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EXHIBIT SCOTT – D-15

DEVELOPMENT AND REVIEW OF SURVEILLANCE PROGRAMS FOR TAILINGS DAMS

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Abstract

A good dam surveillance program is the foundation of an overall tailings dam safety program. Tailings dams are dynamic and continually evolving structures, under construction on a regular, and often near-continuous, basis, and have a closure phase that lasts "forever". This is in contrast to conventional, water-retaining dams, which are built in a single stage at the onset of the project, have a finite operating life and are not required to last "forever". Tailings dams also can undergo environmental as well as physical failure, unlike conventional water-retaining dams that can only undergo physical failure. Accordingly, requirements for tailings dam surveillance, contrary to common perception, can be and frequently are more stringent, requiring frequent review and modification, than is the case for conventional water-retaining dams of equivalent hazard rating. Case history experience has repeatedly demonstrated that a great many tailings dam failure modes give warning signs that, if properly monitored and interpreted, give advance warning of problems, affording the opportunity to take preventative measures. This experience serves to emphasize the importance of a good surveillance program for tailings dams. Such a program involves much more than simply specification of instrumentation, reading those instruments, and filing of data reports. It requires understanding and management of risk, commitment, adequate resources and support, awareness, interpretive imagination, and clarity of communication among all responsible parties.

Introduction

Surveillance of tailings dams, during their construction, operating, decommissioning and closure phases, is the essential foundation of any tailings dam safety program. Surveillance is also an essential element of the observational approach to design and construction that is so ideally suited, and so frequently applied, to tailings dams. Many tailings dam failure modes are preceded by warning signs that can be readily detected well in advance with a proper dam surveillance program. If the warning signs are promptly detected, and appropriately appreciated, time is available for the implementation of remedial measures. For many of these detectable failure modes, a good dam surveillance program, in concert with emergency preparedness and response plans, represents a highly cost-effective, proactive risk management tool relative to the options of a failure or an unnecessarily excessive and expensive degree of design conservatism. It does not however provide a means of safely stewarding a facility whose design and/or construction is flawed. A number of failure modes do not provide readily apparent advance warning signs and it is important to recognize that these failure modes cannot be properly addressed using the observational approach and cannot be appropriately addressed by a dam surveillance program. The only way to deal with these latter failure modes is to use devise appropriate designs and construction measures.

Tailings dams are constructed over a period of many years, and go through several phases (construction, operation, decommissioning, and closure) so their surveillance requirements are constantly changing. Those responsible for surveillance of tailings dams are mining company personnel; i.e. those not in the business of designing, maintaining, and monitoring dams. Geotechnical expertise as applied to tailings dams typically resides with consulting firms. Often more than one consulting firm will become involved over the history of the project and there will often be more than one "designer". This disconnect between geotechnical expertise and the on site personnel carrying out the dam surveillance can represent a serious weakness in the tailings dam safety program unless properly addressed through training and clear communications and understanding of responsibilities.

This paper discusses the essential ingredients and requirements of tailings dam surveillance, with emphasis on those aspects unique to tailings dams. It discusses the use and abuse of the observational method to tailings dam design and construction that must be supported by a surveillance program. Use of simple, qualitative risk analysis, carried out at the minesite in a workshop format to define or audit a dam surveillance program, is described. The paper describes how this workshop format can effectively transfer the essential basics of the observational approach from the designer to those personnel responsible for carrying out the day to day surveillance activities. Finally, less tangible and technical (and therefore less appreciated) but nonetheless critical aspects of tailings dam surveillance are considered in the context of a famous but unconventional surveillance failure case history.

The paper does not address the environmental aspects of tailings dam surveillance, but rather focuses on issues related to the physical stability of tailings dams. It is well known that a stable tailings dam can undergo an environmental failure (e.g. unacceptable seepage and impacts on water quality, acid mine drainage, etc.). Surveillance related to these types of failure modes is not the subject of this paper.

Unique Aspects Of Tailings Dams

The design approach and safety requirements for tailings dams, including dam surveillance programs, are often adapted from the practice of conventional dam engineering. In many respects this is appropriate, but tailings dams have many unique features and operating requirements, which demand specific consideration and do not allow unquestioned adoption of conventional dam engineering practice (Ref. 1). The unique aspects most relevant to the specific requirements of tailings dam surveillance programs are as listed in Table 1.

The common thread of each of these unique aspects and requirements is that, contrary to common perception and practice, the challenges involved and effort required in proper surveillance of tailings dams are often greater than for a conventional water retention dam in a similar physical setting.

Key Aspects Of Tailings Dam Surveillance

Basic Ingredients of Tailings Dam Surveillance

Tailings dam surveillance must serve three vital functions:

1. Confirm that the dam is safe, and is performing in accordance with design criteria and

objectives.

2. Confirm design assumptions, and adjust the ongoing design and construction of the dam as necessary based on observations less favorable than design assumptions, or optimize design and construction based on observations more favorable than design assumptions.
3. Clear identification of failure modes capable of detection by the surveillance program, and those not capable of detection, so as not to lead to complacency with regards to the latter.

