CONDITION ASSESSMENT AND ASSET PERFORMANCE GUIDELINES

Preamble Document

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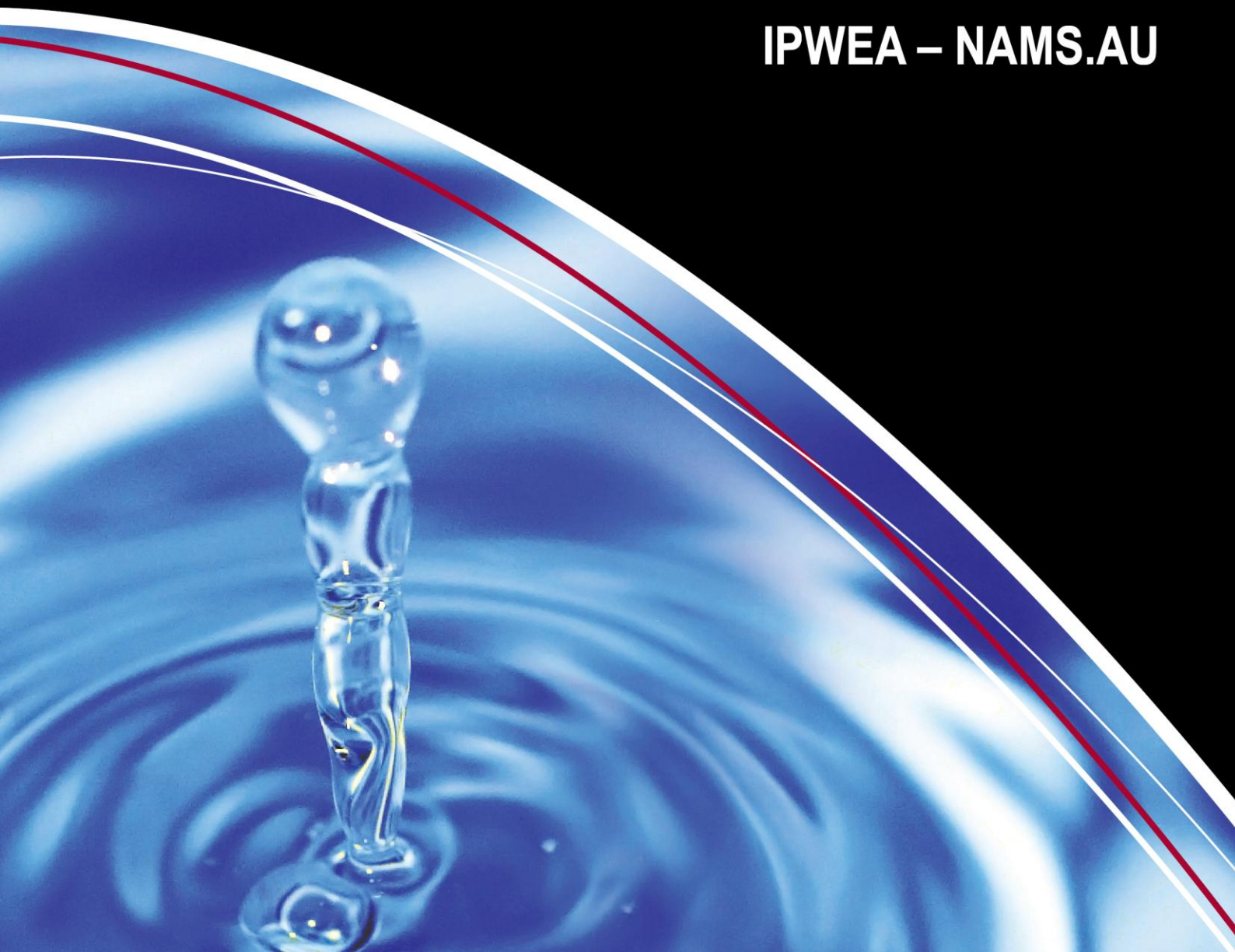

CONDITION ASSESSMENT AND
ASSET PERFORMANCE GUIDELINES

PRACTICE NOTES

IPWEA NAMS.AU has recognised the need for industry guidelines to assist practitioners with Asset Management and Financial Planning. The first three Practice Notes have been developed for Condition Assessment and Asset Performance. A fourth Practice Note is now available for Asset Management for Small Communities. A series of Practice Notes is being researched and will be published to assist with the important task of how best to carry out condition assessments for various classes of assets as well as other important aspects of asset and financial management.

The aim is to foster a national approach and encourage consistency of data and outputs. These documents will be subject to review and updated as further and better information comes to hand.

This Preamble Document is Complimentary (no charge).

This complimentary Preamble Document sets out the generic principles applicable to all types of assets. It covers the basic concepts of condition assessment, performance measurement, risk management and data management.

Practice Notes may be Purchased

Three Practice Notes are available and more are being developed to provide guidance to practitioners in the field for carrying out condition assessment inspections on a range of physical infrastructure asset types including:

- PN1 Footpaths (published Nov 2007)
- PN2 Kerb and Channel(Gutte) (published June 2008)
- PN3 Buildings (published June 2009)
- Storm Water Infrastructure*
- Water and Sewerage Infrastructure*

* in development

Practice Note 4 is available and others are also being developed to give nationally consistent guidelines on:

- PN4 Asset Management for Small, Rural or Remote Communities (AM4SRRC) (published March 2011)
- Long-term Financial Planning (LTFP)*
- Level of Service (LoS)*

* in development

Order Forms. To purchase your copy of the individual Practice Notes, as they become available, visit www.ipwea.org.au/practicenotes.

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CONDITION ASSESSMENT AND ASSET PERFORMANCE GUIDELINES – PRACTICE NOTES

PREAMBLE DOCUMENT

Important Note to Readers

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CONTENTS

CONDITION ASSESSMENT AND ASSET PERFORMANCE GUIDELINES – PRACTICE NOTES

PREAMBLE DOCUMENT

EXECUTIVE SUMMARY

Introduction

These Practice Notes have been developed as an adjunct to the "*International Infrastructure Management Manual" (IIMM)* which should be referenced for full detail on the issues covered herein. They are intended to provide guidance to practitioners in the field, carrying out inspections for condition assessment on a range of various physical infrastructure asset types including:

1. Footpaths
2. Kerb and Channel (gutter)
3. Buildings
4. Storm Water Infrastructure
5. Water and Sewerage Infrastructure

Condition Assessment

Frequency and method of inspections, and data to be collected, should always be related to the service being provided by the particular asset. The aim should always be to ensure data is used to determine need and timing of some preventative or remedial action to maintain the desired level of service.

