude of reasons, some understandable and valid, some that could be perceived as indefensible.

One of these reasons may be the psychological phenomenon of cognitive dissonance and related biases, which cause us to see the rhino charging but find excuses or reasons to not believe it or not act. Cognitive dissonance occurs when there is a conflict between beliefs and actions. Could cognitive dissonance result in irrational decision-making and chronic underestimation of closure liability and hence, potentially, reduced focus and effort provided to integrated closure across the life of a mine?

This paper aims to collate insights into how mining companies can recognise and potentially mitigate cognitive dissonance, thereby improving understanding of the realistic closure liability and perhaps avoiding the charge of the grey rhino.

Keywords: *mine closure, closure liability, business*

1 Introduction

Effective and realistic closure liability estimation, inclusive of uncertainty, is crucial for the efficient closure of mining operations. Accurate financial planning allows legal, environmental and social responsibilities to be met while also safeguarding the financial stability of the mining company, and by extension the future of the mining industry on a whole.

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There is a history of closure liabilities increasing significantly towards the end of operational life, creating 'surprises' for boards, investors and regulators. Closure liability increases occur for a multitude of reasons, some understandable and valid, some that could be perceived as indefensible. The risk of increasing closure liabilities is largely evident and the event foreseeable.

So why, in our collective experience, are closure liabilities a surprise, often triggering anger, denial or calls to 're-run the numbers'? One explanation may be the psychological phenomenon of cognitive dissonance and related biases, which cause us to see the risk but find excuses or reasons to not believe it or not act. Cognitive dissonance occurs when there is a conflict between beliefs and actions.

Getting closure liability 'right': being realistic, defensible and honest about uncertainty is not optional if mines are going to close efficiently and responsibly, yet in practice realistic closure liabilities are frequently resisted, deferred or rationalised as lower despite increasing evidence of underestimation of these liabilities. This paper explores how cognitive dissonance and related biases can influence closure liability discussions, and how mining companies might better recognise and short-circuit those dynamics. By doing so, organisations can improve their understanding of realistic closure liability and perhaps move to a place of acceptance, informed decision-making and action well before the costs are incurred.

2 Importance of closure liability estimation

At its worst, when closure liability estimates are woefully inadequate and the company does not have the resources for the revised upward estimate, the company declares bankruptcy and the liability falls to the state. A 2016 report identified that in just three Canadian provinces, unsecured liability from abandoned mines was between CAD 4 billion and CAD 12 billion (MiningWatch Canada 2016). This situation has the potential to see uncontrolled environmental impacts continue unmitigated from these abandoned sites.

At the very least, escalating closure liability estimates on the financial reports can impact investor sentiment and credit ratings. An assessment by Moody's Ratings (2024) highlighted that asset retirement obligations, or closure provisions, reported in financial reports were accelerating significantly and could top industry's debt obligations by 2033. And while, at an early stage of a project, highly optimistic closure liability assumptions may enhance near-term project financial metrics, over time they can materially erode financial performance and asset value as more realistic estimates emerge and obligations and impacts are better understood, particularly where closure has not been integrated into design and operations.

When these closure liabilities are realised, they draw on free cash flow from company's growth funds, hindering the ability to invest in growth and expansion projects, to optimise operations and to build financial resilience. This constraint is particularly acute for single-asset operations or asset portfolios approaching the end of their productive life, where future revenue streams are limited or absent. In such cases, closure liabilities may be realised without the benefit of ongoing cash generation, placing direct pressure on balance sheets and materially constraining the ability to fund closure while maintaining financial resilience.

3 History of closure liability increases

Sanders et al. (2024) highlighted a number of significant closure liability increases over 5-year periods once the mines started closure, including Giant mine, Canada, increasing from CAD 1 billion to CAD 4.3 billion in 5 years; Ranger uranium mine in Australia, increasing from AUD 512 million to over AUD 2.2 billion (Sanders et al. 2024); and Faro mine, Canada, increasing from CAD 14 million in 2002 to CAD 5.79 billion in 2023 (Office of the Auditor General of Canada 2024).

