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Risk
noun \ˈrisk\

- The possibility that something bad or unpleasant (such as an injury or a loss) will happen. Merriam-Webster
- An uncertain event or condition that, if it occurs, has an effect on at least one [project] objective. PMBOK 5th Edition
- The potential of gaining or losing something of value *IOSR Journal of Business and Management*
- Risk = Probability of Occurrence x Impact if Realized

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Risk Management

- the identification, assessment, and prioritization of risks (defined in ISO 31000 as *the effect of uncertainty on objectives*) followed by coordinated and economical application of resources to minimize, monitor, and control the probability and/or impact of unfortunate events or to maximize the realization of opportunities.

Risk Management Methodology

1) Identify Risks
2) Quantify the impact of the risk if realized
3) Qualify the likelihood of the risk occurring
4) Determine a total risk score for each risk
5) Sort the risks based upon the highest risk score
6) Develop mitigation strategies (elimination, acceptance, transfer, reduction) for each risk
7) Assign an owner to each risk
8) Re-assess risks after mitigation strategies are in place
9) Continually monitor the risks throughout the project

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Risk Categorization

Likelihood

Level	Descriptor	Likelihood over 5 years	Likelihood over 5 years
1	Low	>0.005%	>1 in 20,000 chance
2	Medium-low	>0.05%	>1 in 2,000 chance
3	Medium	>0.5%	>1 in 200 chance
4	Medium-high	>5%	>1 in 20 chance
5	High	>50%	>1 in 2 chance

Impact

Level	Descriptor	Impact
1	Limited	Little to no impact on the project in terms of schedule, cost or quality. Little to no impact on project strategy, outcome or operational activities. Little to no stakeholder concern.
2	Minor	Minor impact on the project in terms of schedule, cost or quality. Little impact on the project strategy, outcome or operational activities. Low stakeholder concern.
3	Moderate	Considerable impact on the project in terms of schedule, cost or quality. Moderate impact on project strategy, outcome or operational activities. Moderate stakeholder concern.
4	Significant	Severe impact on schedule, cost or quality. Major adverse effect on project outcome or operational activities. Major stakeholder concern.
5	Catastrophic	Impact would kill the project.

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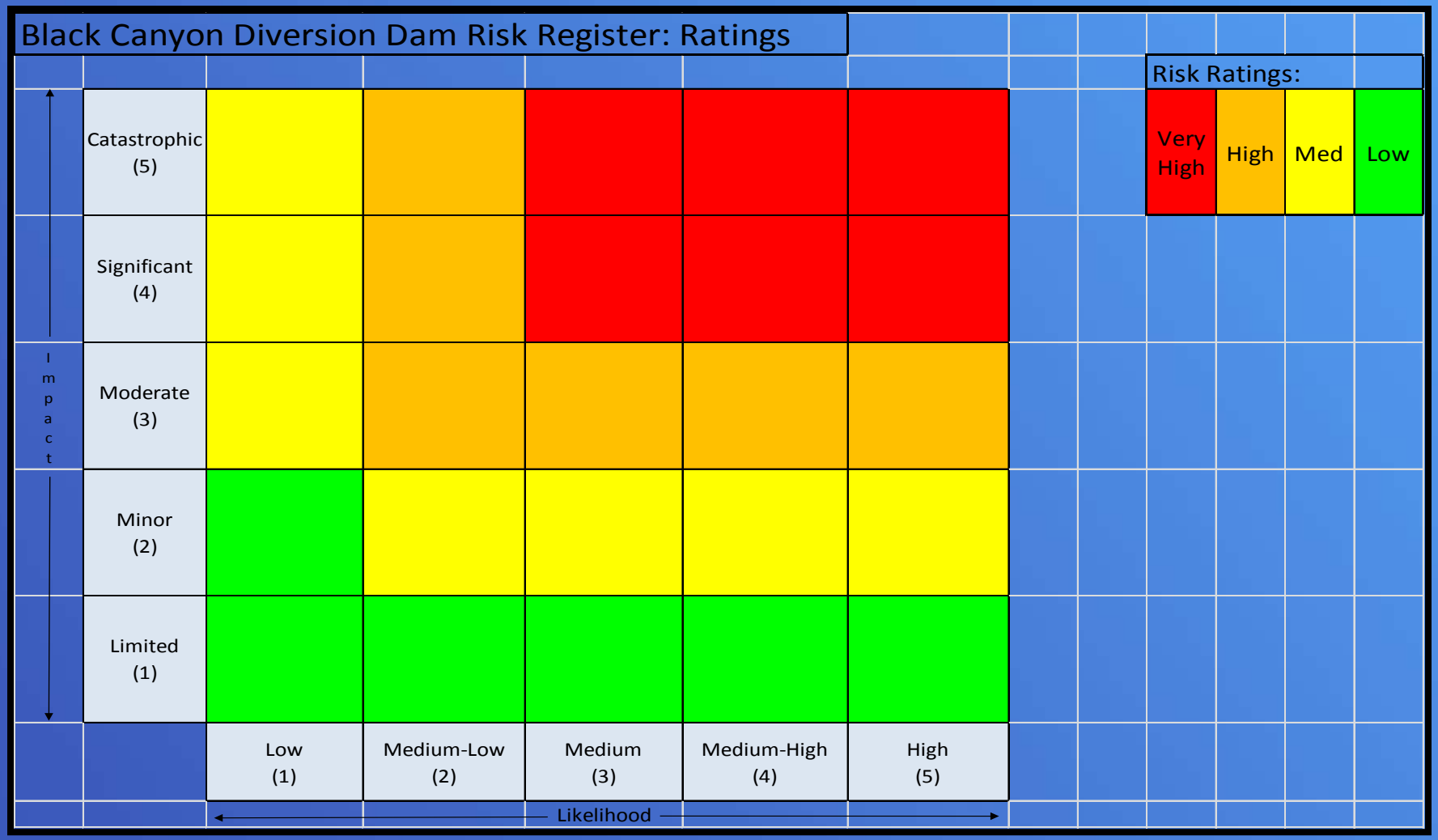
Risk Matrix



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Risk Register

Risk Register

Black Canyon Diversion Dam Projects
PM: Chris Vick
Date Updated: May 15, 2013
Version: 1.0