Generally core condition gradings from 1 (very good) to 5 (unserviceable) are recommended, although more advanced monitoring can be employed to expand ratings over a larger scale. (Refer IIMM for more detail). The IIMM also has a good flow chart that outlines the process for developing Condition Monitoring Programs, as shown at *Appendix 1*.

Risk Assessment and Management

Each asset class will have its own particular risk profile that needs to be considered by the organisation in terms of its corporate and strategic objectives. Application of a risk matrix based on consequence and likelihood as set out in standards such as AS4360 should be followed. The flow chart from the IIMM *Appendix 2* sets out a good framework to follow. Importantly, a documented outcome should be a risk management plan that includes treatments and operational activities to be applied; and by whom.

Data Collection / Management

The Practice Notes are aimed at providing guidance in the type of condition data to be collected and suggested formats for such. This can be generally managed on spreadsheets as a minimum, but obviously more sophisticated methods using GPS and electronic recording devices possibly linked to AM software, is not discouraged. It will be up to each organisation to determine its availability of resources to expand into more sophisticated data management.

Conclusion

It is reiterated that organisations should not fall into the trap of simply collecting condition data that is then not utilised to make decisions about how to best manage the assets. The aim is to ensure delivery of service standards agreed as being the target for that particular asset class. Good maintenance plans, remedial actions and / or asset renewal planning should all be the outcomes of this process.

CONDITION ASSESSMENT AND ASSET PERFORMANCE GUIDELINES – PRACTICE NOTES

PREAMBLE DOCUMENT

1.0 INTRODUCTION

Based on Industry feedback, these Practice Notes have been developed as an adjunct to the *"International Infrastructure Management Manual" (IIMM)*. Reference should be made to *Section 3.3* of the IIMM for full detail of the importance and relevance of condition assessment and performance monitoring and how these sit in the overall context of asset management.

These Practice Notes are intended to be a living document that will be developed over time and expanded as further information comes to hand. In this way they will also best reflect new methods and new technology that is constantly evolving.

They are intended to provide practitioners with information on best practice techniques available and will follow a similar philosophy to that of the IIMM with both *Core* and *Advanced* techniques described. Importantly, the aim is to also provide nationally consistent methodologies in terms of rating systems for condition assessment and the like.

The Practice Notes will be developed incrementally with each asset subject distributed for review prior to publication and addition to the suite of such Practice Notes. Industry feedback has provided guidance as to the priority for developing each set of Practice Notes and the current intent is to develop the practice notes for the following, in the order as listed:

- Footpaths
- Kerb and Channel (gutter)
- Buildings
- Storm Water Infrastructure
- Water and Sewerage Infrastructure

Additional sets of Practice Notes for other assets may be developed as the need is identified.

The following documentation provides a common preamble to each of the individual Practice Notes that follow and is intended to provide the over-arching principles that could be seen to be generic to the task for each asset type.

2.0 CONDITION ASSESSMENT PRINCIPLES

Whilst there will be specific issues to be dealt with when considering each class of asset for which practice notes are developed, there are common principles that apply in every case. The following section provides an overview summary of these guiding principles, drawn largely from the IIMM.

2.1 Summary of Condition Assessment Principles

Condition data is typically used to determine the need and timing of some preventative or remedial action to prevent loss of service or economic loss. Understanding asset failure modes leads to better AM decision-making. Being aware of the failure modes allows effort to be focused on understanding the timing and consequences of the failure, and the expected expenditure patterns.

The *Core* approach focuses on data collection for managing risks associated with critical assets and monitoring key performance measures.

The condition grading standards adopted will tend to be simple (i.e. 1- 5 rating scale)

For *Advanced* methods, condition assessment will be undertaken at a component level (making use of sampling techniques where appropriate) to support predictive modelling and decision-making. More sophisticated grading standards may be used to manage multiple asset failure modes.

Asset performance will be monitored using a greater number of customer and technical performance measures to enhance decision-making focused on achieving strategic objectives and network optimisation.

Condition Assessment should not be carried out in isolation. Related issues need to be considered, such as:

- Risk Management.
- Maintenance Management Planning
- Data Collection Techniques

These are all addressed in the following sections and in the Practice Notes.

2.2 What is 'Condition / Performance' of an Asset and why monitor it?

Asset Condition reflects the physical state of the asset, which may or may not affect its performance. The performance of the asset is the ability to provide the required level of service to customers. Generally this can be measured in terms of reliability, availability, capacity, and meeting customer demands and needs. All of this is critical information for determining the remaining useful life of an asset and more importantly the timing for possible intervention steps to bring levels of service, provided by the asset, back to a desired standard.

However, do not forget that other factors can also determine useful life. Factors such as:

- Technical advances which might make the existing asset obsolete.
- Changes in community expectations meaning that the asset no longer has the capacity to meet community standards.
- Growth impacts meaning that the asset's capacity falls short of the new demands.
- Compliance - changing standards mean the asset becomes non-compliant.
- Economic life - whereby the costs of continuing to operate the asset warrant it now being replaced.

It is critical that service organisations have a clear knowledge of the condition of their assets and how they are performing. All management decisions regarding maintenance, rehabilitation and renewal revolve around these two aspects.

Not knowing the current condition or performance of an asset may lead to the premature failure, which leaves the organisation with only one option - to replace the asset (generally the most expensive option!). The unforeseen failure of an asset can have major consequences that constitute a business risk or potential loss to the organisation.

