Design Value Management, Constructability Dialogos and Risk Assessment

Third Lane Locks Project

22ND August to 26th August 2005

14 September 2005

MONDAY, 22ND AUGUST – THURSDAY, 25TH AUGUST
DESIGN VALUE MANAGEMENT AND CONSTRUCTABILITY DIALOGOS

FRIDAY, 26TH AUGUST
RISK ASSESSMENT

FOR

THIRD LANE LOCKS PROJECT

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EXECUTIVE SUMMARY

Five days of value management, constructability dialogos and risk assessment workshops were held at Panama Canal Authority headquarters to consider the Third Lane Locks project. To ensure that all of the stakeholders' needs were accounted for in the design, representatives of various stakeholders were present. The representatives were carefully selected as the success of the workshops is dependent upon the input of participants, as too is the level of commitment to the recommendations emanating from the workshops.

A strategic diagnosis was carried out with the senior management of the ACP prior to the workshops in which the limits of the Project and of the workshops were defined and a S.W.O.T. analysis (strengths, weaknesses, opportunities and threats) in relation to the project to date was evaluated. From these, critical issues were identified. Topics to be covered by workshop presenters were also identified. These topics, together with the briefing document circulated to the participants prior to the start of the workshops, represent the baseline information given to the participants to enable their constructive input. Draft project objectives, workshop objectives and project scope were also formulated. During the strategic diagnosis the overarching objective for the project was identified as being:

> **To increase capacity to meet growing cargo carrying demand along major international trade routes**

The information stages of the workshops comprised, in each case, the presentations by identified participants, a structured question and answer session and a functional analysis section, which identified eight categories for each workshop to be idea generated.

The idea generation for the design value management workshop produced 267 ideas which ultimately were converted into a series of working lists. This included 48 design notations which represented stakeholders' needs and were, by consensus, to be incorporated into the design. In addition to the design notations a number of items were identified as being of possible benefit but which required further development or investigation. These were developed into a specific action plan. Importantly, the major design notations and action plan items identified in the value management workshop were estimated to reduce the project cost by at least $720 million. Details of these estimated cost reductions are given on page 21.

Within the value management workshop several of the visiting experts suggested alternative design concepts from their own knowledge and experience which was felt may add further value to the Project, either through reducing the cost of its construction and/or operation and maintenance, or by improving its performance and/or maintainability. Dr Gabriel Fernandez, specialist in geotechnical engineering and Professor of Civil Engineering at the University of Illinois, presented sketches explaining the suggested change in the lock wall design, the cost savings from which are included in the table on page 21, and Jens Korsgaard of Han Padron presented an alternative valve for connection of the water saving basins to the lock chambers which would have no moving parts and so may simplify maintenance, and also would reduce the number of conduits required. Copies of all these presentations are given in Appendix 3.

One idea of particular interest was presented by the experts from Bundesaustalt für Wasserbau of Germany, where water saving basins are used with locks. All of these use an alternative system of filling and emptying of the lock chambers from the bottom, using an underfloor chamber rather than longitudinal and transverse conduits as found in the existing Panama Canal locks. This avoids the problem of excessive hawser forces being generated and operates equally well with or without the water saving basins in use, and was commended for further study.

For the constructability "dialogos" a total of 348 ideas were generated. These ideas were divided into three categories. The first were the action planning items which indicated actions to be undertaken by ACP prior to award of contract. The second category of ideas were those that had to be addressed by the contractor when putting forward a bid/proposal, while the third category of ideas related to those items that must be complied with by the contractor by way of the contract.

Many hundreds of ideas generated in the constructability session related specifically to actual constructability issues (if the session was on constructability, wouldn't that have to be the case?). These items had been taken out of the consideration for constructability strategy at this point in time of the project as they related to ideas which would be at the option of the contractor. Although these ideas did not fall into the categories indicated above and were considered beyond the reach of the ACP to require of the contractor, they were considered, by consensus, to be of potential benefit to the Project and should at least not be precluded by the final design, specification or contractual terms. Because of this it is recommended to consider passing the constructability part of this report (together with relevant appendices) over to interested contractrors as part of the supporting material to the tender documents. Some of the issues might help them put together their thoughts in the first place, particularly as they are drawn from the aggregated experience and wisdom of the ACP and of many experts from around the world (can you mention the countries they came from?).

A preliminary risk assessment was undertaken. Eight risk categories were identified by the participants. These included political; operational; labour; site conditions; administration; construction; design and financial factors. Three hundred and thirty-six specific risks were identified in relation to these categories. For the major risks indicated in the report it is considered necessary to develop a proactive action plan. This will need to be formulated as a post workshop activity. A draft, indicative-only action plan has been included in this report.

Finally, a series of recommendations have come from the facilitator based on his extensive experience running workshops worldwide on similar types of projects. The first recommendation to be considered is for value engineering studies to be carried out as soon as applicable for other elements of the expansion project, for example the access channels (for which this could be done now). The second recommendation relates to the successful implementation of the many excellent ideas emanating from the workshops. To this end it is suggested that a nodal body is identified within the ACP to coordinate the identified actions and outcomes of the parties articulated in the action plans for design and constructability. The final recommendation, also coming from the facilitator is based on the degree of discussion during the risk assessment session. This recommendation is that there be an intensive 2-day workshop to develop a strategy for the Referendum, using the same collaborative decision-making principles.

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1. INTRODUCTION

1.1 Background to the Design Value Management Study and Constructability Dialogos

In June 2005 the design consultant, CPP, submitted its updated conceptual design of the Project. Both the Atlantic and Pacific locks consist of triple lift lock structures with 3x3 water saving basins to new design criteria. The same roller gate and side filling/emptying systems are now used for both sets, the main difference between the two deriving the small tidal variation at the Atlantic Ocean, the large excavation volumes required for the Atlantic side, especially for the water saving basins, and the different rock base characteristics. At the same time it was possible to further optimize the hydraulic E/F (emptying and filling) system in line with the hawser forces criteria.

The design is based on the following special criteria and requirements (as has been discussed with ACP):

- The new locks are a demand driven system, and its operating times determine the capacity of the system
- Reliability is another basic factor, as any shutdown time means loss of income
- Maintenance has to be kept to a minimum
- Construction cost should be minimized
- Operation facilities and systems should be kept simple and reliable

In general, the following main modifications have been applied to the original (Pacific) concept design:

- Reduction of lock width by 6m from 61m to 55m;
- Reduction of vessel basin;
- Tug boat assisted positioning system instead of locomotives;
- New channel alignment;
- New seismic conditions;
- Reduction of minimum water depth (16.8 instead of 18.3)

Taking into account the social and environmental considerations, it is being investigated as to whether or not a system with 3x2 water saving basins would be beneficial (technical-economical), as a possible solution to reduce the excavation volumes would be to adopt such a solution for the Atlantic side.

At this stage, it is important to carry out a review of the proposed design of the locks in order to:

- Validate the key aspects of the selected design and to identify any manifest flaws in the concept prior to moving ahead with the physical modeling;
- Identify any remaining gaps in the information needed to finalize the design brief (either in order to move the design forward within a design-bid-build framework, or as the basis of the functional specification for a design-build contract);
- Identify opportunities to enhance the value of the project by improving its functionality for cost-effective operation and maintenance, adding additional revenue-generating features, and/or reducing the cost of the constructed works;
- Identify opportunities to improve the constructability of the lock complexes and so reduce the risk of the project, particularly of a time and/or cost over-run;
- Obtain the commitment of ACP stakeholder groups to the selected design, particularly those in MR who will take on the operation of the Project on its completion and who hence may be required to live with any flaws in the design or its construction.

In order to achieve these inter-related objectives in the most timely and cost-effective manner, a joint value management and constructability *dia-logos* undertaken by a single multi-disciplinary team was proposed (*dia-logos* roughly translates as "suspending judgement on a final decision until all the relevant factors have been considered").

The composition and selection of the value management and *dia-logos* team is of fundamental importance to the success of the process. The proposed team comprised a disparate group of people representing the various ACP internal stakeholders involved with or affected by the Project, supported as necessary by outside experts. In addition, an overt commitment by executive management greatly enhances the value management process by providing the team with a corporate benchmark for maintaining the study focus.

Ultimately five days of workshops were held in August 2005. The team for the value management and *dia-logos* was led by an external specialist to provide facilitation, organization and reporting to structure and advise the team on the process so as to ensure its independent level of enquiry, probing and discussion of the study topic. In this case the facilitator was Professor David Stevens, an experienced facilitator with expertise in related projects carried out worldwide (see Appendix 1). This report constitutes the outcomes of the five days of workshops.

1.2 Project Objectives

At a strategic diagnosis meeting prior to the workshops, a draft of the objectives for the project were modified and then confirmed as follows:

> To increase capacity to meet growing cargo carrying demand along major international trade routes

1.3 Value Management and Dialogos Workshop Objectives

The workshop objectives were also formulated as a result of the strategic diagnosis meeting carried out preceding the value management and dialogos. They were considered and with changes were confirmed as follows:

- To value manage the concept design for the locks and to identify
  - areas for improvement
  - areas for added value/cost reduction
- To review (by dialogos) the constructability aspects of the project
- Identify areas of uncertainty for further investigation (both workshops)
- To identify the risks associated with the actual construction of the locks (a separate risk management workshop was held on Friday, 26th August)

At the conclusion of the value management, dialogos and risk management workshops it was considered the objectives were achieved.

2. VALUE MANAGEMENT AND DIALOGOS METHODOLOGY

The value management methodology followed the Lawrence Miles approach which is that accepted by Standards Australia and by the Treasury of NSW as the mandatory requirement for value management studies. This approach has been accepted internationally as a benchmark. In summary the study consisted of:

a) an in-depth initial briefing (by email)
b) a strategic diagnosis of the existing situation
c) the value management workshop which covered:
   - scoping of the project
   - the information phase
   - a speculation phase
   - an evaluation phase
   - a planning phase
   - the reporting phase

Due to the complexity of the project, and the numbers of participants involved in the value management workshop, and to ensure the accuracy and validity of the recording and decision making, a dedicated in situ workshop recorder was engaged to commit information to a word processor as decision making unfolded.

The "dialogos" component is implicit in value management if facilitated correctly. Dr Stevens the facilitator for these sessions, is the initiator of this term. With constructability, particularly, he emphasized the suspension of judgement until all perspectives had been looked at.

3. THE STRATEGIC DIAGNOSIS: 18TH AUGUST 2005

A brief meeting was held with the facilitator, consultants and the client to draft certain aspects for confirmation at the workshops. Those present at the strategic diagnosis were:

Table 1 - Strategic Diagnosis Participants

Name	Organisation
Manuel Benitez	Deputy Administrator - ACP
Agustin A Arias	Head of Engineering Department – ACP
Jorge L Quijano Jorge de la Guardia	Head of Operations Department – ACP Head of Office of Project Development - ACP
Ilya E. de Marotta	Engineer, Office of Project Development -ACP
Reece Shaw	PB, Program Manager
George Currie Corina Briceño	PB, Contracts Manager Engineer, PB
Facilitation Team	
Dr. David Stevens	Social Enterprise Consulting.
Caroline Shindlair	Social Enterprise Consulting

3.1 Strategic Diagnosis Agenda

- Introduction by client
- Introduction to participants and facilitators role
- Draft scope of the project and project objectives
  - Draft workshop objectives
  - Introduction to the strategic diagnosis (S.W.O.T. analysis - strengths, weaknesses, opportunities, threats)
  - Identification of the critical issues which must be confronted by the design value management workshop, the constructability dialogos and the risk management workshop.
- Topics and speakers for information stages of the workshops
- No-no parameters
- Workshop participants
- Final agenda for the workshop; and venue logistics
- Finish

The main aspects of interest in the strategic diagnosis were firstly the formulation of the objective of the project. This has already been tabled. The second was to describe the scope of the project to ensure that the initial value management workshop was run efficiently and that the participant's attention would be focused truly on the task at hand. It served the same purpose for the constructability dialogos and risk management workshops.

4. SCOPE OF THE PROJECT

A draft "scope of the project" was formulated at the strategic diagnosis meeting and then reworked and confirmed at the workshops. It was as follows:

4.1 Geographical Parameters

- Northern boundary is defined as the Atlantic anchorage
- Southern boundary is defined as the Pacific anchorage
- Eastern boundary is defined as the Southern approach to the canal from the Pacific
- Western boundary is defined as the Atlantic entrance to the breakwater

4.2 Topographical Parameters

- Maximum height for design: 100m Precise Level Datam (PLD)
- Maximum height for constructability: 40m Precise Level Datam (PLD)
- Maximum depth: –22m Mean Low Water Spring (MLWS) Pacific
- Range of approximately 120m

4.3 Temporal Parameters

- Referendum by 30th June 2006
- Construction commences 1st January 2008

- Final construction completed 31st December 2013
- Civil works 100 year scenario
- Operational/maintenance scenario maximum 25 years (2038)

4.4 Financial Parameters

- Project Cost: Circa US$4 billion
- Locks Cost: Circa US$3 billion

5. WORKSHOP SCOPE

The scope of the workshop was identified as a subset of the project scope, limited to the three contiguous step lock system for the third lane at the Atlantic and Pacific ends, including the WSBs, gates and other equipment, and approach walls but excluding the access channels.

5.1 No-No Parameters

One of the areas identified at the strategic diagnosis is known as the "no-no" parameters. These are areas that are considered would waste time if pursued during the value management study (as well as the constructability dialogos and risk assessment workshop). There were four of these and they were introduced at the value management workshop itself. They were as follows:

- Lock size is fixed (width and length) can't be debated
- 3 contiguous steps at Atlantic and Pacific ends not be debated
- Pumped recycling of water will not be used
- Alternative to tugs not to be debated

5.2 SWOT Analysis (Strengths, Weaknesses, Opportunities & Threats)

At the strategic diagnosis a "snap-shot" view of the project as it stands at present, was effected by looking at the strengths, weaknesses opportunities and threats of the project. These are listed below and were presented briefly to the participants at the beginning of the workshop to focus their minds on the most significant issues.

Table 2 - SWOT Analysis

Strengths /Opportunities
Capture more demand
Increase revenue
Proven technology
Proven demand
Delivering a new product
Adding value to customers needs
Synergies with other projects (mega port)
Weakness/Threats
Market sensitivity to pricing
Logistics associated with large project in small country
Seasonality

Cost overruns
Construction/program delays
Lack of delivery of key components
Impacting existing operations during construction
Unforeseen site conditions

5.3 Critical Perspectives (Design and Constructability)

A series of critical perspectives were identified which were to be addressed by the workshops. These in fact form a backdrop or context within which the value management and dialogos studies are undertaken. The critical perspectives are as follows:

- Filling/emptying system
- Reliability of systems (maintenance)
- Impact on operations (for repair)
- Minimization of disruptions/downtime
- Navigational safety
- Maximize throughput
- Water consumption
- Salinity (migration)
- Ship mooring system/positioning
- Interfacing
- Interfacing with existing operations and between contractors

6. INFORMATION STAGES FOR DESIGN VALUE MANAGEMENT AND CONSTRUCTABILITY DIALOGOS

After the introduction by the client and a general introduction by the facilitator, Dr. David Stevens, speakers gave presentations on topics considered important to raise the level of awareness of all participants of all the major issues surrounding the project, for the design value management session and the constructability dialogos.

6.1 Overview of Presentations

Notes on each of the areas indicate issues considered to be critical from the stakeholder's perspective as presented by the speaker. Those notes are presented in Appendix 3 and represent, at an early stage in the workshop, only the views of the individual stakeholders without the benefit of interaction of other stakeholders.

To stimulate thought and to encourage active rather than passive listening to the presenters, each participant was asked to form a "Link Thinking" sheet with a central theme of "Optimise design" for the value management session, and "Optimise constructability" for the dialogos on each of the topics presented by the speakers. The Link Thinking Sheets served as the basis for the formal questions which were constructed at the end of all the presentations.

6.2 Questions Raised as a Consequence of the Information Stage

Because of the number of participants involved, and the complexity of the issues associated with the project, it was decided to have a highly structured clarificatory questioning process for both sessions. This consisted of a series of identified and written questions being presented to

a panel composed of the initial presenters with their responses being recorded by individuals asking the questions.

The responses to the questions are not recorded at this stage in the proceedings as those responses would not represent consensus views of the group. Also the responses in turn were only being used as a technique for the raising of the level of awareness to further issues or to the complexity of issues to be appreciated by all participants. Finally many of the responses that were given ultimately were to change after the full idea generation and evaluation stages had been worked through. Seventy-two questions are indicated in Appendix 4 for the design value management session and seventy-five for the constructability dialogos.

DESIGN VALUE MANAGEMENT

MONDAY 22ND AUGUST AND TUESDAY 23RD AUGUST 2005

7. DESIGN VALUE MANAGEMENT WORKSHOP AGENDA

The value management methodology is best described by reference to the agenda actually carried out. This is as follows:

Day 1: Design VM Design: Monday 22nd August

8.00	Introduction by client Deputy Administrator and introduction to facilitator (mobile phone use)
8.15	The 5-day program in detail (derived from strategic diagnosis)
8.25	Personal introductions and role in project by participants
8.45	Introduction to the VE/VM process: special techniques
9.00	The facilitators role and role of the delegates
9.05	Link Thinking introduced
9.10 10.10	Presentations on key aspects of the project Structured clarificatory questions on the project presentations
10.15	**Break**
10.30	Continuing of clarificatory questions
12.30	**Lunch**
1.15	Functional Analysis 1 Introduction to Link Thinking Hierarchy: breaking up the project into digestible components
3.15	**Break**
3.30	Idea generation commences
4.30	**Finish**

Day 2: Design VM Design: Tuesday, 23rd August

8.00	Additional idea generation
8.30	Introduction to evaluation process
8.40	First level of evaluation (qualitative rating)
10.30	**Break**
10.45	Second level of evaluation.
12.15 1.00	**Lunch** Idea development/cost savings/value enhancements identified
3.00	**Break**
3.15	Action planning
4.30	**Finish**

8. TOPICS AND SPEAKERS

A series of topics were identified to be addressed by specific speakers talking for five minutes or less at the information stage of the value management workshop. Eight topics with respective speakers were identified and scheduled for the value management workshop. They were as follows:

Table 3 - Topics and Speakers

Days 1-2: Design		
Topic	**Speaker**	**Organisation**
Canal operations (video)	Jorge Quijano	ACP
Site conditions	Luis Alfaro	ACP
Civil works	Jose de Regge	CPP
Gate systems	Rik Thomas	CPP
Hydraulic systems	Sebastien Roux and Jean Louis Mathurin	CPP
Machinery Vessel positioning	Rik Thomas Arcelio Hartley	CPP ACP
Water supply	Jorge de la Guardia	ACP

9. DESIGN VALUE MANAGEMENT PARTICIPANTS

The participants for the workshop were carefully selected to ensure appropriate technical and user input to the decision making. The group was larger than normal, but it was considered necessary to extend the range of participants in this case to provide credibility to the findings and to ensure true stakeholder representation was achieved.

Table 4 - Workshop Participants

	Name	Organisation
1	Jorge L Quijano	Autoridad del Canal de Panama
2	Agustin A Arias	Autoridad del Canal de Panama
3	Jorge de la Guardia	Autoridad del Canal de Panama
4	Luis Alfaro	Autoridad del Canal de Panama
5	Ilya de Marotta	Autoridad del Canal de Panama
6	Max Newman	Autoridad del Canal de Panama
7	Eduardo Hevia	Autoridad del Canal de Panama
8	Arcelio Hartley	Autoridad del Canal de Panama
9	Raul Brostella	Autoridad del Canal de Panama
10	Cesar Kiamco	Autoridad del Canal de Panama
11	Juan Wong	Autoridad del Canal de Panama
12	Rogelio Gordon	Autoridad del Canal de Panama
13	Cheryl George	Autoridad del Canal de Panama
14	Efrain Isaza	Autoridad del Canal de Panama
15	Dr Gabriel Fernandez	University of Illinois
16	Jens Korsgaard	Han Padron
17	Bernhard Kemnitz	Bundesaustalt fur Wasserbau
18	Eberhard Grimm	Bundesaustalt fur Wasserbau
19	Bengt Forsberg	Retired Construction Manager - Skanska

	Name	Organisation
20	William Caitlin	Retired Construction Manager - Washington Group
21	Rick Schultz	US Army Corps of Engineers: USA
22	Larry Dalton	US Army Corps of Engineers: USA
23	David Williams	Parsons Brinckerhoff International, inc; USA
24	John Roberts	Parsons Brinckerhoff International, inc; Taiwan
25	Jose De Regge	Consorcio Post-Panamax
26	Jean Louis Mathurin	Consorcio Post-Panamax
27	Rik Thomas	Consorcio Post-Panamax
28	Sebastien Roux	Consorcio Post-Panamax
29	Reece Shaw	Parsons Brinckerhoff International, inc; Panama
30	Corina Briceno	Parsons Brinckerhoff International, inc; Panama
31	George Currie	Parsons Brinckerhoff Asia Limited; Philippines
	Facilitation Team	
	Dr. David Stevens	Social Enterprise Consulting
	Caroline Shindlair	Social Enterprise Consulting

9.1 Workshop Groupings for Design Value Management

To enhance the value management process, four syndicate groups were formed to carry out a variety of workshop activities. The constitution of the groups is indicated below.

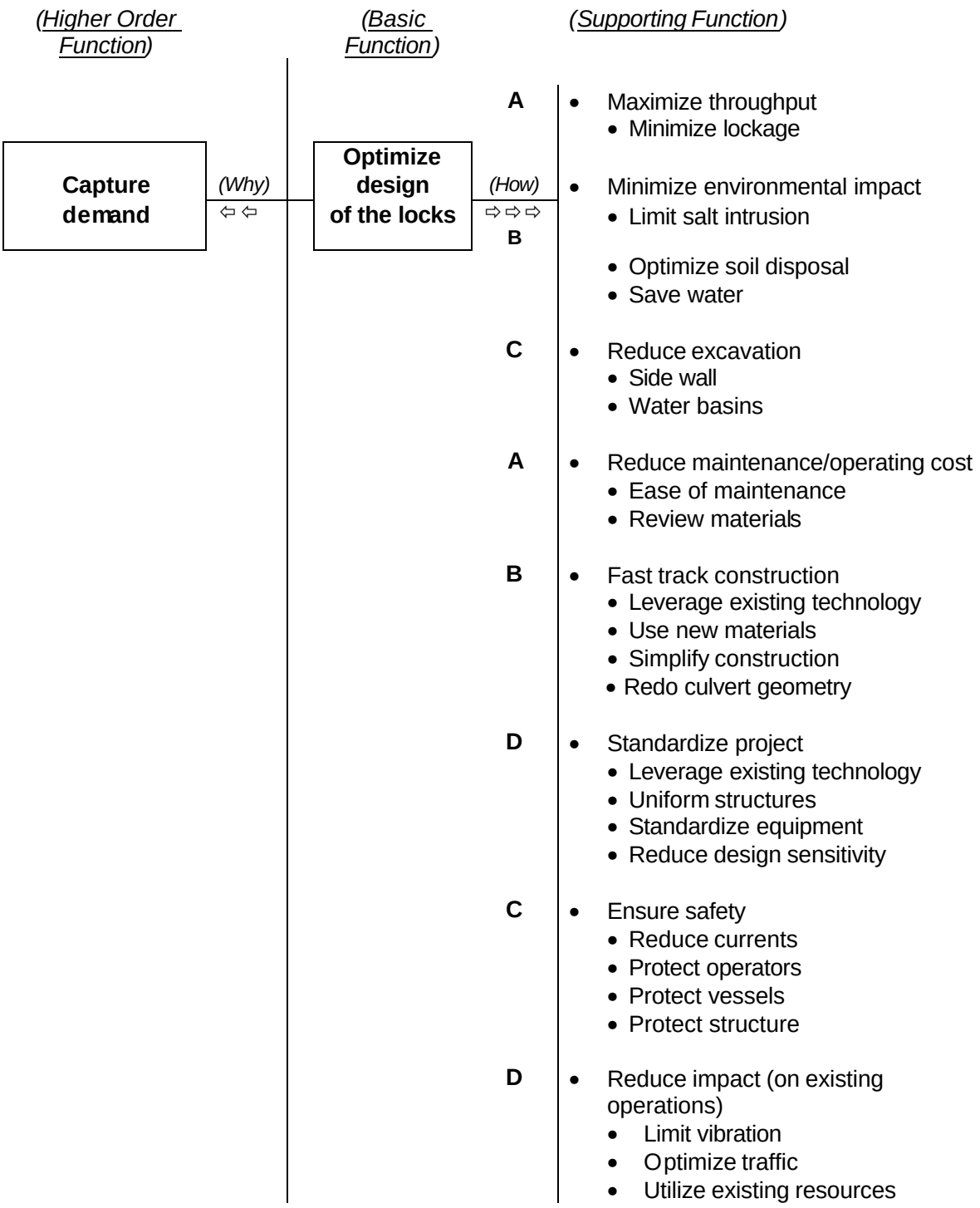
Table 5 - Groupings

Group A	Group B	Group C	Group D
Jorge de la Guardia	Luis Alfaro	Dr Gabriel Fernandez	David Williams
Juan Wong	Bernhard Kemnitz	Eberhard Grimm	Sebastien Roux
Rogelio Gordon	Rick Schultz	Cesar Kiamco	Ilya de Marotta
Raul Brostella	Jorge L Quijano	Arcelio Hartley	Max Newman
Efrain Isaza	Jens Korsgaard	Jean Louis Mathurin	Eduardo Hevia
William Catlin	Bengt Forsberg	John Roberts	Agustin A Arias
Rik Thomas	Jose De Regge	Larry Dalton	George Currie
Reece Shaw	Corina Briceno	Cheryl George	

10. LINK THINKING HIERARCHY FOR DESIGN VALUE MANAGEMENT

A link thinking hierarchy was constructed as shown in Figure 1. The objective of the link thinking hierarchy is to formally structure the decision making processes of participants to ensure that the workshop objectives, in terms of “Optimize design of the locks”, are attained and that discussion does not stray onto irrelevant issues.

Figure 1 - Link Thinking Hierarchy



11. IDEA GENERATION AND EVALUATION STAGE

11.1 Idea Generation

As a result of the link thinking hierarchy, the eight supporting functions were used as a basis for creating ideas speculating on alternative ways to “Optimize design of the locks” (basic function).

A total of 267 ideas were generated and are found in Appendix 5.

11.2 Evaluation Stage

A series of evaluation techniques were used to reduce the 267 ideas generated into meaningful sets of ideas for further evaluation.

11.2.1 1st Evaluation Stage

In the first instance, ideas were rated:

1 = Worthy of further consideration
2 = Requires further elaboration as the idea is not understood
3 = The idea can be discarded because of:
  a) Repetition of an earlier idea
  b) Not "fully formed" idea
  c) Outside of the scope set
  d) Instantaneous rejection
  e) Doesn't directly relate to objectives

This process enabled a considerable number of ideas to be rapidly rejected by consensus by all participants, to bring the number of ideas to a workable level.

Any idea rejected by consensus on a "3" rating was done on the most conservative basis. Only one member of the group would need to object to that rating and then the item would not be rejected. Participants were also advised that in the context of the workshop, once "fast track consensus" had been reached using this technique, that those items would not be revisited. The process has been well tested and is really a device to rid the results of the idea generation stage of those items that very apparently do not require further serious consideration. The technique has been researched carefully and works very effectively, but does require sustained and focused attention by the participants.

By reference to Appendix 5 and by following the rating number, readers can establish which ideas were culled out on this first level of evaluation.

11.2.2 2nd Evaluation Stage

This evaluation was then followed by a second more sophisticated culling exercise. This was achieved by a sorting of ideas into a series of categories as follows:

AP = Action Plan Item
DN = Detailed Design Notation (these are items that by consensus by all stakeholders are to be included in the final concept design)
CR = Cost reduction

To substantiate the second evaluation level, six "knock-out criteria" were included. These are listed below. These six knock out criteria enabled the participants to be able to further cull out ideas that did not make significant contributions to the project and further reduced the 267 ideas to a more workable list. Again, any item deleted was done on the basis of consensus as described above. However, at this point the decision making has reached a level at which more specific reasons for deletion must be given.

- Perceived cost prohibitive
- Politically unacceptable (salination, massive use of water)
- Greater than 24 hour continuous canal closure more than twice a year
- Extends lock construction greater than 2013
- Reduces lockage to less than 14 per day
- Insufficient supply

11.2.3 Design Notation

Design notation is the first point at which stakeholder input in the value management process is starting to become clearly articulated and consensus decision making becomes effective.

As a result of the evaluation forty-eight ideas were identified for "Design Notation" and are listed below in Table 6. These design notations were accepted as consensus decisions by the key stakeholders to be incorporated in the final concept design. They represent a significant breakthrough in communication between stakeholders and reflect areas of concern that need discussion. Also it demonstrates commitment to design enhancement and design validation ideas.

Table 6 - Design Notation

No.	Idea
	ENVIRONMENTAL IMPACT **Limit salt intrusion**
1	Place F/E ports as low as possible in the bottom of the chamber
8	Use 2 water saving basins instead of 3
	Contamination
26	Design for adequate oil containment both for machinery and from vessel
27	Specify use of biodegradable oil for hydraulic system
	MAXIMIZE THROUGHPUT **Minimize lockage time**
33	Reduce gate opening and closing time
35	Reduce time used for F/E system
	Minimize down time
46	Provide chamber lighting to transit vessels at night
	Operate with or without water saving basins
56	To maximize throughput and during maintenance periods
	STANDARDIZE PROJECT **Standardize equipment**
72	Standardize size for gates and valves. It is important to standardize to achieve cost savings
73	Uniform specifications
	Leverage existing technology
77	Materials and gates – steel
	Standardize equipment
87	Specify / utilize off the shelf items
	MINIMIZE IMPACT ON EXISTING OPERATIONS **Limit vibration**
91	Blast mitigation measures
	Utilize existing resources
111	Review existing power requirements vs installed capacity

	Optimize traffic during operations
121	Central control for all lanes (one at the Pacific / Miraflores and one at the Atlantic / Gatun for gates and valves operation)
	SAFETY **Protect operators**
135	Adequate lighting of locks – both for vessel movement and personnel movement
136	Means of rapid evacuation of vessels in case of an emergency / locks to be provided fire fighting capability
137	Minimize work in confined spaces
138	Provide proper ventilation in confined spaces
	Protect vessels
142	Lock approach wall to be aligned with chamber
	Protection of structures and gates
148	Cathodic protection on gates
149	Grounding of all metal components
150	Limit water velocity to minimize concrete erosion
151	Proper concrete coverage to prevent rebar corrosion
155	Provide manual means to open and close gates
	REDUCE EXCAVATION **Water basins**
170	Reduce minimum depth in WSB by 1.0m by improving drainage system with a slope
	FAST TRACK CONSTRUCTION **Simplify construction**
192	Detach cable duct/trench
199	Use self lubricating material for gates
200	Specs/rail system designed to be replaced by divers and to have a quick removal/fastening system
202	Canister design for culvert valves
207	Design should be flexible so that structures can be considered independent
	REDUCE MAINTENANCE/OPERATING COST **Mechanical parts**
216	Design to reduce under water wagons maintenance needs
221	Replace cast slab over the upper wagon track with a removable plate
	Steel structures
227	Specify adequate corrosion protection (paint)
228	Design for salt water condition (worst condition)
229	Specify vessel impact force for gate design
	Concrete
232	Specify inspection time; inspect every 20 years
233	100 years life time design
	Personnel required
237	Automate as much as possible (include a failure detection system)
	Accessibility to structure in dry conditions
240	All to be easily accessible (electro mechanical parts)
	Maintenance design parameters for mechanical parts
244	Gates – Major overhaul: 25 years; 2 year anode inspection
245	Wagons – Major overhaul: 5 years; inspect every year
246	Valves – Major overhaul: 10 years; inspect every 2 years
247	Rails – Major overhaul: 25 years; inspect every year
	MAXIMIZE THROUGHPUT **Locks illumination**
248	Design illumination system to be able to transit vessels 24/7 for all vessels at all times

	(all night)
	Vessel positioning
249	Vessel positioning warning system
	RADICAL IDEAS
253	Consider 4th lane when designing the 3rd lane locks to enhance construction of the 4th lane.
	Constructability Dialogos: Other ideas for maximizing production
305	Provide water sumps connected to lock chambers for dewatering

11.2.4 Cost Reduction Items

Many of the ideas had the potential to reduce capital cost. These are listed below with estimated cost reductions. A remarkable $US720 million, minimum, of potential cost reduction was identified.

Table 7 – Cost Reduction Items

No.	Idea	Percentage	$
	ENVIRONMENTAL IMPACT **Limit salt intrusion**		
8	Use 2 water saving basins instead of 3	-6%	180m
	STANDARDIZE PROJECT **Leverage existing technology**		
78	Materials and gates – composite plastic	+25%	N/A
	REDUCE EXCAVATION **Side walls**		
163	Side walls – excavate culvert as a tunnel		
164	Side walls – use rock as back wall form	-7% Atlantic cost	See below
165	Side walls – excavate material from above rock only	-13% Pacific cost	See below
166	Side walls – use rock bolts or other techniques rather than -1.5m thick concrete blocks on lock chamber floor	-10% total (#163,164, 165)	300m+
167	Side walls – excavate culverts in floor rather than in the sidewall	-1% to 3%	30m
	FAST TRACK CONSTRUCTION **Simplify construction**		
192	Detach cable duct/trench	-1%	30m
194	Replace RC for RCC	-20% for unit price of concrete	N/A
196	Replace water saving basin RC for pond type structure	Same as #250	See #250
198	Use syphon as a water ejector from/to water saving basin	1%	30m+
210	Use precast concrete walls separated from culverts	Not really savings	N/A
	REDUCE MAINTENANCE/OPERATING COST **Mechanical parts**		
222	Analyze and determine critical systems and priority for redundancy need	??	N/A
	RADICAL IDEAS		
250	Use earth instead of concrete design and build the pond rubber membrane for the	-5%	150m

	lining/bladder (water saving basin)		
		Total	**720m+**

12. PLANNING STAGE

12.1 Action Plan

A series of items were raised during the value management study that required actions to be carried out after the study. These are detailed below. They were prioritized as follows:

A = Immediately (next 6 months)
B = Intermediate (6-12 months)
C = Eventually (more than 12 months)

Table 8 - Action Plan

No.	Idea	Action	Responsible	Priority
	MAXIMIZE THROUGHPUT **Minimize lockage time**			
37	Provide locks fendering: chamber, approaches	Concept design plus costing	IPI+MR	B
38	Analyze and determine most effective method to move personnel from chamber to chamber	Do it	IPC+MR	C
	Minimize down time			
43	Provide redundancy in culverts (number)	Design and cost	IPC+MR with CPP	A
44	Build sluice valves into gates to complement filling and emptying of chambers	Expand 1985 studies on existing locks and report	IPIM+MR	C
45	Use of mechanical system to re-position tugs track (marine railroad, vertical lift, small locks) vs more tugs	Investigate, concept design and cost	IPC+IPI+MR with CPP	C
	Pre-position vessels			
47	Construct approach walls (floating, prefab)	Concept design	IPC+IPI+MR with USACE	B
48	Study currents: move lock discharge or dissipate energy	Concept design	IPC+MR with CPP	B
	Minimize hawser forces			
53	Use bottom filling system	Revaluate and cost (see Appendix 3)	IPC+MR with CPP	A
54	Increase UKC (under keel clearance)			
55	Provide symmetrical filling (double culvert central filling with side port manifold)			
167	Excavate culverts in chamber floor rather than in the sidewall			

169	Raise bottom of chamber reducing water depth of 18.3 to 16.5m – dig trenches in bottom of chamber for culverts – put ports in bottom of chamber rather in side walls			
265	Fill from bottom next to the walls along the chamber to help keep the ships off the walls			
	Alternative mooring system			
62	Floating bits (vertical movement)	Analyze concept design and cost	IPC+MR with CPP	B
63	Self releasing mooring hooks (fixed)			
64	Vessel based mooring system			
67	Moving bits (longitudinal movement)			
68	Centre chamber mooring system	Analyze concept design and cost	IPC+MR with CPP	A
69	Side wall mooring system			
	STANDARDIZE PROJECT **Uniform structures**			
75	Culvert plastic liner to improve water flow	Study, cost and determine throughput gain	IPC with CPP	C
173	Investigate plastic pipe as culvert			
	Leverage existing technology			
78	Materials and gates – use of composite plastic	Investigate and cost	IPC+IPI with CPP	B
	MINIMIZE IMPACT ON EXISTING OPERATIONS **Limit vibration**			
95	Experimental pre-construction investigation	Do it	IPC+IPI with CPP	B
	SAFETY **Protection of structures and gates**			
29	Implement an hydraulic ship arrestor	Carry out study	IPC+MR with CPP	C
152	Explore alternative concrete mixes	Do it and report	IPC+IPI	B
156	Make provisions to convert to locomotive ship positioning system in future	Concept design and cost	IPC+MR with CPP	C
	REDUCE EXCAVATION **Side walls**			
163	Side walls – excavate culvert as a tunnel	Concept design and cost	IPC with CPP	B
164	Side walls – use rock as back wall form			
165	Side walls – excavate material from above rock only			
166	Side walls – use rock bolts or other techniques rather than -1.5m thick concrete blocks on lock chamber floor			

210	Use precast concrete walls separated from culverts			
	FAST TRACK CONSTRUCTION **Leverage existing technology**			
178	Metallizing of gates to prevent corrosion	Evaluate and cost	IPC	C
	Procurement			
182	Proceed in physical hydraulic model	Do it	IPC with CPP	B
	Simplify construction			
186	Tunnel – small x crossing, under wet floor	Investigate and cost	IPC with CPP	B
194	Replace RC for RCC	Investigate and cost	IPC with CPP	B
198	Use syphon as a water ejector from/to water saving basin	Design and cost	IPC with CPP	C
203	Use different culvert geometry	Design and cost	IPC with CPP	A
212	Use Gatun rock formation as backfill for the Atlantic locks	Design and cost	IPC with CPP	B
213	Use reinforced earth (using geogrids) as part of Gatun backfill to make it stronger	Design and cost	IPC with CPP	C
215	Use electro-mechanical (single screw) instead of hydraulic system to operate valves	Design and cost	IPC+IPI with USACE	C
	REDUCE MAINTENANCE/OPERATING COST **Mechanical parts**			
222	Analyze and determine critical components to prioritize need for redundancy and spares	Do it and cost analysis	IPC+IPI+MR with CPP	A
	RADICAL IDEAS			
196	Replace water saving basin RC for pond type structure	Design and cost	IPC with CPP	B
254	Reconsider locks design to incorporate an emergency gate at each lock. These emergency gates would be used to preserve Gatun Lake in case of an accident and to optimize future “dry chamber” (if needed) work at Locks	Concept design and cost	IPC+IPIM +MR with CPP	A
260	Perform analytical and physical models to study the “piston effect” caused by the larger than workhorse vessels	Do it	IPC+MR with CPP	B

Legend:

ACP	Autoridad del Canal de Panamá
MR	Marine Operations Department
IP	Engineering and Projects Department
IPC	Canal Capacity Projects Division
IPI	Engineering Division
IPIM	Mechanical Section
CPP	Consorcio Post-Panamax

USACE U.S. Army Corps of Engineers

13. ADDITIONAL ALTERNATIVE DESIGN IDEAS PRESENTED

Within the value management workshop several of the visiting experts suggested alternative design concepts from their own knowledge and experience which was felt may add further value to the Project, either through reducing the cost of its construction and/or operation and maintenance, or by improving its performance and/or maintainability. Copies of all these presentations are given in Appendix 3.