These increases occur for a multitude of reasons, some understandable and valid. Given that the first legislation requiring some level of reclamation, including posting of a bond, was enacted in West Virginia, USA, in 1939 (Hockley & Hockley 2015), i.e. 87 years ago, and one of the most comprehensive guides to good practice, the International Council on Mining and Metals (ICMM 2008) *Planning for Integrated Mine Closure: Toolkit* was first published in 2008, 18 years ago, some reasons for increasing closure liabilities could be considered indefensible.

In the United States, Nevada's current emphasis on realistic closure cost estimation and standardised bonding tools is not theoretical. It is the direct outcome of hard lessons learned during the 1990s gold mining boom. During this period, Nevada experienced rapid growth in large-scale open pit heap leach operations, many of which advanced under bonding frameworks that, in hindsight, failed to fully capture the true cost of closure and post-closure obligations (Parshley & Struhsacker 2009).

Several mines in the state entered financial distress or bankruptcy late in their operational lives, at precisely the point when closure liabilities became more concrete. In these cases, posted financial assurances proved insufficient to cover reclamation, water management and long-term stability requirements, forcing state and federal agencies to step in and complete portions of the work using public resources. These sites, many of which became part of Nevada's Abandoned Mine Lands inventory, demonstrated a clear pattern: closure costs had been underestimated early, escalated late and ultimately shifted risk from operators to regulators and taxpayers.

4 Reasons for increased closure liability

There are numerous reasons for increases in closure liability. Dunow & Kalisch (2022) identify the following as the primary reasons for poor closure liability estimation from their experience:

1. Omission of scope from the estimate
2. Overly optimistic performance assumptions (construction resources, supply chain and execution planning)
3. Possible risk omitted, including political (regulatory), economic, social, technological and environmental; point number 2 could also be considered execution risk, and the disconnection of risk to closure cost estimates is reinforced by Byrne (2024)
4. Lack of integrated project management approach with adequate controls and assurance
5. Inadequate understanding of bonds and insurances (Dunow & Kalisch 2022).

The Nevada experience from the 1990s identified that the increasing reclamation liabilities were not solely the result of bad actors or unforeseeable failures. Instead, they reflected systemic weaknesses and biases in closure cost estimation itself. Bond amounts were often developed using bespoke, company-specific methods, inconsistent assumptions and optimistic productivity rates. When mines failed financially, agencies were left to reclaim sites under circumstances fundamentally different from those assumed in the original cost estimates, including using contractor fleet rather than operational, longer execution durations, and often with heightened environmental risk (Parshley & Struhsacker 2009).

Other high-profile examples have cited closure liability escalation because of the following:

- Indirect costs are often significantly underestimated or inconsistently applied. Costs can also be incurred over a prolonged period associated with schedule delays, such as additional project and site management costs, including water management and power generation (Energy Resources of Australia Ltd 2022).
- Evolving understanding of water quality and water quantity predictions. For example, in 2024 Newmont reported an additional expected average spend of USD 600 million annually over the following 2 years on the water treatment plants at Yanacocha (Newmont 2025). In some cases, this evolving understanding can be linked to optimism, omission of scope or the disconnection of liability to risk.
- Changes in closure designs and planning may occur as original designs and closure methods have been generic, lack applicability to the individual site context or have been purely theoretical without field trials to prove the success of the concept. Similarly, closure designs and methods can change as stakeholders and rights holders are engaged, realistic post-closure land uses considered and closure methods required to provide appropriate land capability.

All of these reasons can potentially sit in the above-mentioned buckets of omissions of scope, overly optimistic performance assumptions and possible omission of risk. The other overly optimistic performance assumption evident throughout these reasons is schedule. Optimistic schedules are common, particularly for those companies that may not have previously closed a site and have not completed the requisite work prior to ceasing operations to provide for an execution-ready closure plan and governance structure in place for active closure. Common delays to schedule include lack of construction ready designs, lack of stakeholder agreement on works to be conducted, optimistic assumptions regarding productivity and the impact of seasonal constraints.