Therefore the benefits of knowing the current condition and performance level of an asset are:

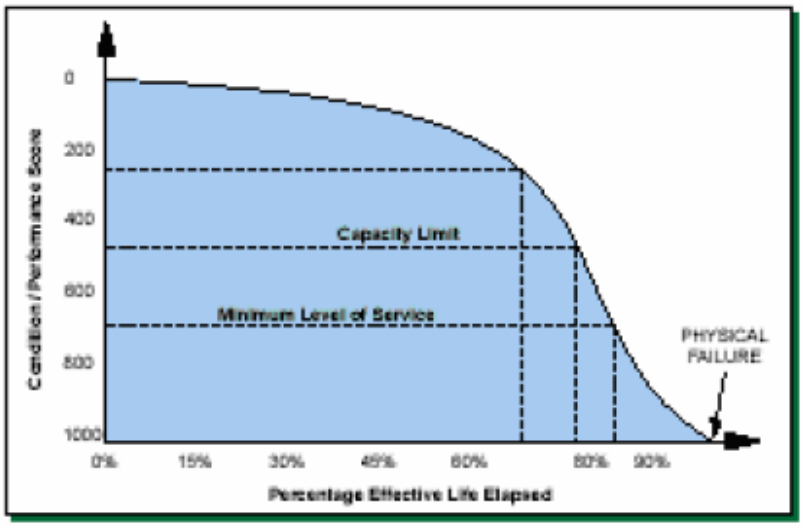
- Ability to plan for and manage the delivery of the required level of service.
- Avoidance of premature asset failure, leaving open the option of cost effective renovation.
- Risk management associated with asset failures, and mitigation of the consequences of failure.
- Accurate prediction of future expenditure requirements through understanding remaining asset life and capital investment needs.
- Refinement of maintenance and rehabilitation strategies.

2.3 Objectives of Condition Assessment Process

The objectives of systems to monitor asset condition and performance should be to:

- Identify those assets which are underperforming
- Predict when asset failure to deliver the required level of service is likely to occur
- Ascertain the reasons for performance deficiencies
- Determine what corrective action is required and when (maintenance, rehabilitation, renewal)
- Record asset failures for use in advanced AM techniques.

The development and continued use of condition assessment data will allow preparation of verifiable predictive decay curves for particular asset types and hence permit prediction of remaining life. By considering the current condition point on an assumed decay curve, the profile can predict the effective life (time) before failure. This failure time can be physical end of life, minimum level of acceptable service, or limit of capacity of the asset.



It is important that consideration be given here to reporting not only at various asset component levels but also at the whole asset portfolio level. That means assessments can be made about how well a network or asset type is achieving its strategic objectives in terms of delivering outcomes against required levels of service.

It is also important to develop formal condition assessment techniques to give repeatable and objective assessments.

Typical asset condition questions to be considered when preparing an assessment strategy are :-

- When was the asset constructed / rehabilitated / replaced?
- Where is the asset / component in its lifecycle?
- What is the asset's theoretical effective life?
- What is the estimated residual life until rehabilitation and / or replacement is necessary?
- Has the asset been inspected physically and by what process?
- How can the asset's deterioration be predicted?
- How can the asset's failure be predicted?
- How could planned maintenance prevent the asset's failure or extend the time to failure?
- Can the asset be rehabilitated and at what cost?
- What level of service will the asset deliver once rehabilitated and for how long?
- Is the asset technically or commercially obsolete?
- Are asset condition gradings appropriate and relevant?
- Are asset condition monitoring processes effective?

Condition monitoring of all assets, whether they are passive infrastructure assets or dynamic ones such as plant / equipment and even landscape assets, must be:

- economically justified as a benefit to the organisation
- carried out in the most cost-effective and efficient manner
- applied consistently
- repeatable.

2.4 Typical Condition Assessment Process/Technique

Many factors need to be taken into consideration when designing the most appropriate process for each asset class and these are typically addressed in formulating the Practice Notes.

For passive assets the extent and repetition of condition assessment will be influenced by:

- The type of the asset
- The criticality of the asset
- The relative age of the asset
- The rate of deterioration of the asset
- The economic value of the outcomes to the business.

Above ground assets can be assessed more easily, and therefore more often, than below ground assets.
These Practice Notes aim to promote standard assessment techniques and processes for an industry or service group to foster consistency between organisations in the same industry.

Typical factors for consideration are as follows:

- Existing asset condition assessment practices (if applicable) with respect to -
    - environmental factors, i.e. ground, traffic, community disruptions etc.
    - asset factors, i.e. material, age, protection and maintenance history
    - past failure history/data, i.e. frequency, repair cost, damage costs, types of failure
    - condition assessment policies including corporate guidelines/objectives and maintenance policies.
- Available Options / Techniques and Sample Size
  The following factors should be considered in setting up the condition assessment program:
    - Investigate available options/techniques of condition monitoring:
        - benchmarking other practices
        - looking to available new technology
        - adopting existing techniques
        - do nothing.
    - For each condition assessment technique, determine the sampling size, such as:
        - all assets
        - problem assets
        - actuarial sample.
    - How much condition assessment should be undertaken, and how many assets should be assessed, should be addressed within each organisation. The level of assessment needs to consider:
        - the type of asset
        - the number of like assets
        - their similarity for sampling opportunities
        - the available budget
        - the techniques available
        - their cost.

- Where there are large numbers of assets and an electronic database of the assets is available, it is possible to do detailed condition monitoring of a small sample of similar assets and extrapolate the findings from this sample across the larger asset base. This substantially reduces the cost of total condition monitoring.

  The basic principle is that it is not necessary to assess all the assets. From an effective management point of view, it is only necessary to look at those assets that are going to be critical to the organisation in the next 10-20 years. Therefore it is important to determine the interval and the method by which the condition monitoring is to be carried out within the organisation, keeping in mind that at all times it is necessary to economically justify this condition monitoring activity in terms of the benefits gained.

  - *Condition Assessment Frequency and Cost.*

    Frequency may be based on:-

    - regular interval
    - condition based
    - other indicators, such as maintenance cost/depreciated replacement cost.

    Identify the resources required for each appropriate technique, including:

    - specialist equipment
    - labour
    - operation
    - training
    - data i.e. capture, storage and analysis.

  - *Benefit/Cost Considerations*

    There will be direct and indirect benefits with each possible option or technique. Some of these will also be quantifiable whereas others may not be so easily quantified.