Dr Gabriel Fernandez, specialist in geotechnical engineering and Professor of Civil Engineering at the University of Illinois, presented sketches explaining the suggested change in the lock wall design, the cost savings from which are included in the table on page 21, and Jens Korsgaard of Han Padron presented an alternative valve for connection of the water saving basins to the lock chambers which would have no moving parts and so may simplify maintenance, and also would reduce the number of conduits required.

One idea of particular interest was presented by the experts from Bundesaustalt für Wasserbau of Germany, where water saving basins are used with locks. All of these use an alternative system of filling and emptying of the lock chambers from the bottom, using an underfloor chamber rather than longitudinal and transverse conduits as found in the existing Panama Canal locks. This avoids the problem of excessive hawser forces being generated and operates equally well with or without the water saving basins in use, and was commended for further study.

CONSTRUCTABILITY DIALOGOS

Wednesday 24th August And Thursday 25th August 2005

14. WORKSHOP AGENDA FOR CONSTRUCTABILITY DIALOGOS

The dialogos methodology is best described by reference to the agenda actually carried out. This is as follows:

Day 3: VM/Dialogos Constructability Issues: Wednesday 24th August)

8.00	Review of design VM/cost savings/design notation
8.15	The 2 day program in detail (derived from strategic diagnosis)
8.25	Personal introductions and role in project by new participants and foreigners
8.45	Introduction to the process
9.00	The facilitators role and role of the delegates
9.05	Link Thinking introduced
9.10	Presentations on key aspects of the project
10.10	Structured clarificatory questions on the project presentations
10.15	**Break**
10.30	Continuing of clarificatory questions
12.30	**Lunch**
1.15	Functional Analysis 1 Introduction to Link Thinking Hierarchy: breaking up the project into digestible components
3.15	**Break**
3.30	Idea generation commences
4.30	**Finish**

Day 4: VM/Dialogos Constructability Issues: Thursday, 25th August

8.00	Additional idea generation
8.30	Introduction to evaluation process
8.40	First level of evaluation (qualitative rating)
10.30	**Break**
10.45	Second level of evaluation.
12.15	**Lunch**
1.00	Idea development/cost savings/value enhancements identified
3.00	**Break**
3.15	Action planning
4.30	**Finish**

15. TOPICS AND SPEAKERS

A series of topics were identified to be addressed by specific speakers talking for five minutes or less, at the information stage. Eight topics with respective speakers were identified and scheduled for the workshop. They were as follows:

Table 9 – Topics and Speakers

Days 3-4: Constructability		
Topic	**Speaker**	**Organisation**
Construction methodology	Cheryl George	ACP
Excavation	Rigoberto Delgado	ACP
Dewatering	George Currie	PB
Disposal logistics	Rigoberto Delgado	ACP
Material supply	Cheryl George	ACP
Labour supply	Boris Moreno	ACP
Special components	Boris Moreno	ACP
Access channel	Rigoberto Delgado	ACP

16. WORKSHOP PARTICIPANTS

The participants for the workshop were carefully selected to ensure appropriate technical and user input to the decision making. The group was larger than normal, but it was considered necessary to extend the range of participants in this case to provide credibility to the findings and to ensure true stakeholder representation was achieved.

Table 10 - Workshop Participants (24th and 25th August)

	Name	Organisation
1	Jorge L Quijano	Autoridad del Canal de Panama
2	Agustin A Arias	Autoridad del Canal de Panama
3	Jorge de la Guardia	Autoridad del Canal de Panama
4	Ilya de Marotta	Autoridad del Canal de Panama
5	Luis Alfaro	Autoridad del Canal de Panama
6	Cheryl George	Autoridad del Canal de Panama
7	Albert Joyce	Autoridad del Canal de Panama
8	Juan Wong	Autoridad del Canal de Panama
9	Rogelio Gordon	Autoridad del Canal de Panama
10	Rigoberto Delgado	Autoridad del Canal de Panama
11	Efrain Isaza	Autoridad del Canal de Panama
12	Adriano Espino	Autoridad del Canal de Panama
13	Roderick Lee	Autoridad del Canal de Panama
14	Cesar Kiamco	Autoridad del Canal de Panama
15	Jose Pascal	Autoridad del Canal de Panama
16	Bernhard Kemnitz	Bundesaustalt fur Wasserbau
17	Rick Schultz	US Army Corps of Engineers
18	Jens Korsgaard	Han Padron
19	Bengt Forsberg	Retired Construction Manager - Skanska
20	Jose De Regge	Consorcio Post-Panamax

	Name	Organisation
21	Corina Briceno	Parsons Brinckerhoff International, inc
22	Dr Gabriel Fernandez	University of Illinois
23	Eberhard Grimm	Bundesaustalt fur Wasserbau
24	Jean Louis Mathurin	Consorcio Post-Panamax
25	John Roberts	Parsons Brinckerhoff International, inc
26	Larry Dalton	US Army Corps of Engineers
27	Rik Thomas	Consorcio Post-Panamax
28	Reece Shaw	Parsons Brinckerhoff International
29	David Williams	Parsons Brinckerhoff International
30	Sebastien Roux	Consorcio Post-Panamax
31	George Currie	Parsons Brinckerhoff International, inc
32	William Caitlin	Retired Construction Manager – Washington Group
	Facilitation Team	
	Dr. David Stevens	Social Enterprise Consulting
	Caroline Shindlair	Social Enterprise Consulting

16.1 Workshop Groupings

To enhance the value management process, four syndicate groups were formed to carry out a variety of workshop activities. The constitution of the groups is indicated below.

Table 11 - Groupings for 24th & 25th August

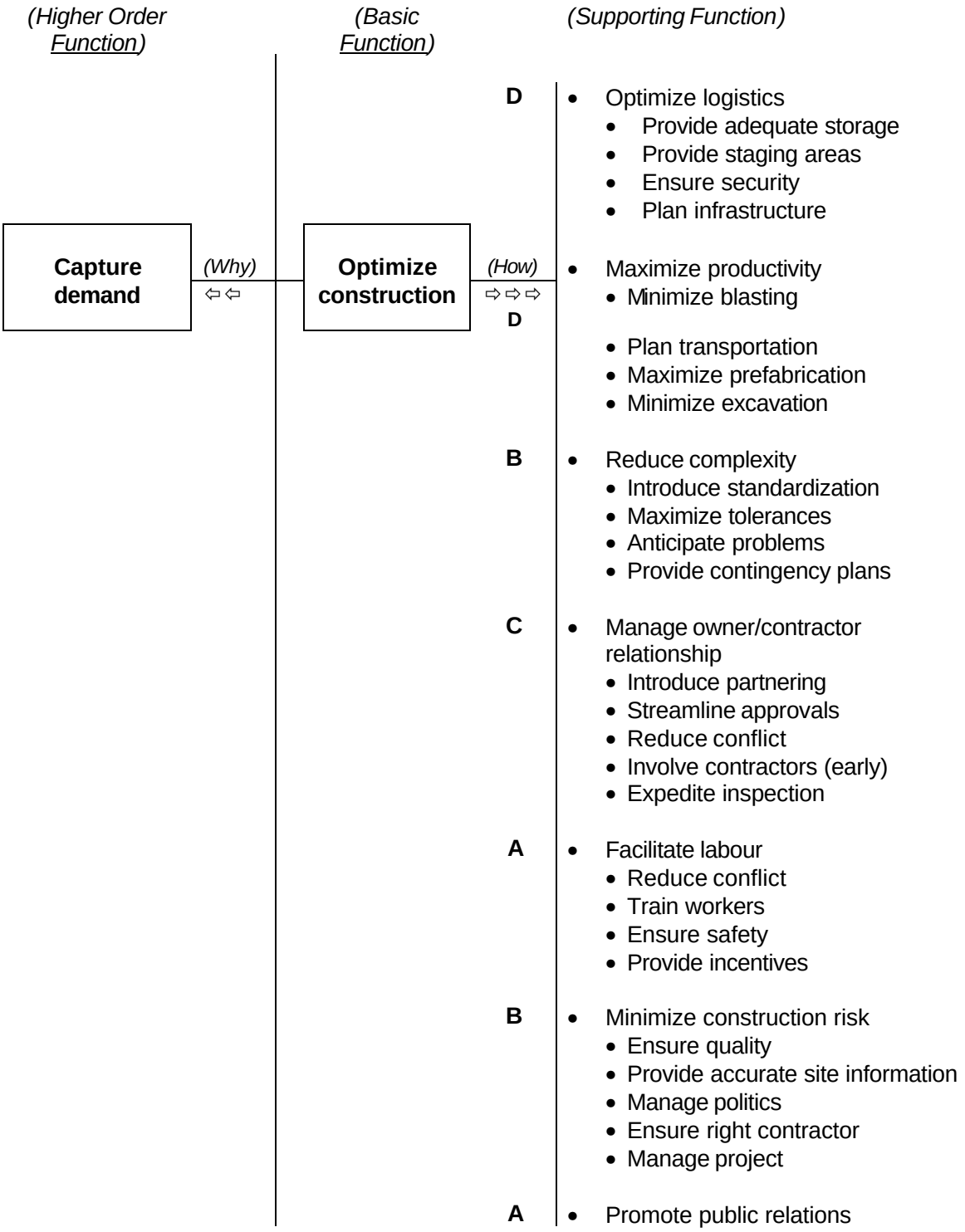
Group A	Group B	Group C	Group D
Jorge de la Guardia	Luis Alfaro	Dr Gabriel Fernandez	David Williams
Juan Wong	Bernhard Kemnitz *	Eberhard Grimm	Sebastien Roux
Rogelio Gordon (Thursday only)	Rick Schultz	Cesar Kiamco	llya de Marotta
Rigoberto Delgado	Jorge L Quijano	Jose Pascal	Adriano Espino
Efrain Isaza	Jens Korsgaard	Jean Louis Mathurin	Roderick Lee (Thursday only)
Reece Shaw	Bengt Forsberg	John Roberts	Agustin A Arias
Rik Thomas	Jose De Regge	Larry Dalton	George Currie
Albert Joyce	Corina Briceno	Cheryl George	William Catlin
	Boris Boreno		

*In Group D for Thursday session

17. LINK THINKING HIERARCHY FOR CONSTRUCTABILITY DIALOGOS

A link thinking hierarchy was constructed as shown in Figure 2. The objective of the link thinking hierarchy is to formally structure the decision making processes of participants to ensure that the workshop objectives, in terms of "Optmize construction", are attained and that discussion does not stray onto irrelevant issues.

Figure 2 - Link Thinking Hierarchy



		• Understand culture • Educate contractors • Disseminate information • Respond to concerns • Expedite environmental issues

	C	• Plan interfacing
		  • Minimize operations conflict
		  • Plan sequencing
		  • Coordinate contractors
		  • Have a masterplan

18. IDEA GENERATION AND EVALUATION STAGE

18.1 Idea Generation

As a result of the link thinking hierarchy, the eight supporting functions were used as a basis for creating ideas speculating on alternative ways to "Optimize construction" (basic function).

A total of 348 ideas were generated and are found in Appendix 5.

18.2 Evaluation Stage

A series of evaluation techniques were used to reduce the 348 ideas generated into meaningful sets of ideas for further evaluation.

18.2.1 1st Evaluation Stage

In the first instance, ideas were rated:

1 = Worthy of further consideration
2 = Requires further elaboration as the idea is not understood
3 = The idea can be discarded because of:
  a) Repetition of an earlier idea
  b) Not "fully formed" idea
  c) Outside of the scope set
  d) Instantaneous rejection
  e) Doesn't directly relate to objectives

This process enabled a considerable number of ideas to be rapidly rejected by consensus by all participants, to bring the number of ideas to a workable level. The process was described in detail in the Design value management section.

By reference to Appendix 5 and by following the rating number readers can establish which ideas were culled out on this first level of evaluation.

18.2.2 2nd Evaluation Stage

This evaluation was then followed by a second more sophisticated culling exercise. This was achieved by a sorting of ideas into a series of categories as follows:

PR = Proposal Requirement Item (must be submitted with proposal)

KR = Contract Requirement (must be complied with after award)
AP = Action Plan Item (actions by the owner/ACP)

To substantiate the second evaluation level, six "knock-out criteria" were included. These are listed below. These six knock out criteria enabled the participants to be able to further cull out ideas that did not make significant contributions to the project and further reduced the 348 ideas to a more workable list. Again, any item deleted was done on the basis of consensus as described above. However, at this point the decision making has reached a level at which more specific reasons for deletion must be given.

- Covered as a "design" issue
- Not politically acceptable (labour loss, significant environmental impact)
- Significant cost increase
- Significant disruption to canal operations
- Extends construction past 2013
- High risk concept

18.2.3 Proposal Requirement Items

As a result of the evaluation twelve ideas were identified for "proposal requirement" and are listed below in Table 12. These proposal requirements were accepted as consensus decisions by the key stakeholders to be submitted by contractors with their proposal/bids.

Table 12 – PR items

No.	Idea
	OPTIMIZE LOGISTICS **Minimize material transport**
1	Identify transport option needs
2	Identify long term (time dep) material needs
3	Know your storage capacity
	Provide adequate storage
20	Identify material handling needs
	Provide staging areas
23	Identify preferred locations and staging areas
	Plan infrastructure
35	Identify power needs/designate
36	Identify consumption potable/industrial water needs
37	Identify waste water needs
38	Identify fuel storage/handling needs
40	Unloading facilities (port)
	PUBLIC RELATIONS **Educate contractors**
99	Ensure social responsibility
	REDUCE COMPLEXITY
185	Contractor should use/bring new/reliable construction equipment

18.2.4 Contract Requirement Items

These items are considered to be essential and must be completed with after award of the contract.

Table 13 – Contract Requirement Items

No.	Idea
	OPTIMIZE LOGISTICS **Minimize material transport**
4	Develop material flow plan on site
	Monitor suppliers progress
11	Automated centralized procurement and tracking system (interface)
	Provide staging areas
22	Develop work flow plan
	Ensure security
28	Identify hazardous materials
31	Security (CCTV) alarm sensor/remote 24 hour monitoring security system
32	Adequate identification system for personnel
	Plan infrastructure
39	Identify ice requirements
42	Management of construction debris
	FACILIATE LABOUR **Reduce conflict**
55	Safe and secure labour payment system
	Train workers
57	Scholarships for training
58	Apprenticeship program
59	Technology transfer from contractor
	Ensure safety
63	Medical assistance and benefits
65	Safety training
67	Drug test program – zero tolerance alcohol policy
71	Provide safety incentives and report
73	Job safety plan – safety and industrial hygiene inspection
	PROMOTE PUBLIC RELATIONS **Expedite environmental issues**
123	Require an environmental plan for execution of works
	MANAGE OWNER/CONTRACTOR RELATIONSHIP **Expedite inspections**
142	Contractor do quality control and ACP do QA
145	Have an Inspection and Testing Plan
	Streamline approvals
152	30 day submittal schedule
	REDUCE COMPLEXITY **Anticipate problems**
173	Early implementation of QA/QC – access material testing laboratory with rapid response
174	Major testing before NTP (notice to proceed) of prototype materials
	MINIMIZE CONSTRUCTION RISK **Ensure quality/safety plan implementation**
194	Require as built drawings tied by payment terms by contractor as project progresses as built
195	Use graphical documentation as much as possible (photo's, etc)
196	Keep daily log records/with weekly summary submissions
197	Online program management updates
	MAXIMIZE PRODUCTIVITY **Scheduling of sequencing**

258	Monitor/report/daily in real time (detailed)

18.2.5 Significant Constructability Issues

Although these items were initially rejected, it must be understood that was done because they were considered issues for the contractor only, to be adopted at his option. In terms of being beneficial to the project the following thirty-two items were considered significant, and it was recommended that these should not be precluded by the design, specifications or contractual terms.

Table 14 – Significant Constructability Issues

No.	Idea
	REDUCE COMPLEXITY **Introduce standardization**
163	Reuse of construction material – forms
	Anticipate problems
186	Evaluate dewatering needs
	MAXIMIZE PRODUCTIVITY **Minimize blasting**
238	Use rock ripability
240	Determine design test ripability
241	Consider alternate excavation methodology
242	Use dredging
243	Use mining equipment
244	Use rock cutters
	Maximize prefabrication
246	Use prefab concrete forms
248	Have fabrication done by supplier when convenient
249	Prefabricate offsite
250	Precast rings and valve chambers
251	Do prefab piping outside
252	Use precast cable duct
254	Minimize embedded components
	Selection and utilization of equipment
264	Identify market availability
265	Identify needs/requirement according to production
266	Establish consultation and technical support with equipment manufacturers
	Plan transportation
279	Evaluate and select transportation method
283	Use hydraulic spoil transport
	Minimize excavation
286	Excavate culverts with tunnel boring machine
287	Excavate culverts with drilling and blasting
	Maximize working time
295	Temporary covers work areas during rain
296	Minimize flat slabs – no concrete lining to water saving basin bottoms
	Other ideas for maximize productivity
297	Slip form where possible
298	Use of movable forms
299	Use of prefabricated rebar cages
304	Use vibrating form work
	RADICAL IDEAS

337	Develop (with manufacturer(s)) new combined excavation/concrete laying system for lock section analogous to tunnel boring machines
338	Construct a conveyor belt/railway/skylift to transport material from Pacific lock to Gamboa west for subsequent transfer to barge thus avoiding barging up locks and running through Gaillard Cut.
340	Build precast shells for lock wall monolith construction
348	Build lock walls from giant blocks (colour may be used to improve in-lock visibility and/or designate warning/critical zones)

19. PLANNING STAGE

19.1 Action Plan

A series of items were raised during the value management study that required actions to be carried out after the study. These are detailed below.

A = Urgent – starting as soon as possible – decisions have to be made
B = Important – do when time/resources are available
C = Nice to have – do if possible

Table 15 - Action Plan

No.	Idea	Action	Resp	Priority
	OPTIMIZE LOGISTICS **Monitor suppliers progress**			
14	Pre-qualify suppliers	Draft contractor qualifications	ODP	B
15	Centralized contract administration	Establish	Administrator	A
16	Establish program control system	Implement	ODP/ FM / IM	B
	Provide staging areas			
25	Have available space for contingency/plan material processes – anticipate long lead time for certain materials and components	Analyze availability	IP	C
	Plan infrastructure			
33	Evaluate road requirements	Analyze	IP	B
41	Designate no go areas	Analyze	IP/MR	B
	FACILIATE LABOUR **Reduce conflict**			
49	One contractor for both locks	Analyze and recommend	ODP	A
	Train workers			
62	Job fairs	Organize	HR	B
	Ensure safety			
70	Specify appropriate safety standards	Do it	ES	B
	Provide incentives			
76	For contractor to train people	Evaluate and recommend	HR	C
	Political issues			

86	Maintain stakeholders informed	Develop communication strategy	AE	A
87	Develop program for UXO management	Do it	IP/ES	B
88	Review procedures for explosives handling	Do it	ES	B
	PROMOTE PUBLIC RELATIONS **Understand culture**			
94	Maintain web site	Develop	IM	B
	Educate contractors			
97	Familiarize with local labour laws	Develop information package	GC	B
98	Explain regulations: tax, environmental, social security		GC	
99	Ensure social responsibility		AE	
	Disseminate information			
103	Exhibition hall and model	Construct	AE/IP	A
107	Weekly TV releases/spots	Develop product	AE	C
109	Construction web cam	Plan for	IM	C
112	Organize PIANC (Permanent International Association Navigation Congress) congress	Do it	IP	A
113	Liaise with NGO's	Do it	ES/AE	A
	Respond to concerns			
114	Establish hotline for community	Do it	AE	B
115	Establish community relations office	Do it	AE/ES	A
116	Surveys - periodic (be proactive)	Plan for construction	AE	C
	Expedite environmental issues			
124	Monitor environmental plan	Do it	ES	B
	MANAGE OWNER/CONTRACTOR RELATIONSHIP **Involve contractor (early)**			
125	Construction information on web prior to solicitation	Develop	ODP	B
127	Pre-bid contractor conference (contractor with subcontractors and suppliers)	Organize	ODP/FMC	B
128	Pre-bid visits to physical models and rock cores and exposed cuts	Organize	IP/ODP	B
129	Early pre qualification of contractor's	Do it	ODP/FMC	B
	Expedite payments			
130	Provide mobilization payments	Develop payment strategy	ODP/FM	B
131	Minimize the number of pay items			
132	Minimize/eliminate retention of earnings			
135	Pay twice each month			
136	Pay contractor quickly (20 days) after submittal			
	Expedite inspections			

142	Contractor do quality control and ACP do QA	Develop criteria	ODP/IP	B
146	Identify ACP hold point criteria pre-bid			
	Streamline approvals			
148	Define required submittals	Develop submittal requirements	ODP/FMC/IP	B
149	Have Pre submittal meetings			
150	Have a submittal register			
	Introduce partnering			
156	Include "partnering" in pre-qualification analysis	Analyze and develop partnering strategy/program	ODP/IP/MR/ES	B
158	Partnering workshops at working level			
159	Partnering workshops at executive level quarterly			
	REDUCE COMPLEXITY **Introduce standardization**			
164	Impose construction management software	Analyze and decide	ODP/IP	B
165	Owner supply of specialized components	Evaluate feasibility	ODP/IP	B
166	Electromechanical equipment – required machinery and controls from same supplier	Evaluate	ODP/IP/MR	B
	Anticipate problems			
173	Access material testing laboratory with rapid response	Part of QA/QC	IP	B
182	Fabricate aggregates by ACP/concession	Investigate	ODP/IP	A
187	Test possible concrete mixes early to see if they work	Investigate and include fly ash	IP	B
188	Assure DSL/high speed/satellite internet communications (interfacing with ACP)	Investigate	IM	C
	MINIMIZE CONSTRUCTION RISK **Ensure quality/safety plan implementation**			
191	Develop a training program for inspectors	Do it	HR/IP/FMC	B
195	Use graphical documentation as much as possible (photo's, etc)	Evaluate	FMC/ODP	C
197	Online program management updates	Implement	ODP/IM	B
198	Review project construction work by expert team (board of experts)	Establish	ODP/IP/FMC	B
199	Analyze incentives/penalties for early/late completion	Do it	FMC/ODP	B
202	Use 4D modeling simulation (Common Point)	Evaluate	IP/ODP/IM	C
	Provide accurate site information			
204	Provide statement on availability and quality of local labour	Prepare	HR	B
210	Meteorological statistical information (rainfall)	Prepare	IP/ES	B
211	Geological information	Prepare	IP	B

212	Tidal information	Prepare	IP	B
213	Existing canal operations information	Prepare	MR	B
	Manage politics			
222	Publish Panamanian employment statistics of project	Collate	HR/AE	C
	Manage project			
225	Implement effective project accounting system	Do it	ODP/FM/IM	A
226	Establish a high level ACP project construction/admin team	Do it	AD	A
237	Fix project scope	Do it	AD	A
	MAXIMIZE PRODUCTIVITY **Maximize prefabrication**			
257	Assemble gates on site	Evaluate	IP	B
	Scheduling of sequencing			
260	Establish report formats early	Do it	ODP/FMC	B
	Improve labour productivity			
277	Train ACP in project management	Do it	HR	A
	Balance resources			
289	Have backup labour availability	Develop strategy	HR	B
290	Provide labour register to contractor	Do it	HR	B
	Other ideas for maximize productivity			
302	Minimize number of concrete lifts	Evaluate	IP	B
	PLAN INTERFACING **Minimize canal operation conflicts**			
307	Provide plenty of staging area for floating plant	Evaluate	IP/MR	B
308	Review with operations, the plan & specs as they are developed	Do it	ODP/MR/IP	A
310 a	Coordinate shipping of materials from Pacific to Atlantic with operations			
311	Establish a hot line with operations	Do it	IM/MR	B
312	Have contractor's discuss needs with operations in bids/proposals	Do it	ODP/MR/FMC	B
313	Include operations in partnering	Do it	ODP/MR	B
	Interface with other agencies			
315	Interface with customs for direct deliveries	Establish appropriate government liaisons	GC/AE	B
316	Interface with labour department over imported labour			
318	Interface with public works over traffic management and warning signs			
319	Allow for explosives manufacture on site	Evaluate	ES/IP	B
	Coordinate contractor's			
322	Explain interface requirements in plan & spec's	Develop requirements	ODP/IP	B

324	Start basalt channel excavation as early as possible	Evaluate	IP	A
325	Clearly define handling of basalt aggregate requirements from channel excavation contractor	Do it	IP/ODP	B
326	ACP to define responsibility for road maintenance	Do it	IP	B
327	Have contract early for access road construction and utilities	Evaluate	IP	B
	RADICAL IDEAS			
331	Set up a shop to build all the steel work in Panama. These will increase labour and technology in our country.	Explore	IP/ODP	B
335	Install in dry conditions all gates	Evaluate	IP	B
336	Allow design optimization by potential bidders provided it compiles with a basic set of fixed parameters	Evaluate	ODP	B
339	Use sand asphalt as construction material for water saving basins and dykes	Evaluate	IP	B
342	Use video monitoring for inspection and control	Evaluate	ODP/IM	C
343	Selected contractor and ACP form a construction performance company in which contractor provides the construction organization and ACP provides the procurement, financial and cost accounting functions	Test political sensitivity	GC	B
344	Allow contractor to submit an alternative design if the procurement is design bid build	Evaluate	ODP	B
345	Dewater 1939 excavations at locks selected locations to evaluate site conditions – before call for bids	Do it	IP	A
346	Proposals submitted on an A+B basis (time and cost) where time has a dollar value. The best proposal will be the combination of time and cost. Example each day is worth $500,000. Contractor #2 has a better time and cost proposal even though his cost of work is higher.	Evaluate	OCP/FMC	B
347	Build up each lock as a simple concrete block with minimum joints	Evaluate	IP	B

Legend:

ACP Autoridad del Canal de Panamá
MR Marine Operations Department

IP	Engineering and Projects Department
IPC	Canal Capacity Projects Division
IPI	Engineering Division
IPIM	Mechanical Section
CPP	Consorcio Post-Panamax
USACE	U.S. Army Corps of Engineers

20. ADDITIONAL CONSTRUCTABLITY PRESENTATIONS

There was a concensus amongst the foreign construction experts that the size of the labor force indicated in the ACP presentations may be significantly underestimated. John Roberts presented data from the $15 billion Taiwan High Speed Rail project currently nearing completion and from a hydro electric project in the Philippines supervised by William Catlin. These indicate that the labor needs of the project may be in the order of 12,000 to 15,000 workers. A copy of this additional presentation is included in Appendix 3 of this report.

RISK ASSESSMENT

FRIDAY, 26TH AUGUST 2005

21. WORKSHOP AGENDA

The risk management methodology is best described by reference to the agenda actually carried out, and which was formulated at the strategic diagnosis. This is as follows:

8.00	Introduction to the risk management methodology
8.10	Risk identification (categories and areas)
8.30	Specific risk identification
10.00	**Break**
10.15	Risk assessment (probability and impact)
11.30	Ranking the risks
12.30	**Lunch**
1.15	Potential major risk responses
2.30	Final comments
2.45	Workshop sessions finish
3.00	Formal individual meetings: overseas experts with ACP
5.00	Finish

22. WORKSHOP PARTICIPANTS

Table 16 - Participants

	Name	Organisation / Title
1	Jorge L Quijano	Autoridad del Canal de Panama
2	Agustin A Arias	Autoridad del Canal de Panama
3	Jorge de la Guardia	Autoridad del Canal de Panama
4	llya de Marotta	Autoridad del Canal de Panama
5	Albert Joyce	Autoridad del Canal de Panama
6	Cheryl George	Autoridad del Canal de Panama
7	Adriano Espino	Autoridad del Canal de Panama
8	Boris Moreno	Autoridad del Canal de Panama
9	Angie S. de Hanily	Autoridad del Canal de Panama
10	Juan Wong	Autoridad del Canal de Panama
11	Rogelio Gordon	Autoridad del Canal de Panama
12	Efrain Isaza	Autoridad del Canal de Panama
13	Luis Alfaro	Autoridad del Canal de Panama
14	Cesar Kiamco	Autoridad del Canal de Panama
15	Enrique Sanchez	Autoridad del Canal de Panama
16	Bernhard Kemnitz	Bundesaustalt fur Wasserbau

	Name	Organisation / Title
17	Rick Schultz	US Army Corps of Engineers
18	Jens Korsgaard	Han Padron
19	Bengt Forsberg	Retired Construction Manager - Skanska
20	Jose De Regge	Consorcio Post-Panamax
21	Laurie Mahon	Parsons Brinckerhoff International, inc
22	Dr Gabriel Fernandez	Montgomery Watson Harza
23	Eberhard Grimm	Bundesaustalt fur Wasserbau
24	Jean Louis Mathurin	Consorcio Post-Panamax
25	John Roberts	Parsons Brinckerhoff International, inc; USA
26	Larry Dalton	US Army Corps of Engineers
27	William Caitlin	Retired Construction Manager – Washington Group
28	Rik Thomas	Consorcio Post-Panamax
29	Reece Shaw	Parsons Brinckerhoff International, inc; Panama
30	David Williams	Parsons Brinckerhoff International inc; USA
31	Sebastien Roux	Consorcio Post-Panamax
32	George Currie	Parsons Brinckerhoff International, inc; Malaysia
33	Corina Briceno	Parsons Brinckerhoff International, inc; Panama
	Facilitation Team	
	Dr. David Stevens	Social Enterprise Consulting
	Caroline Shindlair	Social Enterprise Consulting

23. PRELIMINARY RISK ASSESSMENT

23.1 "Ultimate" Risk Hierarchy & Identified Risks

To ensure the successful delivery of the concept design for the locks a preliminary risk study was undertaken.

To assist in the risk identification component of the study a risk hierarchy was created. A primary or ultimate risk was identified as being "Project failure".

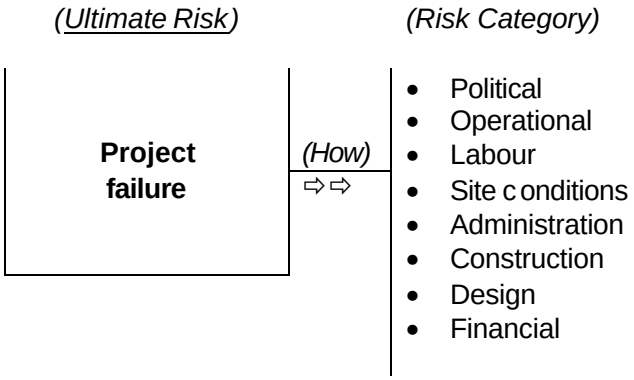
Risk category areas were then identified as:

- Political
- Operational
- Labour
- Site conditions
- Administration
- Construction
- Design
- Financial

As a third component in the risk hierarchy, risk areas were identified for each of the risk categories. This process formed a basis for the final specific risk identification, ensuring that it is a very comprehensive process.

A summary of the risk hierarchy is found below in Figure 3.

Figure 3 - Initial Risk Hierarchy



An expanded level of risk categorisation and risk areas is listed below in Figure 4. The risk identification surrounding the hierarchy identified a total of 336 risks.

Figure 4 - Risk Hierarchy:

(Ultimate Obstacle)		*(Risk Category)*		*(Risk Areas)*
Project failure	*(How)* ⇨⇨	• Political	**B**	• Referendum • NGO's • Central government • Internal • ANAM
		• Operational	**C**	• Navigational • Existing locks • Water • New locks • Equipment
		• Labour	**D**	• Supply/availability • Relations • Skills • Productivity • Cost
		• Site conditions	**A**	• Geotechnical • Seismic • Weather • Archeological • Environmental
		• Administration	**A**	• Environmental • Project management • Procurement • Planning • Controls
		• Construction	**D**	• Environmental • Schedules • Cost • Quality • Materials supply
		• Design	**C**	• Materials • Technology • Performance • Criteria • Schedules
		• Financial	**B**	• Foreign exchange • Inflation • Budget • Financing • Cashflow

23.2 Risk Identification: Work Groups

To enhance the risk identification process, four syndicate groups were formed to carry out a variety of workshop activities. The constitution of the groups is indicated below, with the areas of risk that those groups would be focussing on, also listed.

Table 17 - Syndicate Groups

Group A	Group B	Group C	Group D
Jorge de la Guardia	Luis Alfaro	Dr Gabriel Fernandez	David Williams
Juan Wong	Bernhard Kemnitz	Eberhard Grimm	Sebastien Roux
George Currie	Rick Schultz	Cesar Kiamco	Ilya de Marotta
Albert Joyce	Jorge L Quijano	Enrique Sanchez	Adriano Espino
Efrain Isaza	Jens Korsgaard	Jean Louis Mathurin	Boris Moreno
Reece Shaw	Bengt Forsberg	Cheryl George	Agustin A Arias
Rik Thomas	Jose De Regge	Larry Dalton	William Catlin
Corina Briceno	Laurie Mahon	Rigoberto Delgado	John Roberts
	Angie S. de Hanily	Raúl Brostella	

Risk Categories Covered

Group A	Group B	Group C	Group D
Site conditions	Political	Operational	Design
Administration	Financial	Design	Labour

23.3 Risk Assessment

The initial part of the risk assessment was to identify impact and probability of risk on a qualitative three level evaluation described as “High, Medium, Low” probability, and “High, Medium or Low” impact.

After considerable debate, probability was qualitatively described as “high”, meaning almost inevitably going to occur, “low” meaning almost certainly won’t occur and “medium” as being somewhere in-between. Impact was considered as high if it meant that additional or unscheduled resources would need to be called into play for a significant disruption to the project or at least to the delivery of the appropriate proposals. Medium impact means that the effect would be able to be managed within the scheduled or existing or allocated resources. Minor impact would mean generally it was an irritant and nothing more.

The second aspect of the assessment was to rank the risks, “Major, Moderate or Minor”.

Major:	Moderate:	Minor:
HH MH	HM MM	HL ML
	LH	LM
		LL

Major risk was defined in terms of High Impact and High Probability, and also in terms of Medium Probability and High Impact.

Risks ranked "moderate" were defined as risks being of Medium Impact with Medium Probability, High Probability and Medium Impact and Low Probability with High Impact.

Minor risks were described as those risks with Low Probability and Low Impact or High Probability and Low Impact or with Low Probability and Medium Impact or with Medium Probability and Low Impact.

Major risks were to attract immediate attention and were to be pro-actively action planned with risk management strategies including transfer of risk, mitigation of risk, avoidance of risk and acceptance of risk; responsibilities being defined with due dates also being scheduled.

Moderate risks were to be re-actively considered, and as such considered part of effective project management during the implementation of the project.

Finally, minor risks were to be ignored. These minor risks can be found in Appendix 7.

23.4 Identify Specific Risks

From the eight risk categories that were identified, and as a result of the forming of the four syndicate groups, 336 specific risk areas were identified. A complete list of the risks identified corresponding to each of the categories can be found in Appendix 6 which also indicates the probability and impact levels on the extreme right hand side of the table with the ranking in the furthest right hand column. (Can you comment here on the systemic relationships of risks and how the participants became aware of these?)