Table 1 Tailings dams vs. conventional dams in terms of surveillance requirements

Conventional dams	Tailings Dams	Implications for tailings dam surveillance program
Construction occurs in a single stage, followed by operation under steady state conditions.	Construction occurs on a regular, near-continuous basis. Steady state is not achieved until closure.	The conditions of the dam and the loadings to which the dam is subjected, and therefore surveillance requirements, are constantly changing. There is no opportunity to "relax".
Constructed and operated by organizations experienced and focused on dam operation and surveillance.	Constructed and operated by organizations whose focus and expertise is in extracting wealth from the ground, not in building dams.	Operations personnel require training, support, and commitment from corporate to mine management level.
Typically owned by state or large utility with substantial financial resources to apply to dam safety.	Economics of mining limit the resources that can be applied in construction and operation of the dam.	Tailings dam owners must resist the inevitable temptation to cut back on surveillance program in favor of devoting more resources to profit centers. Resources applied to surveillance must be independent of cyclical business environments.
Viewed as a significant asset (generates revenue) by the owner and, typically, by the public which derives direct, tangible benefit from the dam.	A cost center for the mining operation, a "necessary evil", and understandably not the focus of the operation. Definitely not viewed as an asset by the public.	As above, tailings dam owners must resist the obvious and understandable temptation to reduce resources available for dam surveillance. Must not just practice due diligence, but be seen to be doing so to reassure regulators and the public.
Owners generally have in-house dam engineering expertise, including personnel whose sole function is surveillance.	Typically no in-house dam engineering expertise – reliance on consultants. Dam surveillance is not a career path for miners.	Disconnect exists between those carrying out the surveillance program (operators) and the dam engineering expertise required to evaluate the results of the program (consultants). Continuity of advice, and clear communications essential.
Have a finite operating life – do not have to last "forever".	Have a closure phase as well as operational phase – have to last "forever".	Most tailings dams will require some degree of surveillance "forever", particularly so for the increasing number of water retaining tailings dams being used to keep sulfide tailings submerged.

Tailings dam surveillance is defined as all activities required for achieving these two objectives, and should include all of the following ingredients:

determination of the data that needs to be gathered to confirm satisfactory performance;

design of a surveillance program that will obtain the required data, with a suitable level of redundancy (repeatability);

training of those personnel responsible for collection of the data as to how to obtain and manage the data, and to provide awareness as to warning signs;

provision of the installations and resources required (e.g. instrumentation, time, personnel, access) to permit responsible personnel to carry out the program;

maintenance of the installations (e.g. piezometers, inclinometers, seepage weirs) required to carry out the program – a corollary is establishing a level of "respect" for installations within all on-site personnel to avoid, for example, damage to critical installations by vehicle traffic.
appropriate presentation and communication of the data (e.g. plot of piezometer level vs. time, including trigger levels) to allow for quick and effective interpretation and response;
prior definition of warning signs and response plans to be enacted in the event that warning signs are noted;
clear and documented lines of communication and responsibility in terms of data gathering, plotting, reporting, and action;
regular tailings dam designer review and input in terms of data requirements, interpretation, and response;
appropriate documentation and database management practices to avoid a malady dubbed by the authors as "tailings database amnesia" (Ref. 2), a problem that has had serious consequences where lack of continuity in personnel and consulting advice occurs;
review and updating of the surveillance program, involving the dam designer, no less frequently than once per year (less frequently likely suitable during closure phase) – where a mine is but one of several owned by a mining company, a review of surveillance program consistency between sites, and a corporate person with an active role in dam safety in general and dam surveillance in particular, are important;
periodic independent auditing of the program, by an expert independent of the design team; and
documentation of the surveillance program requirements, procedures, and lines of responsibility, typically in the form of an Operations Manual.

Addressing Surveillance at the Design Stage

Assisting the owner in the development of a comprehensive tailings dam surveillance program is a vitally important responsibility borne by the designer. A surveillance program is every bit as integral a part of a facility design as the design analyses, construction drawings and specifications. Without a comprehensive surveillance program, a tailings dam design is incomplete.

It is now considered to be the state-of-practice in management of tailings facilities to have in place an Operations Manual, within which the tailings dam surveillance program should be included. The benefits of having an Operations Manual in place, and in documentation of the dam surveillance program within the manual, are as follows:

1. It provides a concise, practical document that can be used by site operating personnel for operation and surveillance of the tailings facilities.
2. It serves as a useful training document for new personnel involved in tailings management and operations, therefore providing for some continuity in expertise and knowledge, particularly important for personnel responsible for surveillance activities.
3. Its existence provides reassurance to senior level management and to regulatory personnel that formalized practices are in place for the safe operation and surveillance of the facility.
4. It is an important step in demonstrating due diligence on the part of the owner.

Reliance on the preparation of an Operations Manual, and the surveillance program therein, by a consultant/designer only should be discouraged, as this does not foster an intrinsic understanding of the surveillance program by operations personnel, nor an understanding of operations on the part of the consultant/designer. Such an approach is also likely to result in a document that will collect dust on someone's shelf. Further, it is essential that the surveillance program takes into account the perspective, knowledge and experience of operations personnel, and the site-specific constraints under which they must carry out their responsibilities. The designer must be aware of these constraints.