Risk Number	Date Initiated	Risk Description	Likelihood	Impact	Risk Score	Control Measures	Risk Owner
1. Example	15-May-13	Bids are high	3	4	12	Engage stakeholders; Determine impact to BPA budget; Determine risk threshold for BPA.	Chris Vick
2							
3							
4							
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Risk Management Plan

Risk Register

Black Canyon Diversion Dam Projects
PM: Chris Mick
Date Updated: November 26, 2013
Version: 1.0

Risk Number	Date Initiated	Risk Description	Likelihood	Impact	Risk Score
Example	15-May-13	Risks are High	2.5	5	12.5
30	1-Nov-13	[illegible]	5.5	4	22
31	1-Nov-13	[illegible]	5	4.5	22
110	1-Nov-13	[illegible]	5	4.5	22.5
113	1-Nov-13	[illegible]	5.5	4	22
2	1-Nov-13	[illegible]	5	4	22
3	1-Nov-13	[illegible]	5	4	22
4	1-Nov-13	[illegible]	5	4	22
30	1-Nov-13	[illegible]	5	4	22
32	1-Nov-13	[illegible]	5	4	22
33	1-Nov-13	[illegible]	5	4	22
34	1-Nov-13	[illegible]	5	4	22
110	1-Nov-13	[illegible]	5	4	22
111	1-Nov-13	[illegible]	5	4	22
112	1-Nov-13	[illegible]	5	4	22
37	1-Nov-13	[illegible]	5.5	4.5	24.75
38	1-Nov-13	[illegible]	5.5	4	22
39	1-Nov-13	[illegible]	5.5	4	22
40	1-Nov-13	[illegible]	5.5	4	22
41	1-Nov-13	[illegible]	5.5	4	22
42	1-Nov-13	[illegible]	5.5	4	22
43	1-Nov-13	[illegible]	5.5	4	22
44	1-Nov-13	[illegible]	5.5	4	22
45	1-Nov-13	[illegible]	5.5	4	22
46	1-Nov-13	[illegible]	5.5	4	22
47	1-Nov-13	[illegible]	5.5	4	22
48	1-Nov-13	[illegible]	5.5	4	22
49	1-Nov-13	[illegible]	5.5	4	22
50	1-Nov-13	[illegible]	5.5	4	22
51	1-Nov-13	[illegible]	5.5	4	22
52	1-Nov-13	[illegible]	5.5	4	22
53	1-Nov-13	[illegible]	5.5	4	22
54	1-Nov-13	[illegible]	5.5	4	22
55	1-Nov-13	[illegible]	5.5	4	22
56	1-Nov-13	[illegible]	5.5	4	22
57	1-Nov-13	[illegible]	5.5	4	22
58	1-Nov-13	[illegible]	5.5	4	22
59	1-Nov-13	[illegible]	5.5	4	22
60	1-Nov-13	[illegible]	5.5	4	22
61	1-Nov-13	[illegible]	5.5	4	22
62	1-Nov-13	[illegible]	5.5	4	22
63	1-Nov-13	[illegible]	5.5	4	22
64	1-Nov-13	[illegible]	5.5	4	22
65	1-Nov-13	[illegible]	5.5	4	22
66	1-Nov-13	[illegible]	5.5	4	22
67	1-Nov-13	[illegible]	5.5	4	22
68	1-Nov-13	[illegible]	5.5	4	22
69	1-Nov-13	[illegible]	5.5	4	22
70	1-Nov-13	[illegible]	5.5	4	22
71	1-Nov-13	[illegible]	5.5	4	22
72	1-Nov-13	[illegible]	5.5	4	22
73	1-Nov-13	[illegible]	5.5	4	22
74	1-Nov-13	[illegible]	5.5	4	22
75	1-Nov-13	[illegible]	5.5	4	22
76	1-Nov-13	[illegible]	5.5	4	22
77	1-Nov-13	[illegible]	5.5	4	22
78	1-Nov-13	[illegible]	5.5	4	22
79	1-Nov-13	[illegible]	5.5	4	22
80	1-Nov-13	[illegible]	5.5	4	22
81	1-Nov-13	[illegible]	5.5	4	22
82	1-Nov-13	[illegible]	5.5	4	22
83	1-Nov-13	[illegible]	5.5	4	22
84	1-Nov-13	[illegible]	5.5	4	22
85	1-Nov-13	[illegible]	5.5	4	22
86	1-Nov-13	[illegible]	5.5	4	22
87	1-Nov-13	[illegible]	5.5	4	22
88	1-Nov-13	[illegible]	5.5	4	22
89	1-Nov-13	[illegible]	5.5	4	22
90	1-Nov-13	[illegible]	5.5	4	22
91	1-Nov-13	[illegible]	5.5	4	22
92	1-Nov-13	[illegible]	5.5	4	22
93	1-Nov-13	[illegible]	5.5	4	22
94	1-Nov-13	[illegible]	5.5	4	22
95	1-Nov-13	[illegible]	5.5	4	22
96	1-Nov-13	[illegible]	5.5	4	22
97	1-Nov-13	[illegible]	5.5	4	22
98	1-Nov-13	[illegible]	5.5	4	22
99	1-Nov-13	[illegible]	5.5	4	22
100	1-Nov-13	[illegible]	5.5	4	22
11	1-Nov-13	Key personnel leave federal service	5	3	15
40	1-Nov-13	Modifications to contract	5	3	15
93	1-Nov-13	Unknown conditions are discovered	5	3	15
107	1-Nov-13	Powerplant footprint is too small causes chokehold in assembly	5	3	15
202	1-Nov-13	U1/2 trash rake - redesign required if Schedule B is not awarded	5	3	15
42	1-Nov-13	Modifications exceed funding amount	4.5	3	13.5
95	1-Nov-13	Vandalism	4.5	3	13.5
148	1-Nov-13	TSC designers retirement	4.5	3	13.5
108	1-Nov-13	Change in management at BIA changes priorities of investments	5	2.5	12.5
211	1-Nov-13	Not allowing a longer construction window (Nov 1-Apr 1)	5	2.5	12.5
4	1-Nov-13	Work below high water mark on d/s side of dam	4	3	12
47	1-Nov-13	Geologic anomaly is discovered; period of indecision	4	3	12
132	1-Nov-13	Contractor's first time working with gov't	4	3	12
60	1-Nov-13	While contractor is onsite, additional work is requested, contractor needs to accelerate and bring in more resources	3.5	3	10.5
130	1-Nov-13	Equipment inavailability increases costs	3.5	3	10.5
158	1-Nov-13	Multiple amendments cause delays	3.5	3	10.5
209	1-Nov-13	Irrigation districts want us to deliver water until Oct 31	3	3.5	10.5
54	1-Nov-13	Cement shortages	2	5	10
55	1-Nov-13	Steel shortages	2	5	10
58	1-Nov-13	Empty pipe shortage	2	5	10
64	1-Nov-13	Politics interfere with project	2	5	10
128	1-Nov-13	Cannot throw out a low bidder with a bad proposal	2.5	4	10
21	1-Nov-13	Coffer dam leaking excessively	3	3	9
30	1-Nov-13	Demolition hits a spike	2	4.5	9
37	1-Nov-13	Excessive water seepage through foundation rock	3	3	9
38	1-Nov-13	Protest(s) to award	3	3	9
39	1-Nov-13	Protest to bid causing delay and re-cost	3	3	9
62	1-Nov-13	Contractor selects a subcontractor that has mediocre past performance with Reclamation	3	3	9
90	1-Nov-13	We award Schedule A, not B	2.5	3.5	8.75
19	1-Nov-13	Safety issue, i.e., grand coulee top overhaul	2	4	8
20	1-Nov-13	Delay in coffer dams delivery	2	4	8
43	1-Nov-13	Bad castings are received from manufacturer	2	4	8