23.5 Major Risks

Fifty-six major risk areas were identified as listed and summarised below in Table 18. (Can you explain how 56 is an appropriate number given the total # of risks identified?) These form the basis of the proactive action plan in Table 20 found in Section 24.

Table 18 - Major Risks

No	Risk Area	Specific Risk
	Risk Category: Administration	
16	Planning	External impositions
20		Inexperience in planning
34	Project management	Lack of authority
41		Inadequate contracting method
42		Inadequate coordination of contractors
45		Lack of execution capability
48	Environmental	Failure to complete studies
	Risk Category: Labour	
59	Supply/availability	Lack of local labour
60		Lack of skills
61		High turnover
67	Relations	Strike
74		Competition between contractors
95	Cost	Wage escalation
99		Bid proposals higher than the cost estimates
	Risk Category: Operational	
125	New locks operation	Underestimated lockage time

126		Unforeseen problems with tugs
	Risk Category: Design	
139	Materials	Insufficient supply
152	Performance	Design incompatible of operational needs
160	Criteria	Lack of foresight
	Risk Category: Site conditions	
176	Geotechnical	Incorrect interpretation
179	Seismic	Incorrectly defined standards
200	Environmental	UXO (unforeseen)
	Risk Category: Financial	
210	Foreign exchange	Material/supply cost increase
212	Inflation	Higher project costs
214		Unavailability of local labour
216	Budget	Underestimating
220		Lack of bidders
221	Financing	Availability of acceptable finances
226		Inability to meet environmental requirements
228		Contractor bankruptcy
233	Cost overrun	Materials supplies cost increase
234		Unforeseen site conditions
235		Schedule changes
245	Demand	Misjudgement of price sensitivity
	Risk Category: Political	
246	Referendum	Delay
247		Clarity of mandate
248		Poor communication strategy
249		Negative outcome
253	NGO	Stopping financing
255	Central government	Failure to act timely
258		Interference
260	Internal politics	Labour communications
263		Inability to restructure
264		Lack of expertise
270	Panamanian public	Lack of project understanding
271		Unavailability of local labour
	Risk Category: Construction	
283	Environmental	Noncompliance with program
285		Inadequate management of NGO's
291	Schedule	Delays due to cash flow problem
294		Unexpected events
301	Cost	Growth in volumes (materials)
303		Increase in labour cost
308		Major schedule delays
322	Materials	Global shortages
324		Delivery delays
329	Equipment	Delays to mobilization

23.6 Moderate Risks

One-hundred and ninety-four areas were identified as moderate risks. These moderate risks are addressed in terms of potential responses to be handled by the project manager during the course of the project and are indicated below in Table 19.

Table 19 - Moderate Risks

No	Risk Area	Specific Risk
	Risk Category: Administration	
1	Controls	Inadequate contract records
2		Inadequate control software
3		Loss of records
4		Absence of controls
5		Inadequate support (staff)
6		Failure to update
7		Incompatible software
8		Unrealistic expectations
9		Non-assignment of responsibilities
11		Inadequate records
12		Poor interface with contractor
13	Planning	Failure to plan
14		Unrealistic estimates
15		Faulty assumptions
17		Misalignment of resources
18		No contingency plans
19		Delays in planning
21		Ownership of float
22	Procurement	Inadequate pre-qualification
23		Delays in procurement
24		Inadequate contract format
25		Inadequate selection procedures
26		Inadequate contract negotiation records
27		Lack of participants
27a		Deficient quality control requirements
28		Lack of accountability of ACP team
29		Inadequate scope
30		Inadequate size
31		Lack of bonding capacity
32		Corruption
33	Project management	Weak project manager
35		Insufficient staffing
39		Inadequate procedures
40		Inadequate communications
43		Poor claims management
46		Excessive subcontractors
47	Environmental	Approval delays
49		Inadequate records
50		Change of standards
51		Failure to coordinate with ANAM
52		Lack of pollution control
53		Inadequate inspection
54		Insufficient planning
55		Discovery of new species
56		Discovery of endangered species

58		Failure to obtain permits
	Risk Category: Labour	
62	Supply/availability	Absenteeism
63		Restrictions on imported
64		Lack of transportation
65		Insufficient housing
66	Relations	Work slowdown
75	Skills	Lack of training
76		Inadequate recruitment
77		Lack of effective supervision
78		Lack of knowledgeable inspectors
84	Productivity	Bad weather conditions
88	Safety	Inappropriate equipment
89		Lack of training
91		Lack of safety program
96	Cost	Wage differentials (local vs imported)
	Risk Category: Operational	
101	Navigational	Ship accidents
102		Landslide (dam instability)
104		Destabilization of existing slopes
105		Loss of Gatun Lake
106		Union (pilots)
107		Contractor interference with existing operations
108		Lack of emergency response plan
109		Density currents
110	Existing lock operations	Damages from vibrations
112		Dust
114		Float equipment interfere with navigation
115	Water	Dam overtopping (floods)
116		Loss of Gatun Lake
117		Draught
122	New locks operation	Malfunction of gates
124		Excessive hawser forces
127		Integrity of concrete/settlements
130	Equipment	Insufficient redundancy
132		Over/under designed
135		Poor Maintainability
	Risk Category: Design	
138	Materials	Poor quality
140		High cost
150	Performance	Poor choice of designers
153		Contractors can't build it (too difficult)
155		Incompatible with project desire
157	Criteria	It changing in the middle
158		It being improper
159		Lack of flexibility
163a		Under estimation of outside water needs
164		Inappropriate criteria for temporary structures
165	Schedule	Being unrealistic
166		Missing milestones
167		Changed conditions (site)
168		Changed criteria
169		Inflexible to construction/field changes

170		Lack of coordination of activities
	Risk Category: Site conditions	
171	Geotechnical	Lack of accurate information
172		Insufficient information
173		Unforeseen conditions
174		Unrealistic assumptions
175		Incorrect inter-poplation
177		Rock unsuitable as aggregate
180	Seismic	Incomplete information
181		Lack of sensitivity analysis
182		Incompatible design criteria
185		Tsunami
187	Weather	Occurrence of flood
188		Occurrence of drought
190		Rain
191		Storms
192		Slides
193		Fog
194		Wind
195		Heat
197	Archeological	Lack of information
198		Delay result of discovery
199		Costs result of discovery
202	Environmental	Air pollution
203		Noise pollution
204		Dust pollution
206		Vibration
207		Oil/spills
	Risk Category: Financial	
211	Foreign exchange	Mismatch of foreign currency
213	Inflation	Energy prices increases
215		Impact on financing
217	Budget	Over design
218		Incomplete scope
219		Modifications
222	Financing	Cost of financing being more expensive
223		Unacceptable terms and conditions
224		ACP's low credit rating
227		Legal requirements
229	Cash flow	Changes in draw down schedule
230		Lack of availability of revenues
231		Cost overruns
232	Cost overrun	Over design
236		Accidents
237		Owner scope changes
239		Acquisition delays
240	Demand	Changing market conditions
241		Competitors increase market share
244		Global economic crisis
	Risk Category: Political	
250	NGO	Organized opposition
257	Central government	Demands for additional funds
259		Failure to provide permits

262	Internal politics	Changes in top management
265	ANAM	Changing rules and procedures
266		Untimely authorizations
267		Interference
268		Mitigation requirements
269		Project delay
273	International	Lack of support from other countries
274		Tying – demands for specific treatment for $$ support
275		Negative interpretation of N treaty
276		US intervention – N treaty
277		War
278		Naval blockage
	Risk Category: Construction	
279	Environmental	Lack of permits
284		Restrictions of UXO area (unexpected)
286		Inadequate monitoring
287	Schedule	Delays in supplies
288		Incomplete design
289		Unrealistic schedule
290		Conflicting activities
292		Lack of coordination
293		Poor contractor/owner relations
295		Owner caused delays
296		Interference by operations
297		Inadequate contractor performance
299		Differing site conditions
300	Cost	Material escalation
302		Consumables escalation
304		Major change orders
305		Major growth in work scope
306		Major claims
307		Increase in transportation cost
311	Quality	Poor specifications
312		Poor design
313		Noncompliance with plans & specs
314		Ineffective QA/QC
315		Poor quality materials
318		Improper contractor coordination
320	Materials	Lack of adequate supplies
321		Inadequate planning
323		Unexpected processing requirements
325		Changes to disposal requirements
328	Equipment	Lack of availability
330		Improper equipment
331		Lack of maintenance
332		Under performance
333		Lack of spare parts/units
334		Inadequate infrastructure of operations
335		Irreparable damage
336		Sabotage (vandalism)

23.7 Minor Risks

Eighty-two areas were identified as minor risk and it was generally agreed by the risk management participants that these were areas that could be appropriately ignored by the project team at this stage. A complete list of the minor risks which are by, definition eradicated from the risk management study will be found in Appendix 7.

24. PLANNING STAGE

24.1 Major Risk Response

It is normal procedure to take the major risks identified and then brainstorm a series of responses and/or strategies to these risks. The strategies normally take one of four forms, ie. risk avoidance; risk transfer; risk mitigation or risk acceptance. After a period of brainstorming on each of the major risks identified, these ideas are then evaluated and the best ideas incorporated into an action plan. This in fact occurred in the workshop with the resulting action plan being formulated in Table 20 below. However, given the 336 risks were re-assessed on the basis of probability and impact, it is suggested the major risks identified earlier should be reworked for appropriate risk responses. (Explain why there are responses only for 40 risks and not for the 56 major risks)

Table 20 - Major Risk: Response Strategy and Plan

Risk Area / Specific Risk	Proposed Risk Response / Action
CATEGORY: Finance	
Item 210: Material supply cost increase	Hedge Long term fixed price supply
Item 214: Unavailable of labour	Training Lobby for law exemptions
Item 216: Budget underestimating	Contingency Incorporate risk into budget
Item 220: Lack of bidders	Contracting methodology Reduce bonding requirements Assume more risk (ACP)
Item 221: Unavailability of acceptable financing	Structured campaign for potential funding sources
Item 226: Inability to meet environmental requirements	Adequate EIS
Item 228: Contractor bankruptcy	Contract terms permitting ACP to take over equipment and personnel
Item 231: Cost overruns	See Item 210, 214, 220
Item 234: Unforeseen site conditions	Additional site investigation Purchase insurance
Item 235: Schedule changes	Partnering with contractor
Item 245: Misjudgement of price sensitivity	Re-evaluate market regulation
CATEGORY: Political	
Item 246: Referendum delay	Expedite board approval
Item 247: Clarity and mandate	Legal expert to assist in creation of mandate
Item 248: Poor communication structure	Hire good PR and election strategist
Item 249: Negotiate referendum	Same as item #248
Item 255: Government failure to act timely	Lobby government and congress
Item 258: Government interference	No solution
Item 263: Inability to restructure	Seek external qualified person to do the work
Item 264: Lack of expertise	Hire outside help
Item 270: Lack of public understanding	PR firm Allocate significant dollars
Item 271: Unavailability of local labour	Training program/lobby for law exemption
CATEGORY: Administration	
Item 9: Assignment of project controls responsibility	Develop project control plan identifying responsibilities and secure management approval

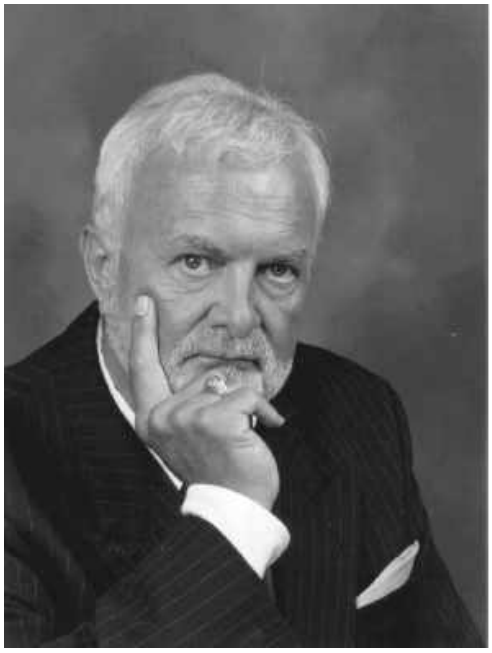
Item 14: Use of unrealistic estimates for project planning	Peer review to validate planning estimates
Item 16: imposition of target dates by senior admin/politicians	Provide realistic schedules to allow administrator to educate/inform BoD/Pols
Item 20: Project planning inexperience	Establish project management office and give high hierarchy authority
Item 34: Lack of authority of project management	Establish project management office and give high hierarchy authority
Item 42: Inadequate coordination of contractors by Project Manager	Develop and implement project management plan and contracts monitoring controls
Item 45: Lack of project management expertise	Project manager to instigate/arrange project management training
Item 48: Failure to complete environmental studies	Identify and schedule all required environmental studies and contract as necessary
CATEGORY: Operations	
Item 115: Water – dam overtopping; underestimating the inflow; picked the wrong dam type	Better hydrological assessment Increase to height Increase the spoil way capacity Increase the spoil way capacity of Gatun Lake Better design
Item 125: Under estimate transit time Item 126 as part of 125: F/E system rate; operating rate on gates; vessel positioning; malfunction of water saving basin; density currents; discharge currents	Consider these issues in design process Use physical and numerical models
CATEGORY: Design	
Item 139: Materials/insufficient supply (sand)	Sand manufacture Difficulty to quarry material deposits
Item 152: Performance incompatible with operations Item 160: Criteria: Lack of foresight	Proper lock size Miss a significant failure node
CATEGORY: Construction	
Item 285: Inadequate management of NGO's (environmental)	Ensure environmental consideration in design process Disseminate environmental sensitivity (publication, website, public meetings) Develop EIP early Show compliance
Item 291: Delay due to cash ACP flow problem (ACP and contractor) Item 301: Growth in quantities	Provide appropriate funding contingency Pre-qual of contractor finances Ensure reasonable payment terms Use lump sum contract Ensure site information as accurate as possible
Item 322: Global shortage	Consider alternative materials
Item 99: Bid/proposals higher than cost estimate	Do trend analysis to the design (verify if they are added or reduced cost) Peer review of cost estimates Pay for mock bid Accurate detail engineering estimate
Item 324: Delivery delays	Ensure excess float time

APPENDICES

Appendix 1 – Summary Resume of Professor David Stevens

Dr David Stevens is generally regarded as one of the worlds leading facilitators, particularly in value management, value engineering, risk management, partnering, project alliancing and strategic planning.

He has worked on major projects including hospitals, airports, railways, highways, retail and commercial buildings. He has carried out over 1000 workshops worldwide over the past two decades. Railway clients include London Underground, Mass Transit Railway Corporation Hong Kong, Taiwan High Speed Rail Corporation, and the railway corporations in most states of Australia. Hospital clients include major and teaching hospitals in the UK, Hong Kong, New Zealand and Australia. Other clients include Kimberly Clarke, Department of Defence, Australian State and Local Government Departments, and most divisions of the Hong Kong Government. His facilitation in strategic planning has been at board level for a wide range of public and private companies.



Relevant work preceding Panama third lane locks project include deepening of the Port of Melbourne to carry post panamax vessels, creation of "Trash Island" in Victoria Harbour in Hong Kong and major land reclamation projects in Hong Kong with the concomitant navigational aspects.

His academic qualifications include two Masters degrees and a PhD in Psychology; he is currently undertaking a second PhD in Engineering. The framework and theoretical basis for his facilitation techniques are derived from his specialization as an organizational psychologist. He is a member of the Australian Psychological Society and the College of Organizational Psychologists. Dr Stevens is an Adjunct Professor at the College of Engineering and Industrial Design at the University of Western Sydney and is currently Chairman of the Enterprise and Public Relations Committee. He has acted as an external examiner of doctoral level theses. He has authored 5 books, one of which is a major international text published by McGraw Hill. He has held several board positions and has been Chairman of an Australian Standards Committee.

Professor Stevens has been cited in Barons and Marquis international Who's Who on numerous occasions for his work in group problem solving and participatory decision making, as well as the IBC Cambridge's 2000 outstanding scientists of the 20th Century. He is listed in the Asia Top 500 Leaders for the year 2000.

Social Enterprise Consulting

Social Enterprise Consulting is a newly formed division of Cumberland Industries Limited (CIL), a not-for-profit organization providing training and employment for people with disabilities. Recently Dr Stevens joined CIL's senior executive team as Head, Marketing and Strategic Development. Dr Stevens also acts as the Director for Social Enterprise Consulting, bedding in this new division.

Social Enterprise Consulting came from two sources. One was to respond to the increasing awareness of Triple Bottom Line Accountability and Corporate Social Responsibility (CSR) by

corporations. Many corporations now wish to have a statement on their CSR in their annual reports. In the United States there has been a distinct trend where market capitalisation and share prices have increased in line with public statements about CSR by listed companies. The second source is to actually produce more revenue to enable additional resources for people with disabilities.

The essence of Social Enterprise Consulting is a register of highly experienced and highly credentialed consultants. Through these registered consultants Social Enterprise Consulting is able to offer a broad range of expertise relevant to corporate and government needs. Dr Stevens also offers his services as a consultant through Social Enterprise Consulting.

Appendix 2– Individual Contacts

Name	Organisation/Title	Email
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	Project	
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Eberhard Grimm	Bundesaustalt für Wasserbau	Eberhard.grimm@baw.de
Jean Louis Maathurin	CPP	j.mathurin@cnr.tm.fr
John Roberts Larry Dalton	PB; Construction Manager, Taiwan High-Speed Rail Project USACE	Robertsjoh@pbworld.com Larry.l.Dalton@lrl02.usace.army.mil
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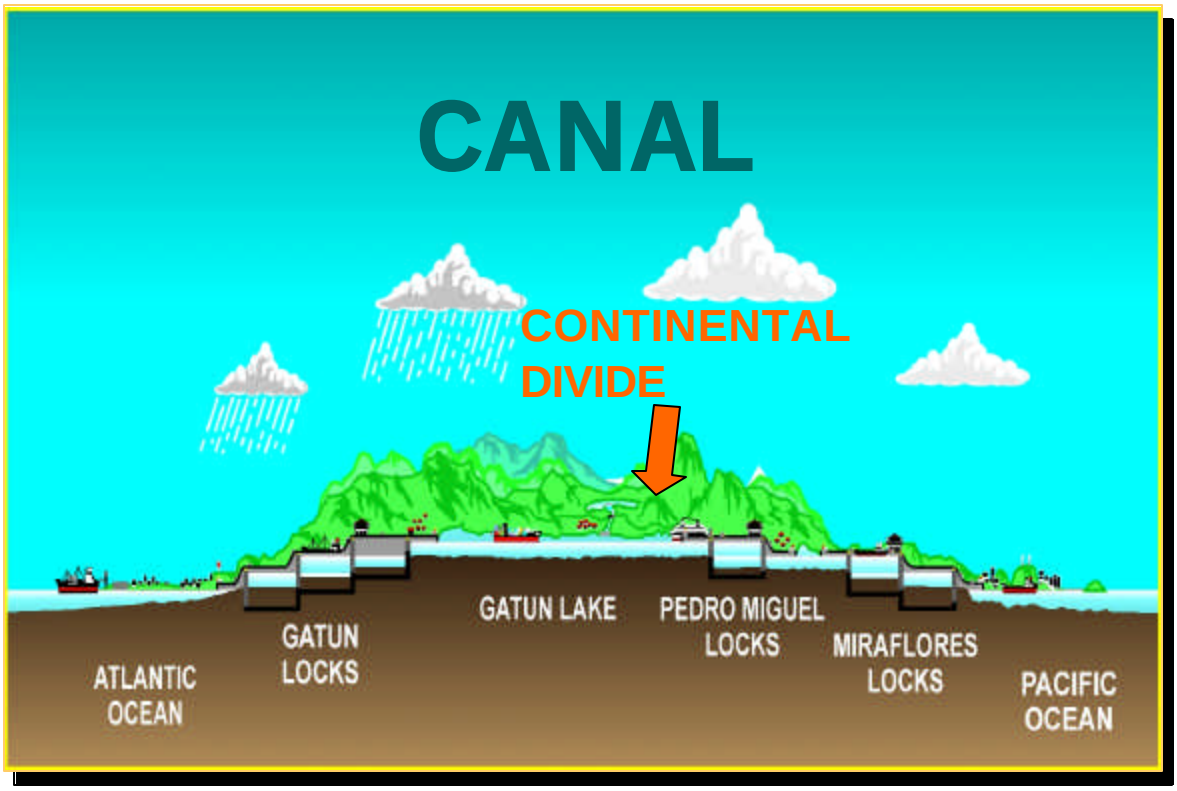
Caroline Shindlair Raúl Brostella	Marketing Assistant, Cumberland Industries Limited Pilot – ACP	carolines@cumbind.com.au Mrtc-rbr@pancanal.com
Arcelio Hartley	Canal Operations Captain – ACP – ACP	MRT@pancanal.com
Eduardo Hevia	Superintendent Pacific Locks – ACP	MRLP@pancanal.com
Max Newman	Tug Captain, Chief Tugs Branch - ACP	MRRT@pancanal.com
Enrique Sánchez	Head – Contracting Division - ACP	Esanchez@pancala.com
Boris Moreno	Engineer - ACP	Bmoreno@pancanal.com

Appendix 3 - Overview of Presentations

Panama Canal Operations Brief – Jorge L Quijano

- The Panama Canal operates 24 hours, 365 days a year
- Average transits: 38 per day
- Can sustain an average of 40 transits per day depending on ship mix
- Transit time averages less than 11 hours

Canal Profile



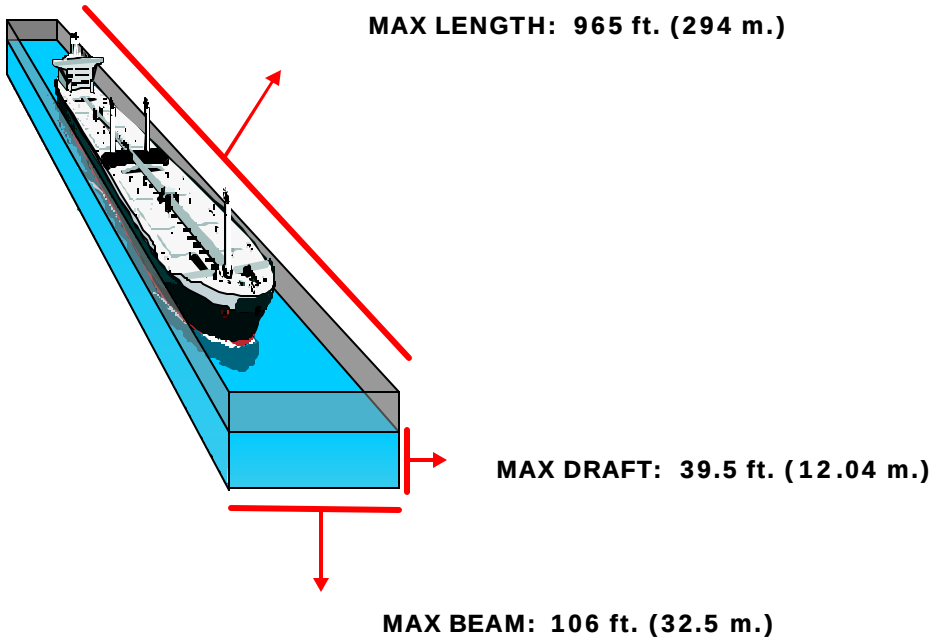
50 Miles (80 km)

24 hours Canal Waters Time

Types of vessels and Cargo

- Chemical tankers
- Container
- Nuclear submarines
- LPG
- Crude or product tankers
- Dedicated radioactive cargo transport

Panamax Vessel



Impact of type and size of vessel

<80'Beam

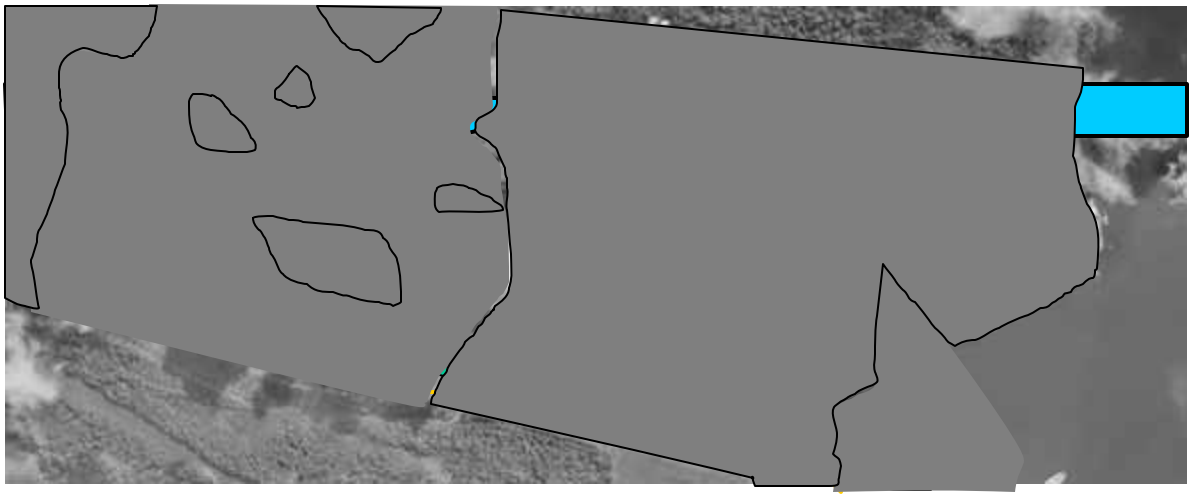
- Locks through Gatun in 1 hour
- Requires 4 locomotives
- 3 tug assistances
- 1 pilot
- No transit restriction

Panamax

- Locks through Gatun in 2 hours
- Requires 6-8 locomotives
- 7-10 tug assistances
- 2-3 Pilot
- Daylight and clear cut transit

Site Conditions – Luis Alfaro

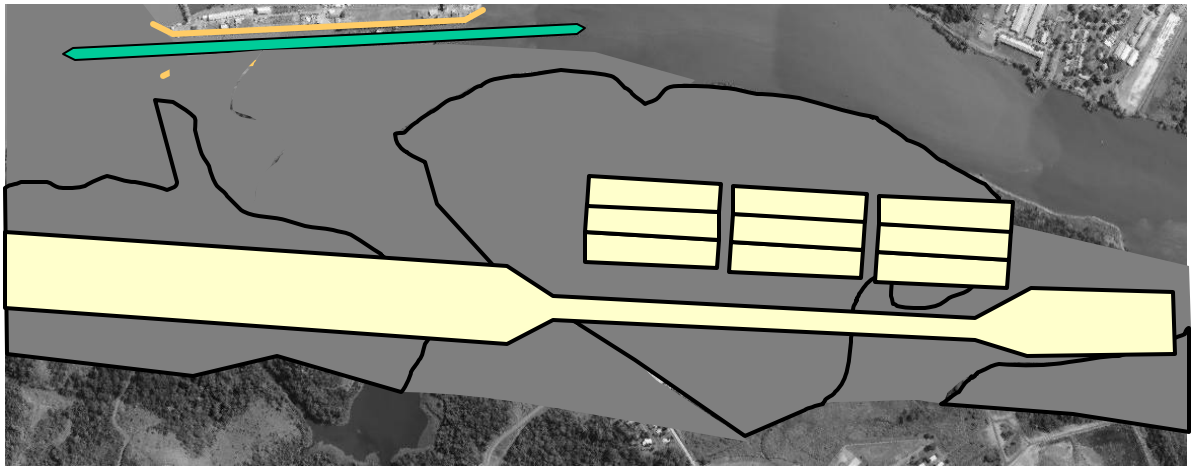
Geologic map for Atlantic Lock



Gatún Formation (soft rock)

Holocene Sediments (mostly alluvium)

Geographic map for Pacific Locks



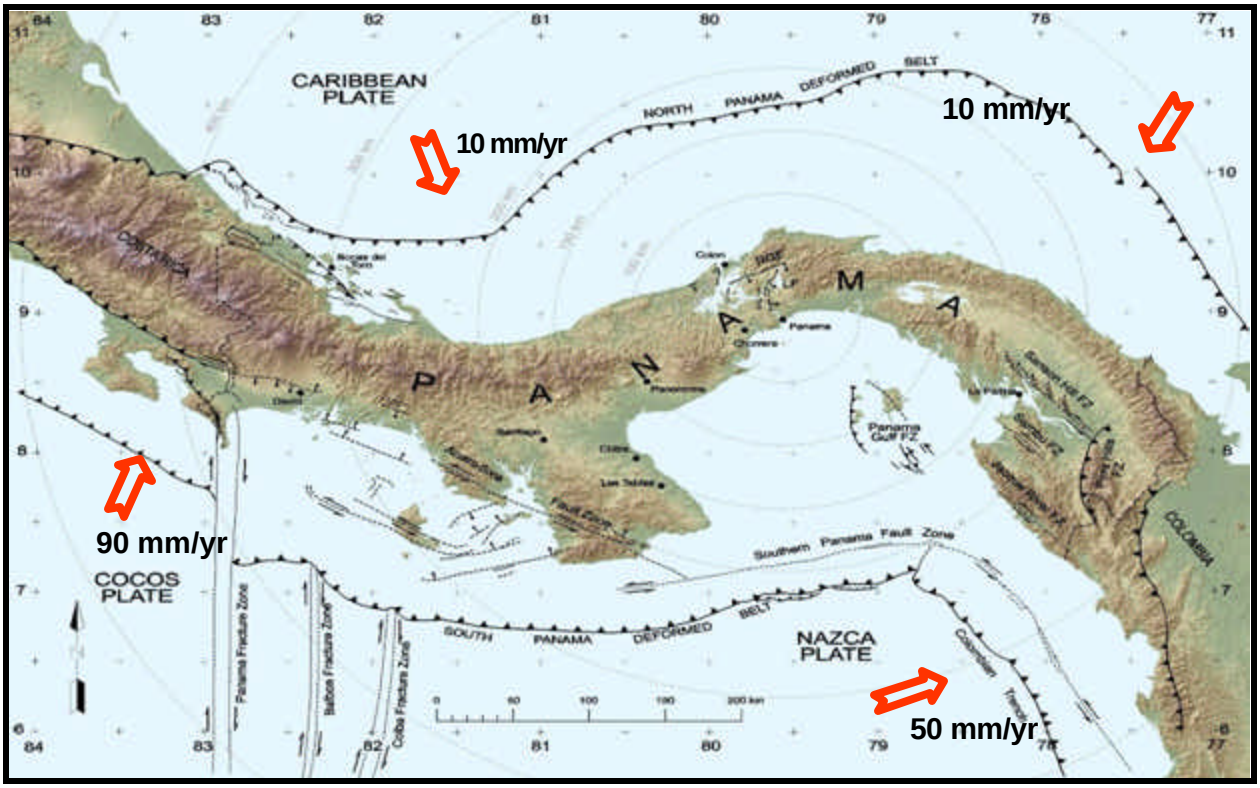
Basalt (hard rock)

Pedro Miguel Agglomerate (medium to hard rock)

Cucaracha Formation (soft rock)

La Boca Formation (soft rock)

Tectonic map of Panama

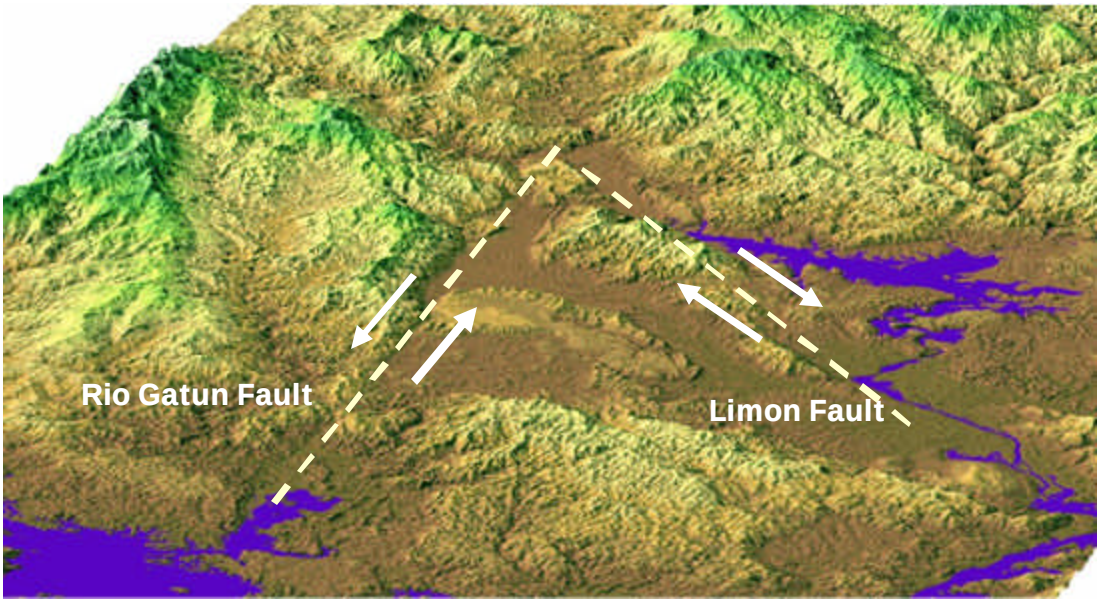


Current design ground accelerations

Return (years)	Miraflores Locks PGA (g)	Gatun PGA (g)	Gatun Dam PGA (g)
1,000	0.22	0.22	0.22
5,000	0.4	0.41	0.41
10,000	-		0.51

- 5,000 years corresponds to ground motions applicable to new lock structures
- 10,000 year corresponds to existing earth Dams (Gatun and some saddle dams).