The Importance of Independent Auditing of the Surveillance Program

Each of the ingredients listed previously represent an essential link in the surveillance chain, and a weakness or lack of any one or more of these ingredients can be the undoing of even the best-designed surveillance program. Though no one ingredient will always necessarily be more important than another, the authors stress the importance of independent auditing of the program because this is an ingredient that is usually not recognized or practiced. It is preferable that someone other than the designer carry out the audit because the designer cannot be completely objective as to their own design and the potential vulnerabilities associated with that design. The designer's surveillance program is inevitably based largely on the designer's conceptions of what could happen and what could not. An objective viewpoint can detect and correct weaknesses in the surveillance program.

If the design consulting firm has a good internal review process, as every consulting firm should, then that internal review can in some instances form the independent audit. However, for major projects, and from a mine owner's risk management perspective, this is a second best solution and is not preferable. Consider the following conclusions drawn by Dr. N.R. Morgenstern in a workshop on tailings risk management following the recent spate of highly publicized tailings dam failures (Ref. 3):

1. All of the failures involved to varying degrees recognized geotechnical consultants qualified by either national or international standards.
2. In no case was there systematic third party review.
3. A well-intentioned corporation employing apparently well-qualified consultants is not adequate insurance against serious incidents.
4. Mine management should employ third party reviews at appropriate stages.

The authors concur with all of these conclusions and recommendations, while emphasizing that tailings dam safety is about a great deal more than third party review. Tailings dam safety is heavily dependent on a good dam surveillance program. This program has got to be right, and independent, expert review is an important and under-utilized quality assurance and risk management tool at mining companies' disposal. Tailings dam designers, rather than feeling threatened by having independent peer review of their work, should welcome and promote this practice. Owners and regulators should be wary of the designer that rebuffs independent review and/or fails to demonstrate a track record of successful designs where such review was an essential component of those successes.

Risk Management Using The Observational Method

Description of the Method

The observational method as described by Dr. R.B. Peck (Ref. 4) is predicated on observing the behavior of the structure, and making design/construction adjustments as necessary, based on favorable versus unfavorable performance relative to the original design assumptions and performance criteria. Even the safest dam cannot be without risk. To manage this residual risk, dam engineering practice in general, and tailings dam engineering practice in particular, places considerable reliance on monitoring of the structure performance to confirm satisfactory performance and to confirm design assumptions, the two basic functions of tailings dam surveillance. Tailings dam construction, because it happens on a near-continuous basis, provides the opportunity (if not the necessity) to optimize design and construction due to the ability to monitor performance and adjust design and/or construction accordingly. This is perhaps the one aspect of tailings dams working in their favor relative to conventional water retaining dams. The observational method is in fact a risk management method established and widely used in geotechnical engineering long before risk analysis and risk management became fashionable terms. The attraction of the method is that, if applied properly, it permits avoidance of initial designs that may be excessively conservative (though an appropriate degree of conservatism is always warranted) and overly expensive.

The elements of the observational method are as shown schematically on Figure 1.

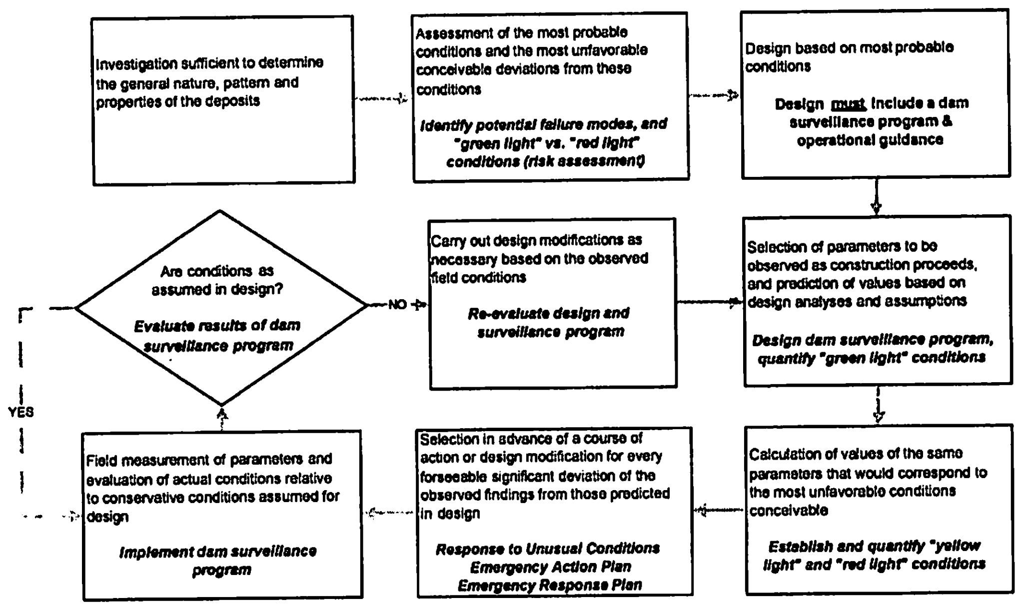

Figure 1. Risk management via the observational method

Failure to correctly apply each element of the method as illustrated schematically in Figure 1 results in following the "hope for the best" method rather than the observational method, and tailings dam designers satisfied with the "hope for the best" method are strongly encouraged to seek an alternate career path. The most common abuses of the method involve one, and more typically combinations of, the following:

