Characterizing tailings professional labor demand

by D. Louise Spencer, Christopher A. Bareither, Joseph Scalia IV, Christopher N. Hatton and Kelly J. Ward

Expanding the world's green economy and developing more sustainable energy production relies on critical minerals including rare earth elements, precious metals and base metals. However, mineral extraction generates mine waste. Thoughtful stewardship of mine waste requires skilled tailings professionals.

Management of mine waste has once again been thrust into the forefront because of recent events (for example, Morgenstern et al., 2015, 2016; Robertson et al., 2019), yielding an increased emphasis on improving engineering, management, governance, and transparency. The promulgation of new tailings guidance includes recent contributions from the Canadian Dam Association, Mining Association of Canada, Australian National Committee on Large Dams, International Committee on Large Dams, and the International Council on Mining and Metals (ICMM). The Global Tailings Review convened in March 2019 to create the Global Industry Standard on Tailings Management (GISTM; GTR, 2020) for tailings facility design, construction, management, and closure throughout the lifetime of a tailings facility. The GISTM was finalized in August 2020 with supporting guidance provided by ICMM through the Tailings Management Good Practice Guide (2021) and Conformance Protocols (2021).

The disposition and frequency of tailings dams worldwide is poorly understood and documented. Commonly cited estimates with respect to the number of tailings facilities worldwide vary substantially, with estimates ranging from 3,500 (Davies et al., 2000) to 18,400 (Herza et al., 2019) to 35,000 (World Mine Tailings Failures, 2020). Previous research described in Hatton et al. (2020) and Spencer et al. (2021) was expanded and refined, updating the estimated number of tailings facilities worldwide. Revised estimates were then used to project the future labor resources required to support tailings operations (including active and inactive operations). Considering the large number of tailings facilities combined with the new guidance to improve the stewardship of tailings, an important question exists: Is the current tailings professional labor pool sufficient to provide the specialized labor needed to meet new guidance designed to make tailings facilities safer?

The GISTM is supported by ICMM member companies, and these member companies have generally committed the necessary resources to support more rigorous oversight and management of existing tailings facilities, in addition to new guidelines for tailings facility design, construction, and closure. For many mines, following the GISTM guidance increases the number of oversight personnel required to manage existing and future facilities. Thus, the hypothesis in this study was that additional qualified and trained tailings professionals are required now, with even more support projected in the future.

Academic departments and disciplines such as geotechnical, geological, and mining engineering that traditionally fed the pipeline for tailings professions are shrinking at many universities (Sichinava and Goetsch, 2019; Saucier, 2020). The perfunctory disassociation of the general public from the industrial complex and the associated need for raw materials limit the understanding and benefit of mining as a tangible and productive career path (Banta et al., 2021). Further, the generally negative perception of mining combined with the unfairly characterized and challenged credibility of mining to operate in an environmentally friendly manner are also contributing to a declining interest in mining-related career opportunities. The unfortunate consequence is a shrinking educational on-ramp that the industry has relied upon for years to generate qualified professionals. This supply shortage is occurring amid the ongoing and imminent retirements of many of the world's leading experts in tailings management, also contributing to the current labor crisis.

The objective of this study was to assess current and future tailings resource needs. The labor demand for tailings professionals was quantified by estimating a range of expected engineering hours required to support a tailings facility considering the GISTM and other guidance. The labor demand was estimated based on the number of tailings facilities presented in the Global Tailings Portal, whereas future demands were estimated based on expected labor applied to the total estimated quantity of tailings facilities worldwide.