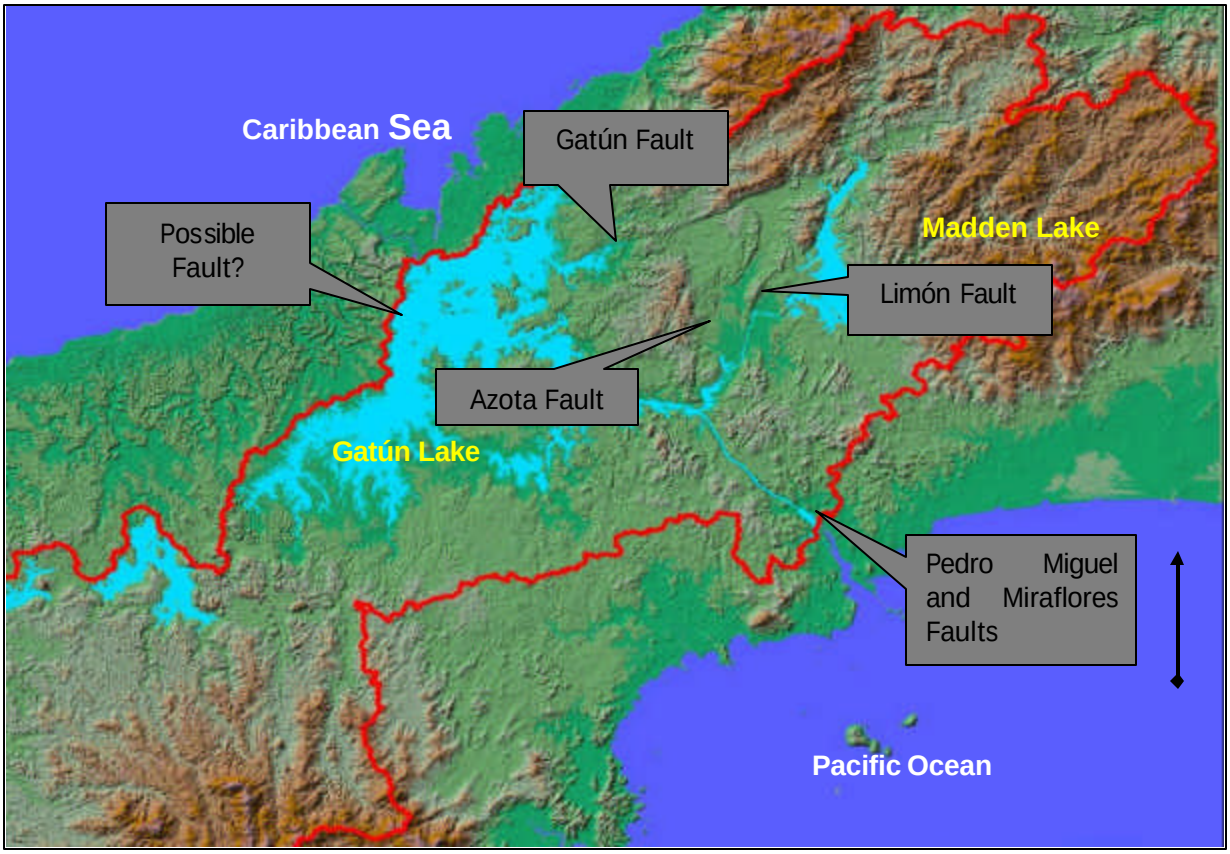
Investigation of the Rio Gatun and Limon Faults



Procedure for defining revised ground motions

Activity	Effort/Cost	Potential Impact	Category*
(a) Identify potential active faults that might cross footprint of critical facilities	Med.	High	1
(b) Investigate existing geodetic data	Low	High	1
(c) Collect existing strong motion records from the 2002 Bayano earthquake	Low	Moderate	1
(d) Review of historical earthquakes	Low	High	1
(e) Additional studies of Gatún and Limón for slip rate, recurrence and slip per event	Med.	High	2
(f) Estimate expected ground motion distribution	Low	Moderate	2
(g) New GPS network	Med./High	High (long-term)	2

Main Faults in the Canal Area



Recommended risk levels from SAB-2

The ACP's Seismic Advisory Board recommended (August 2005) that the output values from the Probabilistic Seismic Hazard Assessment, corresponding to the following risk levels, be used be used for evaluating existing critical structures and designing new ones:

1/1,000 per year	Operating Basis Earthquake
1/5,000 per year	Safe Shutdown Earthquake
1/10,000 per year	Preservation of Gatún and Alhajuela Lakes

Civil Works – Jose de Regge

Triple lift lock system

Design parameters

- Lock dimensions (W-L-D)
- Geotechnical parameters (PAC/ATL)
- Site specific (tides, seismic activity)
- Culvert sizes (BxH = 9x6)

Selection of structure type

- Quantity type – reinforced concrete
- (lock walls, lock heads, entrance walls) – open excavations
- No lock bottom floors
- Culvert integrated in walls

Water spring basins

- Excavations (ATL/PAC)
- Conduits (BxH)
- Valve chambers

Gate systems/Machinery – Rik Thomas

- Rolling gates – barrow type proven system
- L gates
- Floating – collision
- Maintenance
  - Bulkhead
  - Tunnel
  - Dry lock
- Mechanism
  - Gate cables and drums
  - Valves pistons
  - Tugs – width of the lock
- Standardization

Hydraulic F/E system conception – Sebastien Roux

Objectives

- Allowing ships to pass a lift of ~30 m in a secure way
- Allowing the crossing of at least almost 15 ships per day
- Allowing the crossing of Post Panamax type vessels

Guidelines

- Water consumption
- Salinity
- System reliability
- System durability
- Safety of the ships during lockage
- Easiness of maintenance
- Investment costs

Main stages

- Review of the different F/E systems and multicriteria analysis
- Analysis of 2 concepts of F/E circuits
- Study and comparisons of 3 arrangements (locks/saving basins)
- Analysis of the interest of an additional water recycling system (pumps + reservoir)
- Harmonization of Atlantic and Pacific locks F/E systems

Main results reached by calculation

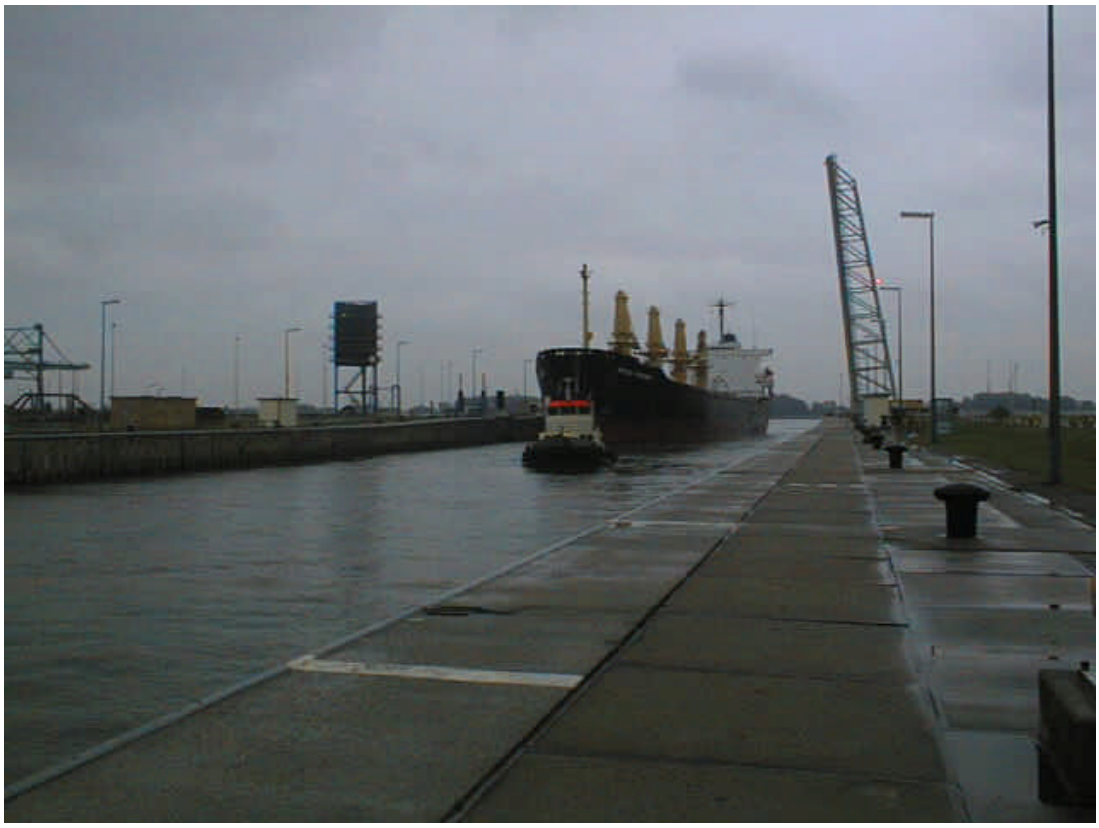
- Extreme water levels and heads
- Water consumption
- Water levels, flow discharge, velocity vs time
- Filling/emptying times
- Hawsers forces assessment
- Daily number of ships lockage

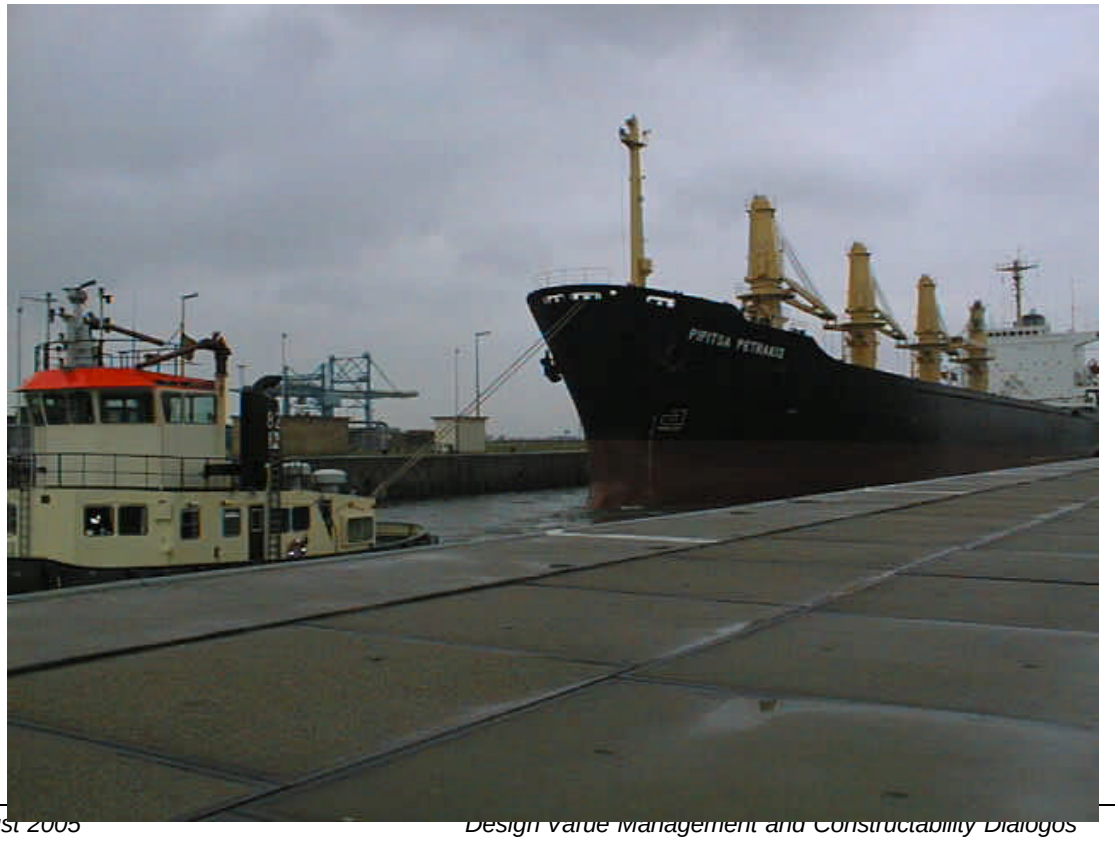
Vessel positioning – Captain Arcelio Hartley

In October, 2002 a group of Panama Canal Operations employees traveled to Belgium to visit operations at Post Panamax Locks in the Port of Antwerp.

The group was conformed of:

- Two Canal Pilots
- Two Tugboat Captains
- Locks Maintenance Engineer
- Multidisciplinary Engineer





Main recommendation

Conduct a field test with a proportioned vessel to corroborate the feasibility of this system in multiple lift locks

Based on results of observations and test results, we are proposing a future locks process similar to the following:

Water Supply – Jorge de la Guardia

Weather

- Wet/dry seasons
- Wet/dry years

Canal Watershed water uses

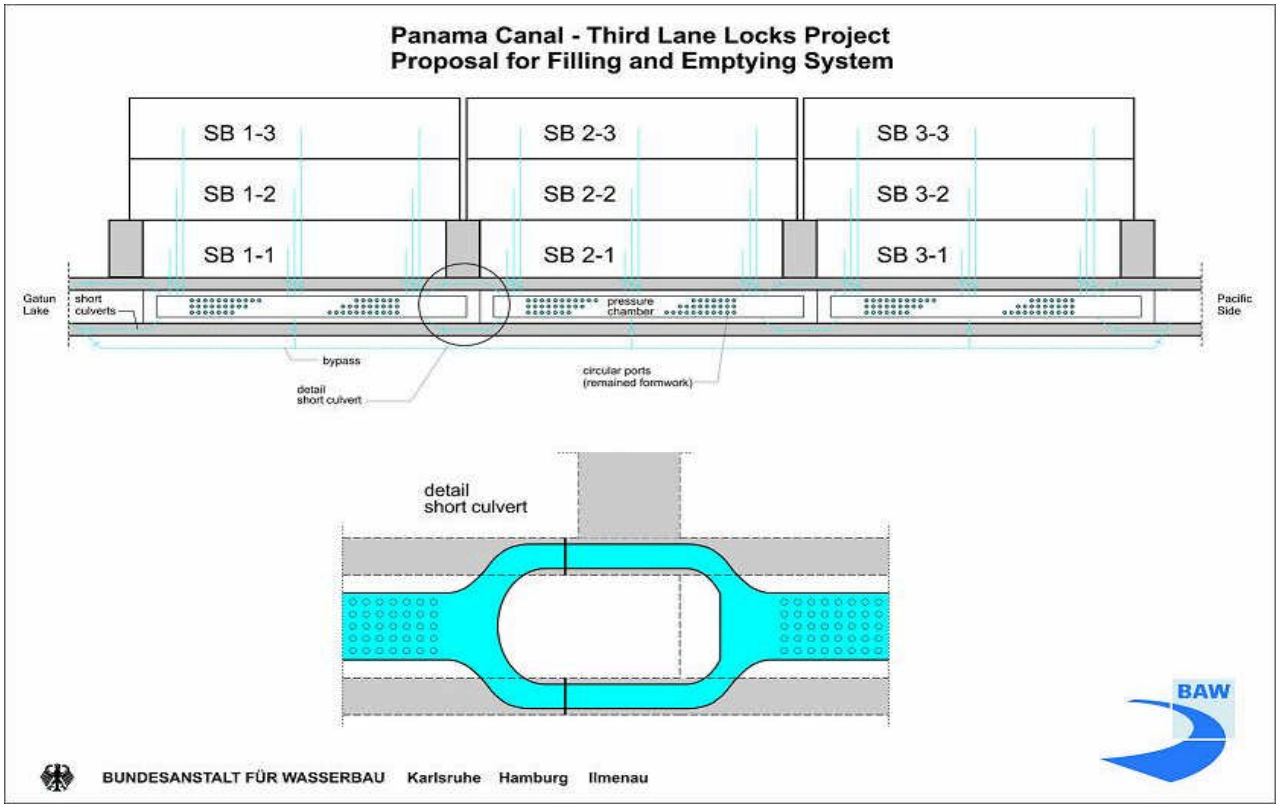
- Human consumption
- Industrial uses
- Shipping

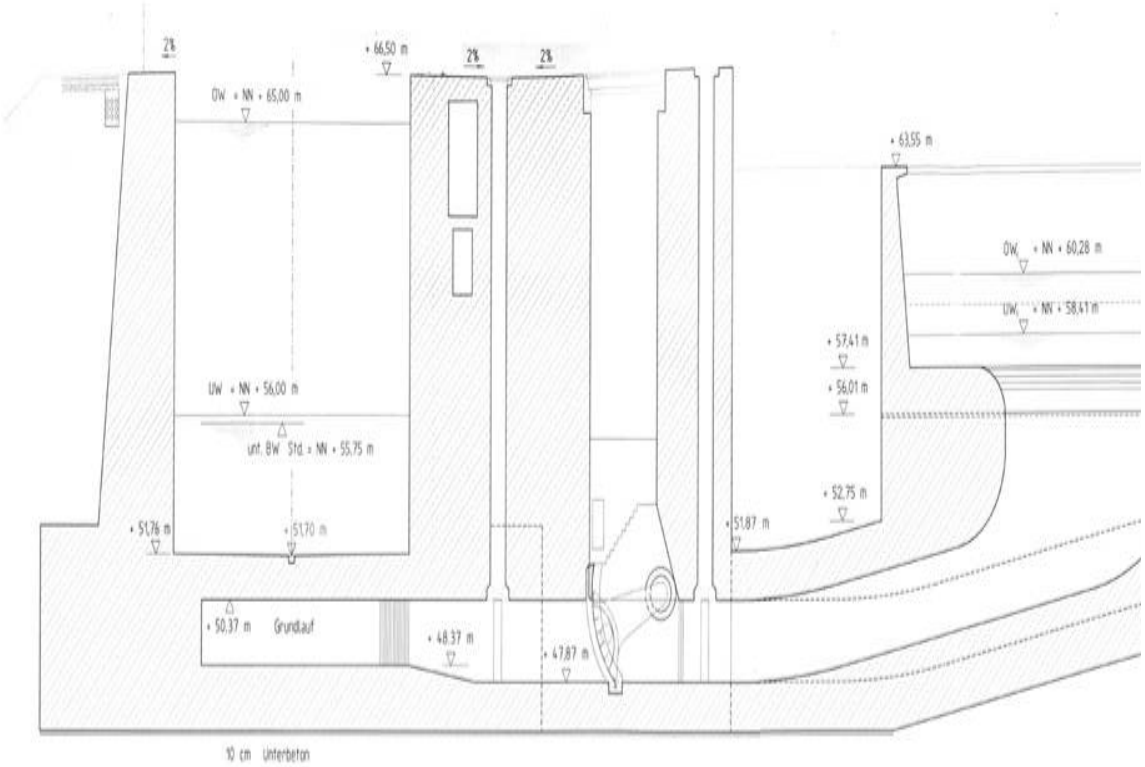
Water supply alternatives

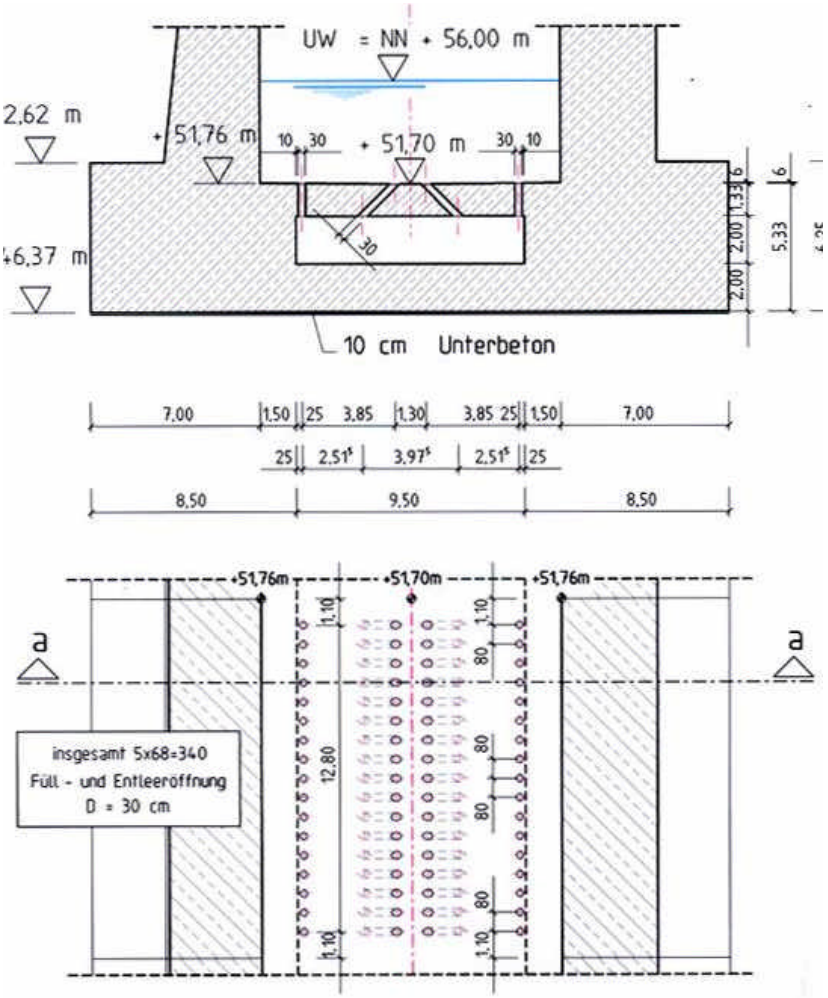
- Deepening of navigational channels
- Increased maximum level of Gatun Lake
- External sources
- Water saving basins

Additional Presentations

Presentation of an Alternative System of Filling/Emptying from the Bottom by Bernhard Kemnitz and Eberhard Grimm (Bundesaustalt fur Wasserbau)

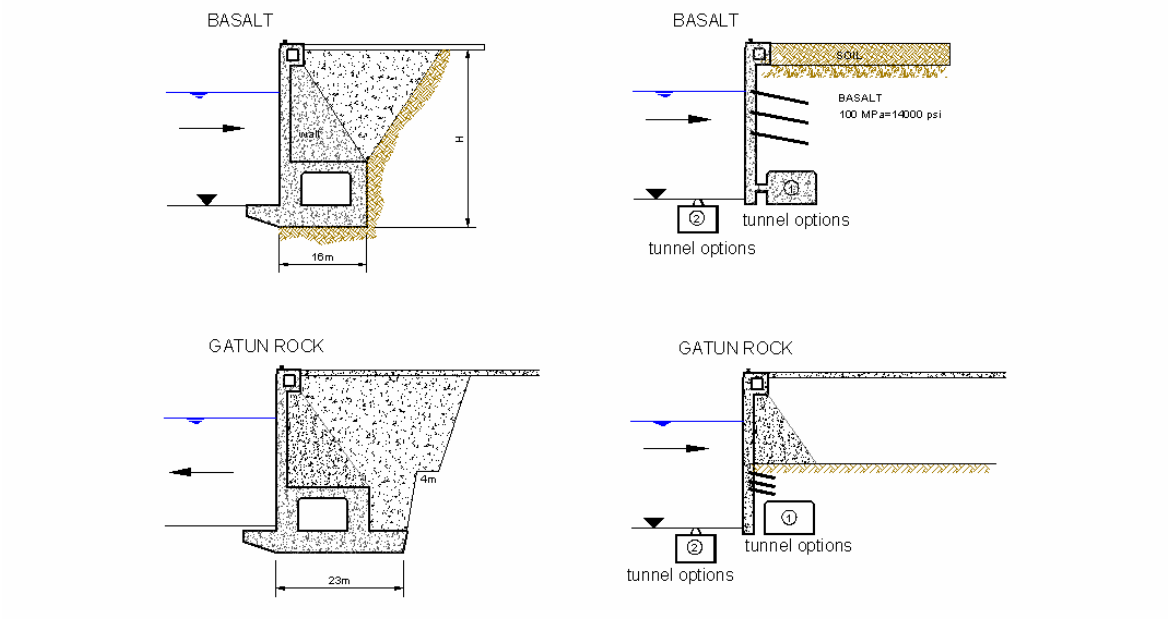


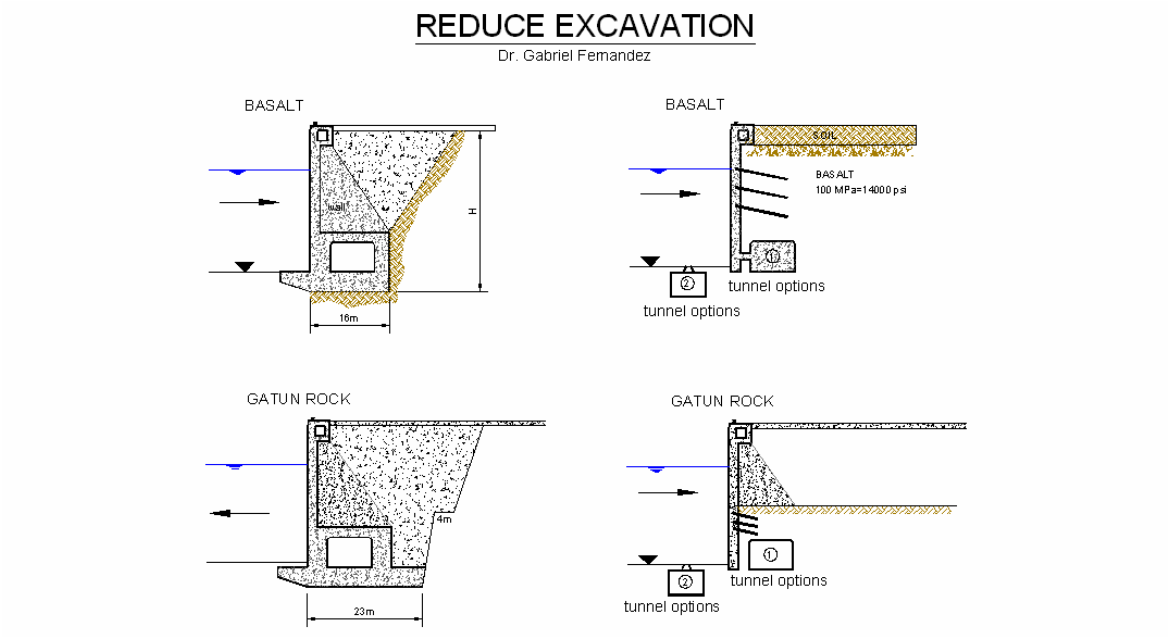



UW = NN + 56,00 m
2,62 m
+ 51,76 m
+ 51,70 m
10 30
30 10
30
6,37 m
10 cm Unterbeton
7,00 1,50 25 3,85 1,30 3,85 25 1,50 7,00
25 2,51 3,97 2,51 25
8,50 9,50 8,50
+51,76m
+51,70m
+51,76m
a
a
insgesamt 5x68=340
Füll - und Entleeröffnung
D = 30 cm
12,80
1,10
80

Grundriss

Presentation of Alternative Concepts for Lock Wall Designs by Dr Gabriel Fernandez (University of Illinois)

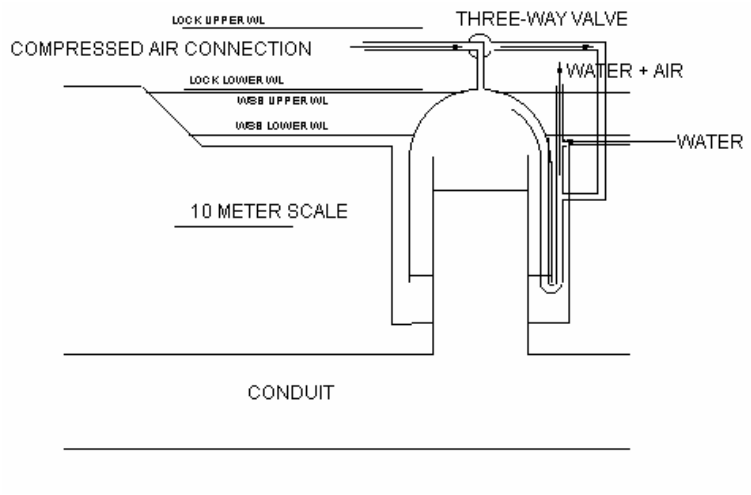




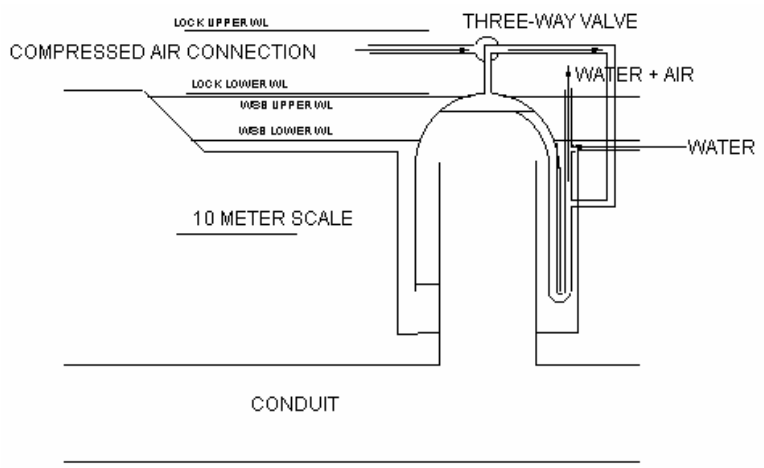
Presentation of Alternative Valves for the Water Saving Basins having No Moving Parts by Jens Korsgaard

Located in water saving basin (wsb)
Works on siphon principle
Siphon active when compressed air released
Closes at low flow when compresses air is applied

Valve shown closed



Valve shown open

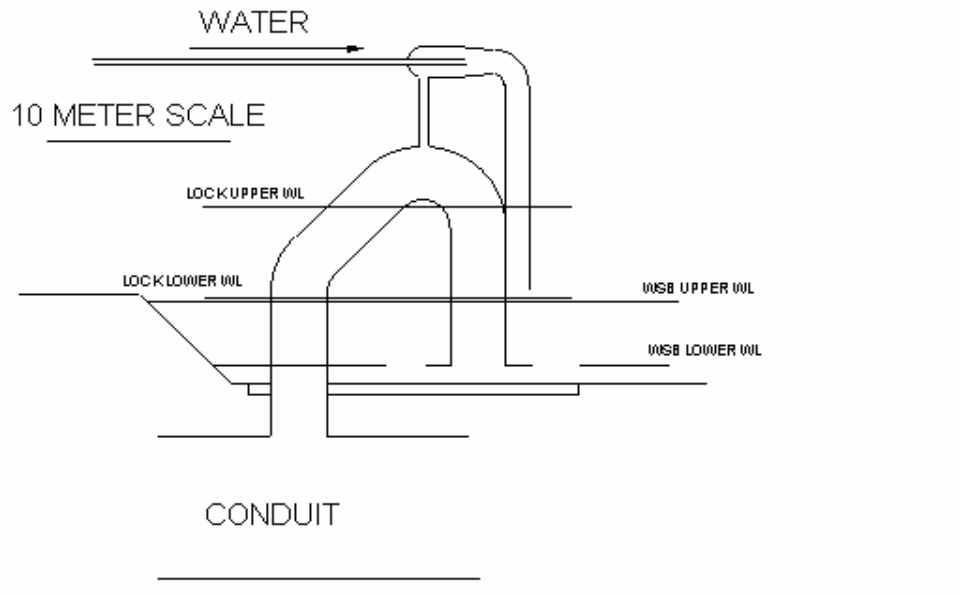


Advantages
Opens fully very fast <10 seconds
Only moving part 24" – 3-way air valve
All 3 wsb connected to one common culvert
Eliminates valve chamber and mechanical valves
Subjected only to very low external
Hydrostatic collapse pressure
Reduces lock time

Disadvantages

Cannot be closed while flowing fast
Opens if compressed air pressure is lost
Possible accumulation of sediments in well
Relatively high flow resistance
May increase forces on ships in the lock
May open by transients in conduit

Version Using Water Instead of Compressed Air
Siphon is working whenever water flows in air ejector pump.
Closes when water to air ejector is shut off



Advantages
Extremely reliable
Maintenance almost never required
All 3 wsb connected to one common culvert
Eliminates valve chamber and mechanical valves
Low flow resistance

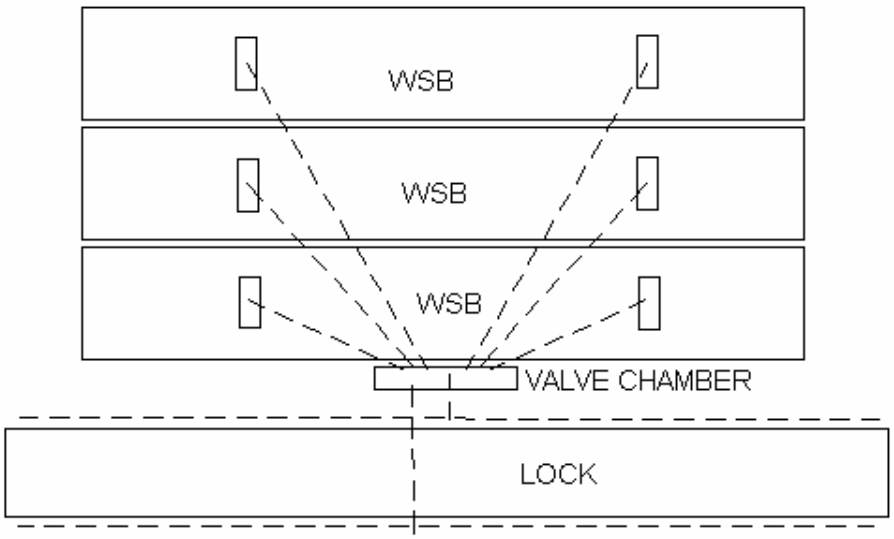
Disadvantages
Pipe diameter limited to 3 meters
6 to 8 parallel units required for each valve
Subject to high external collapse pressure
Possible cavitation at top
Water use increased by 1 to 2 percent
Works only for limited height between water levels

General comments

Siphon lock valves exist in at least 11 locks in Germany.

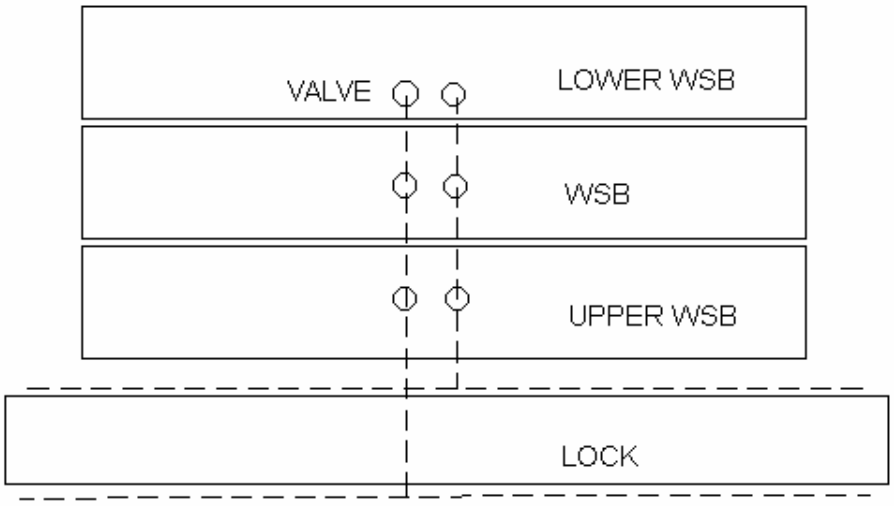
This is a proven system that reduces required lengths of conduit by about 2500 meters siphon operated by air pressure requires 1000 kw air compressor at each set of locks for security duplicate compressed air system siphon operated by water may require an elevated source of

water for upper lock system all parts that may require maintenance are above the water permits moving water saving basin 40 meters closer to lock chamber



Existing proposed system (8/05)

One culvert each side of lock
Two culverts from each water saving basin to valve
Chamber – six side culverts total
Six mechanical valves
Note no space required for valve chamber



Proposed siphon system

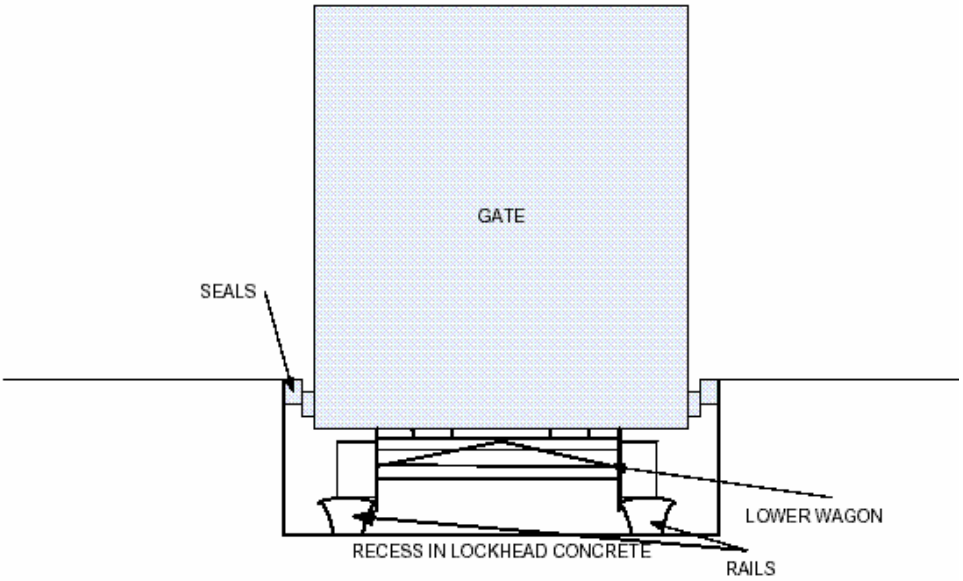
One culvert each side of lock
Two culverts only to water saving basin – two side
Culverts total

No valve chamber
Six siphon valves
Note water saving basin closer to lock chamber

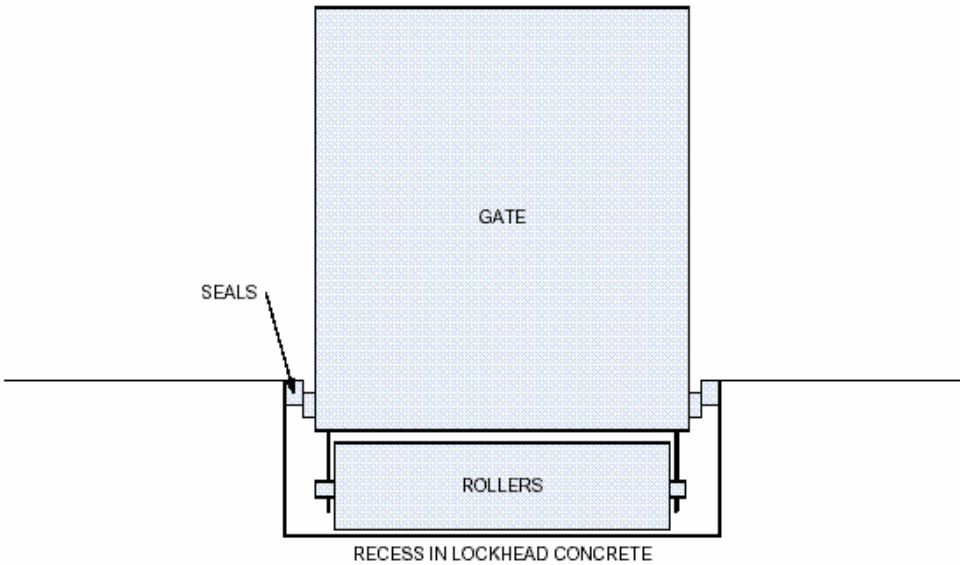
Presentation of Alternative Roller Gate Transport to Avoid Rails in the Lock Chamber

Suggested design of the gate transport using rollers running directly inside the lockhead recess instead of the rail-mounted lower wagon. Rollers mounted on brackets forming an integral part of the gates themselves.