- failure to recognize the most unfavorable conceivable deviations from assumed conditions and performance;

- failure to select in advance a course of action or design modification for every foreseeable deviation of observed conditions from assumed conditions; and
- dependence on the method to detect potential failure modes that occur suddenly with few or no warning signs, and/or with insufficient time to enact suitable countermeasures when (or if) such warning signs are detected.

Finally, the method was never intended to "rescue" a substandard design that was based on inadequate site investigation and insufficient detail, forethought, or, in an alarming number of instances, general inability to properly design and construct tailings facilities. This is the worst form of abuse of the method, but one that is seen all too frequently in tailings dam projects. Economic pressures and/or pressures in feasibility study stages to produce a positive outcome can result in a "don't worry about it now, we'll figure it out later as we go along" mentality. This approach is almost always false economics.

Failure Modes and Warning Signs for Tailings Dams

To consider the use (and abuse) of the observational method for tailings dams, and the surveillance that underpins the method, it is necessary to consider those failure modes to which tailings dams are particularly susceptible. Figure 2 indicates failure modes responsible for reported, documented failures, for upstream-constructed tailings dams, and for all other types of tailings dam. Upstream dams are broken out as a special case because earthquakes and slope failure, together making up nearly 60% of documented upstream dam failures, occur with little or no warning, and occur in sudden and generally catastrophic fashion (flowslides). This results from the contractant, brittle nature of the tailings that often form and/or underlie the dam wall. The viability of the observational method, and the degree to which a surveillance program can be relied upon, must therefore be considered very carefully for any tailings dam whose structure and/or foundation involves brittle materials. The Las Frailes tailings dam failure in Spain is a recent case in point involving a brittle foundation.

Consider the example of pore pressure monitoring of upstream tailings dams. In spite of an unfortunate amount of contrary literature and designs, pore pressure monitoring to allow prediction of a static liquefaction failure of an upstream tailings dam is simply not possible. The propensity for upstream dams to have some degree of susceptibility to contractant behavior leading to undrained conditions during shear by definition excludes pore pressure surveillance as a warning measure against such an occurrence. Such monitoring is essential to understand the pre-failure pore pressure and stress regime within the dam, but that is the limit of the usefulness of pore pressure monitoring in this particular context. .

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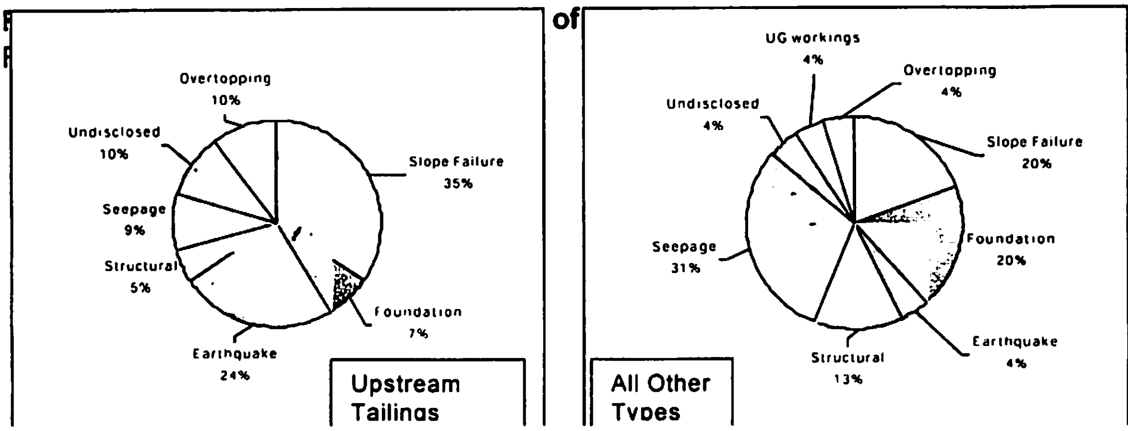

Figure 3, modified from Andersen et al (Ref. 7), illustrates the steps involved in identification of potential failure modes through setting of the surveillance program schedule. The adverse conditions, warning signs, and surveillance measures shown on this figure are by no means exhaustive, and every tailings dam must be considered on a site-specific basis. Figure 3 does illustrate the following:

1. One surveillance measure can provide information to multiple warning signs, which can in turn provide information to more than one adverse condition.
2. The surveillance program is an iterative process, with the program specifics (e.g. how often a certain measurement/inspection is undertaken) dependent on the observation.
3. Warning signs can be relatively sudden and dramatic, but in many instances manifest themselves only as long term trends that are nearly imperceptible unless the data is critically reviewed in terms of its potential long term implications.
4. Earthquakes and severe storms/floods are not included on Figure 3 because these are failure modes that occur without warning.