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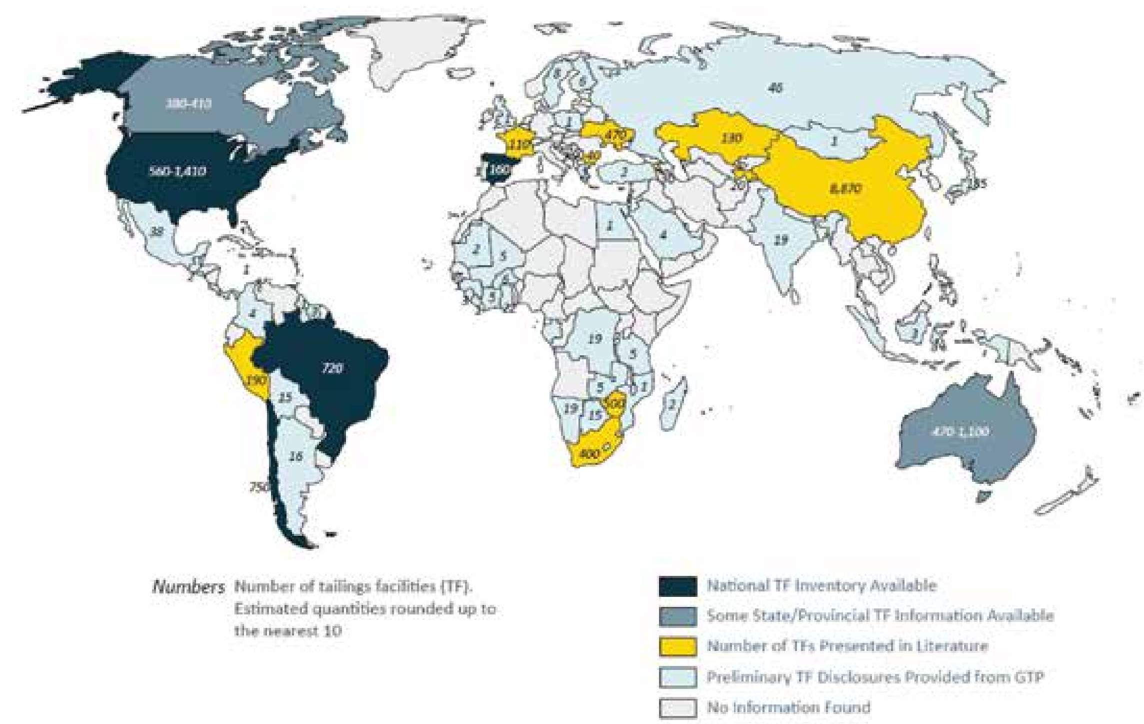
Figure 1

Number of tailings facilities around the world.



Methods

Tailings labor demand. ICMM members have committed to ensure that the members' tailings facilities with "extreme" or "very high" potential consequences conform to the GISTM by August 2023. All other tailings facilities operated by ICMM members that are not adequately closed are committed to complying with the GISTM guidelines by August 2025. The current and future labor demands were quantified using both the GISTM and Tailings Management Good Practice Guide (ICMM, 2021) to establish the labor demands for a tailings facility adhering to good governance and good engineering practices throughout the facility lifecycle. Calculations included consideration for the feasibility, design, and construction phases to life-of-facility management and closure. Personnel duties (labor hours) required for a tailings facility under the GISTM were quantified and then applied to the global estimate of tailings facilities.

Characterizing tailings facilities worldwide. The estimated total number of tailings facilities worldwide was characterized. Initial efforts in Hatton et al. (2020) and Spencer et al. (2021) were expanded upon to yield an (conservative) estimate of 17,000 tailings facilities worldwide. A world map is shown in Fig. 1 with estimates of the number of tailings facilities for specific countries and indication of source data. Data sources are described in Hatton et al. (2020) and Spencer et al. (2021) and include national inventories of tailings facilities, state/provincial databases and/or direct disclosures from regulators, referenced literature, and facilities disclosed and categorized in the global tailings database version 4.0 (GTD, 2021) (an earlier version was used by Hatton et al. 2020, and Spencer et al., 2021).

The estimate of 17,000 tailings facilities was refined by siloing the available tailings facility inventories by crest height, hazard classification, and status (active or nonactive). Tailings facility characterization was developed to proportionally estimate labor resource needs with an understanding that the effort required to service a smaller, lower-production tailings facility (for example) is less than a larger, high-throughput facility.