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Risk Management Plan

Risk Register

Grand Coulee G1-G18 Modernization & Overhead Program
PM: John Nink
Date Updated:
Version: 1.0

Fill in only yellow blocks.
Cross reference risks to each other risk item line.

						Initial Evaluation (No Controls)					After Controls Implemented					
Risk Number	Date Initiated (Risk Register!R10)	Risk Description (Risk Register!C10)	Sub-Project	Project Phase (Risk Register!E10)	Impact Area	Likelihood	Impact	Risk Score	Risk Level	Mitigation / Control Measures	Likelihood	Impact	Risk Score	Risk Level	Acceptance Level (Based on Initial Risk)	Creator
1	7-Jan-15	Current equipment configuration may not be accurately reflected in the drawings leading to delays in equipment installation.	All	Construction	Schedule	4	4	16	High	Drawing updates for at least two (2) units (each configuration) will be completed prior to procurement. Remaining units will be updated in the order of installation; each to be completed prior to the install outage.	2	4	8	Med	Project Sponsor(s)	J. Nink
6	28-Jan-15	Proceeding without adequate planning	All	Scoping	Schedule	4	4	16	High	Project Management Plan being developed with detailed scope. Lessons learned as we go and previous overhauls TPP. Logistics planning study will be conducted. Conservative schedule. Team meetings bi-weekly. Good communication plan with decision authority outlined.	1	4	4	Low	Project Sponsor(s)	GCPO
7	28-Jan-15	Insufficient lay-down space for overhaul and space outside PPs for offices, restrooms, etc	All	Construction	Schedule	4	4	16	High	Logistics study to look at layout space. Take lessons learned from turbine overhaul. Good coordination needed between BOR and contractors.	3	4	12	Med	Project Sponsor(s)	GCPO
8	28-Jan-15	Lead time for critical parts, Spares	All	Construction	Schedule	4	4	16	High	Conservative schedule for manufacturing. Lessons learned from TPP and G-9 windings. Request from contractors list of critical parts and critical path schedule for manufacturing. TPIC consideration. Contract options.	2	4	8	Med	Project Sponsor(s)	GCPO
9	28-Jan-15	Is the spec written that Bost. will provide crane op? If no, lack of gov crane operators (to support round the clock ops, etc)	All	Construction	Schedule	4	4	16	High	Windings contractor will supply operator. Governor and Exciters will use BC personnel. Weekends possible, 24hr ops might be more difficult. Recommend expanding number of crane operators. Make contractors request crane IDs 48-72 hr ahead of ER. Weekly coordination meetings during construction.	2	2	4	Low	Project Sponsor(s)	GCPO
11	28-Jan-15	Retirement-Loss of corporate knowledge	All	Construction	Technical	5	4	20	High	WCH knowledge transfer and training systems. Organized project and contract files, use of sharepoint. Reunion planning and job shadowing.	5	3	15	High	Project Sponsor(s)	GCPO
12	28-Jan-15	Contractors competing for power, water, cranes, space	All	Construction	Schedule	5	3	15	High	Combine with 49.	1	1	1	Low	Project Sponsor(s)	GCPO
14	28-Jan-15	G1-G18 Forced Outage, Need repair (3-4 months)	Windings	Construction	Schedule	5	3	15	High	Have extra critical components ready for the next install. Move forced outage unit to next in line for install. Contract language to leave open possibility of working two units in the same powerhouse.	5	2	10	Med	Project Sponsor(s)	GCPO
33	28-Jan-15	Loss of key Staff to other projects or leaving BOR	All	Construction	Technical	4	4	16	High	WCH knowledge transfer and training systems. Organized project and contract files, use of sharepoint.	4	3	12	Med	Project Sponsor(s)	GCPO
45	29-Jan-15	Spot repair cost deviations due to condition variance. (See below for breakdown)	Penstocks	Construction	Cost	5	3	15	High	Lessons learned as contract progresses. Funding reserve for the cost of 1-2 full rescoats if needed.	5	2	10	Med	Project Sponsor(s)	D. Tordonato
2	7-Jan-15	Modernization of the bridge crane controls is not completed in time for the first generator install.	Windings	Construction	Schedule	4	4	16	High	Replace cranes instead of modernize, no outage as they build new crane before removing old.	3	2	6	Low	Project Sponsor(s)	J. Nink
58	10-Mar-15	No internal GCPO resources available to complete adult drawings prior to the release of specifications.	Governors, Exciters, Windings	Design	Schedule	5	4	20	High	Government as-built drawing team supporting the PSP will be moved to as-building the G1-18 drawings. An A/E firm will be used to help support PSP drawing updates.	2	4	8	Med	Project Sponsor(s)	M. Tucker