The internal erosion failure mode (seepage) dominates the failure modes for documented failures of tailings dams other than the upstream type, and surveillance for this mode merits additional discussion. Internal erosion (piping) can take three forms:

a) Base heave at downstream dam toe – typically occurs on first filling of reservoir
b) Backward erosion beneath a "roof" (e.g. in cohesive core material) – will not necessarily occur and in fact is not likely to occur on first filling
c) Removal of joint filling at damfill-foundation contact – can occur on first filling or be delayed

In terms of surveillance for internal erosion, tailings dams are at a considerable advantage over conventional dams in that, being constructed in increments over a number of years, the full stress of the reservoir is not applied until the end of the mine life. This gives plenty of opportunity for observation of the intermediate conditions and extrapolation to the full reservoir stress condition. If extrapolated conditions are deemed unfavorable, there is time and opportunity to implement additional protective measures. Of course, tailings dams are at a disadvantage in that, once a problem is noted, there is no practical opportunity to drain the reservoir prior to a tailings breach event (e.g. the Omai failure which resulted from inadequate internal filters). Sometimes internal erosion can be detected before a serious incident develops, and sometimes it cannot. In the latter category is the 1976 Teton dam failure, which developed in a matter of hours. This makes it all the more essential that surveillance be diligently carried out to increase the likelihood of early detection and correction of a potential problem.

This same process, whereby each adverse condition, warning sign and corresponding surveillance measure is critically assessed in terms of likelihood of advance detection, and time available and ability to implement remedial measures, must be applied for each potential warning sign and adverse condition. It is not just reserved for problematic failure modes such as internal erosion and undrained shear failure of dams involving contractant and/or brittle materials. Every tailings dam is unique, so this assessment must be carried out on a case by case basis.