    Condition assessment needs to be justified economically by considering the costs of a program and the benefits expected to be achieved. It is important to ensure that end use of the data is commensurate with collection costs to avoid too detailed an approach when an initial random sample with interpolation of results would be more cost-effective.

    As with all economic analysis, a sensitivity analysis should be carried out on those parameters which are more likely to be beyond the control of the organisation, such as market forces affecting the opportunity cost of capital, community expectations/perception on risk and factors in the long-term.

2.5 Condition Grading Systems

These Practice Notes will be formulated using the condition grading systems, which are consistent with the methodology as outlined in the IIMM. All are based on the simple 5-level ranking system where 1 is ‘Very Good’ and 5 is ‘Unserviceable’.

- ***The Simple Approach***

Rank	Description of Condition
1	**Very Good Condition** Only normal maintenance required
2	**Minor Defects Only** Minor maintenance required (5%)
3	**Maintenance Required to Return to Accepted Level of Service** Significant maintenance required (10-20%)
4	**Requires Renewal** Significant renewal/upgrade required (20-40%)
5	**Asset Unserviceable** Over 50% of asset requires replacement

The condition assessment model shown in the adjacent Figure is a typical approach for an organisation responsible for major groups of passive assets (e.g. roads, pipe networks, distribution assets) as well as some dynamic assets (e.g. pumps, plant and equipment).
This outlines a simple method to assess asset condition.

- ***The Intermediate Approach***

Rank	Description of Condition	
3.0 3.4 3.8	Level of Service Maintenance	Minor Average Significant
4.0 4.2 4.4 4.6 4.8	Requires Major Upgrade	Minor Average Medium Substantial Significant
5.0 5.2 5.4 5.6 5.8	Asset Basically Unserviceable	Minor Average Medium Substantial Significant

The approach shown in the adjacent Figure involves the enhancement of the organisation's ability to rank more effectively those assets that constitute a significant problem at condition levels 3, 4, and 5.

The intermediate condition rating approach is usually expanded to suit:

- asset types
- failure modes
- evidence of distress.

The simple and intermediate approaches allow development of predictive decay curves. The sophisticated approach using greater numbers of parameters, will generate more accurate curves and give greater certainty to the current condition of the asset.

- ***The Sophisticated Approach***

Although these sophisticated systems may allow the condition to be assessed on up to ten different parameters with condition scores between 0 and 1,000 they can still be broken down into the base scores of 1 to 5 if required.

The adoption of sophisticated condition ranking systems may not be justified for all assets. However, with the advancements being made in AM techniques and practices, it is likely that most asset owners will employ sophisticated methods for all their assets within 10 years.

3.0 MONITORING ASSET PERFORMANCE

Condition assessment and asset performance are inexorably linked. Condition and performance failure can be considered as 'cause' and 'effect' respectively. That is, condition deterioration is a cause of failure, the effect of failure is poor performance (failure to meet required levels of service).

However, there are other causes of failure and poor performance than just condition, for example:

- Lack of capacity or utilisation (e.g. failure of a road to handle the expected traffic, with resultant time delays)
- Human error
- Obsolescence

An asset can be considered to have *failed* when it no longer achieves the required levels of service or when it is no longer providing the most cost effective means of providing that service (e.g. it becomes more economic to replace than to continue to maintain).

3.1 Performance Monitoring Systems

Typical performance questions to be considered when prepared a monitoring process are:

- What service levels and performance measures have been set for each asset type?
- What technical performance measures will be used to manage asset performance.
- What are the risks associated with asset performance?
- Determine whether the asset is performing reliably, and meeting user capacity/service
- requirements.
- How do the assets meet:
  - occupational, health and safety regulations?
  - public safety requirements?
  - environmental requirements?
- What is the asset's current utilisation compared with its maximum capacity?
- What is the asset's current capacity compared with service demand?
- Is asset performance being fed back into the acquisition decision-making process?
- Are asset performance gradings appropriate?

3.2 Business and Technical Performance Measurement

Business performance measures are related to the strategic objectives of the business and customer service delivery standards, and should be monitored and reported at all levels in an organisation and to customers in an appropriate form. The measurement of business performance provides:

- measurement of actual against desired level of customer service
- information to demonstrate achievement of organisational strategic goals
- accountability to customers
- identification of areas for improvement
- benchmarking between different organisations.

In addition, technical performance measures need to provide information on:

- the types of failure
- the number of customers affected
- the duration of the failure
- the severity of the failure
- the target level of service.

Technical performance measurement and monitoring is undertaken to support decision-making by the asset managers within an organisation. It addresses issues for consideration in effective management of the assets, such as:

- assessing the effectiveness of the operational, maintenance and capital works program
- review and refinement of maintenance and rehabilitation strategies and standards
- assistance in strategic decision-making through definition of remaining life based on the measure being assessed e.g. capacity of a pipe versus demand.

Benchmarking and other comparison management techniques are used both internally and for external regulation and monitoring, to assess the performance of infrastructure groups, asset owners or business units.

Each organisation needs to consider developing rating systems to judge the assets from both an owner's perspective with the values that this brings to the organisation, and also from a user's or regulator's perspective, in terms of the functionality, suitability, cost and service performance of the asset.

3.3 Capacity or Utilisation Monitoring

Assets must be utilised effectively in order to provide the maximum return on funds invested and to deliver the required levels of service.

If considerable investment is required for an asset that will be used only 10% of the time, then very high standing charges will need to be met, and the asset may tie up considerable capital resources unnecessarily. Wherever possible the aim should be high utilisation of assets.

Under-utilisation of an asset can be considered as a capacity failure. Unlike normal capacity failure (i.e. the demand for the asset exceeds its capacity) this failure represents a lack of demand for the service the asset provides. In this case the demand for the asset does not reach a cost-effective level of utilisation and should be revealed as a unit cost failure or non-performing asset through a good asset information system.

For prioritising works, inputs are required that indicate clearly the need for assets (functions being undertaken), and the utilisation being made of the assets concerned.

The peak demand may only occur 10% of the time and in this case, instead of having an asset base capable of providing peak demand services, it may be possible and more cost-effective to introduce operational changes to provide the service in a different way.