59	8-May-15	The RPH cranes are needed for a 3ft (rotor removal) that exceeds the current down-rated capacity.	Cranes	Construction	Technical	5	4	20	High	Cranes will be modernized or replaced prior to the first RPH generator winding installation (July 2020) where the 3ft is required.	1	4	4	Low	Project Sponsor(s)	G. Friend
60	22-Jun-15	NEPA Process may delay entry into procurement for all G1-18 projects thus not being able to meet planned outage dates for the first units.	All	Procurement	Schedule	5	4	20	High	If needed, outage window for unit G-7 (No windings) will be shifted to from Jan-Jul 2018 to Sep 2019 - Mar 2020. Thus aligning with the G-8 outage at the same time. Neither G5 or G7 units will have new windings installed.	5	2	10	Med	Project Sponsor(s)	J. Nink
61	14-Sep-15	Delay of 230KV RPH (G7/G12-18) transformer replacement of 2-6 years is anticipated as a result of RPA and SCPO studying the feasibility of using 500KV transformers for RPH. The current transformer replacement schedule is coordinated with G1-18 modernization, so delays in transformer replacement will likly cause schedule and logistics conflicts.	Transformers	Construction	Schedule	5	2	10	Med		5	1	5	Low	Project Manager	J. Nink
13	28-Jan-15	Rotor Cracks (Spider) found	Windings	Construction	Schedule	3	4	12	Med		1	1	1	Low	Project Manager	GCPO
15	28-Jan-15	Crane outages during overhaul: rope, sheaves, drives etc.	All	Construction	Schedule	3	4	12	Med		1	1	1	Low	Project Manager	GCPO
16	28-Jan-15	Rigging and special tools needed for jacks and disassembly	All	Construction	Cost	3	4	12	Med		1	1	1	Low	Project Manager	GCPO
17	28-Jan-15	Gov Staff Turnover: Trades and Crafts	All	Construction	Technical	4	3	12	Med		1	1	1	Low	Project Manager	GCPO
18	28-Jan-15	G1-G18 Forced Outage, Needs rewind (12-18 months)	Windings	Construction	Schedule	3	4	12	Med	Same as 14.	1	1	1	Low	Project Manager	GCPO
19	28-Jan-15	Unable to restore unit to alignment specs	Windings	Construction	Technical	4	3	12	Med		1	1	1	Low	Project Manager	GCPO
20	28-Jan-15	Gov Staff Turnover: Technical (ER, PM)	All	Construction	Technical	5	2	10	Med		1	1	1	Low	Project Manager	GCPO
21	28-Jan-15	All fails to meet schedule (for Crane spec)	Cranes	Design	Schedule	3	3	9	Med		1	1	1	Low	Project Manager	GCPO
22	28-Jan-15	Contractor Staff turnover: Insufficient manpower	All	Construction	Schedule	3	3	9	Med		1	1	1	Low	Project Manager	GCPO
23	28-Jan-15	Penstock coatings dry out and crack, or quantities underestimated	Penstocks	Procurement	Cost	3	3	9	Med	Same as 45.	1	1	1	Low	Project Manager	GCPO
24	28-Jan-15	Station service forced outage	All	Construction	Schedule	3	3	9	Med		1	1	1	Low	Project Manager	GCPO
25	28-Jan-15	Pole Problems found	Windings	Construction	Schedule	4	3	12	Med	Refurbish all poles.	4	1	4	Low	Project Manager	GCPO
26	28-Jan-15	Bid Protest	All	Procurement	Schedule	3	3	9	Med		1	1	1	Low	Project Manager	GCPO
27	28-Jan-15	Lack of Bidders	All	Procurement	Schedule	3	3	9	Med	RFIs, prequalification. Market research. Reduce bond requirements. Bidders conference to discuss project & contracting strategy before RFPs.	1	1	1	Low	Project Manager	GCPO
28	28-Jan-15	Bids above IGE	All	Procurement	Cost	3	3	9	Med		1	1	1	Low	Project Manager	GCPO
29	28-Jan-15	Safety- tough complicated work	All	Construction	Schedule	3	3	9	Med		1	1	1	Low	Project Manager	GCPO
30	28-Jan-15	Safety- Numerous simultaneous activities	All	Construction	Schedule	3	3	9	Med		1	1	1	Low	Project Manager	GCPO
31	28-Jan-15	Large, long lead time items don't pass inspection when they reach the site	All	Construction	Schedule	2	4	8	Med		1	1	1	Low	Project Manager	GCPO
32	28-Jan-15	Procurement Process Delays (staff approval, issue etc)	All	Procurement	Schedule	4	2	8	Med		1	1	1	Low	Project Manager	GCPO
37	28-Jan-15	Keep or TPP accounts for critical resources	All	Construction	Schedule	4	3	12	Med	Percent BC crew for G1-18 available.	4	2	8	Med	Project Manager	GCPO
38	28-Jan-15	Noise or Vibration problem with windings design	Windings	Construction	Technical	3	4	12	Med		1	1	1	Low	Project Manager	GCPO

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Risk and Project Management Key Takeaways

- Risk Management is not complicated!
- Risk identification begins at initiation of the project
- First risk identification session should occur before 30% design
- Mitigate as many risks through design
- Accept risks with low risk score
- Transfer appropriate risks to contractor
- Executive Sponsors should sign off on risk register
- During construction, revisit risk register constantly

Questions?