A similar proportional distribution of labor resource time was applied in terms of tailings facility hazard classification or status, with high-hazard tailings facilities (for example) requiring more labor to design, effectively manage and close as compared to low-hazard facilities. Hatton et al. (2020) grouped the identified tailings storage facilities into three general classification types (A, B and C) with respect to structure height and hazard potential (United States) or potential associated damage rating (Brazil). The range of percentages for each facility type was then applied to the total number of tailings facilities to aid in labor resource estimates.

The total estimated number of global tailings facilities falling into each of the three general classification types was then partitioned into active and inactive facilities. Although information for some closed tailings facilities is available, an unknown number of historical/legacy facilities are not documented or are completely unknown. Thus, existing data sources collected as part of the Hatton et al. (2020) and Spencer et al. (2021) research were queried to summarize the percent of total facilities categorized as active. The average percentage of active tailings facilities was then applied to the total number of facilities to approximate the number of active and nonactive (inactive or closed) tailings facilities. The resources required to service a nonactive facility were assumed to be less compared to an active facility (described subsequently).

Tailings labor demand under the GISTM. Calculations for labor resources required to service global tailings facilities were estimated under consideration of requirements for tailings facility design and management under the GISTM (GTR, 2020). Labor needs include the following personnel roles: senior technical reviewer or independent tailings review board (ITRB), accountable executive, engineer of record (EoR), responsible tailings facility engineer (RTFE), project engineer, and staff engineer.

A summary of experience level, specific GISTM requirements and estimated labor for types A, B and C tailings facilities is presented in Table 1. Experience levels and estimates for labor were developed based on GISTM requirements. The full-time equivalent (FTE) was calculated assuming a 40-hour work week. Initial drafts of Table 1 were circulated to leading tailings industry professionals to provide feedback and guide the estimated values presented herein.

Labor intensity levels by tailings facility classification. The amount of labor required to design and manage a given tailings facility varies based on a combination of factors, such as site geology, topography, climate, hazards, dam height, impoundment volume, and construction method. Labor estimates for each personnel role were divided into three levels of anticipated labor intensity based on the three tailings facility classifications. For example, a type C tailings facility is classified as high hazard (or high dam height) and corresponds to this study's highest estimated level of labor intensity. Labor intensity levels were chosen to represent the range of potential labor resources needed for facilities with varying characteristics and by distinctions in requirements within the GISTM. Under the GISTM, facilities with potential consequence ratings of high, very high, and extreme have more requirements for independent reviews than facilities with potential consequence ratings of low or significant. The service needs from a given personnel role for a given type of facility are generally consistent based on anticipated needs and represent activities that can be estimated and roughly quantified.

Personnel roles. Assumptions used to quantify personnel duties as described herein were associated with tailings facility design,

Table 1

Personnel and labor resource demands under the Global Industry Standard on Tailings Management.

Personnel role	Typical experience range	GISTM applicable requirements	Estimated average labor quantity and frequency for life of project [1]			Resource demand as FTEs (assuming FT = 40 hours per week)		
			Type A TF [2]	Type B TF [2]	Type C TF [2]	Type A TF [2]	Type B TF [2]	Type C TF [2]
Senior technical reviewer or ITRB [3]	25 years +	3.2, 4.2, 4.7, 4.8, 5.7,10.1, 10.5,10.6	2 days/ year	10 days/ year	15 days/ year	0.01	0.04	0.06
Accountable executive	10-20 years +	4.3, 4.7, 5.7, 7.1, 8.2, 8.3, 8.4, 8.5, 8.6, 8.7, 9, 12.1	1 hour/ month	4 hours/ month	15 days/ year	0.01	0.03	0.04
RTFE	10 years +	6.3, 6.4, 6.5, 7.2, 7.3, 7.5, 8.5	8 hours/ week	16 hours/ week	32 hours/ week	0.2	0.4	0.8
EoR	10 years +	4.8, 6.3, 6.4, 6.5, 7.4, 7.5, 9, 10.4	4 hours/ week	12 hours/ week	24 hours/ week	0.1	0.3	0.6
Project engineer	5-15 years	None — Assist EoR and RTFE	4 hours/ week	12 hours/ week	24 hours/ week	0.1	0.3	0.6
Staff engineer	0-5 years	None — Assist EoR and RTFE	16 hours/ week	24 hours/ week	32 hours/ week	0.4	0.6	0.8