VM Proposal – Eliminate rails and lower wagon for rolling gates



EXISTING DESIGN



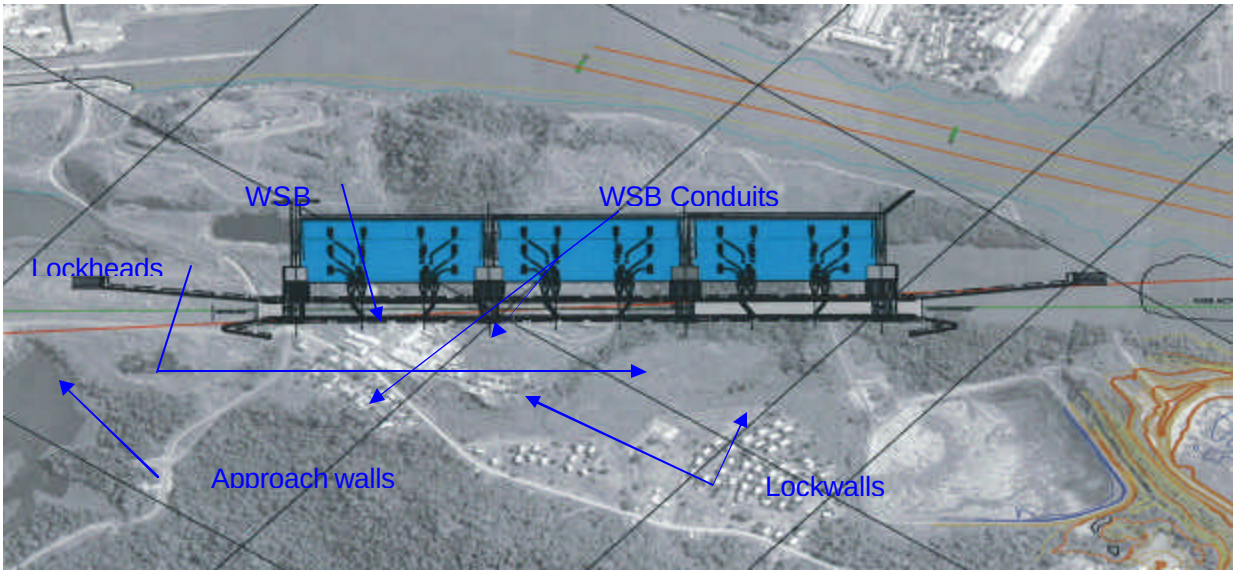
SUGGESTED ALTERNATIVE
WITHOUT RAILS INSIDE LOCK
CHAMBER

Constructability Dialogos Workshop Presentations

Cheryl George – Construction methodology and material supply

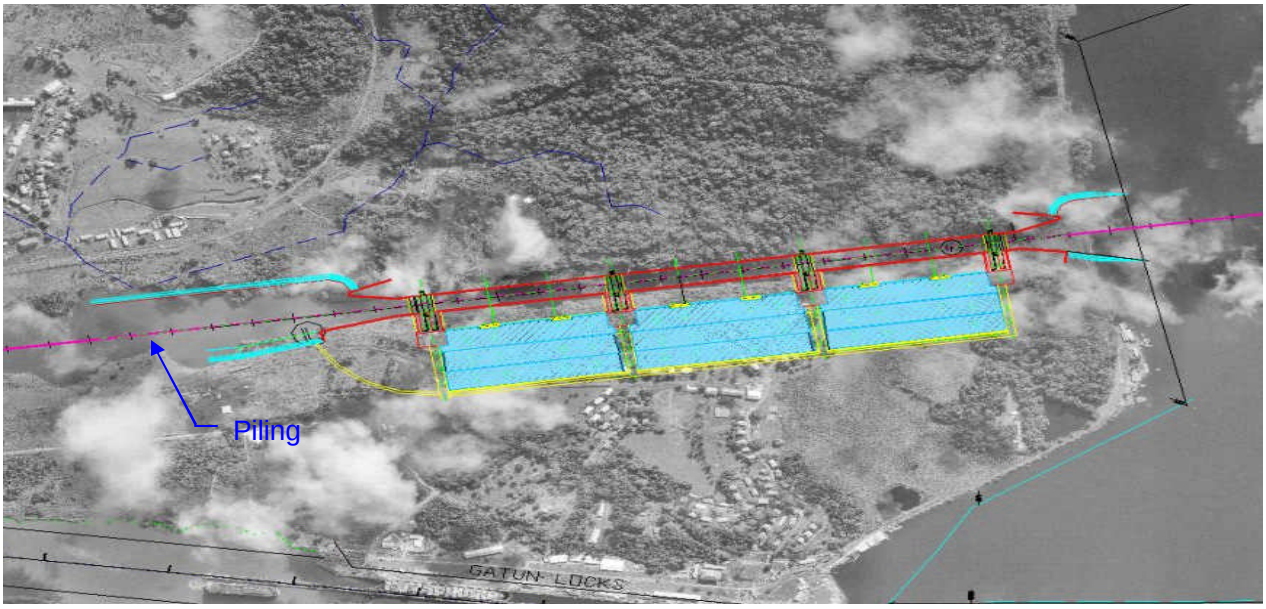
Pacific

Pacific – 3 water saving basins

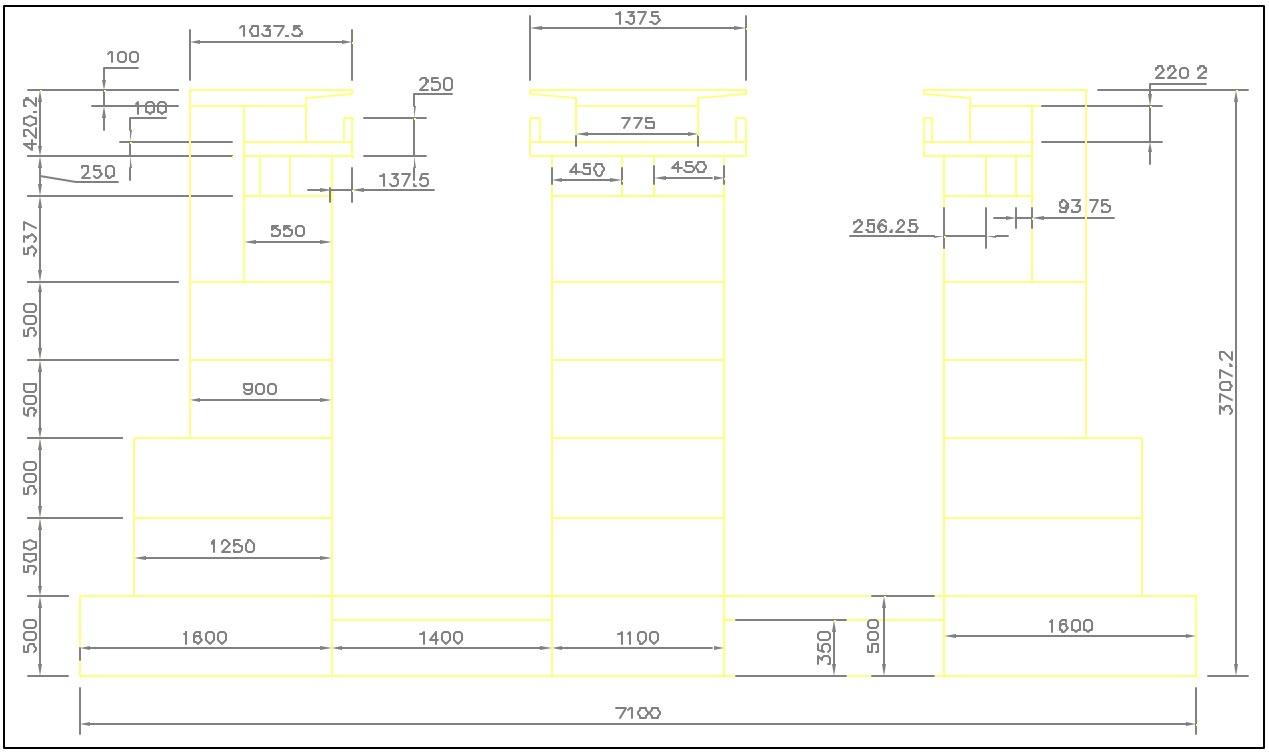


Atlantic

Atlantic – 3 water saving basins



Lockhead


1037.5
1375
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250
220.2
100
420.2
775
250
137.5
450
450
93.75
256.25
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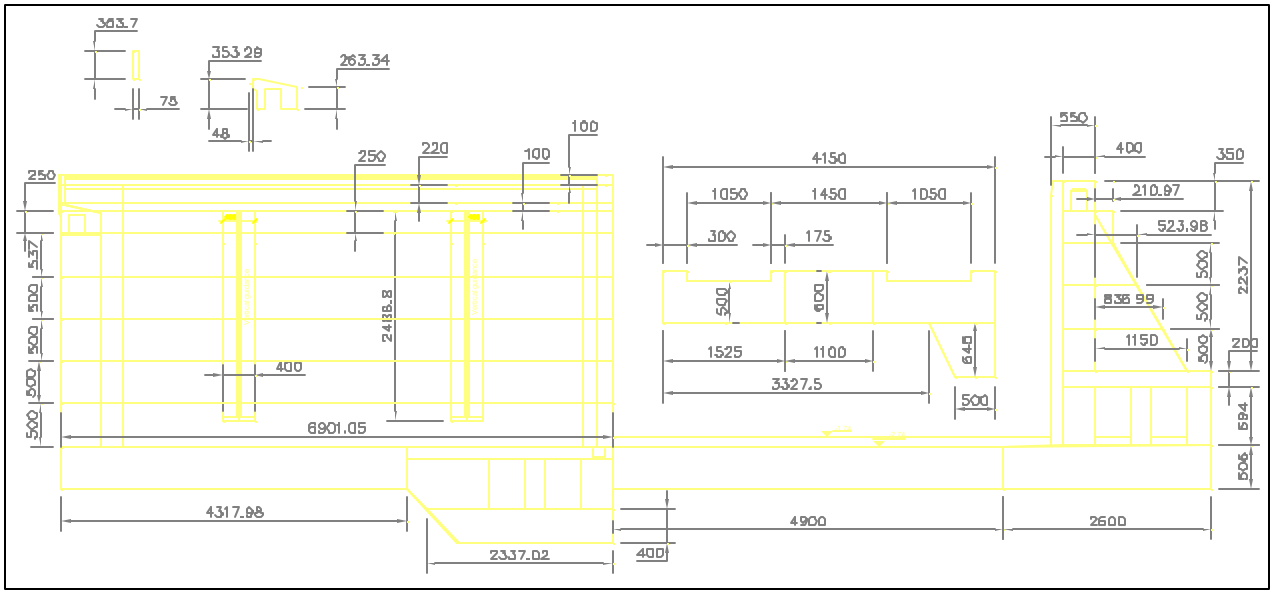
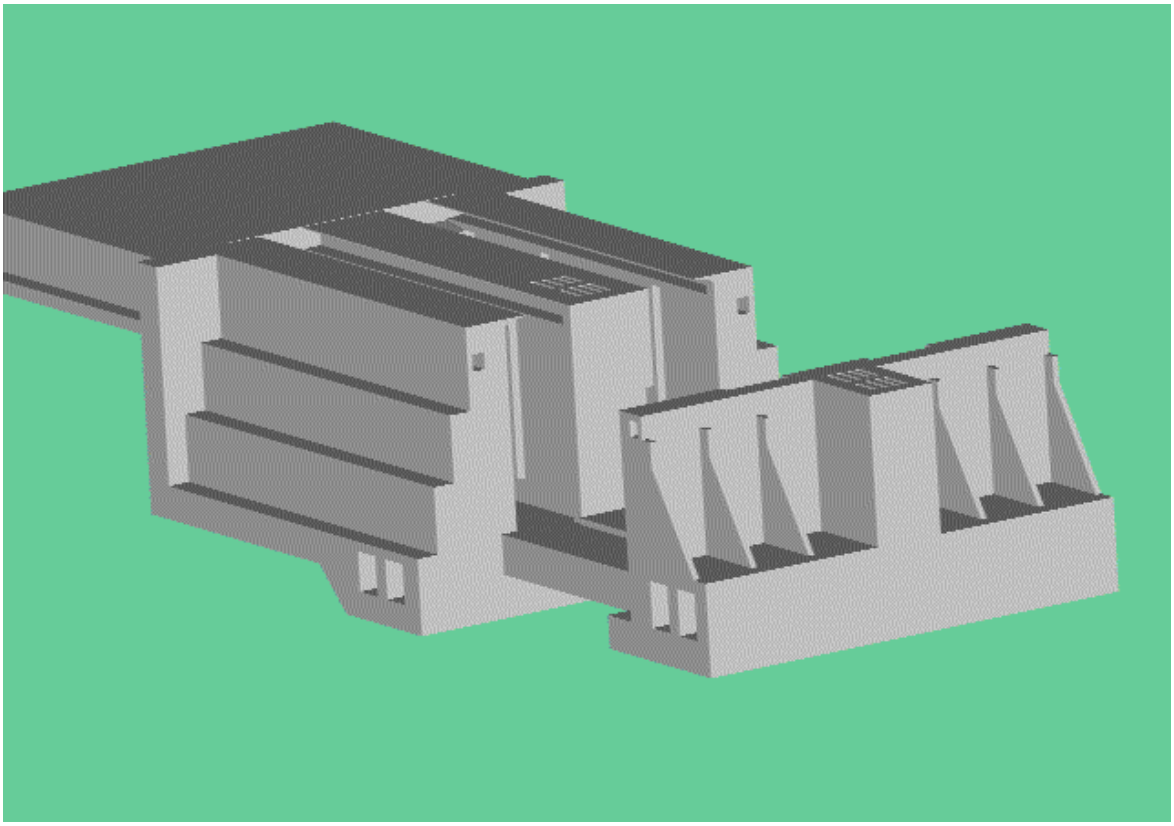
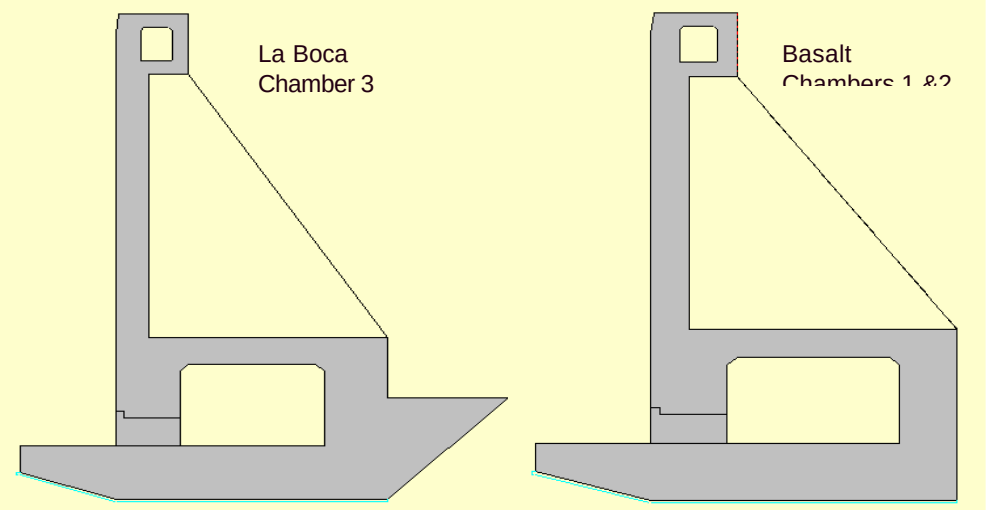
1400
1100
350
500
1600
7100


363.7
353.28
263.34
75
48
250
220
100
100
250
4150
550
400
350
1050
1450
1050
210.97
300
175
523.98
537
500
500
500
500
500
2438.8
500
600
500
2237
836.99
500
1150
500
200
400
1525
1100
645
3327.5
500
6901.05
594
506
4317.98
4900
2600
2337.02
400

		No. 1	No. 2	No. 3	No. 4		Total
Pacific		97,547	137,269	137,269	144,703		516,78
Atlantic		97,547	137,270	137,270	136,861		508,94

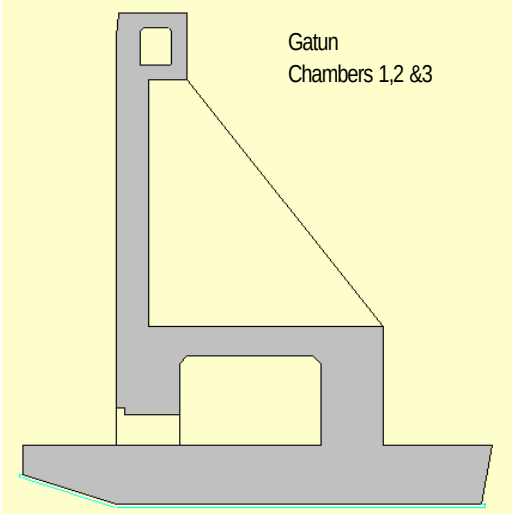


Lockwalls – Pacific



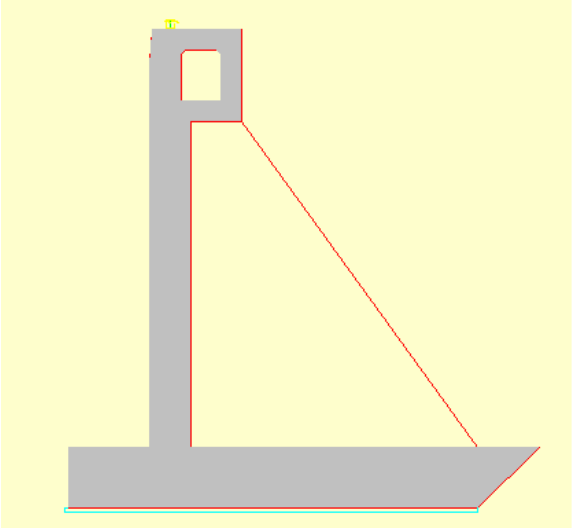
		No. 1	No. 2	No. 3		Total
Volume		145.464	145.398	175.687		466.549

Lockwalls – Atlantic



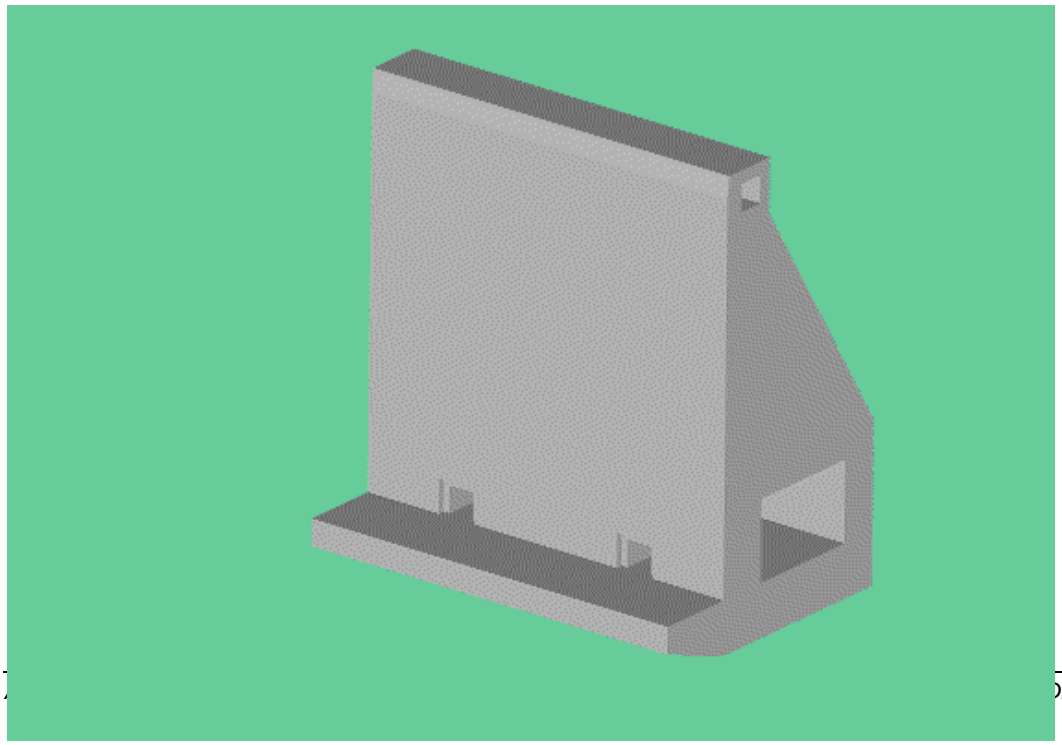
		No. 1	No. 2	No. 3		Total
Volume		229,662	202,385	228,651		660,698

Approach walls

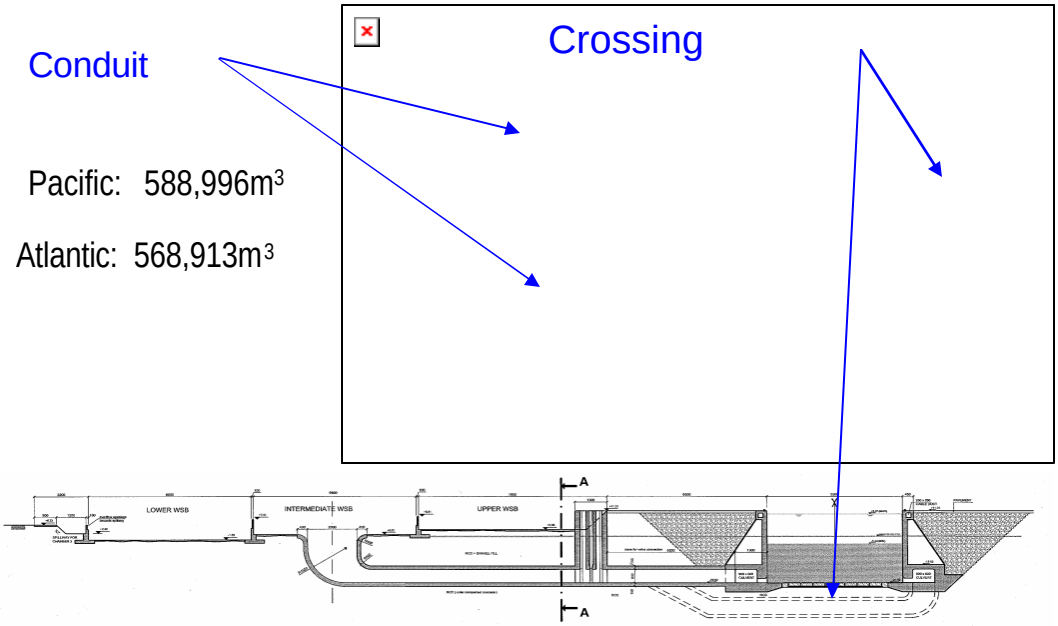


		Forebay	Tailbay		Total
Pacific (m^3)		79,238	90,354		169,592
Atlantic (m^3)		42,262	53,146		95,408

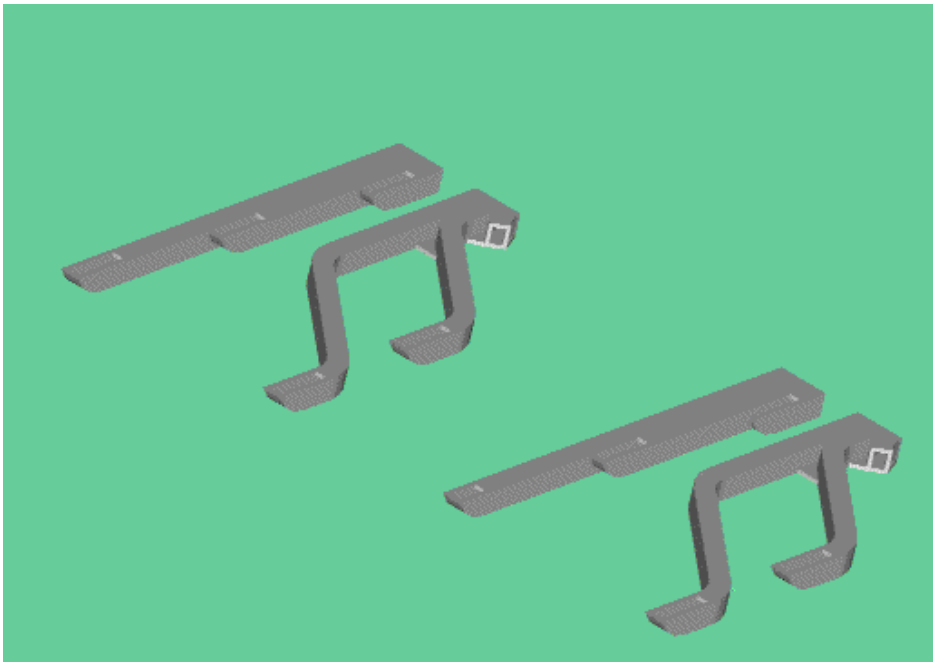
Lockwall

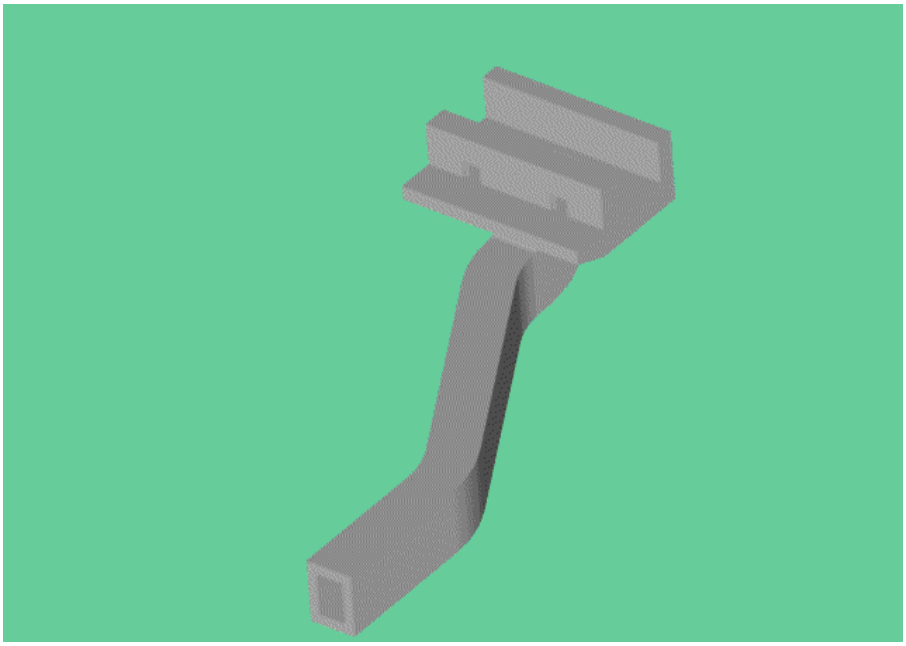


Water Saving Basins

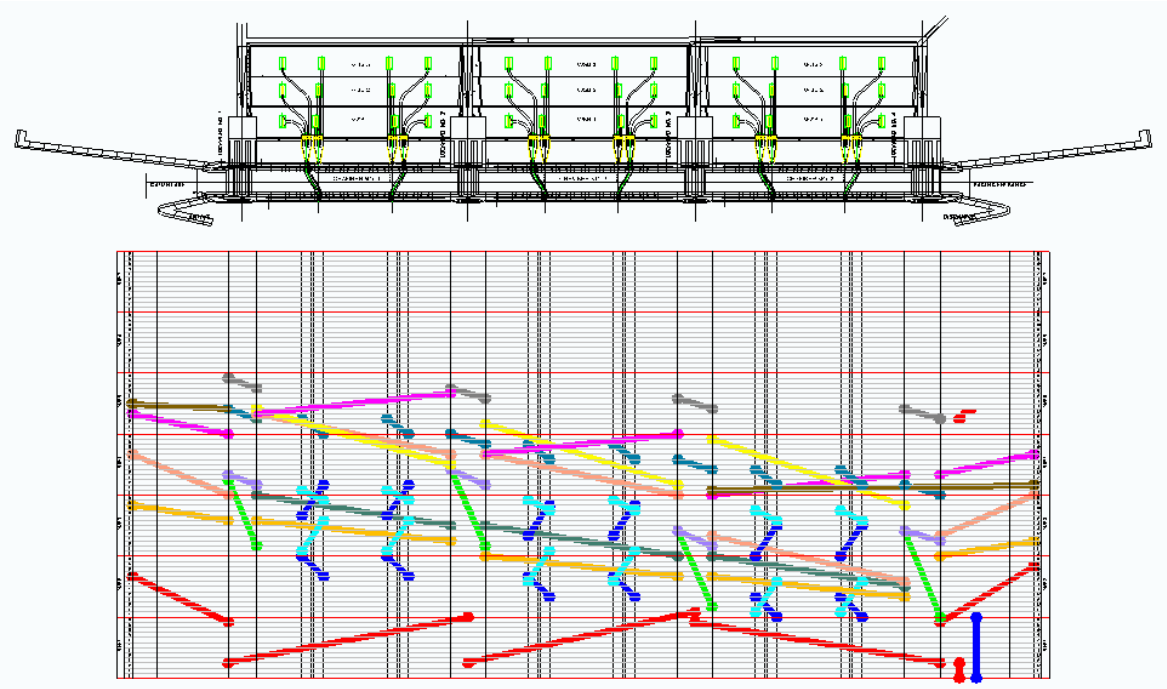


Conduit

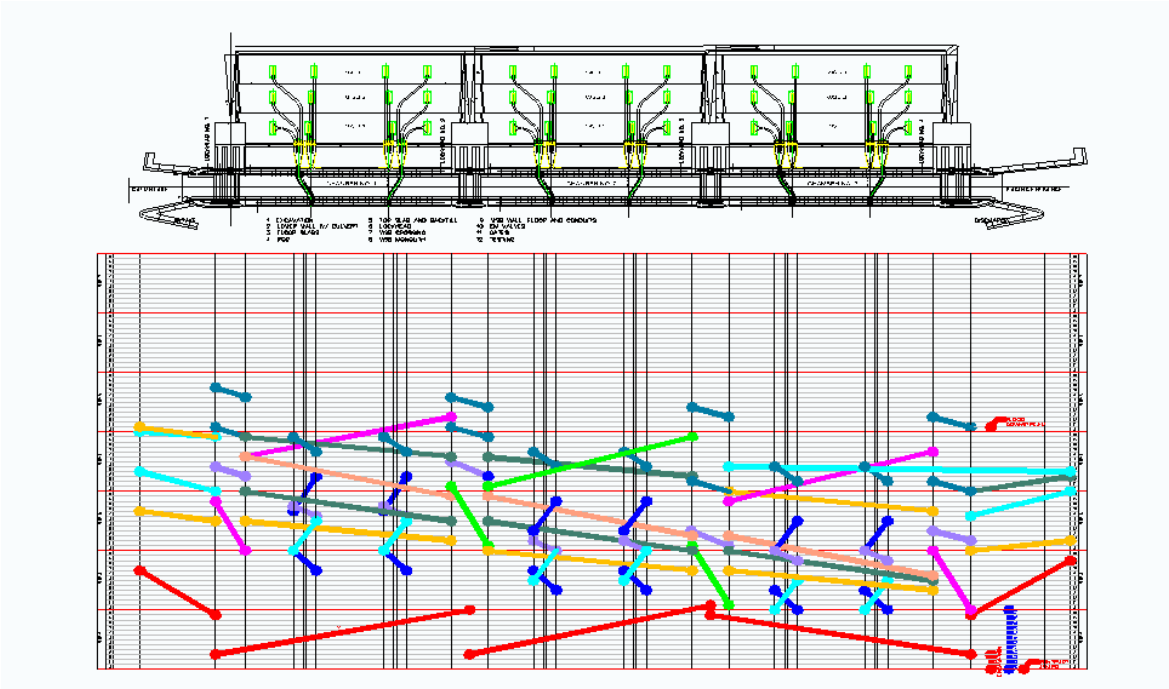




Pacific Schedule



Atlantic Schedule



Plants

- Concrete Batch/Mix: 2 - 300 m^3 per lock
- Aggregate Crushing: 1 – 1,000 ton per lock
- Ice: 1 – 1,000 ton per lock
- Aggregate Pre-cooling: 1 – 850 ton per lock

Equipment

- Pumps: 80 m^3/hr nominal
- Truck belt: 216m^3/hr nominal
- Cranes: 100t crawler; 20t and 14t wheel
- Silobuses: 9 m3

Civil Works Quantities (in thousands)

Material	Unit	Pacific	Atlantic	Total
Reinforced Concrete – Locks	m^3	1,869	1,830	3,699
Roller Compacted Concrete	m^3	137	334	470
Reinforcing Steel	Ton	131	127	278
Cement	Ton	487	483	970
Aggregates	m^3	2,652	2,739	5,391
Processed Fill Material	m^3	4,179	3,751	7,930

Electro-mechanical quantities

Equipment	Pacific		Atlantic	
	Amount	Ton	Amount	Ton
Valves	52	3,766	52	3,268
Bulkheads	24	3,004	24	2,760
Gates	8	20,674	8	20,190
Totals		27,444		26,218

Lock Costs (US$ 2005 in millions)

Pacific Lock: 1,482
Atlantic Lock: 1,469

Material Supply

<u>Permanent Materials</u>

Imported Materials (quantities in thousands)

Permanent Materials	Unit	Pacific	Atlantic	Total
Reinforcing Steel	Ton	131	127	278
Cement	Ton	487	483	970
Piling (flexible dolphins)	Ton	0	1,200	1,200

Local Materials (quantities in thousands)

Local Materials	Unit	Pacific	Atlantic	Total
Aggregates	m^3	2,652	2,739	5,391
Processed Fill Material	m^3	4,179	3,751	7,930

Source:
Pacific – Pacific lock excavation
Atlantic- Pacific access channel excavation

<u>Construction Materials</u>

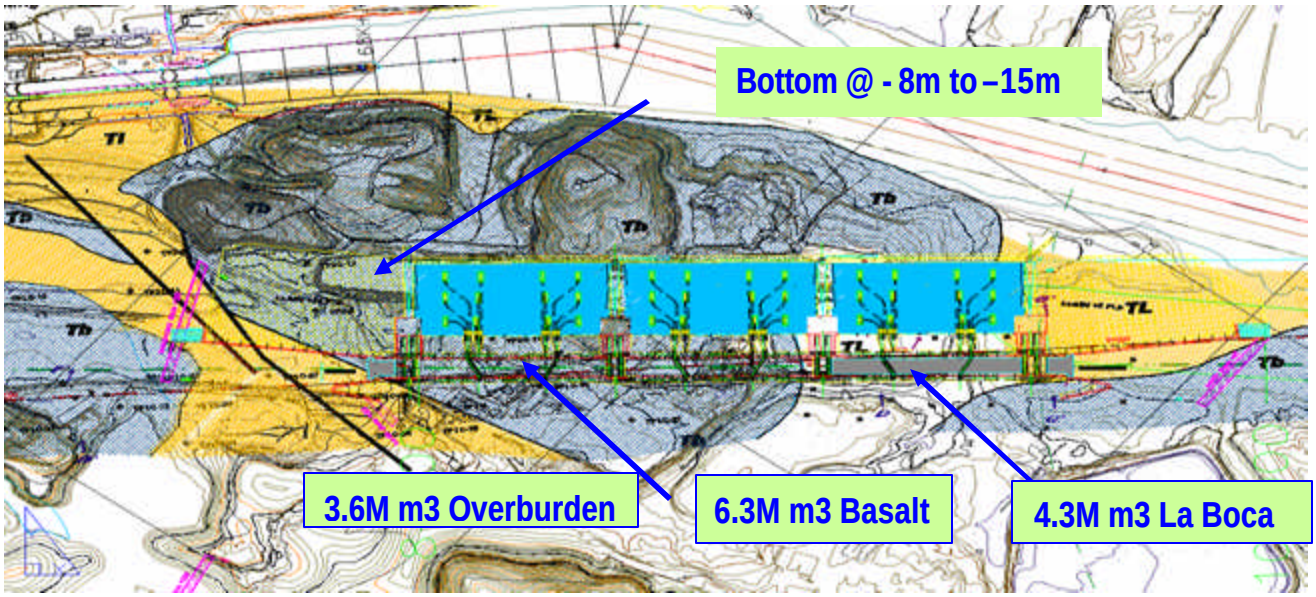
Construction Materials	Unit	Pacific	Atlantic	Total
Forms	m^2	909	842	1,751
Sheet piling	Ton	1,245	0	1,245
Drill bits & accessories	m	1,760	0	1,760
Explosives	Ton	5,206	0	5,206