Determining when and how the increased demand will be met is a critical part in the development of the overall strategy and function for the asset.

3.4 Functionality/Suitability

In addition to capacity issues, suitability or 'fitness for purpose' also needs to be monitored.

Suitability needs to recognise service needs for current and future purposes. By assessing the suitability of an asset, opportunities for varying the level of service, and hence the cost of service, can be considered.

Where the overall asset consists of many individual components that come together to form an operational asset, the task of performance assessment becomes more difficult. This is especially so where it is not only the condition but also the functionality or usability of the asset that impacts on the customer's level of satisfaction.

The key to any assessment of this type is the ideal or perfect standard, against which this asset will be judged.

If an organisation is going to adopt this type of approach then the key factor is specification and definition of what constitutes a perfect asset. It is essential that organisations document this clearly, and wherever possible include photographs or other forms of visual assessment that enable condition assessors and others to understand the condition scores given for individual elements and the total asset or network.

A further problem with this type of assessment is that standards will always improve. In many cases standards will rise every five or ten years and if the assets are judged against these new standards then the condition and performance ratings will fall.

Another issue of importance when considering an overall asset made up of many components is the need to be able to compare possible asset renewal options and projected timings. In some cases it might be economically better to replace the whole asset or system rather than intermittent rehabilitation or renewal of components.

4.0 RISK ASSESSMENT AND MANAGEMENT

When carrying out condition assessment and performance monitoring, to support decision making about possible preventative or remedial action to ensure desired levels of service are being provided, the issue of risk assessment and management must also be considered. Reference should be made to *Section 3.4* of the IIMM for full detail on this aspect. The following provides a summary of the risk management issues relevant to the condition assessment task.

Risk management is increasingly being viewed as a core business driver that influences all decision making, rather than an activity undertaken as an isolated process. A corporate risk management framework needs to be consistently applied across the organisation. The degree of sophistication applied will be up to each organisation and no doubt dependant on the resources it is prepared to commit to address its perceived risk exposure.

For the purpose of these Practice Notes, the issue of risk assessment/management will be addressed specifically for each class of asset to which the Practice Notes relate. Accordingly, recommended actions will differ dependant upon asset types. However, the following general principles apply, and the risk management process steps are generally as follows:

1. Risk management context: establish the corporate risk framework, including the criteria against which risk can be evaluated and the responsibilities for risk management.
2. Risk identification: identify the risks an organisation may encounter and explain the impact of those risks on the organisation.
3. Risk analysis: establish a risk rating for each asset group and assess which assets represent the greatest risk for the organisation.
4. Risk treatment: identify what actions to take to minimise risk at asset or asset group level.
5. Monitor and review: the ongoing process for ensuring risk levels remain acceptable even if risks change.

Some organisations take a purely risk-based approach to decisions. The risk cost (or risk exposure) associated with the proposed projects are used to prioritise the option or project that should proceed first.

Emergency Management such as for natural disasters calls for a process described above. However there is more need for comprehensive response and recovery planning to manage these events.

Emergency managers often refer to the risk treatment options (step 4 above) as being:

- Reduction / prevention (mitigation to reduce the risk consequence or probability).
- Readiness / preparedness.
- Response and recovery. (The latter three activities relate to managing the consequences of the failure, such as by reducing response and recovery times.)

Core Asset Management Plans, as a first step, should as a minimum identify critical assets and associated risks and outline risk management strategies for these.

For the more advanced asset management planning, the risk management process is applied to all significant / critical assets at an individual level, and to less critical assets at a ‘group’ or ‘facility’ level.

Reference should also be made to the Australian Standard AS 4360 for a fully rigorous description of risk management processes. Figure 3.4.3b from the IIMM is appended here *(Appendix 2)* to include a concise picture of a successful model for the application of an integrated risk management framework in any organisation.

Some worthwhile points to note when deciding the scope of a risk management program are:

- Where an organisation seeks to transfer risk by insurance when an unacceptable business risk has been determined, the premium paid may relate to the level of confidence insurers have in an organisation's risk management program.
- Insurance policies for infrastructure assets may limit liability when there is a failure to act to address a known risk.
- Risk management is mandatory in some circumstances if an organisation is to avoid prosecution (e.g. environmental regulations or health and safety legislation).
- The effort put into assessing and managing the risk needs to be proportional to the risk exposure but less than the potential risk reduction.
- A uniform approach to risk reduction across all business units as part of appropriate asset management is essential. This allows corporate management to judge the relative merits of risk across the organisation.
- Organisations must develop a clear picture of the assets that provide the services, current asset condition, decay profile, mode of failure, and the rehabilitation or replacement required to meet the minimum acceptable level of service, as expected by the customers, without compromising the acceptable level of risk.
- Risk cost to an organisation needs to be assessed for all failures, from those needing minor maintenance, to major catastrophic structural failures. The reduction or avoidance of risk needs to be quantified as a benefit to the organisation.

4.1 Risk Identification

All decisions about the rehabilitation, replacement or disposal of an asset, and the timing for such activities, should be based on a sound determination of what the critical failure mode is. This will ensure an organisation focuses on the assets and failures that can have the most impact on its business.
If the critical failure mode for an asset can be determined, it is possible to target and refine maintenance plans, capital expenditure plans, and investigative activities, to address that failure.

Once risks are identified they are generally recorded in a risk register. Usually there will be a formal six monthly or annual review of the risk register. There should also be processes for recording other risks as they are identified.

Risk events could be grouped into:

- Natural events, where there is no real control over the timing or the extent of the event, although the probabilities may be understood e.g. floods, lightning strikes, high winds;
- External impacts, for example other organisations not providing services that impact on the organisation or individuals, such as power supply failures, material supply failures;
- Physical failure risks, where condition or performance of the asset could lead to failure;
- Operational risks, where errors in the management of the asset or asset management activities might impact adversely on the performance of an asset.

4.2 Critical Asset Identification

It is important to identify critical assets as well as the critical failure modes. As mentioned before, it is then possible to target and refine maintenance plans, capital expenditure plans, and investigative activities at the critical areas.