The information presented in this table does not establish requirements or recommendations for experience or labor quantity for any specific tailings storage facility. This table is solely intended to approximate nonproject-specific averages to estimate global tailings professional resource demands. **Abbreviations:** EoR-Engineer of Record; FT-Full Time; FTE-Full-Time Equivalents; GISTM-Global Industry Standard on Tailings Management; ITRB-Independent Tailings Review Board; RTFE-Responsible Tailings Facility Engineer; TF-Tailings Facility. **Notes:** [1] Estimated labor quantity and frequency are presented as an average over the life of the project for active, regular operations. Estimated labor would be expected to be higher during design and expansion phases and lower in closed/inactive phases. [2] Dam-type classifications are not intended to implicate that specific TFs require the criteria shown in the table. Three dam-type levels were chosen to represent the range of potential labor resources needed for facilities with varying characteristics. For example, the level of effort required to service a smaller, lower production TF would be less compared to a sizeable, world-class facility. [3] Senior Technical Reviewer or ITRB, as required under the GISTM. ITRB assumed to consist of 2-3 people for a total of the days listed.

construction, and management based on the GISTM and Good Practice Guide and include the required interaction with operations and continuous engineering support. The resource demand calculations in Table 1 include support for day-to-day tailings facility operation and intentionally exclude items such as the design of capital expenditure projects (CAPEX), sustaining capital projects, and specific aspects of operational expenditures (OPEX). The calculations do not include associated overhead costs, supporting labor such as word processing, or other administrative support services such as drafting and communications. Finally, and significantly, the estimate does not include associated labor from regulators, manufacturers, vendors, bankers, insurance providers, and educators, among other professions, that are related to serving tailings management and governance of the mining industry.

Senior technical reviewer/independent tailings review board (ITRB). The GISTM stipulates independent (third-party) review of tailings facilities, conducted by either a senior technical reviewer or ITRB, as dictated based on potential consequence rating under the GISTM. Facilities with a potential consequence rating of "low" or "significant" may have their independent review conducted by a senior technical reviewer, whereas facilities with consequence ratings of "high," "very high" or "extreme" must have a full ITRB conduct the review. Typical minimum experience levels of independent reviewers are generally agreed to be around 25 years.

The independent review duties (Table 1) are assumed to consist of one to three people for approximately two to 15 days per year, per tailings facility. Estimating labor effort ranges for independent reviews is particularly difficult because the level of effort depends on how well

Table 2

Percentages of active tailings facilities (TF) from various sources. Average = 40 percent.

Region	Total TF records	Active TF records	Percent active TF	Data source
Worldwide	1,942	827	42 percent	GTD, 2021
Chile	742	104	14 percent	Servicio Nacional de Geología y Minería (Sernageomin), 2019
Chile	449	175	39 percent	Villavicencio et al., 2013
Chile	660	257	39 percent	Ghorbani and Kuan, 2016
Peru	183	90	49 percent	Wallingford, 2019
Western Australia	492	277	56 percent	Personal communication (2020), Mine Safety Directorate of Department of Mines, Industry, Regulation and Safety
United States	1,363	560	41 percent	MSHA, 2019; NID, 2018

stewardship is executed prior to initiating an independent review and/or how long a particular tailings facility has been under independent review. The estimated effort for independent review duties presented is intended to be a wide range to capture a variety of needs.