Excavation/disposal logistics/access channel - Rigoberto Delgado

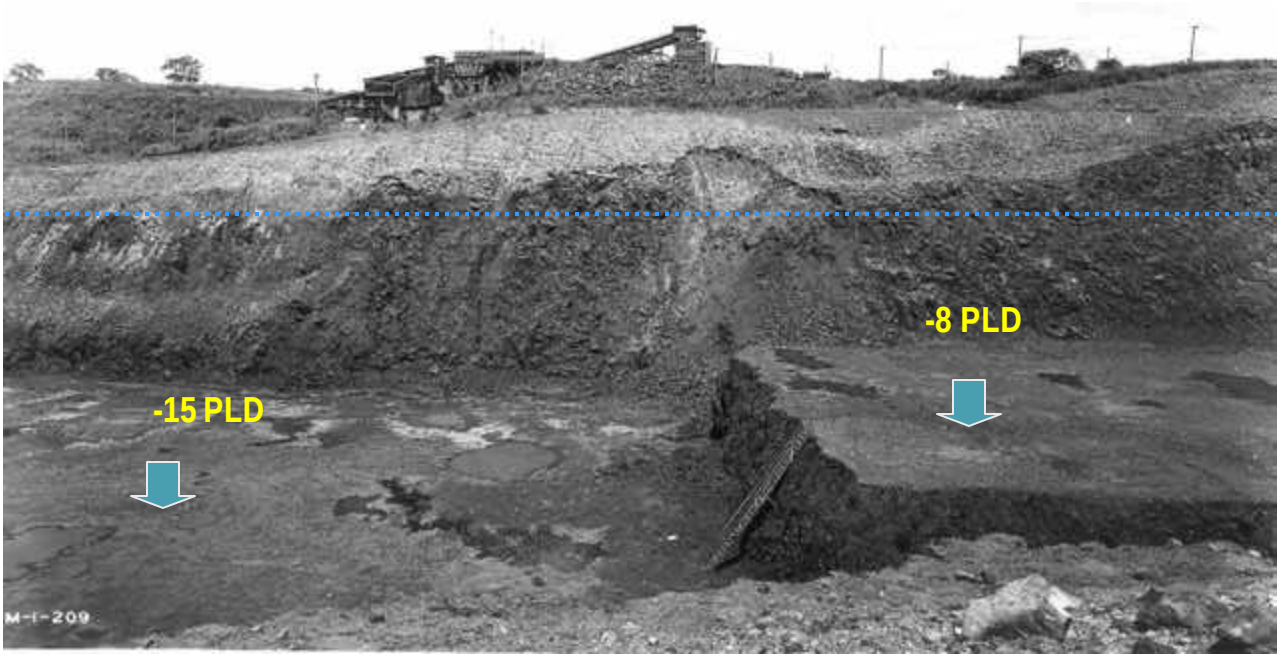
Excavation

Pacific

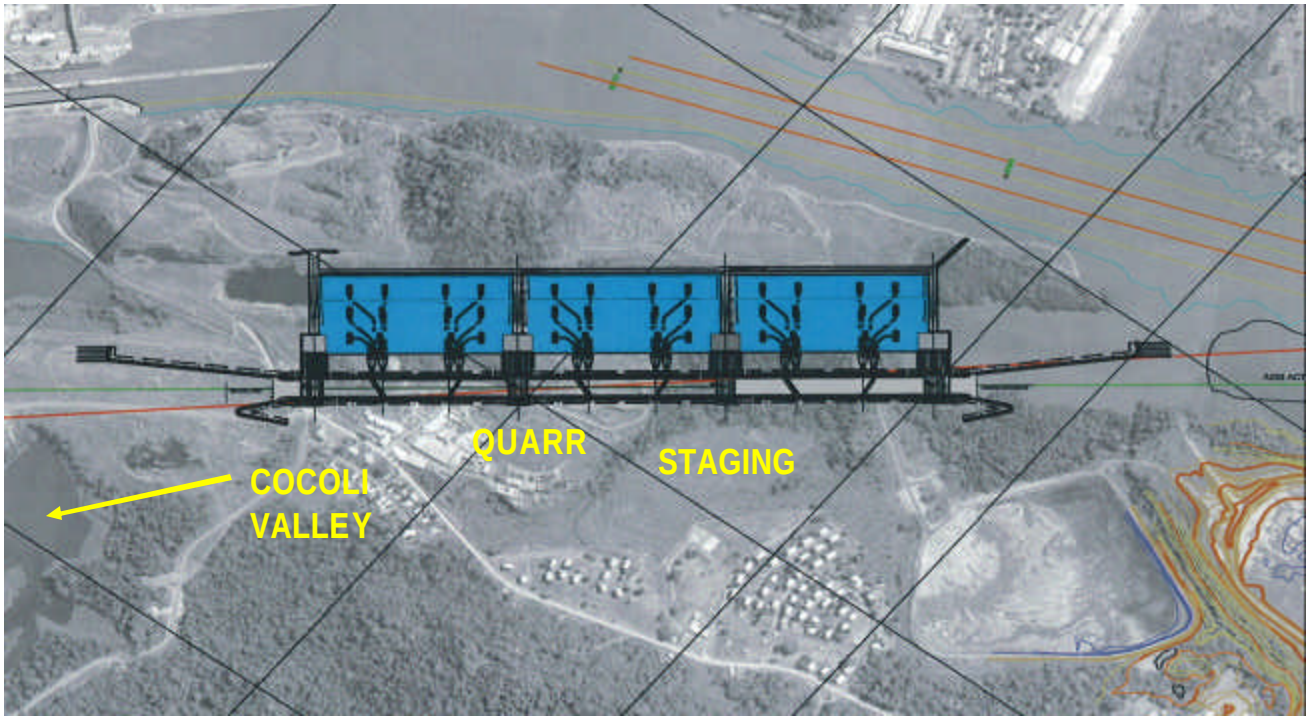
Pacific Lock Excavation

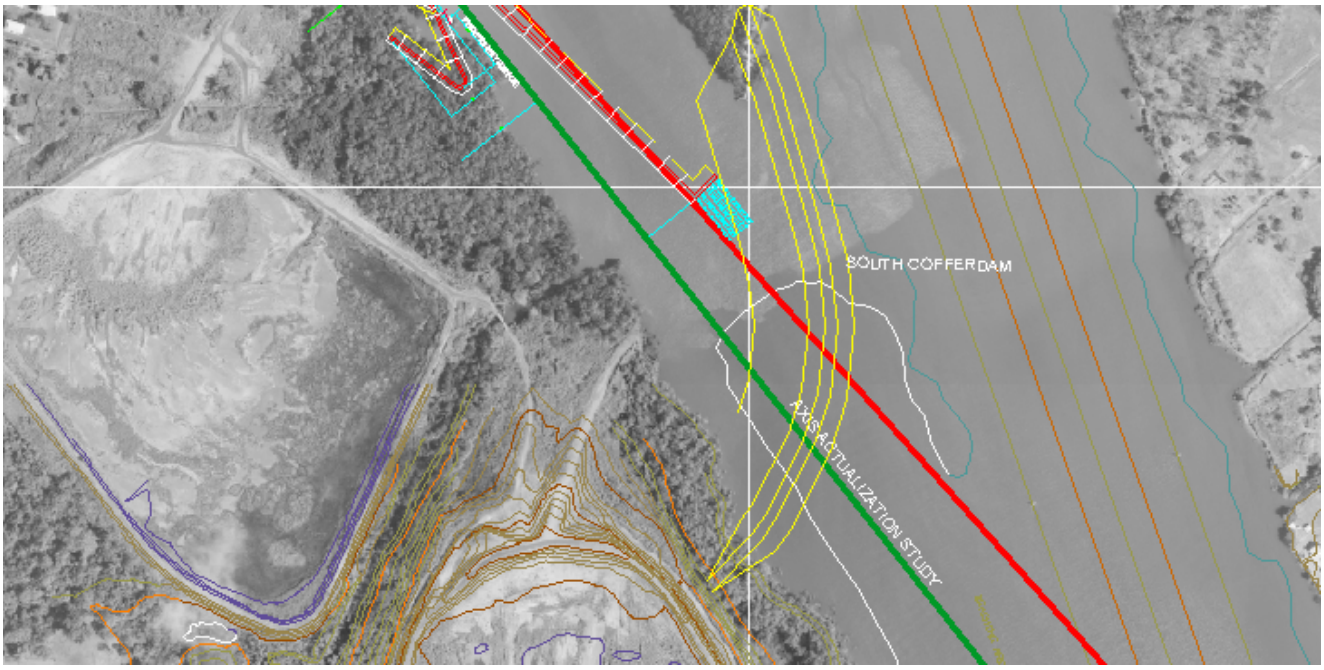


Pacific – 1939 excavation

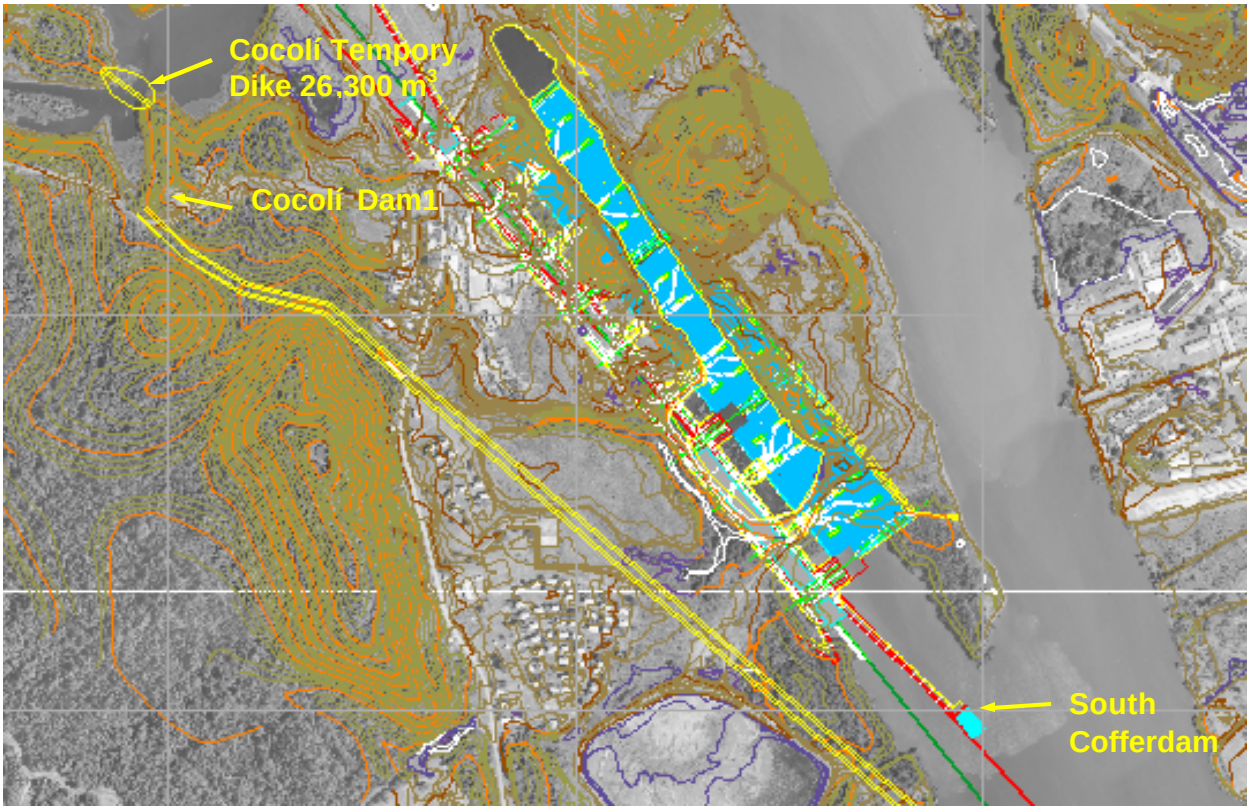


Pacific – 3 Steps and 3 water saving basins

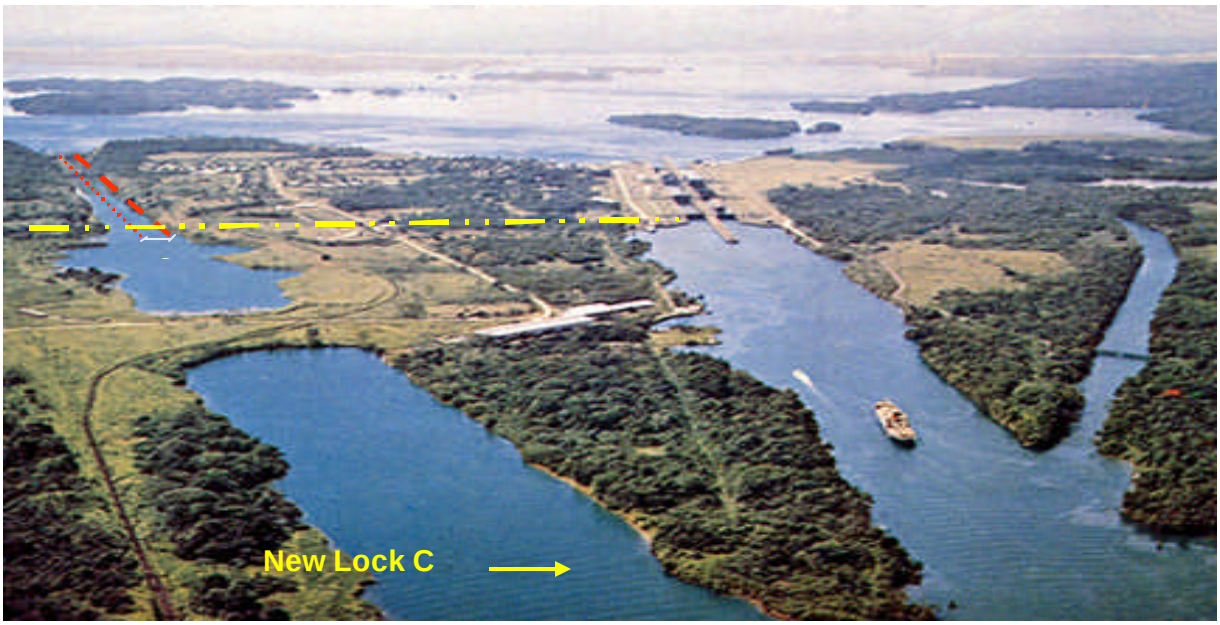




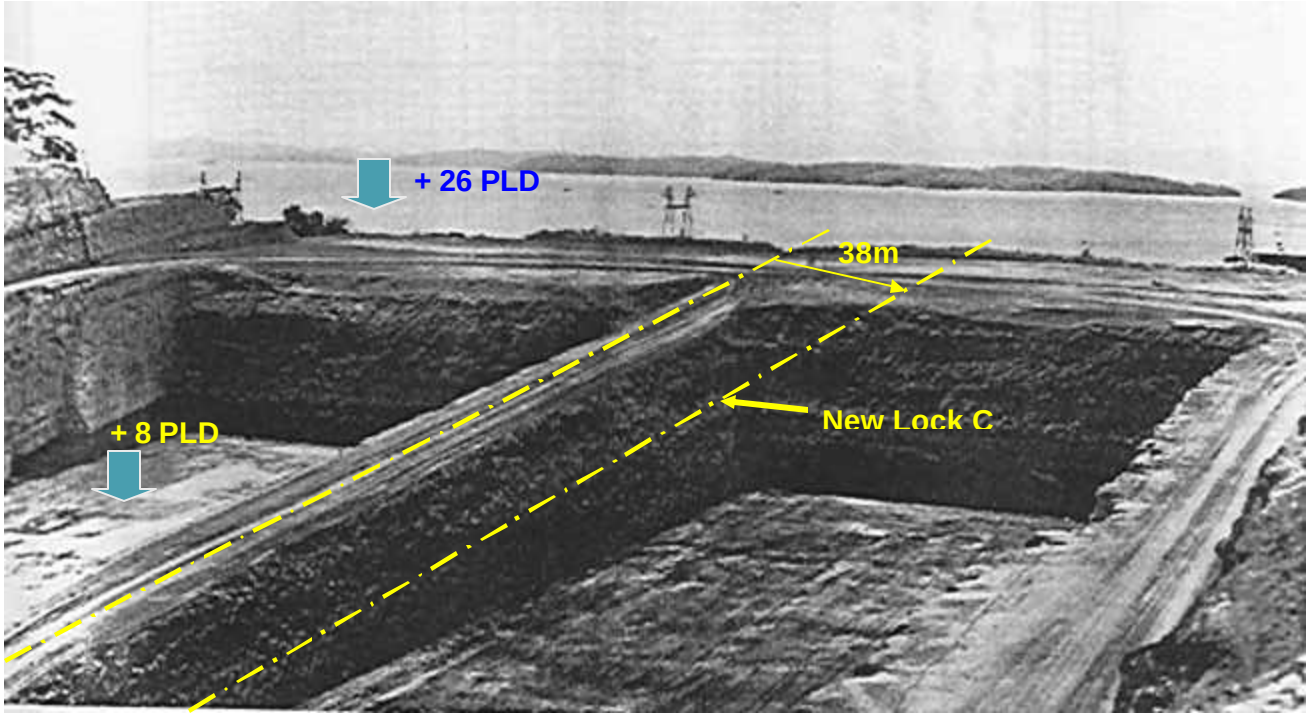
Pacific Lock - Río Cocolí diversion



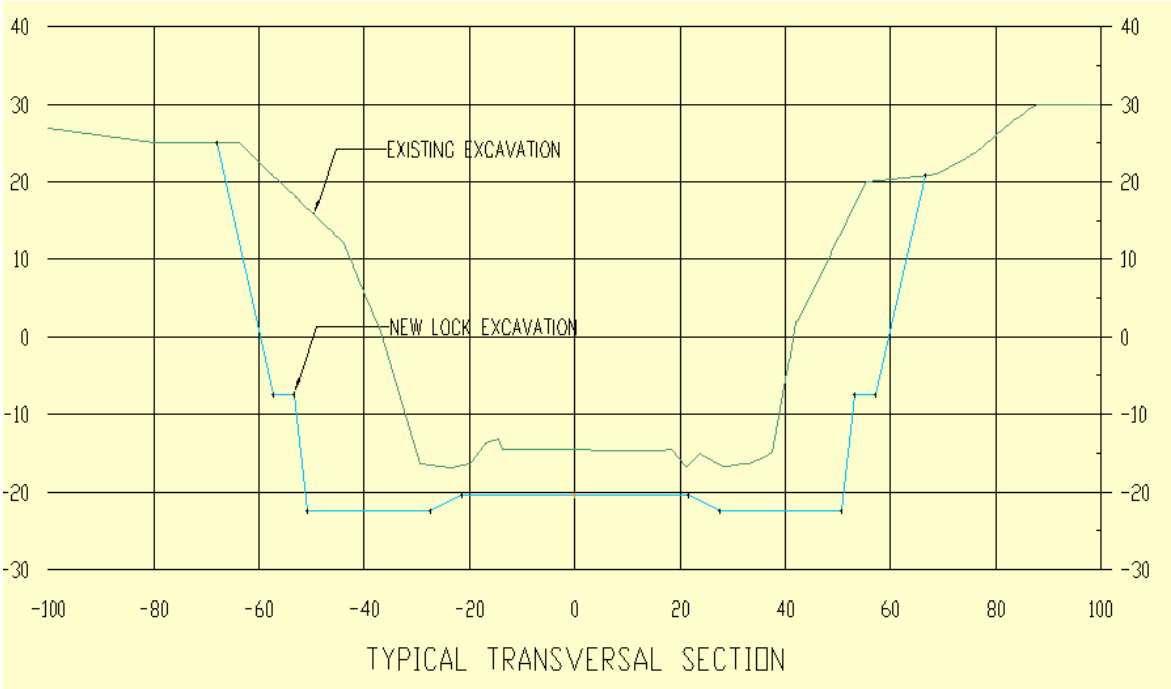
Atlantic



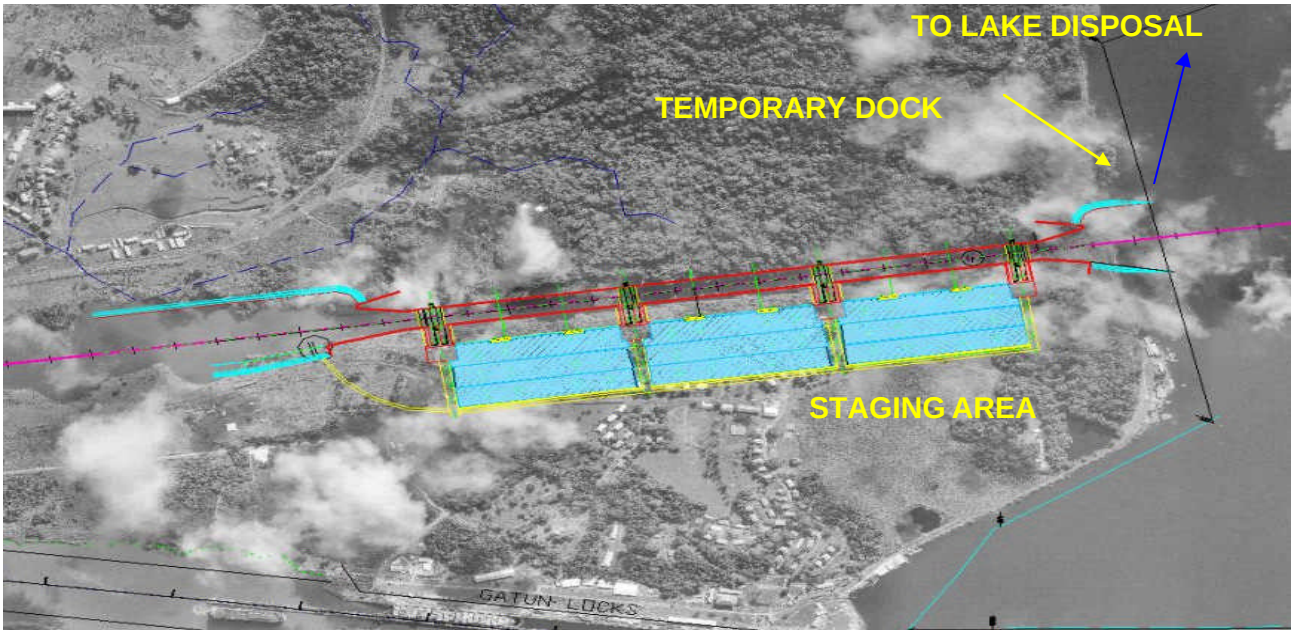
Atlantic – 1939 excavation



Atlantic Excavation 18 M m^3



Atlantic: 3 Steps + 3 WSB's



Disposal Logistics

Equipment

2004: Mining equipment
CAT 785 – 154ton

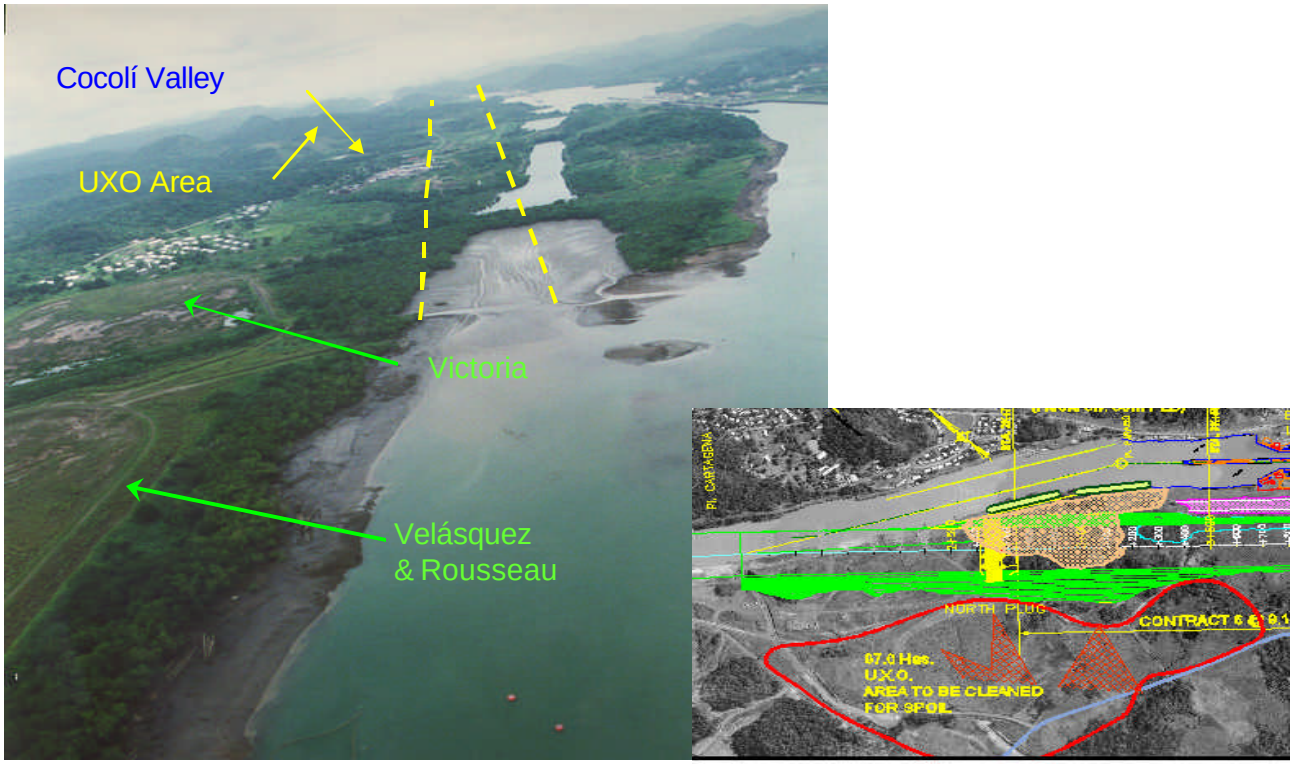
2005: Smaller equipment
CAT 5130 – 18.5m^3

Materials

Material	Unit	Pacific	Atlantic	Total
Concrete aggregates	m^3	2,652	2,739	5,391
Processed materials for fill	m^3	4,179	3.751	7,930
Common materials for fill	m^3	5,101	-	5,101
Lock & Web's Excavation	m^3	14,204	10,060	32,264

(Quantities in thousands)

Pacific Potential Deposits



Atlantic Disposal Deposits

Barge: 3,500m^3 + 50+ Tug
Volvo & CAT trucks

Pacific Access Channel

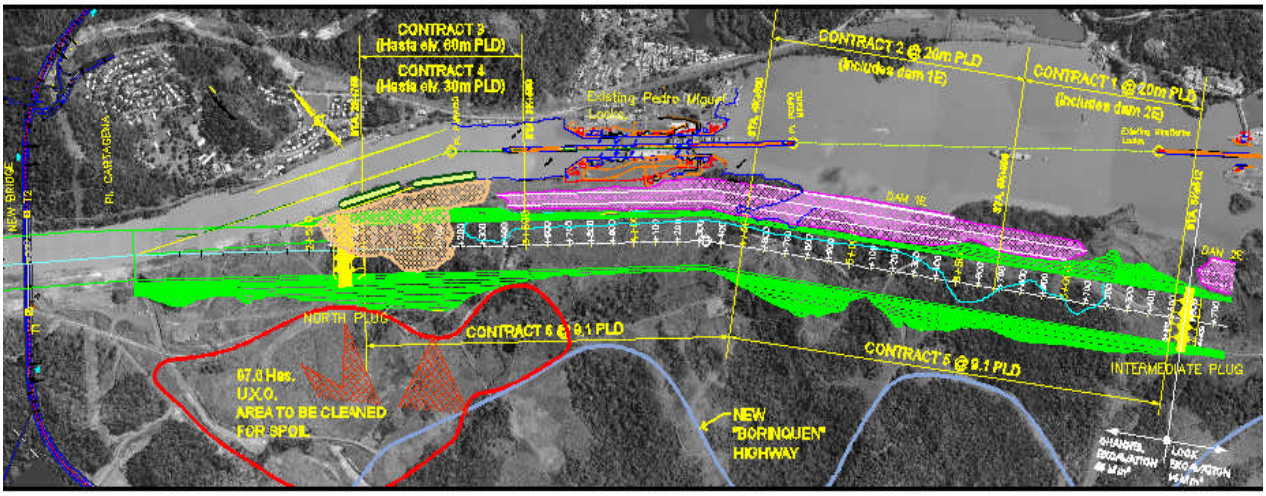
Conceptual Design by ACP

Alignment	PMD
Aproximate Length	6.5 Km
Width at prism line	218 m
Bottom elevation	9.14 m PLD

Variable slopes (as per geology and topography)

Access Channels

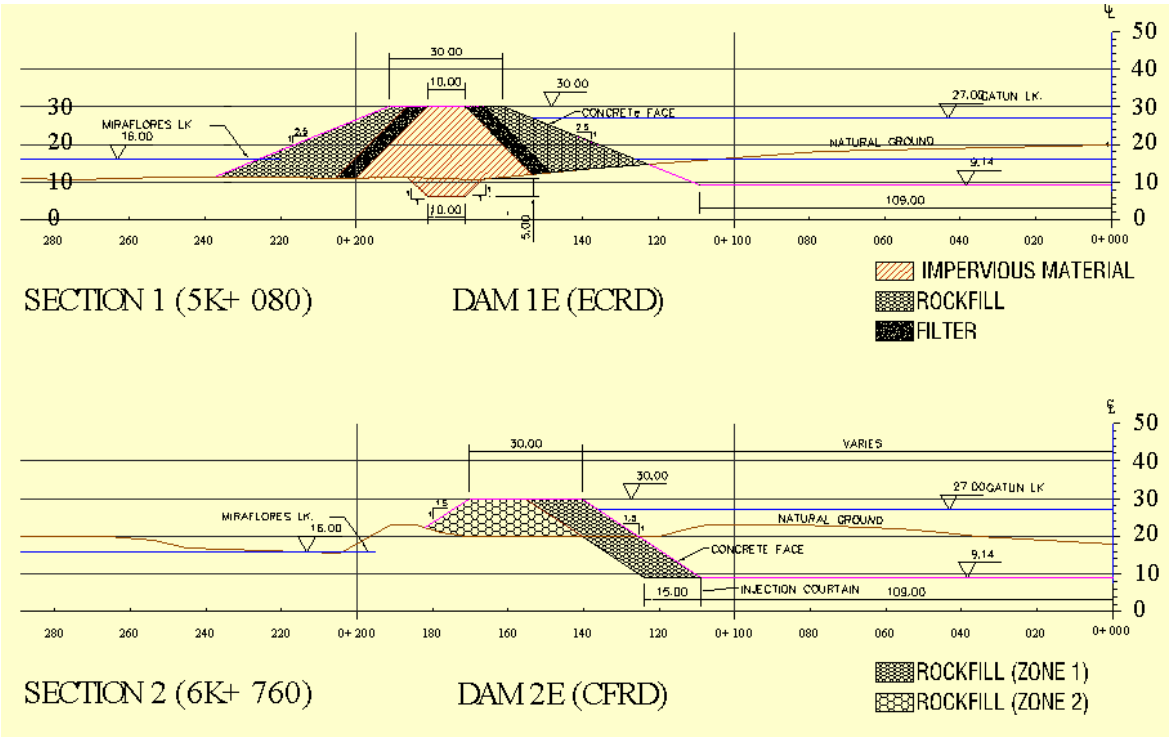
Pacific - Excavation contracts



		Contract 1 5k+680 - 6k+530 (to 20m PLD)	Contract 2 4k+500 - 5k+680 (to 20m PLD)	Contract 3 2k+740 - 3k+500 (to 60m PLD)	Contract 4 2k+740 - 3k+500 (60 to 30m PLD)	Contract 5 4k+500 - 6k+530 (20 to 9.1PLD)	Contract 6 2k+740 - 4k+500 (30 to 9.1PLD)
Overburden	m^3	2,440,000	2,404,350	1,655,800	600,000	856,580	2,273,190
Weathered rock	m^3	1,626,256	1,202,176	1,505,882	750,000	1,427,645	1,753,762
Sound rock	m^3	4,065,000	4,407,983	3,383,765	3,383,765	3,426,352	2,988,098
Total	m^3	**8,131,256**	**8,014,509**	**6,545,447**	**4,733,765**	**5,710,577**	**7,015,050**
Cleaning & Grubbing	Ha	34	47	30			40
Distance to UXO area	km	4.0	3.0	2.0	2.0	3.0	1.2
Distance to dam	km	1.3	0.5				
Distance to quarry	km	1.6					

Roca meteorizada = La Boca, Pedro Miguel o basalto meteorizado
Roca sana = Pedro Miguel y basalto

Pacific Permanent Dams



Labour demand and supply/special components – Boris Moreno

The Canal expansion program, required workforce projections, are based on the following assumptions:

1) The vast majority of the required workforce for the construction projects should be Panamanian and contracted by local or foreign companies or consortiums.

2) The numbers include:

- Preliminary works (cofferdams, docks, utilities relocations, water control)
- Construction of two lock structures and the excavation of the Pacific access channel
- Contractor's technical and support personnel
- ACP's project management & supervision
- Dredging program personnel

3) The labor requirements are based on the latest lock construction cost estimates (ACP/PB) that assumes 2 ten hours shifts and also on the dredging program cost estimate (ACP)

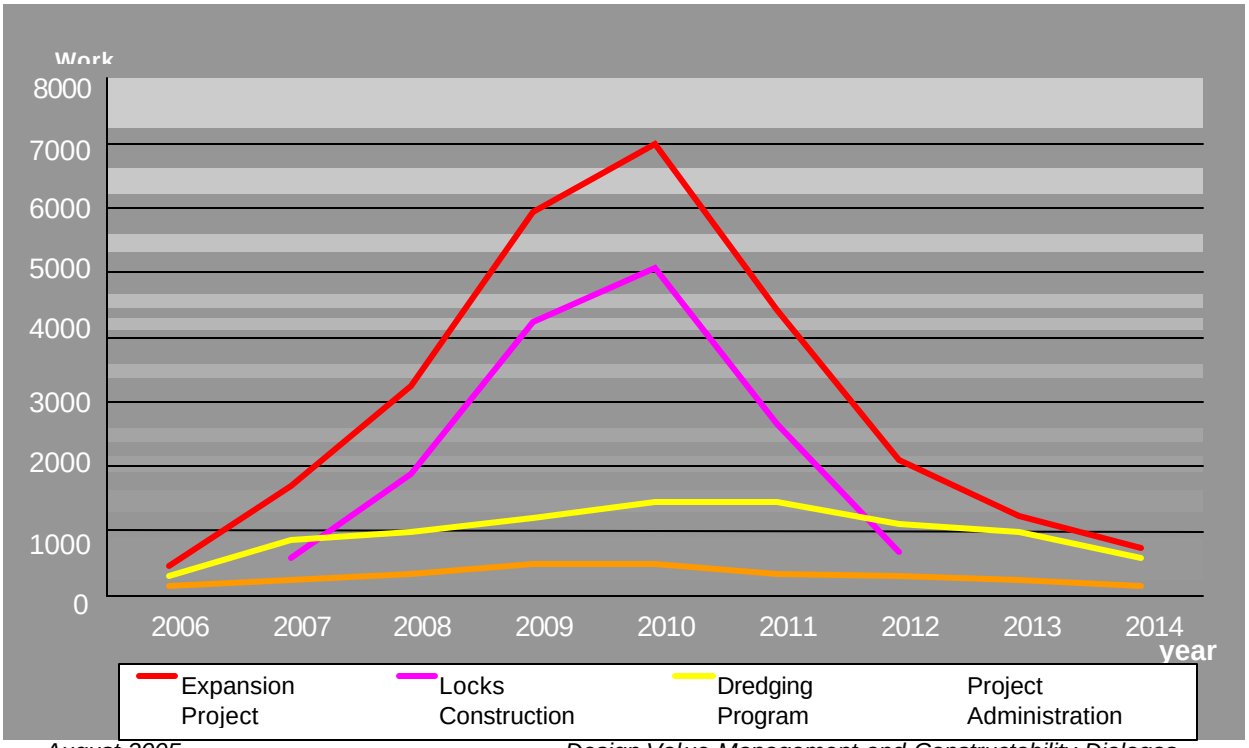
Resulting in these preliminary figures for the expansion program:

REQUIRED WORKFORCE	
Working Groups	**Quantity**
Contractor's Technical & Craftsmen Occupations	**5,650**
Contractor's Professional & Technical Support Personnel	**550**
Contractor's Administrative Support Personnel	**650**
ACP´s Management, Administrative, Professional and Supervision Personnel	**500**
Operations personnel for the Dredging Program (Contracted)	**400**
Operations personnel for the Dredging Program (ACP)	**660**
Operations support personnel for the Dredging Program (ACP)	**440**
Preliminary Total for the Canal Expansion Program	**8,850**

And an annual distribution by craft of the locks construction direct labor

Crafts	Projected Requirement	Annual Requirements (Max) 2 shifts					
		2007	2008	2009	2010	2011	2012
No Qualification							
Laborer	1650	100	329	1249	1455	604	124
Driver	300	22	43	139	149	58	15
Helpers	500	0	40	383	462	218	76
Craftsman							
Mason	150	0	0	94	119	46	31
Rigger	150	0	0	88	117	50	14
Carpenter	250	0	0	213	251	123	20
Electrician	50	0	14	32	32	36	36
Blasting Worker	250	98	250	202	60	30	0
Heavy Equipment Mechanic	75	16	42	64	62	64	48
Rebarmen	575	0	51	453	554	169	32
Certified Specialist							
Foreman Blasting	20	2	14	12	4	2	0
Welders	175	0	7	126	156	59	13
Heavy Equipment Operators							
Driver - Dump truck	375	106	354	186	92	44	0
Operator - Loader	50	8	44	28	6	4	0
Operator - Grader	20	6	4	11	7	5	0
Operator - Excavator	75	16	58	28	12	4	0
Operator - Cranes	175	0	7	123	157	62	17
Forklift operator	75	0	7	54	61	19	4
Drilling equipment Operator	125	42	106	94	28	14	0
Plant Operator	20	0	4	16	16	16	12
Operator - Roller	25	16	18	20	20	18	12
Operator - Dozer	125	24	122	47	22	13	6
Compressor and Pump Operator	200	0	37	150	164	68	13
Foreman							
Concrete	60	0	8	55	60	38	16
Excavation	60	18	60	33	18	8	4
Drilling	20	2	14	12	4	2	0
Rebarmen	100	0	7	68	82	26	8
Total Direct Manpower	**5,650**	**476**	**1642**	**3980**	**4171**	**1803**	**502**

With the following chart showing the total and segregated demand



ACP has to lead a national effort to assure Panama can supply the required labor demand, by supporting a National Technical & Craftsmen Training Program

The National Program has the objective of:

Guaranteeing the existence and availability of a qualified Panamanian workforce in technical , craftsmen and professional skills that may be contracted to carry out the Canal expansion projects and any other developments in Panama, thus contributing to the nation's wellfare and progress.