Critical assets are defined as those which have a high consequence of failure (not necessarily a high probability of failure). An organisation with highly critical assets may record risks at an individual asset level and look at the various risks of failure such as:

- Structural: where the physical condition of the asset is the measure of deterioration, service potential and remaining life.
- Capacity / utilisation: where it is necessary to understand the level of under- or overcapacity against the required level of service to establish remaining life or timing for renewal.
- Level of service failures: e.g. reliability, image, where performance targets are not achieved.
- Obsolescence: technological change or lack of replacement parts can render assets uneconomic to operate or maintain.
- Cost or economic impact: where the cost to maintain and operate an asset is likely to exceed the economic return expected, or the customer's willingness to pay, to retain an asset.

Understanding the above failure modes will allow an organisation to plan for the impacts of an event. An organisation needs to continually review the possible failure modes as they can be influenced by external events.

As well as direct impacts on assets, the events will usually pose a risk by impacting directly or indirectly on customers and possibly others. The legal liability for nuisance, negligence and third party damage needs to be recognized.

4.3 Risk Analysis – Consequences and Probability

The overall risk depends on both the probability and consequence of the event. To estimate the level of risk, organisations should determine:

- the consequences of failure for events
- the probability of failure of the asset, and
- the probability of the event occurring.

At a simple level, the risk can be assessed using a qualitative matrix approach.

For a more mature approach, risk may be quantified in dollar terms:
Risk $ = Business Risk Exposure = Cost of Consequences x Probability of a Failure

Consequences of failure are linked to the asset types and should be considered in terms of how they score against a triple bottom line sustainability score card of Economic, Social and Environmental factors. Such should include:

Economic Factors	Social Factors	Environmental Factors
▪ Repair costs ▪ Loss of income ▪ Damage to property ▪ Third party losses	▪ Loss of service ▪ Loss of life, or injury ▪ Health impacts ▪ Loss of image	▪ Failure to meet statutory requirements ▪ Environmental damage

The probability of physical failure of an asset is related directly to the current condition of the asset, hence the importance of realistic and accurate condition assessment. Factors such as redundancy of systems must be accounted for when developing probabilities of failure of assets or systems.

The probability of natural and external events is determined less easily but reports of detailed studies are available on the likelihood of occurrence of particular events. These probabilities can be determined from fault tree and event tree analyses, expert opinion and computer modelling.

Probability can be assessed in a qualitative way (e.g. A to E scale) or a quantitative way (e.g. probability of 0.02). The qualitative assessments feeds into the risk matrix approach, the statistical probability is required for those quantifying Risk Dollars.

For qualitative analysis, a matrix of consequences against likelihood is used, as illustrated in the following figure:

Likelihood	Consequence				
	1	2	3	4	5
A	L	L	L	M	S
B	L	L	M	S	H
C	L	M	S	H	H
D	M	M	S	H	H
E	M	S	H	H	H
F	S	H	H	H	H

Risk Rating Matrix

4.4 Managing Risks

When an asset has failed or is expected to fail in the future, then strategies can be developed to avoid or react to the failure. If the failure of an asset is critical to the organisation, failure avoidance is likely to be more effective than reactive activities.

Organisations need to weigh the cost of avoidance against the costs incurred by accepting risk. This involves a cost-benefit analysis - some risks can be addressed more easily (and cost effectively) than others.

Several strategies to manage the total business risk are available:

- reduce the risk by capital or maintenance expenditure i.e. reduce the probability of failure
- reduce the impact of a failure by actions such as preparing emergency response plans
- accept some risk and carry the consequential costs
- insure against the consequential costs
- a combination of the above.

Implementation of these strategies will require an evaluation of:

- the cause of failure and the failure mode
- impact and probability of failure and its criticality
- the current controls to manage the asset for that failure mode, e.g. maintenance plan, rehabilitation plan, augmentation plan
- what treatment options are available to:
  (a) reduce the probability of failure
  (b) reduce the impact of failure
- the suitability and economics of those treatments to ensure reduced business risk.

This step involves the costing of the risk reduction treatment and the savings from risk reduction.

Risk reduction treatments rarely avoid risk altogether, and the risk cost associated with any residual risk needs to be calculated to identify risk reduction savings. The greater the benefit (savings) to cost ratio, the more beneficial is the treatment.

5.0 MAINTENANCE MANAGEMENT PLANNING

Condition assessment, performance monitoring and risk management are all precursors to determining the optimal level of maintenance that should be carried out to ensure assets deliver the standard of service required.

A major challenge for the asset manager is striking the right balance of planned maintenance (inspections, scheduled maintenance etc) and unplanned maintenance (arising from unexpected failures).

These Practice Notes are mainly focused on the carrying out of condition assessment / performance monitoring for assets. For a complete picture of Maintenance Management Planning refer to *Section 3.6* of the IIMM.

Suffice to say however, the key objective of Maintenance Management Planning is to define service levels and performance measures that are the targets to be achieved and then analyse maintenance options to come up with the lowest life cycle cost. From this analysis, a Maintenance Plan is then prepared that specifies the operational approach, methodology and detailed work practices proposed to deliver the levels of service required.

6.0 DATA COLLECTION/MANAGEMENT

By its very nature, condition assessment and performance monitoring involves inspection of assets, either fully or by way of appropriate sampling. Management of how the data collected from the inspections is gathered, stored and integrated is critical to minimising the costs and resource requirements of any asset owning organisation. The use of new technology to assist in this regard should always be considered.

It is critical that this phase is very well planned and managed, with priority given to collecting data which supports minimum financial reporting, performance measurement and technical asset management issues.
Data collection can often be most economically collected as part of day-to-day operation and maintenance activities.

In all cases it is essential that the adopted data collection program is fully documented with standards and quality procedures to ensure that data collected is the right data, and that asset managers can have confidence in the quality and timeliness of data available for analysis. The ongoing management and maintenance of asset data must be given consideration at the outset of data capture activities.

The requirements and capabilities of information systems, the opportunities for ongoing improvement in data accuracy, and the upload of new assets as they are commissioned, are all key issues associated with data management.

6.1 Level of Data Detail

The need for asset data is specific to each organisation and should be defined clearly. It is essential that the data collected support the management decision process.