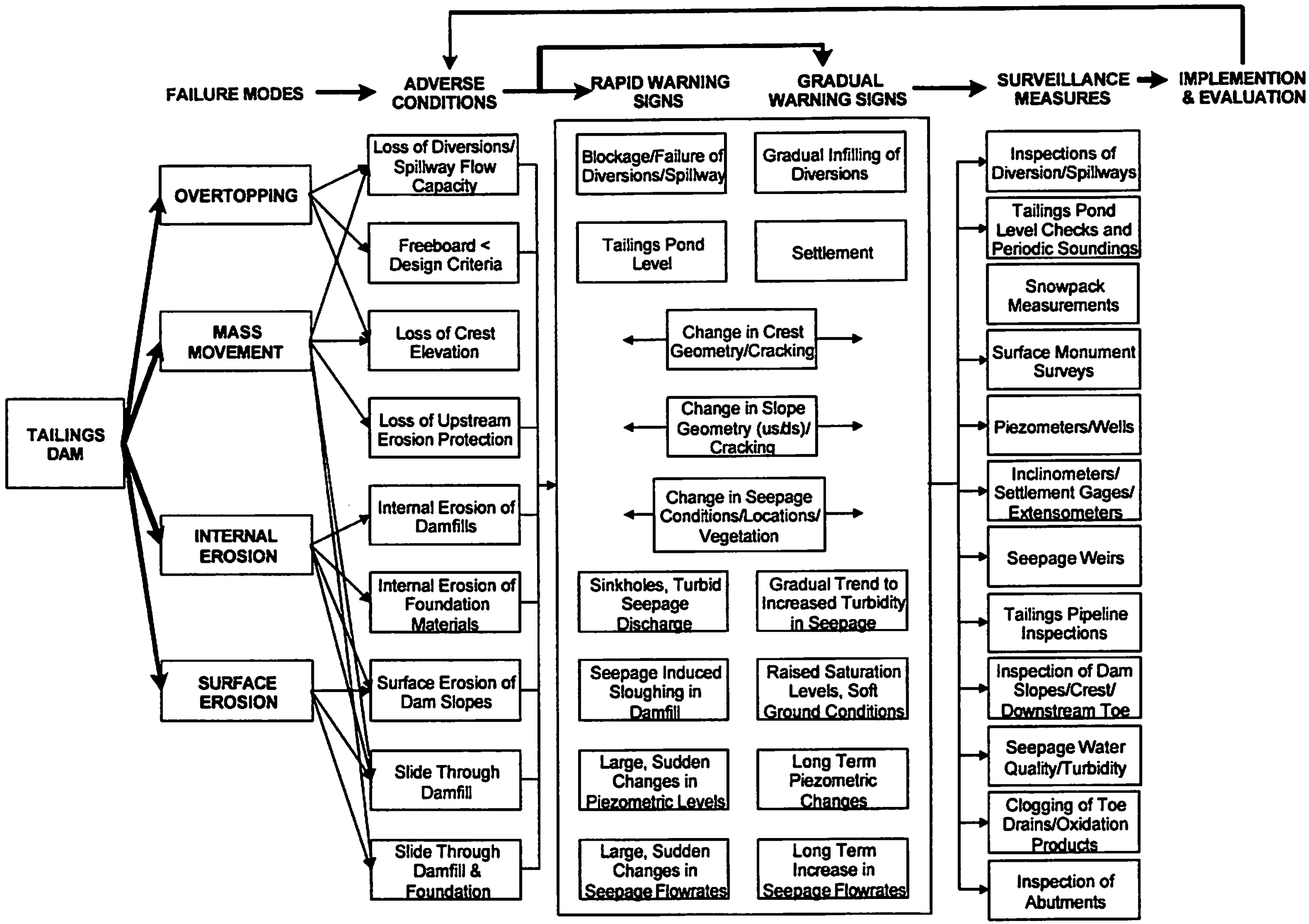

Figure 3 Failure Modes, Warning Signs & Surveillance Measures

Failure Modes And Effects Analysis

Techniques that can be broadly categorized as "risk analysis" are becoming ever more popular, among both mining companies and tailings dam design consultants, for various facets of tailings management. A risk analysis, by the authors' definition, provides answers to the following questions:

1. What can go wrong?
2. How likely is it that it will happen?
3. If it does happen, what are the consequences?
4. What can/should be done to reduce the likelihood and/or consequences of this potential occurrence?

Failure Modes and Effects Analysis (FMEA), or similar such methods, are particularly useful when applied in workshop settings that include the designer and/or independent experts, mine management, and operations personnel. FMEA, and most other qualitative risk assessment methods, are nothing more than organized judgement, common sense with a fancy name, a structured brainstorming session. Such workshops depend on the following elements to be effective:

- A person experienced in the FMEA method to act as facilitator, to keep the session focused and on track, and to elicit the input of all participants;
- A tailings dam expert (can be from the designer consultant's firm, but must be someone reasonably independent of the design team) to inject objectivity into the process, and to play the essential, albeit unpopular, role of "devil's advocate".
- Participation of operations personnel, mill and environmental superintendents (both typically have some responsibility for tailings facility), mine manager, and site security (if depended on for surveillance during weekends, nights, holidays, etc.).

Risk analysis techniques can be used to audit any number of technical and managerial aspects of tailings dam stewardship, and are particularly effective in scoping out or reviewing a tailings dam surveillance program.

The authors have been involved in many FMEA workshops at minesites, the primary objective of which was to identify any potentially high risk elements and determine appropriate risk reduction measures. An interesting outcome of many of these sessions is that, unless serious design and/or operational flaws are identified (usually not the case in the authors' experiences), the most common and cost effective risk reduction measure that typically emerges from these analyses is improved surveillance. The FMEA technique (illustrated schematically in Figure 2), carried out in a workshop setting involving mine management and operations personnel, is particularly effective in scoping out (or auditing) requirements for dam surveillance because it ties in so well to the correct application of the observational method (see Figure 1). Abuses of the method also readily become apparent. The FMEA process captures the key elements of comprehensive dam surveillance, including:

- Identification of potential failure modes, and corresponding warning signs
- Consideration of how quickly failure could occur, and how potential problems can be detected well in advance of their developing into incidents
- Critical assessment of how likely it is that the warning signs will be detected, appreciated, reported, and acted upon

- Consideration of the significance of temporal trends as opposed to single measurements/observations
- Allows "green light" (safe) versus "yellow light" (caution) versus "red light" (stop) limits/criteria to be established
- Review of lines of responsibility and communication
- Review of data management, interpretation, action plans, and reporting