An additional challenge in rising closure liability estimates is that they often escalate as closure approaches, often as the operational life and associated revenue may be declining. It is often during this time that companies start to consider closure readiness and more deeply understand what risks and impacts need to be addressed on closure, what regulatory requirements really mean and what the cost of associated closure remedies might be. Should these processes be started too late or be prolonged (for example, looped back through multiple study phases due to a closure liability assessment deemed 'unacceptable'), any opportunity for operational synergy and financial efficiency can be lost.

Financial treatment can also drive increases in reported closure liabilities. Over longer time horizons, the cumulative impacts of escalation and discounting mechanisms and rates can be substantial, even when underlying closure scope and assumptions remain unchanged. The Association for the Advancement of Cost Engineering (AACE International 2021) cites that over a 50-year period, escalation alone at 3% per year can result in a 400% increase in total cost.

From a publicly reported closure liability perspective, there are increases as the end of productive operations draws near due to the gradual reduction in discounting. That is, financial report closure liabilities (more commonly referred to as asset retirement obligations or provisions) are initially discounted for future value to the time they will be incurred; hence the reported liability increases as the closure date approaches due to the elimination of the time value of money (Byrne 2023). Reported asset retirement obligations/provision values can rise even if the 'real-world' closure work has not changed due to discount rate changes, inflation/escalation, timing revisions and the accounting point at which obligations become reportable. Additionally, several closure costs may not be reportable obligations until the day closure is announced. The inclusion of these can significantly increase the reportable closure liability immediately on closure, although these should be clearly captured in the complete internal life of mine closure liability estimate.

As closure approaches and impacts to be addressed are better defined and optimism reduces in the face of reality, companies often shift from conceptual closure approaches to more engineered controls (such as cover designs, seepage collection, long-term water management, and enhanced stability controls). These changes can materially increase both capital expenditures and long-term operations and management components. The reality often reflects closure executed under more conservative assumptions than early internal estimates.

Even without formal regulatory amendments, expectations can evolve through implementation experience, guidance updates, and lessons learned from legacy sites. Updates to estimation tools are an example of institutionalising these evolving expectations into a repeatable and reviewable approach.

From an internal management perspective, several of the drivers underlying historical closure liability escalation are difficult to justify, particularly where organisations rely on accurate and comparable closure cost information to support strategic planning, capital allocation and long-term risk management. Effective decision-making requires closure cost estimates that are realistic, transparent and reflective of post-closure execution conditions while simultaneously satisfying regulatory requirements and broad societal expectations regarding environmental stewardship and financial accountability.

5 Closure liability as the charging grey rhino

Michele Wucker defines the 'grey rhino' concept in her 2016 book of the same name as '… a highly probable high impact threat, something we ought to see coming like a two-ton rhinoceros aiming its horn in our direction and preparing to charge' (Wucker 2016, p. 7). Wucker goes on to identify that the very obviousness of the threat is part of the reason they are so often ignored.

Mine closure is inevitable. It may not be for decades, it may initially be temporary followed by an operational resurrection, but resources are finite and the best-laid mine plans are also influenced by geopolitics and a fickle commodity market. Fundamentally, the industry is well aware of the requirement to responsibly close, the changing external environment that impacts closure requirements and the expectation of expenditure to mitigate, at a very minimum, environmental impacts to an 'acceptable' level. The requirement for closure at the end of operations is built into legislation across the world, forms part of most project approval processes and is integral to industry financial reporting.

In our collective experience, increases in closure liabilities often trigger surprise, denial, anger and accusations throughout the life of mine, particularly near the end of productive operations when most closure costs are realised.

Grey rhino events, to a certain extent, are predictable, but as Wucker (2016) highlights, predictions are exactly that, predictions, which makes them easy to wave away as unreliable or not applicable to *this* circumstance. How often as closure practitioners do we hear 'we will be different' or 'that estimate must be gold plated'? And given the AACE example cited above of a 400% increase in estimates purely from escalation, is it any wonder many are biased to consider closure estimates as unrealistic or unreliable?

Considering the information presented thus far, closure liability is expected, it is highly probable to increase and it can cause a high impact, thereby firmly meeting the definition of a grey rhino event. That being acknowledged, which inherent cognitive dissonance scenarios and biases get in the way of us identifying the charging rhino and how can we attempt to mitigate them?