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RECLAMATION

Using Risk Registries to Improve Project Management

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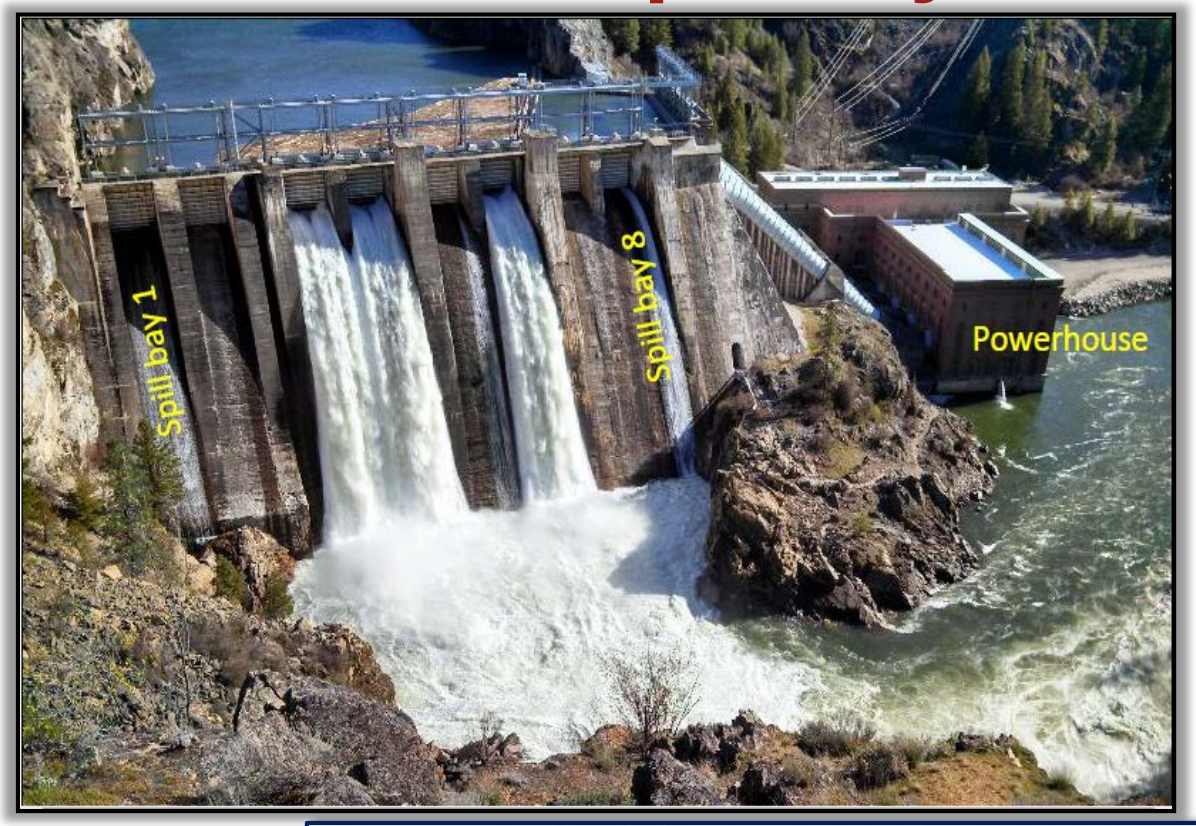
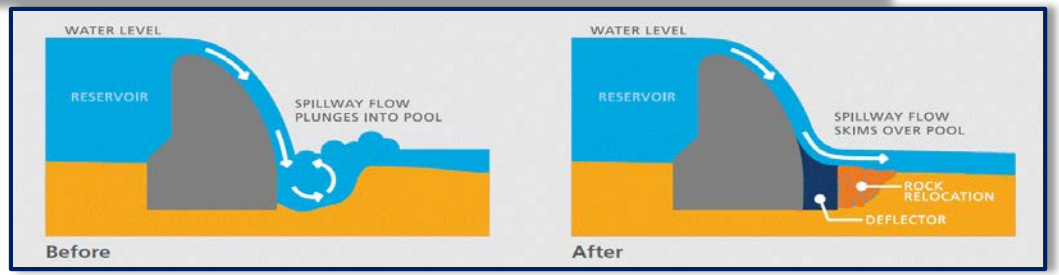
October 27, 2016