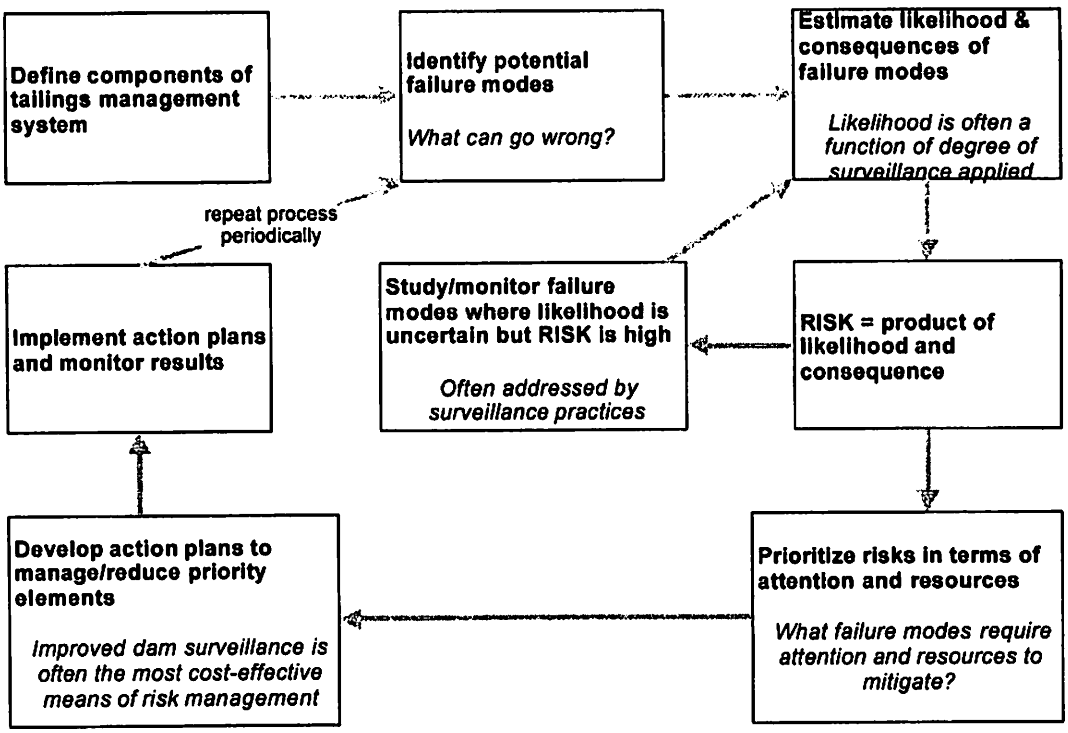

Figure 2: Schematic representation of the FMEA method

The workshop setting of the process, by involving personnel responsible for dam surveillance, as well as management personnel, provides the following:

- Forum for interchange of ideas and concerns
- Technical, operational, environmental, and management input
- Transfer of essential knowledge between the designers and "front line" personnel
- Improved understanding on the part of the designer, and mine management, as to the constraints within which surveillance activities are conducted by "front-line" personnel
- Development of a team approach and buy-in of responsible parties to dam surveillance

The FMEA process itself provides the following:

- A structured, repeatable, defensible, and documented process
- Assessment of current surveillance practices in terms of scope, frequency, reporting and interpretation, response to unusual conditions, and resources available versus required
- Identification of aspects requiring improvement
- Improved understanding of the benefit vs. cost of proposed risk reduction measures,

particularly with respect to improved surveillance versus increased design conservatism
- Justification for allocation of resources to dam surveillance
- An action plan that evolves directly from the process

Perhaps the greatest benefit from this process, apart from the training and awareness provided to "front line" personnel, is that mine management becomes educated in the value of surveillance. For example, the FMEA process might provide a choice between expensive retrofit construction (e.g. a weighted inverted filter over the downstream toe of the dam) or improved surveillance and response plans (e.g. additional piezometers and seepage flow measurements, stockpiled filter material nearby). Mine management quickly comes to recognize that dam surveillance can be more of an investment than a cost.

Important Lessons From A Famous Surveillance Failure

Surveillance of tailings dams is about much more than simply reading instrumentation and recording the data, as outlined previously under the heading "basic ingredients". When a tailings dam surveillance program "fails", it frequently does so as a result of one or more of the less tangible surveillance ingredients, all of which could be broadly classified as "failure to communicate". The FMEA approach as outlined above must include in-depth consideration of these less tangible ingredients. The problem then becomes how to emphasize the importance of this rather dry subject matter to mine personnel as part of an FMEA workshop.

An instructive and engaging analogy can be drawn between tailings dam surveillance and military intelligence activities. To highlight the importance of these less technical and less tangible ingredients of a surveillance program, it is beneficial to consider lessons learned from arguably the most famous military intelligence gathering failure in history: the Pearl Harbor debacle of December 7, 1941. The Pearl Harbor disaster represented a surveillance failure because:

- American intelligence had broken the Japanese codes.
- A large number of decoded intercepts all but advertised not only an attack, but also the date and time of the attack, but no one had bothered to manipulate the data and piece the puzzle together.
- Washington knew the Japanese were about to declare war before the Japanese ambassador in Washington did, but did not pass this information to the Hawaiian military command.
- One key intercept from Tokyo, requiring the Japanese consulate in Honolulu to provide information as to naval vessels in port and their exact locations, a glaring clue as to an impending air raid on Pearl Harbor, was not received by the Hawaiian military command until two weeks after the Pearl Harbor attack;
- The American military was so pre-occupied on what the Japanese would probably do (advance into the South Pacific, the probable failure mode) that it neglected to be on guard for the more serious consequences associated with what the Japanese were capable of doing (attack Pearl Harbor, the less probable but more serious failure mode).
- The U.S. military was aware of the potential for an air raid on Pearl Harbor, having conducted war games to simulate such an eventuality for years, yet there was no aerial reconnaissance in place to detect approaching attackers.

In short, all the information required to piece the puzzle together, predict the attack, and to take pro-active countermeasures, had been gathered, so the data collection ingredients of the intelligence program had been successfully executed, up to a point. It was the interpretation and communication of the data that was lacking, and that allowed the debacle to happen.

In the congressional inquiry launched immediately upon the war's conclusion, Assistant Council Morgan, a junior F.B.I. agent assigned by J. Edgar Hoover to assist the committee, posed a series of points. These points were presented *"not for their novelty or profundity but for the very reason that, by their very self-evident simplicity, it is difficult to believe they were ignored"* (Ref. 8). To this day these points remain mandatory study for F.B.I. agents, as they should be for anyone responsible for some aspect of tailings dam surveillance. Those of Morgan's points most relevant to tailings dam surveillance, and the specific lessons those responsible for tailings dam surveillance should draw from them, are outlined in Table 2.