6 Recognising and mitigating cognitive dissonance

Mine closure and its associated liabilities is routinely treated as a future problem, even when closure liabilities are known to exist, likely to grow and capable of materially affecting reputation, cash flow and business viability. This gap between what the industry knows (closure is inevitable and must be responsibly funded and executed) and what organisations often do (defer action, resist upward revisions or rationalise estimates downward) is a perfect incubator for cognitive dissonance, where discomfort arises as beliefs and actions conflict. Cognitive dissonance motivates people to reduce discomfort not only by changing actions, but also by changing interpretations: discounting warnings, defending early anchors or reframing realistic estimates as 'gold-plated'. The ICMM (2025) *Integrated Mine Closure: Good Practice Guide* emphasises that closure must be treated as core business and embedded early and iteratively across the life of the asset. Is cognitive dissonance a reason why this practice is still not as common as it should be? In other words, cognitive dissonance can be the psychological mechanism that turns a visible, probable closure liability into a 'surprise' when the bill finally comes due, often after impacts have compounded and become more complex.

6.1 Examples of cognitive dissonance

A number of cognitive biases could be in play with respect to recognising and accepting realistic closure liabilities. This is a substantial topic that spans psychology and organisational behaviour; as non-specialists in those disciplines, we do not attempt a comprehensive treatment and instead highlight a small number of illustrative examples most relevant to our experience of closure liability estimation.

Relating back to the primary reasons for cost increases, 'optimism bias' is often high. Optimism bias reflects humans' tendency to overestimate our likelihood of experiencing positive events and underestimate our

likelihood of experiencing negative events. This bias is also universal: encountered across genders, ages and cultures (https://www.leadershipiq.com/blogs/leadershipiq/optimism-bias). While bad things may happen, and closure liabilities may rise, these things will happen to others and not to us. And through selective calibration of our expectations with positive events, we can maintain optimism even in the face of negativity (https://thedecisionlab.com/biases). Selective calibration can occur through poor benchmarking of closure liabilities, for example, without due understanding of the differences between the contexts of sites compared. Mine closure liabilities are based on closure strategies, and closure strategies represent an array of activities tailored to address site-specific regulation, company governance and risk appetite, and social and environmental contexts: as Bent Flyvbjerg identifies, if your project '...depends on other people and many parts, it is all but certain your project is embedded in complex systems' (Flyvbjerg & Gardner 2023, p. 12). Overlay that with the fundamental differences between mine mineralogy and hence waste material geochemistry, impacts, mining, processing and landform configurations and footprint, and then add the variables present on publicly available closure liability estimates such as discount rates, years to closure, and inclusions and exclusions in those cost estimates. With the sheer number of variables to consider, comparing and benchmarking closure cost estimates can go a long way to reinforce optimism bias, i.e. seeing the world through rose-coloured glasses (Sharot 2011, cited in Wucker 2016).

Another bias that can be extremely strong in closure liability estimation is 'anchoring bias'. Anchoring bias causes us to rely too heavily on the information received early in the decision-making process (https://thedecisionlab.com/biases). Liken this to the initial closure liability estimates made at the greenfield project stage, as early as preliminary economic assessments, often based on benchmarks and broad assumptions rather than site-specific data, when the majority of the effort is on the front-end studies and producing an economically viable mine for the operational period to attract investment rather than robust closure planning processes. This is often also the most optimistic stage of the closure planning process; maximum progressive closure activities are built into the operational costs and are assumed to be progressed as required, and all potential environmental and social impacts of the operation have assigned controls that are assumed to perform, thereby minimising closure requirements. Once that initial number is locked into the financial models and associated reports, it can take a Herculean effort for closure practitioners to convince decision-makers to amend the estimate to reflect more realistic and likely circumstance. Once an anchor is set, there is a bias toward interpreting other information and making judgements around the anchor.