LONG LAKE DAM
TOTAL DISSOLVED GAS (TDG) ABATEMENT PROJECT

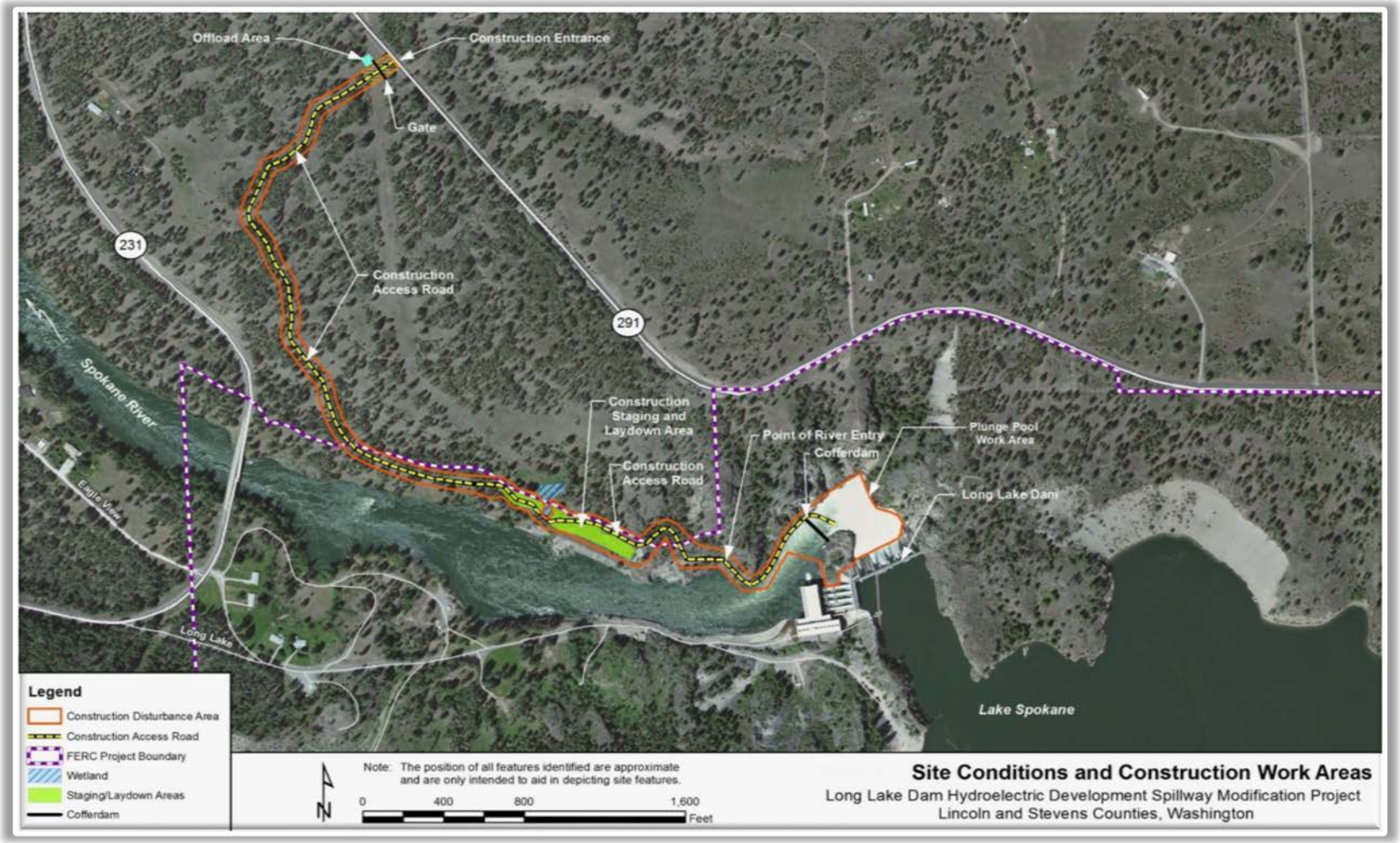
Deflector & Spillway Toe Modification



- Excavate outcrop peninsula downstream of spill bays 7 and 8 to elevation 1353.
- Add two deflectors along the toe of the spillway
  - Lower = continuous across base of spill bays 7 & 8
  - Upper = across base of spill bays 3 thru 6
  - Lower & upper stepped vertically at elevation 1370 & 1375 to allow for skimming flow



Project Site Map



Project Execution Plan Objectives

- Comply w/ FERC license & 401 water quality requirements;
- Conduct integrated planning with key stakeholders;
- Anticipate and provide systematic control of risks;
- Improve reliability of cost & schedule estimates;
- Improve resource planning on projects; and
- Develop a performance measurement baseline.

Key Project Complexities

- 100-year old structure with likely unforeseen challenges;
- Limited availability of footprint for large equipment/crane staging needs within the river channel and below the dam;
- Limited cell/communication services and vendor delivery challenges due to remoteness;
- Limited flexibility in location of temporary road due to steep terrain and protected cultural & historic areas;

Key Project Complexities (continued)

- Supplied power availability on the south side of river versus north side or near plunge pool;
- Planned construction completion necessary in a single season to avoid a minimum of $2.7M increase for rebuilding temporary road and cofferdam;
- Estimated need for approximately 20 permits with federal, state, tribal & local agencies by March 30, 2016; and
- As of the Oct 1, 2015 project kick-off meeting, the work planning was largely conceptual (except for design of concrete spillway deflectors).

Construction Phase Scope & Timeline

ABOVE ORDINARY HIGH WATER MARK (Spring to Summer)

BELOW ORDINARY HIGH WATER MARK (Summer to Fall)

RESTORATION ABOVE OHWM (Fall to Winter)

APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC

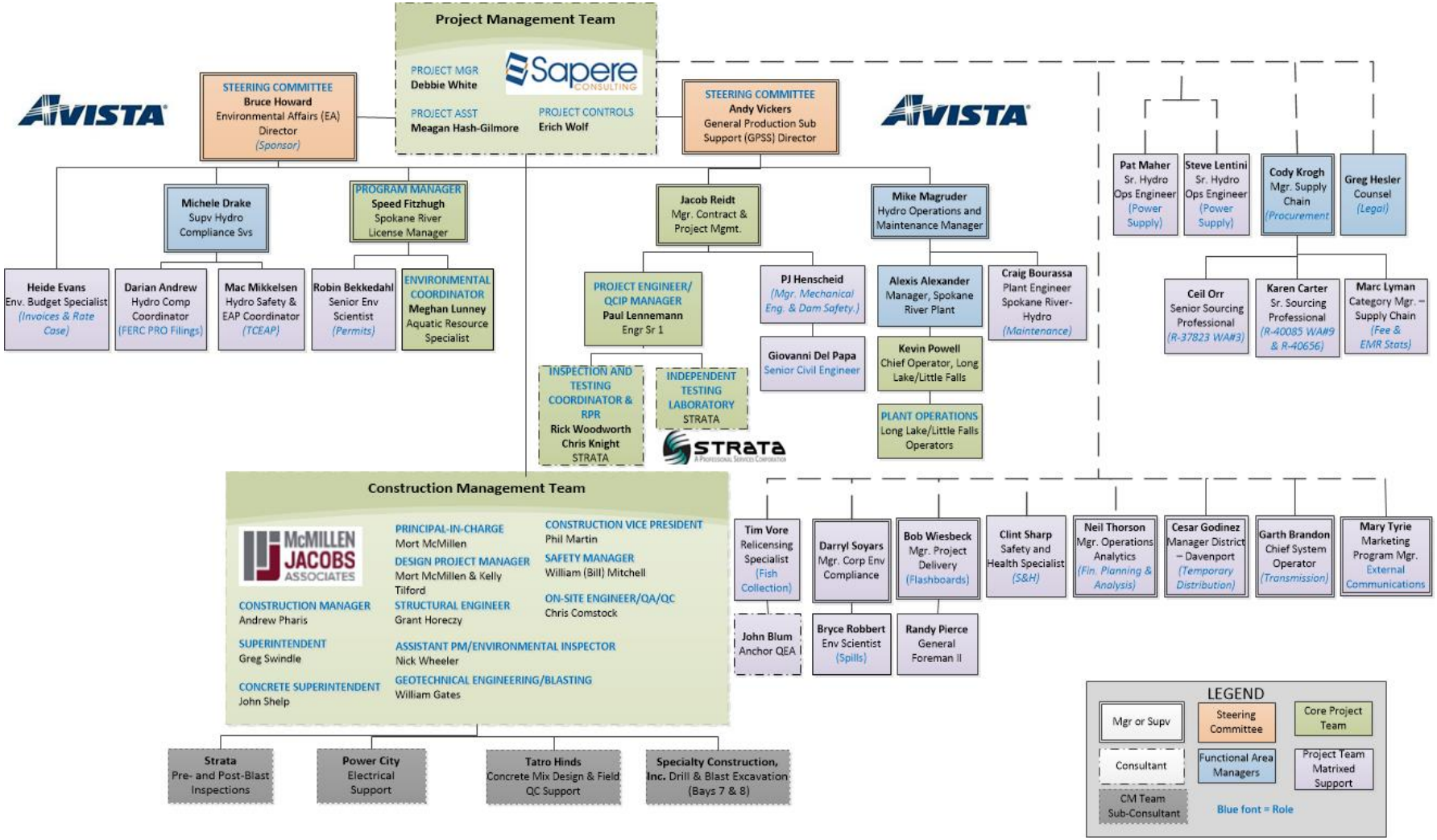
- Construct ~1 mile temporary access road to staging area.
- Excavate and grade ~100,000 square-foot main staging/ stockpile area.
- Construct access road to ordinary high water mark.
- Install temporary power distribution.