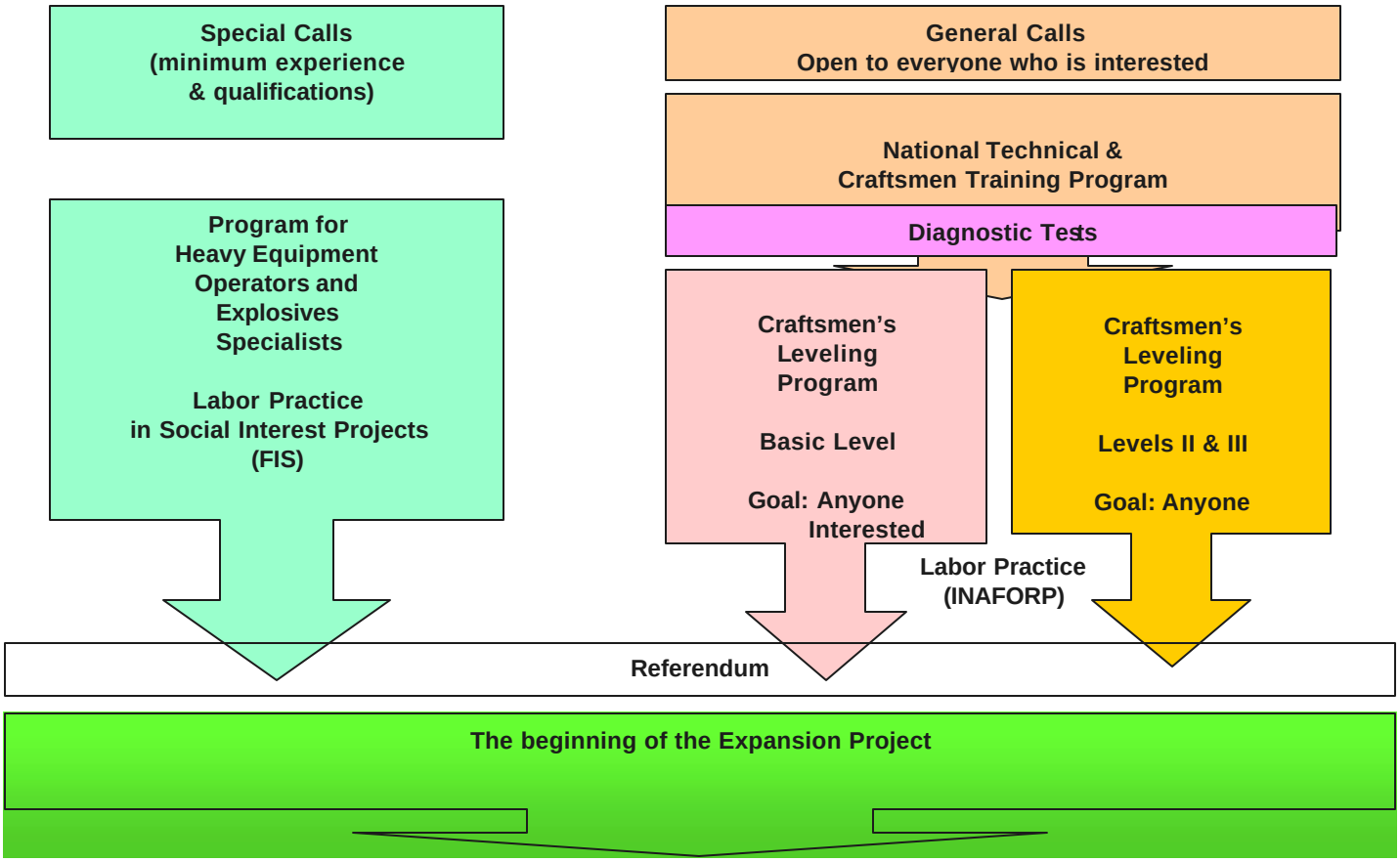
National Technical and Craftsmen Training Program - Assumptions

- It will be a national training program, with the help of other government and private institutions.
- The contracting of Panamanians will depend on the availability of candidates who fulfill the contractor's expectations regarding experience, training, qualifications and certification.
- The total estimate of the manual and professional labor required to carry out the Expansion Program is close to 9,000 direct jobs.
- The training program is focused on craftsmen and technicians in four different categories.
- The program includes the participation of the trainees in public and private projects.

The primary focus of the National Technical and Craftsmen Training Program is in these types of workers

PRELIMINARY NUMBERS PER CRAFTS	
Category	**Qty**
Craftsman	**1,695**
Foreman/Leaders	**240**
Operators	**1,265**
Non Qualified Workers	**2,450**
TOTAL	**5,650**

National Technical & Craftsmen Training Program



Training in critical crafts
- Projects with FIS

Special components

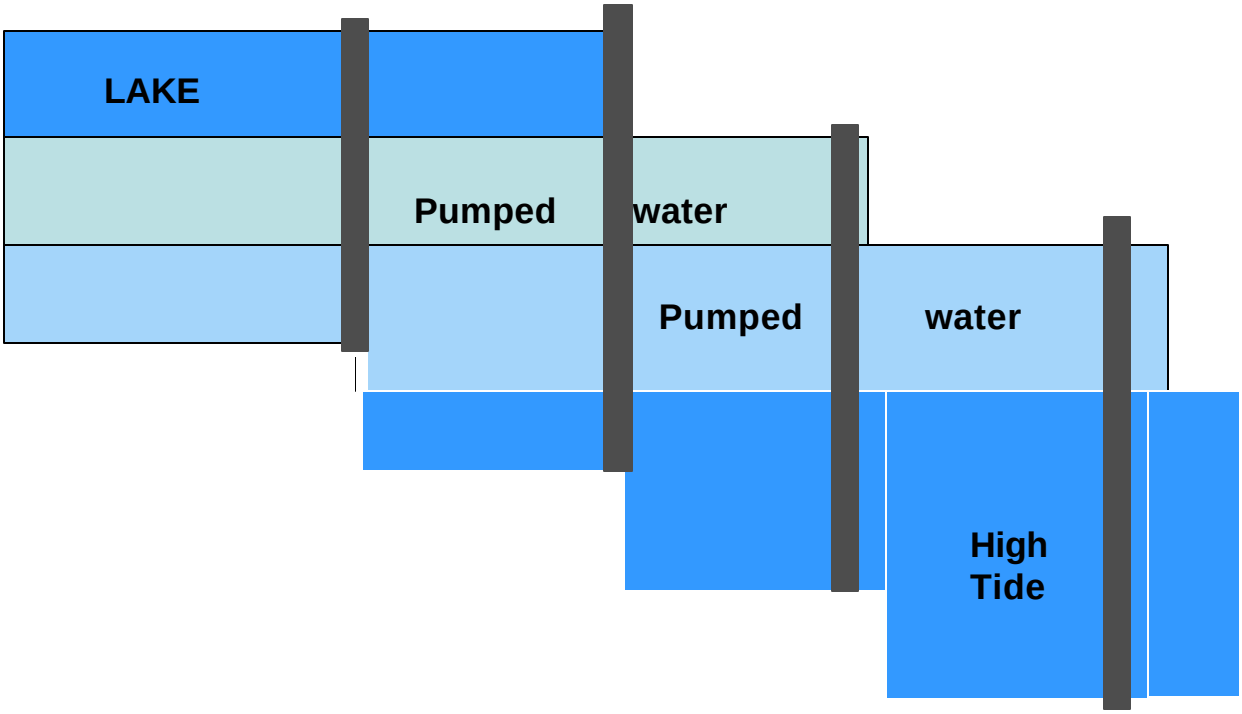
Rolling Gates Design and Fabrication

- Design and fabrication subcontracted to a foreign shipyard or steel works yard
- Work should begin with Locks construction contract award
- 6 months design phase and 3 years for fabrication (Atlantic gates 20,170 tons of steel; Pacific gates 20,674 tons of steel)
- ACP inspection of fabrication

Rolling Gates Transportation

- Transportation time will depend on place of fabrication and type of transport mode selected
- Gates will be in Panama at the start of the fourth year of construction
- Installation will start after initial downstream flooding, at the start of the fifth year of construction

Installation Sequence of the Gates



Floating in manoeuvres

- Gates are stable & floatable
- The gate should be floated into the recess in less than 2 days.
- Followed by the installation of the under and upper wagons
- And finally the operating cables and drives…

A total time of 8 weeks is allowed in the schedule for the installation of one pair of gates (8 months total time)

Culvert And Conduit Valves

- Design and fabrication to start with locks contract award
- For the 2 locks, 32 culvert and 72 conduit valves (2624 tons of steel)
- 30 Maintenanace bulkheads are also needed (682 tons of steel)
- Wagon type valves selected with hydraulic cylinder actuators
- Fabricated at foreign steel works yard
- Transportation by cargo vessel in adequate groups
- Time for design, fabrication & transportation 3 years
- Time for installation 2 months per culvert valves set; 3 months per WSB valves set (13 months total)

Culvert and Conduit Valves Installation

- Design basic data (culvert valves) max.pressure 39.2 m; size 4.5m x 6 m
- Average valve weight 25 tons;bulkhead 23 tons
- Design basic data (WSB conduit valves) max.pressure 44.3 m; size Atl.-4 m x 5 m; Pac.-4.5m x 6m
- Average valve weight 24.9 tons;bulkhead 21.9tons
- Installed by local crew, with specialized supervision
- Installation can start as soon as the lockhead is finished
- Starting with lower level valves to allow lock flooding for gate installation

Control Room

- Central control room
- Computerized and PLC machinery control system
- Fiber optics cables with redundancy

Lighting at the Locks

- Highmast lighting with dedicated gate and chamber lighting to allow nightime transits.

Dewatering – George Currie

Volume

- Volume of excavation
- Transmissivity
- Groundwater flow/recharge
- Rainfall/runoff

Discharge

- Water quality
- Permitted location(s)
- Impact on adjacent works

Water table depression

- Impact on operations
- Impact on ground movements
- Impact on surrounding population

Other Presentations

Labour comparisons– John Roberts

	Panama	Taiwan
Population	2.9m	23m (1:8)
Construction $m per month	60	100 (3:5)
Population base/construction		(~1:5)
% Imported labor used by megaproject		50%
	THSRC	Philippines
Construction per month	60	20
Workers	20,000	6,000
Workers/10 million	3,000	3,000

	Taiwan	Philippines	Panama
Construction per month	100m	20m	60m
Workers	20,000	5,000	
Workers/10m of construction per month	2,000	2,500	
			12,000 –15,000

Appendix 4 - Selected Questions from Information Stage for Design value management and constructability dialogos workshops

Design value management

	Question
1	What is the relation between the amount of water saving basins and salinity? Will 3 WSB increase the salinization of Gatun Locks?
2	Will there be drawings at any stage of the workshop?
3	Will construction schedules and sequence of construction be part of the workshop?
4	Cost increase because of spaced reserved for tugboats?
5	Should the lock be wider to accommodate the post panamax vessels?
6	What additional seismic information is needed to definitely establish the design criteria and when?
7	Are fenders to be used in the new locks?
8	Are new tugs not in estimate?
9	If there is a use for the PP locks with several smaller ships, they can't be taken centred/positioned by tugs?
10	What is the allowed damage to the locks/10,000 years?
11	Responsibility for damage for example, to the positioning of the ships – need for fender system along the locks?
12	Is there a need for a protective system for the gates?
13	One presentation mentioned new locks difficulty because of mixed ground. Where as civil engineer said there was a sound rock. Are they sure?
14	What is the size of the vessel?
15	Only 2 or 3 water saving basins considered, what about no basins and what is the effect on design?
16	What is the seismic design acceleration for the existing Panama Canal structures?
17	How does corrosion effect present gates and valves? How serious is it?
18	What about twin locks instead of water saving basins?
19	Why not a bottom filling system for locks?
20	Can equalization be achieved directly between chambers and if so under what conditions?
21	What about maintainability of bottom seals and gate track at chamber entrances?
22	What currents are developed from spilling to sea in front of an approaching vessel?
23	Is the information available in the use of WSB for a sufficient, reliable prediction of salt with intrusion into Gatun Lake?
24	Wheat would be the determining factor to decide whether to keep the vessels in the middle of the locks or tied up against the walls?
25	Would ACP consider the use 4 trips to move the post panamax through the locks?
26	Have air block valves been considered using air pressure to stop and start flows?
27	Have bubblers been considered along sill of roller gates to remove still debris?
28	When was the last major 50 or greater earthquake in this area
29	Have floating approach walls been considered on the ocean sides of the locks?
30	Is the hydraulic design considering how to avoid the current that is affecting the ships coming from sea or approaching the locks?
31	Should the seismic criteria be the same in the Pacific lock design as in the Atlantic lock design? Why yes or why not?
32	Can we operate that locks with and without the water saving basins efficiently? What would it take to do so?
33	Do we want to be able to tie up the ships on the side walls as well as keep it on the water of the chamber? How can we do both?
34	Are the post panamax 3rd lock to accommodate all vessels or just container ships?

	Question
35	Do you need to consider hazards associated with other types of freight?
36	Are you considering incorporating results of further “fault studies” (geologic) into seismic design criteria?
37	Is the 2 gate system primarily for redundancy (safety) or to allow maintenance?
38	How many type of vessel, from a shape point of view can be identified?
39	Will the use of tugboat slow down the entry or exit time for the ship?
40	Do you require to dry chambers the locks for maintenance and what is the impact to a single lane?
41	Trade-off due to hawser forces, turbulences vs throughput?
42	What is the procedure for gates replacement, if needed?
43	Will ground water be a concern during excavation?
44	Is it necessary to increase the lock chambers dimensions to use the vessel positioning system with tugs?
45	The third lane is being added primarily for larger container ships, what about tankers and other types of large ships, will larger tankers etc be able to use the third lane?
46	In the aerial photo showing the locations of the third lane locks and channels, there appeared to be houses there already. Is land available now for construction of the third lane including space needed for construction?
47	The existing locks have single gates. The barriers to protect the gates in the original construction were removed because it was determined to be not necessary. Has a cost/benefit analysis been made to justify the cost of gates and larger lock heads in the third lane?
48	Is it the intent that the construction of the proposed expansion will be done with no interference with present operations?
49	Is there going to be some restrictions to present operations?
50	For the seismic hazard assessment did you compare the answers obtained with the prosolithic approach with accelerations obtained from a deterministic method where event so of given magnitudes are assigned to specific seismic sources?
51	Is there any active faults within the proposed footprint of the locks, can these locks be displaced?
52	What environmental impact percentage of available water is used for human consumption for industrial use and shipment?
53	What additional percentage of water is going to be required for the new locks?
54	Please clarify the rock characteristics of the Atlantic end
55	If the culverts were not in the lock walls could the walls be founded significantly higher?
56	In regards to the roller gates and the side port system is their experience with the magnitude of differential head (not draft) that will be experienced also at the canal?
57	Are approach walls required to put ships through the lock
58	In case of electric failure is there a mechanical or hydraulic means to open the gates?
59	How do you plan to acquire additional spill capacity in order to raise Gatun Lake?
60	Are saving basins really necessary when the dry season is only 1/3 of the year?
61	Why do you prefer an imbalanced hydraulic F/E system?
62	Why don’t we use a twin lock?
63	Why was a side port filing system selected over a bottom filling system?
64	What is the most effective in terms of throughput, vessel safety and cost, vessel “vertical” positioning system and for what vessel size?
65	What are the lock chamber filling/emptying times with water saving basin vs not using water saving basin?
66	Why are slopes in harder rock (pacific basalt) look flatter than the slopes in softer rock in Gatun (Atlantic)?
67	Side filling system doesn’t it makes the vessel more unstable?
68	Why the use of rectangular culvert design?
69	Actual vessel transit has a maximum of 38 to 40 proposed filling/empty system shows 15

	Question
	day lockages will this satisfy demand?
70	What is the role of the approach walls when using the boats for vessel positioning?
71	What is the risk and impact of tsunami?
72	What is the permeability of the Gatun, La Boca and basalt formations?

Constructability Dialogos Workshop

	Question
1	In what basis was the availability of equipment (trucks and shovels) determined?
2	Do the local suppliers of cement intend to bid the work?
3	What should the ACP do about the issue of creating national shortages of construction materials (if anything), ie cement?
4	Is the centralized control tower and system in the budget?
5	Could the rolling gates be supplied in modular sections in order to complete the assembly on Panama?
6	If aggregates for concrete are easy to obtain why not start assessing as soon as possible for the present and future needs?
7	Can the fabrication and transportation of lock gates can be combined with local assembly of parts?
8	Does the tie up station need to be relocated?
9	Beneficial uses for excavation material?
10	Is UXO costly? Future use?
11	Coating – at dock and later touch up?
12	The gates are to be furnished and available on the 4th year of construction and will be installed at the 5th year of construction. Are we assuming a 1year diphase?
13	How much money will be required to train the good workforce?
14	What institutions will be responsible for the training?
15	What types of workers will be imported and from what countries?
16	Do we have a preferred excavation sequence for the locks? (upstream to downstream or from the center outwards) Is this the contractor's choice?
17	Any sources of natural sand instead of manufactured sand?
18	Does the permanent dam in the Cocoli River have the capacity to provide a railway to alleviate the present spilling deficiency at Gatun?
19	Is there fly ash available for replacement of cement? If not in Panama, where is the closest source?
20	Was the quarry thrown an excavated hole or just a stone processing site?
21	What is the source of the imperious material?
22	Who will be responsible to furnish and install the "special components"; gates, valve and light fixtures, the contractor or ACP?
23	What are the environmental concerns may affect the cost of schedule of construction of the 3rd lane?
24	For Panamanian labour who have gone through the training program, how will their wage scale be determined? Will ACP or the government determine the wage or will it be based on supply and demand?
25	How is the cofferdam on the Pacific entrance to be constructed?
26	What are the requirements for drainage of water in the work areas during construction? Foreseen pumping capacity?
27	Is there at this stage a plan for infrastructure for the work areas – like access roads, etc?
28	Shear valves instead of rolling valves – is it possible?
29	We have almost 3km of dams between Miraflores and Gatun Lakes. Would it be convenient to convert a segment of these dams into a tie-up station for post-panamax

	Question
	ships?
30	Is dredging (cutter) impossible?
31	Gates are floated in, into the gate recesses one by one at the gates have to been in dry conditions
32	Is it not possible to choose another cement type and coat the concrete?
33	Who will operate material supply vessels; ACP or contractor? How large a vessel?
34	Frequency of supply vessel movements? How many shipments per week?
35	2-10 hour shifts, 7 days a week
36	Wouldn't it be more efficient using buoys?
37	Is there no sand that can be dredged in the ocean?
38	Aren't there any opportunities for new projects?
39	Has plastic sheet pile been considered for the project?
40	How many pumps are being considered for the dewatering?
41	Has security been considered or is it a concern here?
42	What is the plan/type of lighting to light up the inside of the chamber?
43	Are you considering individual power units for the hydraulic culvert valves?
44	Will the Pedro Miguel it up station be affected by the Pacific channel excavation?
45	What is planned to do with the Rio Grande?
46	Can enough sand be produced for both locks concrete production from the Pacific excavation time or as needed?
47	In your investigation you have selected disposal areas, have you considered the environmental impacts?
48	What is the average transportation distances to the disposal area?
49	Aggregate sources in Atlantic vs transportation from the Pacific side?
50	Problems with Cocoli flooding might impact construction on Pacific side?
51	Concerning the diversion of Cocoli River, is there any risk to affect the existing traffic due to density currents?
52	What will be the roughness of the culverts (smooth concrete)?
53	How will the culverts be completed regarding the roughness?
54	Do you consider additives for the concrete mixes instead of "ICE" to control the heat of hydration?
55	How the material/concrete batches will be transferred from the batching plant to the east walls?
56	Is there any bridge or just the south cofferdam at the Pacific side?
57	How is the ACP required workforce with the foreseen requirement of geologists/specialize labour to deal with grouting – shotcrete and bolting/reinforced rock anchors?
58	What labor competing large projects expected?
59	Do skilled Panamanians leave to work overseas?
60	Have there been combinations on flooding due to filtration from existing water basins and consequential erosion that affect the excavation work?
61	What measures have we planned to not interfere with the operation of the existing canal?
62	Will it be a request to modify existing immigration loss of Panama to allow foreign workforce or labor from other countries?
63	Are there any reasons to fix the lower excavation level?
64	Does the excavated material transported by ships to other points or to the northern part?
65	What kind of water has to be taken to fabricate concrete?
66	What implication in construction would it have going from square/rectangular culverts to round?
67	Is it necessary to dewater 100% the 1939 excavation before depositing material (fill) for the water saving basin?
68	Why is the material excavated in the Atlantic not suitable for fill?

	Question
69	Can sheetpile be driven for the Pacific lock cofferdam?
70	Can you select aggregate or additives to reduce cooling (ice) for mass concrete?
71	Is there a carbon tax in Panama (air quality)?
72	Will more areas be made available for contractors lay down area above shown in presentation?
73	Does present planning anticipate processing backfill material for gretation or moisture requirement?
74	How was dewatering considered?
75	What is the expected local labor turnover? Any previous experiences?

Appendix 5 - Total Ideas Generated for design value management and constructability dialogos workshops

Design value management workshop

No.	Idea	Rating	Category
	ENVIRONMENTAL IMPACT **Limit salt intrusion**		
1	Ports as low as possible in the bottom lock	1	DN
2	Reduce number of water saving basin	3	
3	Bubble curtain at lower end	1	AP
4	Flush regularly	3	
5	Constant monitoring	3	
6	Provide special construction entrance of lock	2	AP
7	Limit use of new locks for post panamax only	3	
8	Use 2 water saving basins instead of 3	1	DN/CR
9	Dissipating system more efficient at ocean entrances	2	AP
10	Reducing water saving basins in lower locks by one pool	2	3
11	To use one pool from lower water saving basins set as a flushing systems in order to avoid salt water getting in when vessel is exiting	2	3
	Optimize soil disposal		
12	Re-use for construction material	C	
12	Reclaim area selection	C	
14	Use to cover UXO areas	C	
15	Road construction	C	
16	Sell aggregates	C	
	Save water		
17	Increase storage volume in Gatun Lake	3	
18	Increase volume of storage of water saving basins	1	3
19	Stacked water saving basins	1	3
20	Building a ship lift	3	
21	Use 3 water saving basins instead of 2	3	
22	Capture water at discharge from lock to be used for drinking water and industrial uses, rather than from Lake Gatun	1	3
23	Additional storage reservoir	3	
	Contamination		
24	Reduce staging areas to minimum	C	
25	Own concrete plants	C	
26	Oil leakage containment both for design of machinery and from vessel	1	DN
27	Specify biodegradable oil	1	DN
28	Use water as working fluid	1	3
29	Implement a hydraulic ship arrestor	1	AP
30	Specify dust control	C	
31	Use non-petroleum lubricant and/or greaseless fittings	3	
	Animal habitat passage		
32	Animal species conservation	3	
	MAXIMIZE THROUGHPUT		

	Minimize lockage time		
33	Reduce gate opening and closing time	1	DN
34	Optimize vessel mix	3	
35	Reduce timing of F/E system	1	DN
36	Reduce timing of vessel movement	2	3
37	Provide locks fendering	1	AP
38	Analyze and determine most effective method to move personnel from chamber to chamber	1	AP
	Minimize down time		
39	Equipment	3	
40	Use proven technology	1	3
41	Provide redundancy in equipment	1	3
42	Increase reliability	2	3
43	Redundancy in culverts number	1	AP
44	Building sluice valves into inside gates to compliment filling and emptying of the chamber	1	AP
45	Use mechanical (marine railroad) to move tugs track vs more tugs	2	AP
46	Provide chamber lighting to input vessel passing through the night	1	DN
	Preposition vessels		
47	Approach walls (floating wall ?)	1	AP
48	Move lock discharge	3	AP
49	Expand Gatun Lake anchorage to improve staging at Atlantic side	3	
50	Expand Atlantic outside or sea entrance anchorage	3	
51	Use access channel as an improve staging area for the Pacific side	3	
52	Implement stages areas/tie stations, mooring or docks for post panamax vessels as demand increase	3	
	Minimize hawser forces		
53	Use bottom filling	1	AP
54	Increase under the keel clearance	1	AP
55	Symmetrical filling (double culvert - stacked)	1	AP
	Operate with or without water saving basins		
56	During maintenance requirements	1	DN
57	Reduce salinity	3	
58	Reduce lockage time	1	AP
59	Add water saving basins on both sides of lock	1	3
60	Quantify increased lockages above present thinking	3	
61	Analyze possible silting of water saving basins	1	3
	Alternative mooring system		
62	Floating bits (vertical)	1	AP
63	Self releasing mooring hooks (fixed)	1	AP
64	Vessel based mooring system	1	AP
65	Specialized tugs	3	
66	Gates	3	
67	Moving bits (longitudinal)	1	AP
	Vessel positioning		
68	Centre chamber mooring system	1	AP
69	Side wall mooring	1	AP
70	Use thrusters/water jets in the chamber positioning system	1	3

	Optimize design of the locks		
71	In order to maximize throughput and to ensure safety we recommend the bottom filling and emptying system	3	
	STANDARDIZE PROJECT **Standardize equipment**		
72	Standardize size for gates and valves. It is more important to standardize because the savings otherwise would not be significant	1	DN
73	Uniform specifications	1	DN
	Uniform structures		
74	Making specific calculations and optimizing calculations (iterative process)	3	
75	Culvert plastic liner as flowing water improvement	1	AP
	Leverage existing technology		
76	Materials and gates - concrete	1	3
77	Materials and gates – steel	1	DN
78	Materials and gates – composite plastic	1	AP/CR
79	Materials and gates – fibre reinforce concrete and locks	1	3
80	Simplification of equipment	3	
	Prefabricate		
81	Modular design	1	C
82	Floating segments (pre-fab)	1	C
	Uniform structures		
83	Using same design parameters (criteria)	3	
84	Constant design criteria	3	
85	Using uniform materials	3	
	Standardize equipment		
86	Adjustable controls	1	3
87	Off the shelf items	1	DN
	Reduce design sensitivity		
88	Overdesign	2	3
89	Rigid design	2	3
90	Design for critical values	3	
	MINIMIZE IMPACT ON EXISTING OPERATIONS **Limit vibration**		
91	Blast mitigation measures	1	DN
92	Maximize separation of locks	1	3
93	Types of blasting techniques	C	
94	Relative depth of excavation of 1939	2	3
95	Experimental pre-construction investigation	1	AP
96	Rubber walls	1	3
	Optimize traffic during construction		
97	Build a bridge over the locks (Atlantic)	1	3
98	Connect road from site to Centennial Bridge	3	
99	Build new rail loading station at Centennial Bridge	3	
100	Dig East to West	C	
101	Do not transfer aggregate to the Atlantic between source	C	
102	Find a new source for aggregate	C	
103	Build new road to Atlantic and use ferry	3	
104	Build new bridge on the Atlantic side not to interfere with their locks operations	3	

105	Do not move materials on water	C	
	Utilize existing resources		
106	Minimize excavation	3	
107	Do not use the existing locks for transportation	C	
108	Use helicopter for moving materials	C	
109	Maximize off site fabrication	C	
110	Coordinating transit activities on water	3	
111	Review existing power requirements vs installed capacity	1	DN
	During construction		
112	Reduce excavating volume to reduce water drainage requirements	3	
113	Roof area during construction to minimize water collection from rainfall	C	
114	Well systems design	C	
115	Design drainage system (perimeter)	1/C	
	Hydrodynamic impact on shipping		
116	Study currents at discharge	1	AP
117	Design dissipaters	1	3
118	Design a separate open channel to guide the brackish water	1	3
119	Control release to minimize impact on vessel (holding tank or similar) of water	1	3
	Optimize traffic during operations		
120	Design/select staging areas	C	
121	Central control for all lanes (one for Pacific and one for Atlantic for gates and valves)	1	DN
122	Traffic light installation for navigation in canal	3	
123	Tug programming/availability	3	
124	Computer scheduling	3	
125	Build a tug system to expedite the reposition of tugs	1	AP
126	Build a new small lane for tugs	1	3
127	Estimate the use of existing equipment resources	3	
	Minimize sediment removal trucking		
128	Minimize sediment deposition in WSBs	3	
129	Provide sediment barge loading point	1	3
	Utilize existing resources		
130	Utilize basalt to produce aggregate	3	
131	Land reclamation using excavation material	3	
132	Use a lower design grade concrete	1	3
133	Build golf courses	3	
134	Create artificial reefs offshore	3	
	SAFETY **Protect operators**		
135	Adequate site lighting – both for vessel movement and personnel movement	1	DN
136	Means of rapid evacuating of ship in case of an emergency/fire fighting	1	DN
137	Minimize works in confined spaces	1	DN
138	Provide proper ventilation in confined spaces	1	DN
139	Eliminate confined space	1	3
	Protect vessels		
140	Reduce water currents at discharge	3	

141	Fenders on walls	3	
142	Align lock approach wall with chamber alignment	1	DN
143	Float bollards/camels for small vessels	1	3
144	Minimize turbulence in chamber	3	
145	Special design of tug boats	3	
146	Locate filling and emptying ports at the end of the lock chambers	1	3
147	Bottom filling and emptying system	3	
	Protection of structures and gates		
148	Cathodic protection on gates	1	DN
149	Grounding all metal components	1	DN
150	Limit water velocity to concrete from erosion	1	DN
151	Proper concrete coverage to prevent rebar corrosion	1	DN
152	Explore alternative concrete mixes	1	AP
153	Investigate different concrete aggregates	1	C
154	Install protective chains at entrances to locks	3	
155	Provide manual means to operate the gate	1	DN
156	Make provisions to convert to locomotive ship positioning system in future	1	AP
157	Grout – treatment of channel excavation between the Mirofores and Pedro Miguel locks	3	
158	Provide inside chamber fendering system	3	
	Protect water level in Lake Gatun		
159	Emergency closure system	1	AP
160	Floating crane with linear winches	2	3
	REDUCE EXCAVATION **Side walls**		
161	Use flexible dolphins at Pacific Locks rather than fixed entrance walls	1	3
162	Use floating approach walls rather than fixed approach walls	1	3
163	Side walls – excavate culvert as a tunnel	1	AP/CR
164	Side walls – use rock as back wall form	1	AP/CR
165	Side walls – excavate material from above rock only	1	AP/CR
166	Side walls – use rock bolts or other techniques rather than -1.5m thick concrete blocks on lock chamber floor	1	AP/CR
167	Side walls – excavate culverts in floor rather than in the sidewall	1	AP/CR
168	Split the water saving basins to eliminate under chamber culverts	1	3
169	Raise bottom of chamber from water depth of 18.3 to 16.5 – dig trenches in bottom of chamber for culverts – put ports in bottom of chamber rather in side walls	1	AP
	Water basins		
170	Reduce 1.0m minimum depth in WSB by improving drainage system with a slope	1	DN
171	Stack WSB on top of each other	3	
	FAST TRACK CONSTRUCTION **Leverage existing technology**		
172	New materials can be used – latest technology in construction to be utilized/adapted	3	
173	Investigate plastic pipe as culvert	1	AP
174	Replace reinforcement vs fibres (steel, fiberglass)	1	3

175	Replace fiberglass skin plates in gates	1	3
176	Use rock anchor to control excavation of slope freezing ground	1/C	3
177	Shotcrete use for temporary slope stabilization	C	
178	Metalising of gates materials to prevent corrosion	1	AP
	Procurement		
179	Unit price vs LS with shorten bid analysis DB - build against	3	
180	Unit commodity price does not need final design	3	
181	Include time and saving incentives	3	
182	Proceed in physical hydraulic model	1	AP
183	Contracting alliance – public tendering (owner – engineer – cost plus)	3	
184	Include cost incentives	3	
185	Utilize/use DRB & VE	3	
	Simplify construction		
186	TBN (tunnel boring machine) – small x crossing, under wet floor	1	AP
187	Reduce number of culverts	1	3
188	Remove WSB	3	
189	1 gate instead of 2	1	3
190	Pre-cast panels	3	
191	No upper construction in the platform	2	3
192	Detach cable duct/trench	1	DN/CR
193	Minimize reinforcement or eliminate	1	3
194	Replace RC for RCC	1	AP/CR
195	Stacked water saving basin	3	
196	Replace water saving basin RC for pond type structure	1	AP/CR
197	Side feeding of water from water saving basin	1	3
198	Use syphon as a water ejector from/to water saving basin	1	AP/CR
199	Use self lubricating material for gates	1	DN
200	Specs/rail system design should be able to replace by divers and through a quick removal/fastening system	1	DN
201	Store coffeedam/bulkhead in the opposite side	1	3
202	Canister design for culvert valves	1	DN
203	Use different culvert geometry	1	AP
204	Changing the filling/empty porting system general feeding	1	3
205	Changing to bottom filling system distributed along the lock chamber	3	
206	Preconstruct and float lock	1	3
207	Design should be flexible to structures can be considered independent	1	DN
208	Possibility of leaving track system (locos) for future construction	3	
209	Use roller compacted concrete in lock walls and to build the water saving basins	3	
210	Use precast concrete walls separated from culverts	1	AP/CR
211	Flexibility on the design depending on rock conditions	3	
212	Use Gatun rock formation as backfill for the Atlantic locks	1	AP
213	Use reinforced earth (using geogrids) as part of Gatun	1	AP

	backfill to make it stronger		
214	Substituted valves for siphon system	1	3
215	Use electro mechanical system instead of hydraulic system to operate machinery	1	AP
	REDUCE MAINTENANCE/OPERATING COST		
	Mechanical parts		
216	Low wagons maintenance	2	DN
217	Off shelf parts as much as possible	3	
218	Inspection time	3	
219	Maintenance time (how long, how often)	1	3
220	Redundancy of system (spare wagons, valves, bulkheads)	3	
221	Replace cast slab over the upper wagon track with a removable plate	1	DN
222	Analyze and determine critical systems and priority for redundancy need	1	AP/CR
223	Analyze need for dry dock for gate maintenance	1	3
224	Review equipment on existing locks – if feasible, use same manufacturer and model on third lane	2	3
	Steel structures		
225	Define inspection time	1	3
226	Define maintenance time	3	
227	Adequate corrosion protection (paint)	1	DN
228	Design for salt water (worst condition)	1	DN
229	Specify vessel impact force	1	DN
	Coating systems/materials		
230	Wagons to be coated	3	
231	Rails (material)	1	3
	Concrete		
232	Specify inspection time; inspect every 20 years	1	DN
233	Specify life time design; inspect every 100 years	1	DN
234	Control of flow velocity to avoid erosion	3	
235	Specify concrete strength and durability	3	
	Personnel required		
236	Minimize personnel required	1	3
237	Automate as much as possible (failure detection system)	1	DN
238	Centralized operation	1	3
	Accessibility to structure in dry conditions		
239	Ease of maintenance (maintainability)	3	
240	All to be easily accessible (electro mechanical parts)	1	DN
	Adequate spare parts and specialized equipment		
241	Special vessels for maintenance	3	
242	Specialized tools	3	
243	Parts inventory – real time tracking	3	
	Maintenance design parameters for mechanical parts		
244	Gates – Major overhaul: 25 years; 2 year anode inspection	1	DN
245	Wagons – Major overhaul: 5 years; inspect every year	1	DN
246	Valves – Major overhaul: 10 years; inspect every 2 years	1	DN

247	Rails – Major overhaul: 25 years; inspect every year	1	DN
	MAXIMIZE THROUGHPUT **Locks illumination**		
248	24/7 for all vessels at all times (all night)	1	DN
	Vessel positioning		
249	Vessel positioning warning system	1	DN
	RADICAL IDEAS		
250	Use earth instead of concrete design and build the pond rubber membrane for the lining/bladder (water saving basin)	1	AP/CR
251	Use rising sector gates for locks	1	3
252	Use precast concrete segments anchored to rock for all lock walls instead of casting placed concrete	1	3
253	Consider 4th lane when designing the 3rd lane locks to enhance construction of the 4th lane.	1	DN
254	Reconsider actual locks design to incorporate an emergency gate at each lock. These emergency gates would be used to preserve Gatun Lake in case of an accident and to optimize future "dry chamber" (if needed) work at Locks	1	AP
255	Establish a design and constructability review team from independent firms and contractors to review all design and construction plans for the project. This would be a consulting board	C	
256	Use moving hydraulic arms to center/secure ship in chamber	1	3
257	Do not use water saving basin for down lockage to maximize throughput and reduce salinity	1	3
258	Use air instead of water to raise ships	1	3
259	Use only a gate and a flood barrier is to foreseen still have 2 gates at each point for maintenance reasons	1	3
260	Perform analytical and physical models to study the so-called piston effect caused by the larger than workhorse vessels	1	AP
261	Excavate and prepare lock areas Pacific and Atlantic sides. Float steel shell in – dewater – concrete in – flood – open like repeat six times	1	3
262	Use Miter Gates instead of roller gates	1	3
263	Use a through-the-sill intake (discharge) in conjunction with a bottom (in the floor) filling and emptying system. This has ports and culverts in the gate sills with flow controlled by butter fly valve units in the sill that are removable in the wet. There would be spare units such that you can pull and replace a unit very quickly during times of no boats such as at night	C	
264	Rolling fenders along walls	1	3
265	Fill from bottom next to the walls along the chamber to help keep the ships off the walls	1	AP
266	Construction joints in concrete structures. Location of which should be made flexible in order to adapt to contractors methods and equipment	C	
267	Reduce construction time. Construct locks from steel shells with all piping and rebar in place in new shipyard in Gatun Lake. Excavate and prepare lock areas Pacific	1	3

	and Atlantic sides. Float steel shell in –Dewater – concrete in – flood – open dike – repeat six times		