Another, perhaps controversial, bias that may be in play with closure liability is the 'messenger effect'. The Decision Lab (https://thedecisionlab.com/biases) identifies the messenger effect as causing us to judge the validity or relevance of information based on its source. In practice, upward revisions to closure liabilities are often communicated by closure or environmental specialists, whose roles may be perceived by others as peripheral to core operational objectives, or there is the perception that such specialists are biased towards 'higher than required' standards. Additionally, while there are many integrated mine closure good practice guides identifying the collaborative and integrated planning processes that are required for responsible mine closure, there is no universally accepted, jurisdiction-neutral definition for what 'good' mine closure looks like (O'Kane 2025). Further, the sometimes-seeming canyon of difference between regulatory requirements and societal expectations can make site-specific closure requirements, and their associated liabilities, feel uncertain, opaque and difficult to substantiate. And as we have already identified, they are also subject to internal and external influences and can change regularly. A perfect storm for those without the understanding is to judge the messenger with scepticism and judgement. As was cited in one journal article, 'If you want to clear a room of miners, there are few better ways than to raise the topic of mine closure' (Hiyatel 2018).

Sometimes, the strongest bias of all is denial. Denial is not only the first stage of reacting to a grey rhino event but also a strong inherent bias, manifesting as the emotionally motivated rejection (or, less often, embrace) of a factual claim in the face of strong evidence to the contrary (Bardon 2019). Motivations for denial are varied and may include a desire to avoid feelings of insecurity or loss of control or a desire to defend one's cultural or political identity (Bardon 2019) but can also extend to perverse incentives and calculated

self-interest (Wucker 2016). In a closure liability context, denial may also reflect self-protective motives, for example, reluctance to acknowledge that emerging increases were not escalated earlier, a desire to avoid delivering unwelcome news to senior leadership and other key decision-makers, or an incentive to protect performance metrics and reputational standing by deferring re-baselining and the associated governance scrutiny.

With this robust line-up of cognitive biases shaping closure liability perceptions, the question becomes: how can closure practitioners effectively recognise these pitfalls and chart a course toward practical mitigation?

6.2 Mitigation approaches

People take precautions all the time: wearing a seat belt, buying insurance, exercising, or getting a flu shot (Wucker 2016). Mitigating the biases identified above, and others, is a form of precaution against the grey rhino: acknowledging the threat early and addressing it before it gains momentum and charges; rather, it remains grazing peacefully in the field.

6.2.1 Optimism bias

To combat optimism bias, information and case studies can be the starting point. There is a plethora of examples available in the public domain of significant closure liability increases and the associated reasons. Using these as case studies, particularly for sites with similar attributes, similar company size or ethos, to educate the audience of the realities that have come to pass, can be powerful, although it can still often illicit the 'we will be different' response. Highlighting where the impacts to the closure liabilities were as a result of external forces can also help mitigate where optimism bias is resulting in overestimation of the company's abilities or control over its environment.

Optimism bias is also mitigated by challenging 'group think' and including outside and broad perspectives, preferably based on experience supplemented with innovation. Evidence strongly suggests that rigorous debate leads to better decision-making. Create an environment where a diversity of experiences is present and alternative views are encouraged and assign a 'devil's advocate' (https://www.mckinsey.com/capabilities/strategy-and-corporate-finance/our-insights/biases-in-decision-making-a-guide-for-cfos) or use Edward De Bono's six thinking hats to question and facilitate consideration of opposing or alternative views.

Applying reference class forecasting is a strong optimism bias mitigation, a method for predicting the cost and duration of large-scale projects by using historical data from similar, completed projects (Flyvbjerg & Gardner 2023). As opposed to benchmarking, which often compares specific metrics such as rehabilitation cost per hectare, reference class forecasting relevant to closure liability is focused on defining the statistical distribution of actual total closure costs incurred on similar projects. While just as challenging as benchmarking for closure liability given the nuanced requirements of any individual site, it does provide actual, historical data which, applied correctly, can force a more realistic consideration of closure lability.

Similar to reference class forecasting, empirical, using real-world data from individual sites is one of the most powerful mitigations against optimism bias. Do the site-based trials or test plots and monitor the results. What are the actual costs incurred? What was the actual machinery required? What was the actual productivity achieved? Did the method achieve the closure criteria, or is a redesign and recost required? Hard data, founded within the context of the site, are hard to argue as they remove the predictive nature of the estimate along with the assumptions.