- Construct in-river access road to plunge pool.
- Construct cofferdam, dewater & maintain leakage.
- Excavate ~20,000 yd^3 rock outcrop to elevation 1353.
- Construct two deflectors w/ lower at elevation 1370 and upper at elevation 1375.
  - Demolition of concrete to 18" & surface prep.
  - Drill 7,000 holes/epoxy/install rebar dowels.
  - Formwork & placement of ~5,000 yd^3 concrete reinforced with 500,000 lbs. of rebar curtain.
- Fill plunge pool to elevation 1323 including a 7.5 ft. thick mortared riprap cap with drilled vertical drains.
- Remove access road, cofferdam & flood plunge pool.

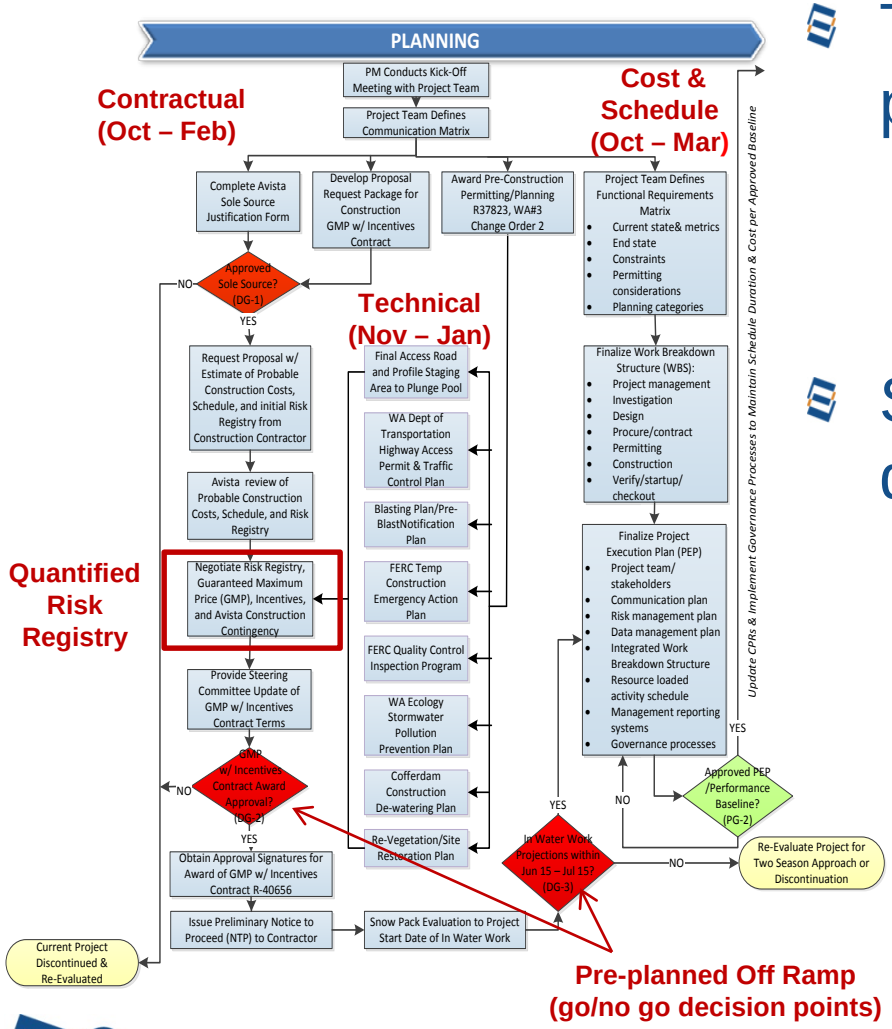
- Remove temporary power distribution.
- Install ~4,000 plants.
- Remove temp road.
- Construct permanent highway access.

Sapere CONSULTING

Integrated Project and Core Team



Planning Phase Strategy



- Technical work plans developed in parallel with contract and baseline;
  - Blasting, Dewatering, Emergency Action, QCIP, Traffic Plan, SWPPP, Restoration, etc.
- Seven primary areas of focus for quantified risk registry:
  - Low Flow/ Spill Window
  - Quantity Variations
  - Dewatering/Seepage
  - Permitting
  - Cultural Resources
  - Power
  - Wildfires

Regulatory Requirements

TYPE	AGENCY
Environmental Report	Federal Energy Regulatory Comm. DC Office ☑
Cultural Assessment Survey/Notification of Adverse Effect/Memorandum of Agreement	State Historic Preservation Officer/ Tribal Historical Preservation Officer ☑
State Environmental Policy Act (SEPA)	WA Department of Ecology **Submitted (Aug '15)**
Shoreline Development Permit	Lincoln & Stevens County
Shoreline Variance Permit	Lincoln & Stevens County
Joint Aquatic Resource Permit App (JARPA)	WA Department of Ecology **Submitted (Aug '15)**
Nationwide 27 & 33	US Army Corp of Engineers
Hydraulic Project Approval (HPA)	WA Department of Fish and Wildlife
Fish Collection Permit	WA Department of Fish and Wildlife
Temporary & Permanent Access Permit	WA State Department of Transportation
General Construction Permit	WA Department of Ecology
Engineering Guidelines for Hydropower Projects, Chapter 7 (QCIP & TCEAP)	Federal Energy Regulatory Commission Portland Reg. Office
Eagle Take Permit	US Fish and Wildlife Service

Show of hands…

…how many would sign up?