Accountable executive. The accountable executive is an in-house executive directly answerable to the chief executive officer and communicates with the board of directors. General experience levels for the accountable executive are assumed to be around 10–20+ years. The accountable executive's duties (Table 1) are assumed to be performed within a range of approximately one to six hours per month, per tailings facility.

Table 3

Estimates of tailings labor demand for the 1,947 facilities disclosed in the global tailings database (2021).

Percent contribution of tailings facilities (TF)				Full-time equivalents (FTEs) needed to service 1,947 tailings facilities with a 75 percent labor reduction for nonactive facilities						
TF screening criteria	Type A [1]	Type B [1]	Type C [1]	Senior technical reviewer or ITRB	Accountable executive	RTFE	EOR	Project engineer	Staff engineer	Total FTEs
Crest height	43–51 percent	32–40 percent	17 percent	30–31	23–24	387–405	267–276	267–276	554–589	1,528–1,600
Hazard	12–32 percent	17–37 percent	51 percent	43–45	30–32	554–598	408–431	408–431	618–706	2,060–2,242

[1] Classification by dam height: Type A < 30 m, Type B > 30 m and < 100 m, Type C > 100 m. Classification by hazard: Type A = low, Type B = significant or medium, Type C = high.

Responsible tailings facility engineer (RTFE). The RTFE is intended to be an in-house, onsite engineer who directly oversees day-to-day tailings facility management and monitoring. Typical minimum experience levels of an RTFE start from 10 years. The RTFE duties (Table 1) are assumed to be performed within approximately eight to 32 hours per week, per tailings facility.

Engineer of record (EoR). Under the GISTM, the operator may nominate an external senior engineer to serve as EoR, or appoint an in-house engineer as the EoR. In the latter case, the EoR may delegate design to an external firm that serves as the designer of record (DoR). For this exercise, a senior external engineer was assumed to serve the EoR role or that the EoR and DoR labor load is captured under EoR efforts (that is, EoR and DoR are grouped as one labor effort).

The typical experience level of an EoR is at least 10 years. For high-consequence or complex facilities, experience levels for the EoR will likely be closer to 15 to 20 years. However, 10 years of experience may be sufficient to be an EoR for lower-consequence tailings facilities, which would serve as a typical and often necessary progression in EoR experience. The EoR duties (Table 1) are assumed to be performed within a range of approximately four to 24 hours per week, per tailings facility.

Project engineer and staff engineer. The project and staff engineer roles are not mandated under the GISTM. However, the level of detail in the tasks required for both the EoR and RTFE necessitate an engineering team's assistance, consisting primarily of project-level and staff engineers reporting to the EoR. For example, the EoR and RTFE are responsible for the construction records report but are likely using data compiled by a project engineer and collected/entered by staff engineers and/or technicians. Like the EoR role, project and staff engineers may be external or in-house employees. Experience levels for staff and project engineers are generally agreed to be around zero to five years and five to 15 years, respectively.

The project engineer duties (Table 1) are assumed to require approximately four to 24 hours per week of support per tailings facility. Staff engineer duties are approximated to be 16 to 32 hours per week, per facility.

Labor quantity discussion. Estimated labor quantity and frequency are presented as an average over the life of the facility for active, regular operations. Estimated labor would be expected to be higher during design and expansion phases and lower in closed/inactive phases. For a conservative estimate of required resources for this study, a labor reduction factor of 75 percent was applied to the labor estimate of inactive/closed facilities to remain in line with the GISTM (that is, it was approximated that, on average, nonactive facilities require 25 percent of the total labor for active facilities). The labor required to service specific tailings facilities varies based on site-specific conditions and may fall outside of the presented labor quantities in Table 1. This project includes assumptions using broad generalizations with the intent to obtain an order-of-magnitude estimate for the number of tailings professionals required to service tailings facilities worldwide. The estimate, in this context, illustrates the significant labor demand for qualified tailings professional resources within the industry.