Cconstructability dialogos workshop

No.	Idea	Rating	Category
	OPTIMIZE LOGISTICS		
	Minimize material transport		
1	Identify transport option needs	1	PR
2	Identify long term (time dep) material needs	1	PR
3	Know your storage capacity	1	PR
4	Develop material flow plan on site	1	KR
5	Use locally available material	1	3
	Minimize labour transport		
6	Provide labour camps/temporary housing	3	
7	Provide catering	3	
8	Use helicopters	3	
9	Provide labour transport (land or water)	3	
10	Automate process and procedures	1	3
	Monitor suppliers progress		
11	Automated centralized procurement and tracking system (interface)	1	KR
12	On site inspection (spot inspection)	3	
13	Pre-release testing	3	
14	Pre-qualify suppliers	1	AP
15	Centralized contract administration	1	AP
16	Establish program control system	1	AP
	Provide adequate storage		
17	Make better use of space by ordering processed materials (pre-fab rebar)	3	
18	Properly surfaced areas	3	
19	Identify storage need	3	
20	Identify material handling needs	1	PR
21	Provide adequate equipment or systems for handling material	3	
	Provide staging areas		
22	Develop work flow plan	1	KR
23	Identify preferred locations and staging areas	1	PR
24	Security and illumination for 24 hour availability	3	
25	Have available space for contingency/plan material processes – anticipate long lead time for certain materials and components	1	AP
	Ensure security		
26	Provide fencing	3	
27	Provide lighting	3	
28	Identify hazardous materials	1	KR
29	Communication means	3	
30	Control access for construction areas	3	
31	Security (CCTV) alarm sensor/remote 24 hour monitoring security system	1	KR
32	Adequate identification system for personnel	1	KR
	Plan infrastructure		**AP**
33	Evaluate road requirements	1	AP
34	Build needed works	3	
35	Identify power needs/designate	1	PR

36	Identify consumption potable/industrial water needs	1	PR
37	Identify waste water needs	1	PR
38	Identify fuel storage/handling needs	1	PR
39	Identify ice requirements	1	KR
40	Unloading facilities (port)	1	PR
41	Designate no go areas	1	AP
42	Management of construction debris	1	KR
43	Identify and provide fire protection	1	3
44	Swimming pool/leisure labour camp	3	
45	Install on-site batching plants	3	
46	Ensure preparation of construction grounds before construction NTP	1	3
47	Separate initial contracts	2	3
	FACILIATE LABOUR		
	Reduce conflict		
48	Good communications	3	
49	One contractor for both locks	1	AP
50	Minimize shift work	2	3
51	Attractive wages	2	3
52	Housing for families	2	3
53	Provide transportation - establish clear work rules	3	
54	Provide security in work areas	3	
55	Safe and secure labour payment system	1	KR
	Train workers		
56	On the job training	3	
57	Scholarships for training	1	KR
58	Apprenticeship program	1	KR
59	Technology transfer from contractor	1	KR
60	Knowledge transfer	3	
61	Limit overtime	3	
62	Job fairs	1	AP
	Ensure safety		
63	Medical assistance and benefits	1	KR
64	Provide safety equipment	3	
65	Safety training	1	KR
66	Security and access control	3	
67	Drug test program – zero tolerance alcohol policy	1	KR
68	Equipment adequate for job – hard hat, boots and eye protection, required contractors obligation	3	
69	Follow safety practice	3	
70	Specify appropriate safety standards	1	AP
71	Provide safety incentives and report	1	KR
72	Weekly safety meeting	3	
73	Job safety plan – safety and industrial hygiene inspection	1	KR
74	Provide safety supervision/staff safety incentive program	3	
75	AIDS awareness program	1	3
	Provide incentives		
76	For contractor to train people	1	AP
77	Bonus for production	1	3
78	Reward long terms	1	3
79	Health benefit	3	

80	Recreation facilities	1	3
81	Mess halls	3	
82	Provide work clothes	3	
83	Provide sanitary infrastructure (showers, lockers)	3	
	Political issues		
84	International labour issues	3	
85	Ensure government support	1	3
86	Maintain stakeholders informed	1	AP
87	Develop program for UXO management	1	AP
88	Review procedures for explosives handling	1	AP
	PROMOTE PUBLIC RELATIONS **Understand culture**		
89	Celebrate public workshops/meetings	3	
90	Listen to concerns	3	
91	Require press releases	1	3
92	Monthly bulletin	1	3
93	Provide PR officer	1	3
94	Maintain web site	1	AP
95	Plan paydays to reduce absenteeism	3	
96	Respect holidays (carnival)	3	
	Educate contractors		
97	Familiarize with local labour laws	1	AP
98	Explain regulations: tax, environmental, social security	1	AP
99	Ensure social responsibility	1	AP/PR
100	Incorporate social justice/laws	3	
101	Work/study programs for university students	1	3
	Disseminate information		
102	Good PR with media	3	
103	Exhibition hall and model	1	AP
104	Hire good PR firm	1	3
105	Organize tours	1	3
106	Set up and update webpage	3	
107	Weekly TV releases/spots	1	AP
108	Open days for visitors	3	
109	Construction web cam	1	AP
110	School packages	3	
111	Use helicopters	3	
112	Organize PIANC (Permanent International Association Navigation Congress) congress	1	AP
113	Liaise with NGO's	1	AP
	Respond to concerns		
114	Establish hotline for community	1	AP
115	Establish community relations office	1	AP
116	Surveys - periodic (be proactive)	1	AP
	Expedite environmental issues		
117	Complete EIA	1	3
118	Hold public hearings and workshops	1	3
119	Ensure compliance	3	
120	Hire foreign expert	3	
121	Coordinate closely with ANAM	3	
122	School presentations	3	
123	Require an environmental plan for execution of works	1	KR

124	Monitor environmental plan	1	AP
	MANAGE OWNER/CONTRACTOR RELATIONSHIP		
	Involve contractor (early)		
125	Construction information on web prior to solicitation	1	AP
126	Pre-bid meetings and site visits	3	
127	Pre-bid contractor conference (contractor with subcontractors and suppliers)	1	AP
128	Pre-bid visits to physical models and rock cores and exposed cuts	1	AP
129	Early pre qualification of contractor's	1	AP
	Expedite payments		
130	Provide mobilization payments	1	AP
131	Minimize the number of pay items	1	AP
132	Minimize/eliminate retention of earnings	1	AP
133	Optimize schedule milestones	1	3
134	ACP review a preliminary/informal pay request ahead of formal submittal	3	
135	Pay twice each month	2	AP
136	Pay contractor quickly (20 days) after submittal	1	AP
	Establish disputes avoidance and resolutions		
137	Resolve at the lowest possible level	1	3
138	Empower people	1	3
139	Have a Dispute Resolutions Board	1	3
140	Have an established elevation process/chain	1	3
141	Resolve as soon as possible	3	
	Expedite inspections		
142	Contractor do quality control and ACP do QA	1	AP/KR
143	Discuss plans in preliminiary construction meetings	2	3
144	Use qualified people	3	
145	Have an Inspection and Testing Plan	1	KR
146	Identify ACP hold point criteria pre-bid	1	AP
	Streamline approvals		
147	Minimize number of submittals required	1	3
148	Define required submittals	1	AP
149	Have Pre submittal meetings	1	AP
150	Have a submittal register	1	AP
151	Set priorities	3	
152	30 day submittal schedule	2	KR
153	Workshop for review comments (face to face)	1	3
154	Expedite submittals for adjustments in field	3	
155	Approve at field level if possible	1	3
	Introduce partnering		
156	Include "partnering" in pre-qualification analysis	1	AP
157	Get commitment from the top	1	3
158	Partnering workshops at working level	1	AP
159	Partnering workshops at executive level quarterly	1	AP
160	Discuss at pre-bid meetings	3	
161	Write a partnering agreement	3	
162	Partnering to be compatible to contract terms	3	
	REDUCE COMPLEXITY		
	Introduce standardization		
163	Reuse of construction material – forms	1	3

164	Impose construction management software	1	AP
165	Owner supply of specialized components (ACP)	1	AP
166	Electromechanical equipment – required machinery and controls from same supplier	1	AP
167	Use metric systems – modular design – prefab as much as possible	3	
	Maximize tolerances		
168	Appropriate tolerances at specifications	3	
169	Design review	1	3
170	Adequate quality	3	
171	No over specification in the design	1	3
	Anticipate problems		
172	Develop contingency for unforeseen conditions	1	3
173	Access material testing laboratory with rapid response	1	AP/KR
174	Major testing before NTP (notice to proceed) of prototype materials	1	KR
175	Implement dispute resolution board early	3	
176	Continuous updating of construction schedule	3	
177	Accurate technical specification	3	
178	Do physical model investigation	3	
179	Strict pre-qualification of major contractor/sub contractor	3	
180	Minimize number of contractors (ideal 1)	3	
181	Provide efficient rigorous inspection	3	
182	Fabricate aggregates by ACP/concession	2	AP
183	Establish early material supply	3	
184	Implement partnering	3	
185	Contractor should use/bring new/reliable construction equipment	1	PR
186	Evaluate dewatering needs	1	3
187	Test possible concrete mixes early to see if they work	1	AP
188	Assure DSL/high speed/satellite internet communications (interfacing with ACP)	1	AP
	Avoid use of exotic material		
189	Don't use specified exotic concrete mixes	2	3
190	Clear specifications of materials	3	
	MINIMIZE CONSTRUCTION RISK **Ensure quality/safety plan implementation**		
191	Develop a training program for inspectors	1	AP
192	Provide adequate monitoring	3	
193	Implement frequent review progress with contractor	3	
194	Require as built drawings tied by payment terms by contractor as project progresses as built	1	KR
195	Use graphical documentation as much as possible (photo's, etc)	1	AP/KR
196	Keep daily log records/with weekly summary submissions	1	KR
197	Online program management updates	1	AP/KR
198	Review project construction work by expert team (board of experts)	1	AP
199	Analyze incentives/penalties for early/late completion	1	AP
200	Inspection by owner	2	3
201	Milestones/completion bonus/penalties	3	

202	Use 4D modeling simulation (Common Point)	2	AP
	Provide accurate site information		
203	Supply contractor with all available information	3	
204	Provide statement on availability and quality of local labour	1	AP
205	Provide statement on infrastructure availability	1	3
206	Provide statement on availability of materials	1	3
207	Information regarding available utilities (water, power, etc)	3	
208	Use of acceptable supplier for equipment and material by ACP	3	
209	Provide with list of locally available equipment	1	3
210	Meteorological statistical information (rainfall)	1	AP
211	Geological information	1	AP
212	Tidal information	1	AP
213	Existing canal operations information	1	AP
	Manage politics		
214	Good external communications	3	
215	Visitor center and web site	3	
216	Install a webcam and special web page for construction	3	
217	High school /university/professional associations visits	3	
218	Organize monthly visit by cabinet minister	1	3
219	Progress bulletins monthly	3	
220	Always tell the truth and keep consistency	3	
221	Press room department office	3	
222	Publish Panamanian employment statistics of project	1	AP
	Manage project		
223	Contract superb Project Manager	1	3
224	Project Manager payment according to cost achievement of schedule targets	1	3
225	Implement effective project accounting system	1	AP
226	Establish a high level ACP project construction/admin team	1	AP
227	Be prepared to process change orders quickly	1	3
228	Use one for all parties project management software	1	3
229	Establish clear point of contact/responsibility in each party	3	
230	Implement quantity/volumes control	3	
231	Ensure right contractor	3	
232	Pay invoices timely	3	
233	Resolve dispute as early as possible	3	
234	Communicate effectively with contractor/owner	3	
235	Develop contingency plans	3	
236	Minimize change orders	1	3
237	Fix project scope	1	AP
	MAXIMIZE PRODUCTIVITY **Minimize blasting**		
238	Use rock ripability	2	3
239	Use adequate blasting/drilling pattern (develop/plan)	3	
240	Determine design test ripability	2	3
241	Consider alternate excavation methodology/work plan	1	3
242	Use dredging	1	3

243	Use mining equipment	1	3
244	Use rock cutters	1	3
245	Require blast plan from contractor	3	
	Maximize prefabrication		
246	Use prefab concrete forms	1	3
247	Use reinforcing steel when possible	3	
248	Have fabrication done by supplier when convenient	1	3
249	Prefabricate offsite	1	3
250	Precast rings and valve chambers	1	3
251	Do prefab piping outside	1	3
252	Use precast cable duct	1	3
253	Identify and plan first and second stage concrete	3	
254	Minimize embedded components	1	3
255	Use precast pipe culverts	3	
256	Establish union management plan	1	3
257	Assemble gates on site	1	AP
	Scheduling of sequencing		
258	Monitor/report/daily in real time (detailed)	1	KR
259	Get useful information	3	
260	Establish report formats early	1	AP
261	Update changes	3	
262	Keep good records	3	
263	Optimize sequence	3	
	Selection and utilization of equipment		
264	Identify market availability	1	3
265	Identify needs/requirement according to production	1	3
266	Establish consultation and technical support with equipment manufacturers	1	3
	Improve labour productivity		
267	Train personnel (driver, mechanics, etc)	3	
268	Provide safety and first aid training	3	
269	Assure safety program in place	3	
270	Have on site doctor and first aid facility	3	
271	Implement substance testing	3	
272	Provide incentive program	3	
273	Provide retention program	3	
274	Pay trainees	3	
275	Eliminate language barrier	3	
276	Provide supervisory training (skills)	3	
277	Train ACP in project management	1	AP
	Plan transportation		
278	Re-use construction material	3	
279	Evaluate and select transportation method	1	3
280	Build a railroad loading station at Centennial Bridge	1	3
281	Maximize concrete truck discharge	1	3
282	Provide portable batch plant	1	3
283	Use hydraulic spoil transport	1	3
284	Maintain roads during rainy season	3	
	Minimize excavation		
285	Use slope stabilization techniques	3	
286	Excavate culverts with tunnel boring machine	1	3
287	Excavate culverts with drilling and blasting	1	3

	Balance resources		
288	Maintain adequate inventory levels	3	
289	Have backup labour availability	1	AP
290	Provide labour register to contractor	1	AP
291	Replace some of the cement with fly ash (in concrete mix)	1	3
	Quality control monitor		
292	Provide on site testing facility	3	
293	QA	3	
	Maximize working time		
294	Work 3 eight hour shifts	1	3
295	Temporary covers work areas during rain	1	3
296	Minimize flat slabs – no concrete lining to water saving basin bottoms	1	3
	Other ideas for maximize productivity		
297	Slip form where possible	1	3
298	Use of movable forms	1	3
299	Use of prefabricated rebar cages	1	3
300	Optimize concrete pouring plan	3	
301	Prepare lift drawings for every pour	3	
302	Minimize number of concrete lifts	1	AP
303	Optimize concrete mix design for workability and flow rate	3	
304	Use vibrating form work	1	3
305	Provide water sumps inside chambers for dewatering	1	DN
	PLAN INTERFACING **Minimize canal operation conflicts**		
306	Establish proper/planned lines of communication	3	
307	Provide plenty of staging area for floating plant	1	AP
308	Review with operations, the plan & specs as they are developed	1	AP
309	Provide sufficient materials load/unload area	3	
310	Meet weekly to interface with operations	2	3
310 a	Coordinate shipping of materials from Pacific to Atlantic with operations	1	AP
311	Establish a hot line with operations	1	AP
312	Have contractor's discuss needs with operations in bids/proposals	1	AP
313	Include operations in partnering	1	AP
	Interface with other agencies		
314	Secure permit from minister of government and justice for transportation and use of explosives	3	
315	Interface with customs for direct deliveries	1	AP
316	Interface with labour department over imported labour	1	AP
317	Interface with social security office over taxes	2	3
318	Interface with public works over traffic management and warning signs	1	AP
319	Allow for explosives manufacture on site	1	AP
	Coordinate contractor's		
320	Have interface meetings regularly	3	
321	Require submittal/quality control plan in bids/proposals	3	
322	Explain interface requirements in plan & spec's	1	AP
323	Have only one contractor responsible for road	1	3

	maintenance, designated by ACP		
324	Start basalt channel excavation as early as possible	1	AP
325	Clearly define handling of basalt aggregate requirements from channel excavation contractor	1	AP
326	ACP to define responsibility for road maintenance	1	AP
327	Have contract early for access road construction and utilities	1	AP
	Master plan of construction operations		
328	Have two helicopters	3	
329	ACP establish commercial quarry policy	1	3
330	One submarine	3	
	RADICAL IDEAS		
331	Set up a shop to build all the steel work in Panama. These will increase labour and technology in our country.	1	AP
332	Temporary facilities and structures to be decided by the contractor forming part of his bid	1	3
333	Don't restrict more than absolutely necessary the contractor's choice of construction equipment.	1	3
334	Allow prefabrication of lock heads	1	3
335	Install in dry conditions all gates	1	AP
336	Allow design optimization by potential bidders provided it compiles with a basic set of fixed parameters	1	AP
337	Develop (with manufacturer(s)) new combined excavation/concrete laying system for lock section analogous to tunnel boring machines	1	3
338	Construct a conveyor belt/railway/skylift to transport material from Pacific lock to Gamboa west for subsequent transfer to barge thus avoiding barging up locks and running through Gaillard Cut.	1	3
339	Use sand asphalt as construction material for water saving basins and dykes	1	AP
340	Build precast shells for lock wall monolith construction	1	3
341	Create construction management team with power and expertise to solve all project issues	1	3
342	Use video monitoring for inspection and control	1	AP
343	Selected contractor and ACP form a construction performance company in which contractor provides the construction organization and ACP provides the procurement, financial and cost accounting functions	1	AP
344	Allow contractor to submit an alternative design if the procurement is design bid build	1	AP
345	Dewater 1939 excavations at locks selected locations to evaluate site conditions – before call for bids	1	AP
346	Proposals submitted on an A+B basis (time and cost) where time has a dollar value. The best proposal will be the combination of time and cost. Example each day is worth $500,000. Contractor #2 has a better time and cost proposal even though his cost of work is higher.	1	AP
347	Build up each lock as a simple concrete block with minimum joints	1	AP
348	Build lock walls from giant blocks (colour may be used to improve in-lock visibility and/or designate warning/critical zones)	1	3

Appendix 6 - Initial Risk Identification and Assessment

No	Risk Area	Specific Risk	Prob	Impact	Ranking
	Risk Category: Administration				
1	Controls	Inadequate contract records	M	M	MO
2		Inadequate control software	M	M	MO
3		Loss of records	L	H	MO
4		Absence of controls	L	H	MO
5		Inadequate support (staff)	M	M	MO
6		Failure to update	M	M	MO
7		Incompatible software	M	M	MO
8		Unrealistic expectations	M	M	MO
9		Non-assignment of responsibilities	L	H	MO
10		Excessive reporting requirements	H	L	MI
11		Inadequate records	M	M	MO
12		Poor interface with contractor	M	M	MO
13	Planning	Failure to plan	L	H	MO
14		Unrealistic estimates	L	H	MO
15		Faulty assumptions	L	H	MO
16		External impositions	M	H	MA
17		Misalignment of resources	H	M	MO
18		No contingency plans	L	H	MO
19		Delays in planning	H	M	MO
20		Inexperience in planning	H	H	MA
21		Ownership of float	M	M	MO
22	Procurement	Inadequate pre-qualification	L	H	MO
23		Delays in procurement	H	M	MO
24		Inadequate contract format	L	H	MO
25		Inadequate selection procedures	L	H	MO
26		Inadequate contract negotiation records	M	M	MO
27		Lack of participants	L	H	MO
27a		Deficient quality control requirements	L	H	MO
28		Lack of accountability of ACP team	M	M	MO
29		Inadequate scope	L	H	MO
30		Inadequate size	L	H	MO
31		Lack of bonding capacity	H	M	MO
32		Corruption	L	H	MO
33	Project management	Weak project manager	L	H	MO
34		Lack of authority	H	H	MA
35		Insufficient staffing	M	M	MO
36		Insufficient office space	L	L	MI
37		Insufficient admin support	M	L	MI
38		Insufficient records storage space	L	L	MI
39		Inadequate procedures	M	M	MO
40		Inadequate communications	H	M	MO
41		Inadequate contracting method	M	H	MA
42		Inadequate coordination of contractors	M	H	MA
43		Poor claims management	M	M	MO
44		Failure to define information required from contractors	L	M	MI
45		Lack of execution capability	H	H	MA

46		Excessive subcontractors	H	M	MO
47	Environmental	Approval delays	M	M	MO
48		Failure to complete studies	M	H	MA
49		Inadequate records	M	M	MO
50		Change of standards	M	M	MO
51		Failure to coordinate with ANAM	L	H	MO
52		Lack of pollution control	M	M	MO
53		Inadequate inspection	M	M	MO
54		Insufficient planning	M	M	MO
55		Unknown requirements	L	M	MI
55		Discovery of new species	L	H	MO
56		Discovery of endangered species	L	H	MO
57		Lack of mitigation strategy	L	M	MI
58		Failure to obtain permits	L	H	MO
	Risk Category: Labour				
59	Supply/availabil ity	Lack of local labour	H	H	MA
60		Lack of skills	H	H	MA
61		High turnover	M	H	MA
62		Absenteeism	H	M	MO
63		Restrictions on imported	L	H	MO
64		Lack of transportation	L	H	MO
65		Insufficient housing	M	M	MO
66	Relations	Work slowdown	M	M	MO
67		Strike	M	H	MA
68		Boycott	L	M	MI
69		Insensitive to culture	M	L	MI
70		Bad attitude (uncommitted)	M	L	MI
71		Language barriers	H	L	MI
72		Worker layoff plan (demobilization)	H	L	MI
73		Over expectation	H	L	MI
74		Competition between contractors	H	H	MA
75	Skills	Lack of training	M	M	MO
76		Inadequate recruitment	H	M	MO
77		Lack of effective supervision	H	M	MO
78		Lack of knowledgeable inspectors	H	M	MO
79		Local vs international skills	L	L	MI
80	Productivity	Absenteeism	Idea taken out		
81		Excessive overtime	H	L	MI
82		Inadequate access onsite	L	L	MI
83		Inadequate tools/equipment	M	L	MI
84		Bad weather conditions	H	M	MO
85		Use of night time shifts	H	L	MI
86		Improper nourishment	M	L	MI
87		Lack of incentive scheme	M	L	MI
88	Safety	Inappropriate equipment	L	M	MO
89		Lack of training	L	H	MO
90		Poor supervision	L	M	MI
91		Lack of safety program	L	H	MO
92		Lack of onsite health facility	L	L	MI
93		Lack of emergency response plan (lack of helicopters)	L	L	MI
94		Major accidents	Idea taken out		

95	Cost	Wage escalation	M	H	MA
96		Wage differentials (local vs imported)	H	M	MO
97		Benefit demands increase	H	L	MI
98		Lack of local labour	Idea taken out		
99		Bid proposals higher than the cost estimates	M	H	MA
100	Environmental	Difficulties with financing	Idea taken out		
	Risk Category: Operational				
101	Navigational	Ship accidents	M	M	MO
102		Landslide (dam instability)	M	M	MO
103		Navigation channels obstruction	L	M	MI
104		Destabilization of existing slopes	M	M	MO
105		Loss of Gatun Lake	L	H	MO
106		Union (pilots)	M	M	MO
107		Contractor interference with existing operations	M	M	MO
108		Lack of emergency response plan	L	H	MO
109		Density currents	M	M	MO
110	Existing lock operations	Damages from vibrations	M	M	MO
111		Disruption of operations due to vibration	L	L	MI
112		Dust	M	M	MO
		Noise	L	L	MI
114		Float equipment interfere with navigation	M	M	MO
115	Water	Dam overtopping (floods)	L	H	MO
116		Loss of Gatun Lake	L	H	MO
117		Draught	M	M	MO
118		Water quality	L	M	MI
119		Damages to existing infrastructure	L	M	MI
120		Salinity (water quality)	L	M	MI
121		Lack of coordination (new- existing) locks	L	L	MI
122	New locks operation	Malfunction of gates	L	H	MO
123		Excess of water comps	L	M	MI
124		Excessive hawser forces	L	H	MO
125		Underestimated lockage time	M	H	MA
126		Unforeseen problems with tugs	M	H	MA
127		Integrity of concrete/settlements	L	H	MO
128		Improper operational interfacing between new and existing locks	L	M	MI
129	Equipment	Tugs undersize	L	M	MI
130		Insufficient redundancy	L	H	MO
131		Incompatibility	L	M	MI
132		Over/under designed	M	M	MO
133		Excessive complexity	L	L	MI
134		Improper training	L	M	MI
135		Poor Maintainability	L	H	MO
136	Technology	Lack of user familiarity	L	M	MI
	Risk Category: Design				
137	Materials	Inadequate selection	L	M	MI
138		Poor quality	L	H	MO
139		Insufficient supply	M	H	MA
140		High cost	M	M	MO

141		Too many choices	L	L	MI
142		Over specification	M	L	MI
143	Technology	Unproven (use of)	L	M	MI
144		Excessive complexity	L	M	MI
145		Incorrect technology	L	M	MI
146		Obsolete	L	L	MI
147		Too rapidly changing	M	L	MI
148	Performance	Lack of qualified designers	L	M	MI
149		Lack of number of qualified designers	L	M	MI
150		Poor choice of designers	M	M	MO
151		Poor quality control	L	M	MI
152		Design incompatible of operational needs	M	H	MA
153		Contractors can't build it (too difficult)	L	H	MO
154		Need materials and/or parts not available	L	M	MI
155		Incompatible with project desire	L	H	MO
156		Not validated design	L	L	MI
157	Criteria	It changing in the middle	H	M	MO
158		It being improper	L	H	MO
159		Lack of flexibility	M	M	MO
160		Lack of foresight	M	H	MA
161		Being too conservative	M	L	MI
162		It being incomplete	L	M	MI
163		Inadequate site characterization	L	M	MI
163 a		Under estimation of outside water needs	M	M	MO
164		Inappropriate criteria for temporary structures	M	M	MO
165	Schedule	Being unrealistic	H	M	MO
166		Missing milestones	M	M	MO
167		Changed conditions (site)	H	M	MO
168		Changed criteria	M	M	MO
169		Inflexible to construction/field changes	M	M	MO
170		Lack of coordination of activities	M	M	MO
	Risk Category: Site conditions				
171	Geotechnical	Lack of accurate information	L	H	MO
172		Insufficient information	L	H	MO
173		Unforeseen conditions	L	H	MO
174		Unrealistic assumptions	L	H	MO
175		Incorrect inter-poplation	L	H	MO
176		Incorrect interpretation	M	H	MA
177		Rock unsuitable as aggregate	L	H	MO
178	Seismic	Lack of seismic standards	L	M	MI
179		Incorrectly defined standards	H	H	MA
180		Incomplete information	H	M	MO
181		Lack of sensitivity analysis	H	M	MO
182		Incompatible design criteria	H	M	MO
183		Improper identification of faults	L	M	MI
184		Assess potential movement of faults	L	M	MI
185		Tsunami	L	H	MO
186		New information	L	M	MI
187	Weather	Occurrence of flood	M	M	MO
188		Occurrence of drought	M	M	MO
189		Inadequate weather information	L	M	MI

190		Rain	H	M	MO
191		Storms	H	M	MO
192		Slides	M	M	MO
193		Fog	H	M	MO
194		Wind	H	M	MO
195		Heat	H	M	MO
196		Snow	L	M	MI
197	Archeological	Lack of information	M	M	MO
198		Delay result of discovery	M	M	MO
199		Costs result of discovery	M	M	MO
200	Environmental	UXO (unforeseen)	M	H	MA
201		Soil pollution	L	M	MI
202		Air pollution	M	M	MO
203		Noise pollution	M	M	MO
204		Dust pollution	H	M	MO
205		Hazmat	L	M	MI
206		Vibration	H	M	MO
207		Oil/spills	H	M	MO
208		Lack of response plan	L	M	MI
	Risk Category: Financial				
209	Foreign exchange	Contractor's performance	M	L	MI
210		Material/supply cost increase	M	H	MA
211		Mismatch of foreign currency	L	H	MO
212	Inflation	Higher project costs	H	H	MA
213		Energy prices increases	H	M	MO
214		Unavailability of local labour	H	H	MA
215		Impact on financing	M	M	MO
216	Budget	Underestimating	M	H	MA
217		Over design	M	M	MO
218		Incomplete scope	L	H	MO
219		Modifications	M	M	MO
220		Lack of bidders	M	H	MA
221	Financing	Availability of acceptable finances	M	H	MA
222		Cost of financing being more expensive	M	M	MO
223		Unacceptable terms and conditions	L	H	MO
224		ACP's low credit rating	L	H	MO
225		Lenders credit rating low	L	L	MI
226		Inability to meet environmental requirements	H	H	MA
227		Legal requirements	L	H	MO
228		Contractor bankruptcy	M	H	MA
229	Cash flow	Changes in draw down schedule	M	L	MO
230		Lack of availability of revenues	L	H	MO
231		Cost overruns	H	M	MO
232	Cost overrun	Over design	M	L	MO
233		Materials supplies cost increase	M	H	MA
234		Unforeseen site conditions	M	H	MA
235		Schedule changes	H	H	MA
236		Accidents	H	M	MO
237		Owner scope changes	M	M	MO
238		Security	L	L	MI
239		Acquisition delays	H	M	MO

240	Demand	Changing market conditions	H	M	MO
241		Competitors increase market share	M	M	MO
242		Technological changes	M	L	MI
243		Increasing energy costs	H	L	MI
244		Global economic crisis	L	H	MO
245		Misjudgement of price sensitivity	M	H	MA
	Risk Category: Political				
246	Referendum	Delay	H	H	MA
247		Clarity of mandate	M	H	MA
248		Poor communication strategy	M	H	MA
249		Negative outcome	M	H	MA
250	NGO	Organized opposition	H	M	MO
251		Expensive mitigating requirements	L	M	MI
252		Vandalism by NGO	L	L	MI
253		Stopping financing	M	H	MA
254		Boycott by NGO's	L	L	MI
255	Central government	Failure to act timely	M	H	MA
256		Changes in government – 2009	H	L	MI
257		Demands for additional funds	H	M	MO
258		Interference	M	H	MA
259		Failure to provide permits	L	H	MO
260	Internal politics	Labour communications	M	H	MA
261		Board changes	M	L	MI
262		Changes in top management	M	M	MO
263		Inability to restructure	H	H	MA
264		Lack of expertise	H	H	MA
265	ANAM	Changing rules and procedures	L	H	MO
266		Untimely authorizations	L	H	MO
267		Interference	M	M	MO
268		Mitigation requirements	H	M	MO
269		Project delay	L	H	MO
270	Panamanian public	Lack of project understanding	H	H	MA
271		Unavailability of local labour	H	H	MA
272		Negative impact of construction on community	H	L	MI
273	International	Lack of support from other countries	L	H	MO
274		Tying – demands for specific treatment for $$ support	M	M	MO
275		Negative interpretation of N treaty	M	M	MO
276		US intervention – N treaty	L	H	MO
277		War	L	H	MO
278		Naval blockage	L	H	MO
	Risk Category: Construction				
279	Environmental	Lack of permits	L	H	MO
280		Approval for disposal sites	L	M	MI
281		Unexpected "sensitive" discovery	L	M	MI
282		Contamination during dewatering	L	L	MI
283		Noncompliance with program	M	H	MA
284		Restrictions of UXO area (unexpected)	M	M	MO
285		Inadequate management of NGO's	M	H	MA
286		Inadequate monitoring	L	H	MO

287	Schedule	Delays in supplies	M	M	MO
288		Incomplete design	M	M	MO
289		Unrealistic schedule	H	M	MO
290		Conflicting activities	H	M	MO
291		Delays due to cash flow problem	M	H	MA
292		Lack of coordination	H	M	MO
293		Poor contractor/owner relations	M	M	MO
294		Unexpected events	M	H	MA
295		Owner caused delays	M	M	MO
296		Interference by operations	L	H	MO
297		Inadequate contractor performance	L	H	MO
298		Require rework/repair	L	L	MI
299		Differing site conditions	L	H	MO
300	Cost	Material escalation	H	M	MO
301		Growth in volumes (materials)	H	H	MA
302		Consumables escalation	H	M	MO
303		Increase in labour cost	M	H	MA
304		Major change orders	L	H	MO
305		Major growth in work scope	L	H	MO
306		Major claims	H	M	MO
307		Increase in transportation cost	M	M	MO
308		Major schedule delays	H	H	MA
309		Require rework	Idea taken out		
310		Differing site conditions	Idea taken out		
311	Quality	Poor specifications	M	M	MO
312		Poor design	L	H	MO
313		Noncompliance with plans & specs	L	H	MO
314		Ineffective QA/QC	M	M	MO
315		Poor quality materials	L	H	MO
316		Unskilled labour	Idea taken out		
317		Lack of adequate testing	L	M	MI
318		Improper contractor coordination	M	H	MO
319	Materials	Lack of market studies	L	L	MI
320		Lack of adequate supplies	L	H	MO
321		Inadequate planning	L	H	MO
322		Global shortages	M	H	MA
323		Unexpected processing requirements	M	M	MO
324		Delivery delays	M	H	MA
325		Changes to disposal requirements	M	M	MO
326		Requirement for exotic materials	L	L	MI
327		Inadequate storage security	L	L	MI
328	Equipment	Lack of availability	M	M	MO
329		Delays to mobilization	H	H	MA
330		Improper equipment	M	M	MO
331		Lack of maintenance	M	M	MO
332		Under performance	M	M	MO
333		Lack of spare parts/units	M	M	MO
334		Inadequate infrastructure of operations	L	H	MO
335		Irreparable damage	L	H	MO
336		Sabotage (vandalism)	L	H	MO

Appendix 7 – Minor Risks

No	Risk Area	Specific Risk
	Risk Category: Administration	
10	Controls	Excessive reporting requirements
36	Project management	Insufficient office space
37		Insufficient admin support
38 44		Insufficient records storage space Failure to define information required from contractors
55	Environmental	Unknown requirements
57		Lack of mitigation strategy
	Risk Category: Labour	
68	Relations	Boycott
69		Insensitive to culture
70		Bad attitude (uncommitted)
71		Language barriers
72		Worker layoff plan (demobilization)
73		Over expectation
79	Skills	Local vs international skills
81	Productivity	Excessive overtime
82		Inadequate access onsite
83		Inadequate tools/equipment
85		Use of night time shifts
86		Improper nourishment
87		Lack of incentive scheme
90	Safety	Poor supervision
92		Lack of onsite health facility
93		Lack of emergency response plan (lack of helicopters)
97	Cost	Benefit demands increase
	Risk Category: Operational	
103 111	Navigational Existing lock operations	Navigation channels obstruction Disruption of operations due to vibration
113		Noise
118	Water	Water quality
119		Damages to existing infrastructure
120		Salinity (water quality)
121		Lack of coordination (new- existing) locks
123	New locks operation	Excess of water comps
128		Improper operational interfacing between new and existing locks
129	Equipment	Tugs undersize
131		Incompatibility
133		Excessive complexity
134		Improper training
136	Technology	Lack of user familiarity
	Risk Category: Design	
137 141	Materials	Inadequate selection Too many choices
142		Over specification
143	Technology	Unproven (use of)
144		Excessive complexity
145		Incorrect technology

146		Obsolete
147		Too rapidly changing
148	Performance	Lack of qualified designers
149		Lack of number of qualified designers
151		Poor quality control
154		Need materials and/or parts not available
156		Not validated design
161	Criteria	Being too conservative
162		It being incomplete
163		Inadequate site characterization
	Risk Category: Site conditions	
178	Seismic	Lack of seismic standards
183		Improper identification of faults
184 186		Assess potential movement of faults New information
189	Weather	Inadequate weather information
196		Snow
201	Environmental	Soil pollution
205		Hazmat
208		Lack of response plan
	Risk Category: Financial	
209	Foreign exchange	Contractor's performance
225	Financing	Lenders credit rating low
238	Cost overrun	Security
242	Demand	Technological changes
243		Increasing energy costs
	Risk Category: Political	
251	NGO	Expensive mitigating requirements
252 254		Vandalism by NGO Boycott by NGO's
256	Central government	Changes in government – 2009
261	Internal politics	Board changes
272	Panamanian public	Negative impact of construction on community
	Risk Category: Construction	
280	Environmental	Approval for disposal sites
281		Unexpected "sensitive" discovery
282		Contamination during dewatering
298	Schedule	Require rework/repair
317	Quality	Lack of adequate testing
319	Materials	Lack of market studies
326		Requirement for exotic materials
327		Inadequate storage security