In determining the level of data to be collected against an asset, the following issues need to be considered:

- the purpose for which the data is required
- availability of resources e.g. skill levels, equipment
- accessibility and quality of existing data
- data management issues e.g. data maintenance costs
- data collection techniques
- whether the extra detail will make a material difference.

6.2 Data Collection Techniques

6.2.1 Field computers

Current technology permits data to be updated by field staff using pen-based field computers and data loggers. These computers allow rapid data input and uploading into the main asset register.

The process applicable is:

- download a sub-set of the asset register applicable to the site or district
- using pen-based or data loggers or map-based technology, update the asset attributes, asset condition or maintenance work order

- return data-set to main office (can be via telecommunications)
- validate the data collected on-site
- upload data to the main asset register and update all appropriate changes
- update the audit trail during the up-load process.

While pen-based computers have proven successful, organisations need to pilot the computers to determine their suitability for the environment in which they operate. Once it has been shown that there are benefits in using the computers, the computers and training can be implemented across the organisation.

6.2.2 Cost Effective Data Sources

Sometimes the most cost-effective data collection can be done internally, by conducting a thorough review of all the information available in various departments of an organisation.

Opportunities for further data collection can be achieved through the following:

- as an integral part of the planned maintenance programs
- when commissioning or upgrading assets
- in combination with other asset groups or external utility operators.

6.3 Pilot Programs

Organisations should select an asset service area or small facility that is representative of the assets owned within each infrastructure asset group. The sample should have sufficient complexity to cover the typical data capture issues that are likely to arise. The pilot assets could comprise a:

- specific park or recreation facility
- section of wastewater, water supply or drainage reticulation
- sample of different categories of roads
- section of a treatment plant facility.

It is important during pilot programs to:

- involve a cross-section of the staff that is likely to be involved in the AM process
- involve staff at all levels to allow their input into the trial and decision-making
- complete the pilot, performing all stages of data collection, entry and auditing
- review outcomes and discuss any problems that have arisen, refocusing on the key objectives of the program
- check that assumptions concerning data accuracy and data capture are valid and investigate opportunities to enhance data collection and entry methods
- amend the program's methods, standards and documentation, as appropriate.

6.4 Data Maintenance

Once sufficient data has been collected and input, the systems will move into the full operational phase. All staff members and contractors will be responsible for the inputting of data in relation to their work activities.

Data should be managed and maintained, with clear accountability given to an appropriate person for management of the information.

With respect to long-term strategic planning, the same staff should be responsible for assessing the condition of assets, the remaining residual life and the rehabilitation or renewal work that could be required in the future.

Once in operation, it is important to review the overall program and determine exactly what has been achieved, and to what level of sophistication and complexity the system has been implemented.

It is through the operation of the system, using the data obtained in the initial data collection exercise, that validation of the quality and an appreciation of the functionality of this initial data can be gained.

Another target is to ensure that the systems remain effective and relevant to the organisation, with regular reviews to determine the efficiency and effectiveness of the system.

7.0 CONCLUSION

The material presented in this Preamble Document to the Practice Notes being produced for condition assessment and asset performance of various asset types, has largely been drawn from the IIMM (copyright).

The aim has been to draw together the salient points that are generic to the task of condition assessment for any asset type. Further detail will now be provided in each individual Practice Note.

Practice Notes may be Purchased

Three Practice Notes are available and more are being developed to provide guidance to practitioners in the field for carrying out condition assessment inspections on a range of physical infrastructure asset types including:

- PN1 Footpaths (published Nov 2007)
- PN2 Kerb and Channel(Gutter) (published June 2008)
- PN3 Buildings (published June 2009)
- Storm Water Infrastructure*
- Water and Sewerage Infrastructure*

* in development

Practice Note 4 is available and others are also being developed to give nationally consistent guidelines on:

- PN4 Asset Management for Small, Rural or Remote Communities (AM4SRRC) (published March 2011)
- Long-term Financial Planning (LTFP)*
- Level of Service (LoS)*

* in development

To purchase your copy of the individual Practice Notes, as they become available, visit www.ipwea.org.au/practicenotes.