Total labor demand calculation. The FTE estimations for each type (Table 1) were applied to the estimated number of tailings facilities worldwide to quantify the total labor demand. The estimated FTEs per tailings facility type (Table 1) are multiplied by the estimated number of active facilities. A 75 percent reduction of FTEs was multiplied by the estimated number of nonactive facilities of each type. The FTE estimations were first applied to the tailings facilities disclosed in the GTD (2021) to reflect the current demand resulting from ICMM member commitments to bring all of their tailings facilities up to the standard within five years. To capture future tailings labor demand, the FTE estimations were then applied to the total global estimate of tailings facilities, with the recognition that to increase the environmental stewardship of mine waste, all global tailings facilities must be brought up to a level of practice with an approximate labor demand like the GISTM requirements. Of note, this future demand does not reflect an anticipated increase in global mining activity in support of future mineral demands.

Results

Characterizing tailings facilities worldwide — characterization by type. Tailings facilities were grouped into the following three classification types based on crest height (Hatton et al., 2020): (1) type A — small structures with crest height < 12 m (40 ft); (2) type B — intermediate structures with crest height > 12 m (40 ft) but < 30 m (98 ft); and (3) type C — large structures with crest height > 30 m (98 ft). In addition, tailings facilities were categorized into three classification types based on hazard potential (United States) or potential associated damage rating (Brazil): (1) type A — low hazard potential or low potential associated damage; (2) type B — significant hazard potential or medium potential associated damage and (3) type C — high hazard potential or high potential associated damage. The classification types used herein are not meant to represent an established consequence classification and do not align with the consequence classification in GISTM (that is, low, significant, high, very high, extreme), but only to serve as a useful binning technique to support labor demand calculations.

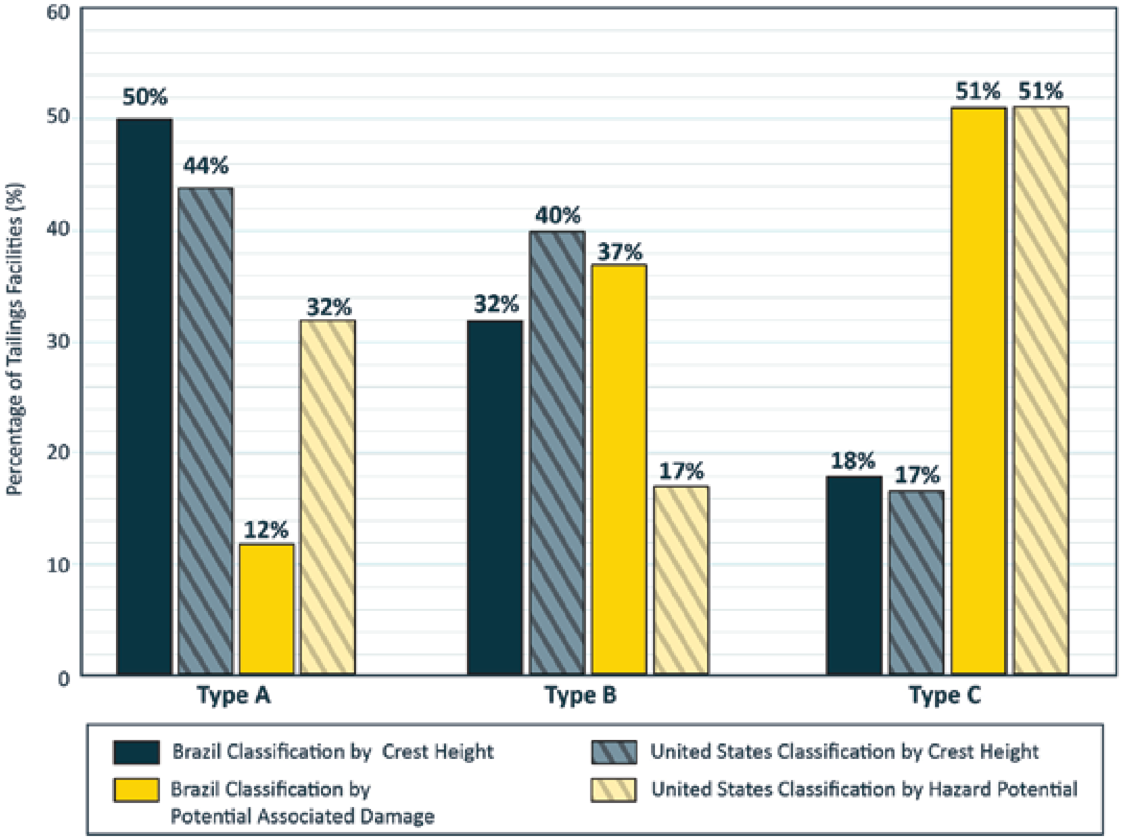
The distribution of tailings facilities in the United States and Brazil that classify into types A, B and C based on height and hazard is shown in Fig. 2. Data available for the United States and Brazil were used to yield estimates of the type A, B and C tailings facilities based on the quality of information available for these two countries on tailings facility quantities and characteristics. Classification by crest height is biased toward smaller dams (type A) for both the United States and Brazil, whereas classification by hazard rating is biased toward high hazard (type C) for both countries. This difference in bias is likely attributed to not accounting for other factors (for example, the volume of tailings impounded, distance from towns/cities) that can influence the hazard rating for a tailings facility with a low dam height. Average distributions of type A, B and C tailings facilities based on height were used to generate a lower-bound estimate for labor demand, and average distributions based on hazard rating were used to generate an upper-bound estimate.