6.2.2 Anchoring bias

Tactics already identified can mitigate anchoring bias, including information and case studies and inclusion of outside and broad perspectives (Hoffman 2024).

One of the most impactful mitigations against anchoring bias is to not provide a singular number internally for closure liability. Risk and uncertainty-based ranges, reference class forecasting probability ranges,

scenario-based ranges: all of these can be communicated to show the potential range of liabilities that could be applicable to the site. The earlier this is communicated, the less anchoring there will be.

Similarly, matching closure cost estimate documentation to the class of estimate and inherent uncertainty can mitigate anchoring bias through removing false precision. For example, reporting a value rounded to the nearest 10 million appropriately signals greater uncertainty than reporting a figure to the cent.

Identifying these ranges and associated uncertainty early in project and life of asset planning also raises the stakes early, signalling a material impact could be possible while not forcing a crisis (Wucker 2016). Combined with some simple analysis of the impact the top and bottom of the range may have on the value of the asset can bring the short and long term into balance, prioritising importance not just urgency (Wucker 2016).

Using this tactic can result in a focus of resources on understanding the material risks, uncertainties and liability drivers, and support the timely addressing of the challenge in an efficient and time-appropriate manner.

6.2.3 Messenger effect

To mitigate the messenger effect, ICMM identifies the role of a mine closure champion within a closure governance structure. This role is responsible for liaising with leadership throughout the organisation on closure planning, including corporate, management and operational leads (ICMM 2025). The closure champion is often not in the same function, nor has the same professional background, as the closure practitioners in the organisation. Having a closure champion, or multiple closure champions, with standing at different levels and in different functions of the organisation can result in information being disseminated by peers, thereby mitigating the messenger effect. Other methods can include use of industry-respected subject matter experts to deliver the message and to deliver the message in a factual manner relevant to the company drivers, devoid of emotion or blame, and focusing on the material aspects of the message, for example the key closure cost drivers or primary reasons for liability changes.

6.2.4 Denial

Wucker (2016) identifies denial as the first stage of a grey rhino event. To tackle denial, it first must be acknowledged, which often requires the other biases identified here to be overcome. Key performance indicators can be powerful tools to force robust questioning of assumptions and status quo, even more powerful if linked to remuneration.

Combating the associated biases using some of the methods we have identified will also mitigate denial bias: diversity of opinion from experts with lived experience, reference class forecasting and awareness of real case studies and highlighting ranges to encompass risk and uncertainty.

Application of triggers can also be a useful tool, initiating a procedural response to a material change rather than relying on a decision-maker's discretion. For example, if the liability estimate for a closure domain shifts by more than an agreed percentage or value, the change automatically triggers a structured review through a governance forum such as an investment and risk, or technical closure steering committee.

And sometimes, where the cognitive dissonance is strong, and the task of mitigating it seems impossible, start small. Identify the top three closure domains or activities with the highest uncertainty or the highest costs and start there. Convert uncertainty into scenarios, quantify the range and agree on the few highest impact actions needed to narrow it.

7 Conclusion

Closure liabilities will continue to evolve and change as closure nears on any given site, as the external and internal context changes, and unforeseen events impact closure planning. Understanding that more often than not, this change is up instead of down, and that this message can be poorly received internally and

externally, allows us as closure practitioners to engage pre-emptive precautions against the inevitable cognitive dissonance that seems ubiquitous in closure liability interactions.

Employing data-driven practices, embracing outside and divergent perspectives and highlighting the broad range of scenarios and associated ranges of closure liability are all tactics that can mitigate the biases. And once the biases are mitigated, sensible planning and actions can be employed to balance hopeful goals with realistic planning. As Wucker (2016, p. 245) identifies, 'grey rhino thinking is a mix of realism and optimism'.

Through understanding some of the potential biases and mitigations associated with closure liability, we as closure practitioners may be able to influence and consider how we approach closure liabilities differently for greater impact and more successful closure outcomes.

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