Summary

There are many unique aspects to tailings dams, relative to conventional, water retaining dams that demand special consideration when developing or reviewing a surveillance program. In many intangible respects tailings dams are at a disadvantage compared to conventional dams, representing a cost rather than profit center, reliance on external consultants for design and ongoing advice, and surveillance being but one of many responsibilities for operations personnel. Surveillance represents an essential element of managing the risks of tailings disposal. As such, the ingredients of a good surveillance plan, and the limitations of dam surveillance, must be clearly understood. A good surveillance program requires "front line" individuals who are dedicated to and genuinely interested in the task, and who recognize and can resist the natural tendency towards complacency. It also requires an owner dedicated to tailings dam safety and surveillance, committed to attracting and retaining dedicated staff, and who understands that tailings dam surveillance is a critical corporate and public responsibility that must be carried out for as long as the dam exists.

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Table 2 Pearl Harbor lessons for tailings dam surveillance

Morgan's Points	Relevance to Tailings Dam Surveillance Programs
1. Operational and intelligence work requires centralization of authority and clear-cut allocation of responsibility.	It is essential for someone to take "ownership" of surveillance, and to document responsibilities, preferably in the form of an Operations Manual.
2. Supervisory officials cannot safely take anything for granted in the alerting of subordinates.	Never "assume" that someone has been alerted. Good surveillance means never having to say "I thought he was alerted", "I took for granted he would understand".
3. Any doubt as to whether outposts should be given information should always be resolved in favor of supplying the information.	It is essential that a knowledge transfer take place between those who understand what to look for (the designer) and those responsible for implementing the surveillance program.
4. The delegation of authority or the issuance of orders entails the duty of inspection to determine that the official mandate is properly exercised.	It is not enough to simply prepare a surveillance program and then assume it gets properly implemented. Auditing is essential. Senior personnel must remain aware and involved.
5. The maintenance of alertness to responsibility must be insured through repetition.	Should be no concern about "crying wolf" accusations. Far better to send the fire engines on 9 goose chases than to hesitate the 10th time and allow a major conflagration to burn out of control.
6. Complacency and procrastination are out of place where sudden and decisive actions are of the essence.	Great and constant effort is required to remain mentally and emotionally keen in the face of environment indifferent, even hostile, to such efforts.
7. The coordination and proper evaluation of intelligence in times of stress must be insured by continuity of service and centralization of responsibility in competent officials.	No surveillance system can compensate for lack of alertness and imagination on the part of those responsible for its execution. Project team changes are inevitable, so steps must be taken to avoid "tailings database amnesia".
8. The unapproachable or superior attitude of officials is fatal; there should never be any hesitancy in asking for clarification of instructions or in seeking advice on matters that are in doubt.	Operations personnel directly responsible for dam surveillance on one end, and the designer on the other, must never hesitate in asking questions. In dam surveillance matters, no question is too stupid to be asked.
9. There is no substitute for imagination and resourcefulness on the part of supervisory and intelligence officials.	Dam surveillance is not a mechanical exercise. It requires imaginative interpretation, and ongoing designer involvement is essential.
10. Communications must be characterized by clarity, forth-rightness and appropriateness.	Communications must be clear and meaningful not only to the sender, but, beyond reasonable doubt, to the addressee as well.
11. There is great danger in careless paraphrase of information received and every effort should be made to insure that the paraphrased material reflects the true meaning and significance of the original.	Surveillance personnel reporting on observations/data must ensure that complete information is provided. The design of the surveillance program must specify the format in which data is to be presented, to insure this clarity is achieved.
12. Procedures must be sufficiently flexible to meet the exigencies of unusual situations.	The surveillance program should be designed such that, if a problem is noted but the mine manager is not available to be notified, an alternate (such as the designer) can be informed.
13. There is great danger in being blinded by the self-evident.	A surveillance program must not concentrate on the most probable, or "self-evident" potential failure modes at the expense of less probable, but higher consequence failure modes.
14. Officials should at all times give subordinates the benefit of significant information.	Personnel responsible for surveillance must be given an adequate level of training, with a transfer of essential knowledge from the designers as to what to look out for, and why.

15. An official who neglects to familiarize himself in detail with his organization should forfeit his responsibility.	Mine management, and to a lesser degree corporate office, should have more awareness of the surveillance program than the simple knowledge that such a program exists.
16. Failure can be avoided in the long run only by preparation for any eventuality.	Again, the natural tendency to look for the probable and ignore signs of the possible must be recognized and resisted.
17. No consideration should be permitted as an excuse for failure to perform a fundamental task.	Dam surveillance is a critical activity and responsibility. It cannot be an "if I have time" fill-in activity.
18. The administrative organization of any establishment must be designed to locate failures and to assess responsibility.	The surveillance program must be, on a regular basis, audited from top to bottom, both to insure that it is being properly implemented, and to update its scope as appropriate.
19. In a well-balanced organization there is close correlation of responsibility and authority.	A closer connection between responsibility and authority facilitates greater devotion to proper execution of the program.