Classification by status (active or nonactive). A summary of relevant literature sources that identify active tailings facilities within a given database is provided in Table 2. The recent global tailings database (2021) catalogued 1,947 tailings facilities, of which 827 (42 percent) are identified as "active." The mean of all sources in Table 2 is 40 percent, which is comparable to that reported by the global tailings database. Thus, 40 percent active facilities was applied to the estimate of 17,000 tailings facilities worldwide to yield 6,800 estimated active facilities and 10,200 nonactive facilities (inactive or closed).

Labor estimate post-GISTM. Companies that have disclosed tailings facilities to the global tailings database (2021) are already bringing their facilities up to the guidelines outlined in the GISTM. This transition is happening now, and demand for the associated personnel roles in the GISTM is increasing rapidly to meet the guidelines. An initial estimate of labor demand is in Table 3, which includes personnel required to service the 1,947 disclosed tailings facilities in the global

Figure 2

Percentage of tailings facility inventory for each type based on Brazilian and United States height or hazard classifications.



governance of all the estimated 17,000 tailings facilities worldwide.

The labor demand required to service the estimated 17,000 tailings facilities in accordance with the GISTM is in Table 4, which includes an estimated 6,800 active facilities and 10,200 nonactive facilities. This labor demand is considerably higher relative to the 1,947 tailings facilities in the global tailings database (2021) and represents a forward-looking projection to capture the mining industry's needs. Thus, if the mining industry wants to manage all (current) facilities worldwide, safely and sustainably, it will need approximately 12,900 to 18,900 FTEs. The labor resources required to achieve this will take time to recruit, develop, retain, and replenish. Another major effort will be to find and catalog the extent of all tailings facilities worldwide to define the magnitude of stewardship required to safely manage each for future generations.

Labor quantification in this study was performed to yield a total number of FTEs. However, fulfilling one FTE role likely will require multiple people. For example, most upper-level technical experts who serve as senior technical reviewers or are on ITRBs do so in addition to other professional duties; in other words, most ITRB members do not serve as ITRB members full time. Therefore, the actual number of experts required exceeds the stated FTE requirement to meet 30–45 ITRB FTEs to service the 1,947 tailings facilities disclosed in the global tailings database (Table 3).

Labor demand under the GISTM has increased per tailings facility due to the addition of personnel roles such as accountable executive and RTFE, which were created explicitly in the GISTM. Labor demand for all personnel

tailings database (2021). The numbers in Table 3 reflect the 42 percent of active facilities reported in the database; the labor required for nonactive facilities was reduced by 75 percent from the labor required for an active facility.