APPENDIX 1 – FLOW CHART FOR DEVELOPING CONDITION MONITORING PROGRAMMES

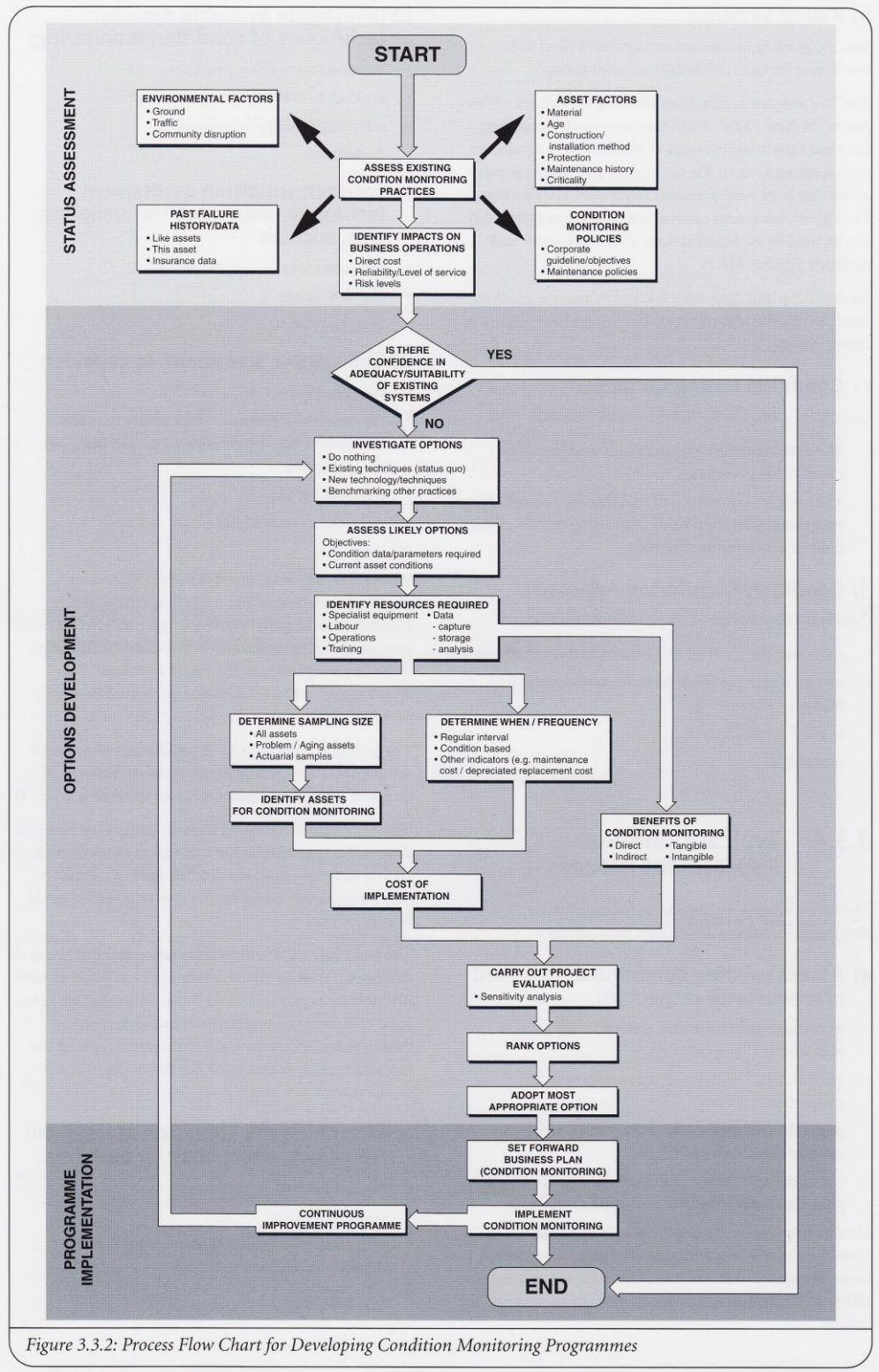


Figure 3.3.2: Process Flow Chart for Developing Condition Monitoring Programmes

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APPENDIX 2 – INTEGRATED RISK MANAGEMENT FRAMEWORK

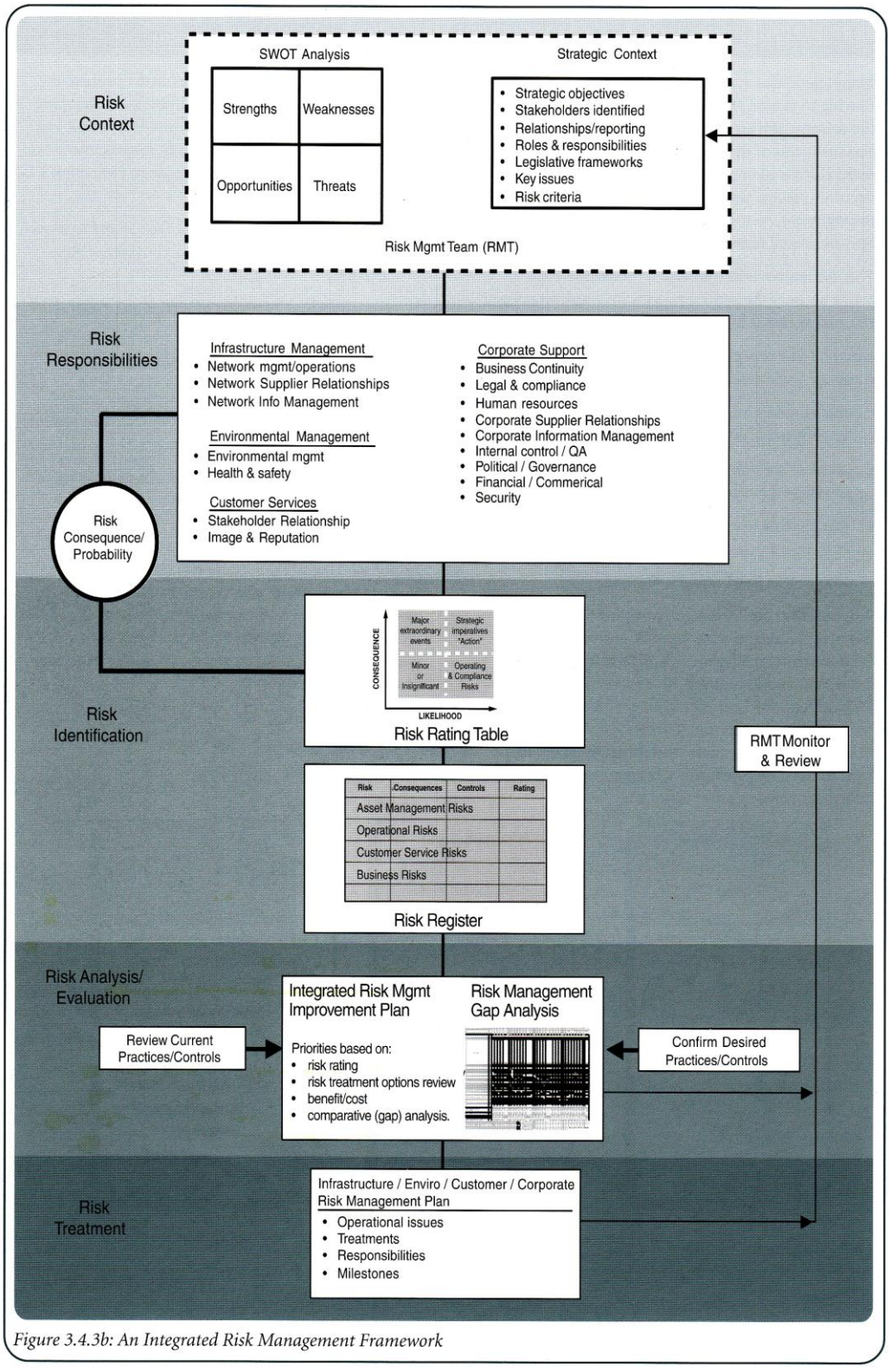

Figure 3.4.3b: An Integrated Risk Management Framework

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