The lower-bound estimate was based on tailings dam crest height and suggests that more than 1,500 FTEs are required to serve the 1,947 tailings facilities, whereas the upper-bound estimate based on hazard rating suggests that more than 2,200 FTEs are required. The total number of FTEs includes all personnel outlined in Table 3.

Appropriate management of all tailings facilities, not just those disclosed in the global tailings database, in accordance with a level of practice equivalent in scope to the requirements of the GISTM, Good Practice Guide, and/or other relevant guidance documents is fundamental for the mining industry to be a leader in its transition to a green economy and sustainable energy future. Additionally, securing investors and insurance policies now and in the future will require mine owners to demonstrate good engineering and governance of tailings facilities. Thus, the interpretation is that the industry will take the steps required to increase uniformity of good engineering practices and

Table 4

Estimates of tailings labor demand for the minimum estimated 17,000 tailings facilities worldwide.

Percent contribution of tailings facilities (TF)				Full time equivalents (FTEs) needed to service 17,000 tailings facilities with 75 percent labor reduction for nonactive facilities						
TF screening criteria	Type A [1]	Type B [1]	Type C [1]	Senior technical reviewer or ITRB	Accountable executive	RTFE	EoR	Project engineer	Staff engineer	**Total FTEs**
Crest height	43–51 percent	32–40 percent	17 percent	255–263	194–201	3,273–3,422	2,253–2,328	2,253–2,328	4,675–4,974	**12,903–13,516**
Hazard	12–32 percent	17–37 percent	51 percent	361–380	250–268	4,675–5,049	3,450–3,637	3,450–3,637	5,217–5,965	**17,403–18,937**

[1] Classification by dam height: Type A < 30 m, Type B > 30 m and < 100 m, Type C > 100 m. Classification by hazard: Type A = low, Type B = significant or medium, Type C = high.

roles also increases as the number of facilities managed according to the GISTM increases. Labor demand changes under the GISTM have happened rapidly, with the expectation that once the GISTM was issued, companies expecting funding from the 100 investors with more than $13 trillion in assets under management supporting the Investor Mining and Safety Initiative will need to bring their facilities up to compliance with the GISTM. The ICMM member commitment pledges to bring all member-owned tailings facilities into compliance with the GISTM between August 2023 and August 2025. This includes retrogressively assessing existing facilities for data gaps to align with the guidelines (although supporting contractor labor for such investigations, such as drillers and geophysicists, is not included in the labor demand estimates), along with modifying existing design and construction projects to comply with the GISTM. Altering the supply chain to incorporate the tailings professionals needed to satisfy the guidelines in the GISTM does not happen instantaneously. New and existing professionals must be drawn into the industry, trained, and spend years gaining practical experience to be qualified to satisfy the personnel roles and the duties listed in the GISTM.

Call to action

The GISTM sets a new standard-of-care associated with the feasibility, design, construction, management and closure of tailings facilities worldwide. The resources required to bring individual tailings facilities from their current management status up to compliance with the GISTM varies widely. For example, some facilities are already operating under the requirements outlined in the GISTM and are prepared to provide any necessary labor resources to satisfy additional/forthcoming guidelines. Other facilities, however, are operating below the GISTM guidelines and may have limited to no financial and/or personnel resources available to upgrade and adhere to the guidelines. Still, other facilities may have been abandoned without consideration of proper closure and management.

This study aims to raise awareness of the growing demand for tailings labor resources and the need for collaboration within academia and industry to recruit, train, and retain future tailings professionals. With promulgated guidance of the GISTM and the ICMM guidelines for standard of care, the industry must rapidly evolve to bring in more professionals. The mining industry must educate and train additional tailings professionals to provide the labor needed to sustainably manage mine waste now and in the future. As a profession, the industry must promote tailings as an interesting and successful career path to reduce future labor shortages. ■

Author statements and acknowledgments

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