Risk Registry Development

- Expected Conditions
- Potential Deviations
- Technical Implementation Impact
- Cost Impact
- Schedule Impact
- Time to Respond
- Probability of Occurrence (high/moderate/low and %)

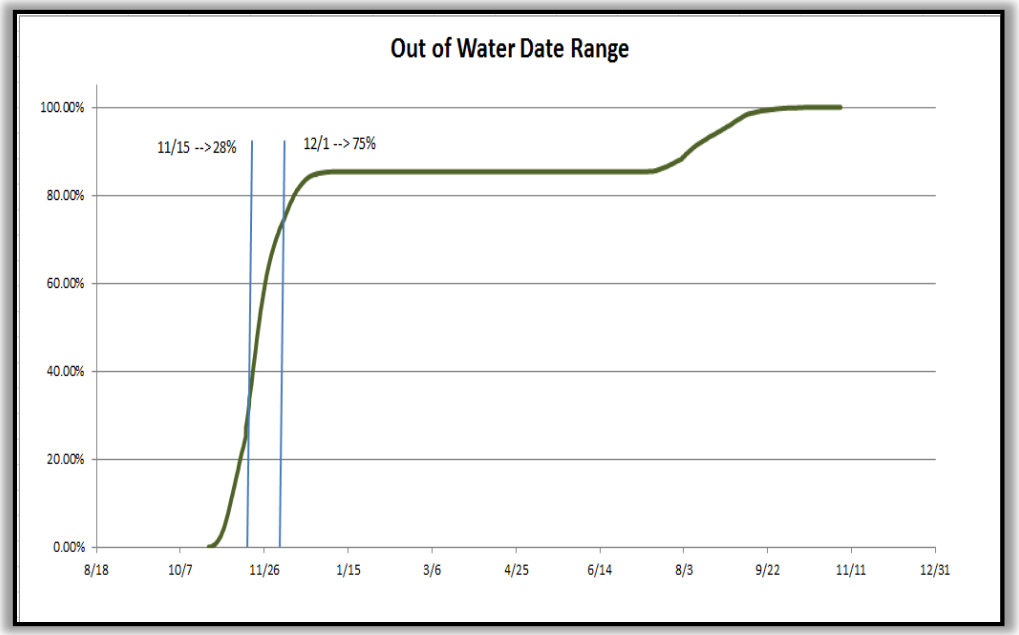
RISK IDENTIFICATION			RISK EVALUATION				
Risk #	Expected Conditions	Potential Deviations	Technical Implementation Impact	Cost Impact	Schedule Impact	Time to Respond	Probability of Occurrence
10	Expect quantity of onsite borrow material to be sufficient for all fill requirements of our proposed plan.	Insufficient borrow material onsite for fill requirements of our proposed plan requires import of material.	Import material.	$18/cy delivered price for up to 20,000 cy	Up to 8 days delay	Immediately. Adjustment to hauling procedures and source availability	Low 20%

~20 identified project risks

>$6M when cost impact column summed

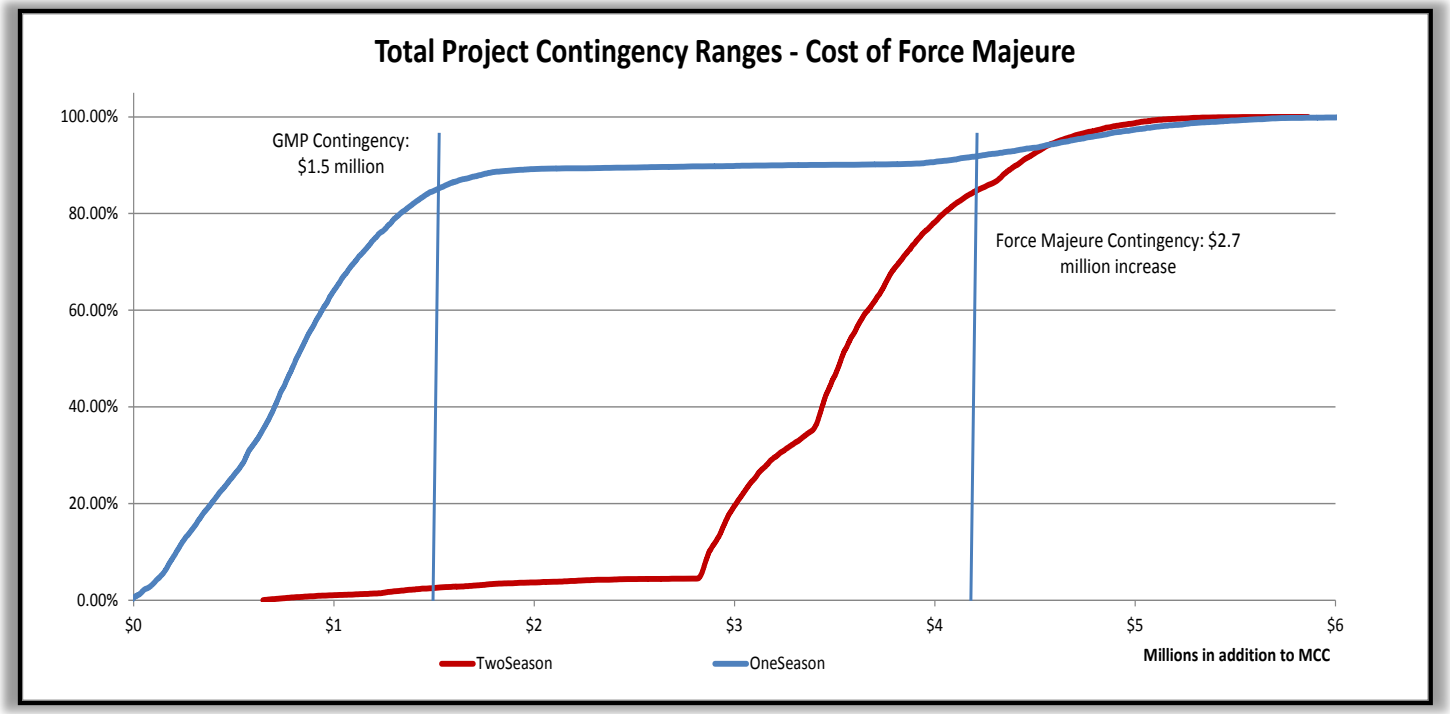
Risk Modeling

- Modeled and simulated all risks over 10,000 times using a Monte Carlo program that returned a range of project costs and out-of-water dates.
- Performed a sensitivity analysis to identify the risks with the highest potential impact to project costs and schedule.
- Predicted out of water date (assuming no risk mitigation):
  - Nov 15th = **28%**
  - Dec 1st = 75%



Acquisition Strategy Decision Support

- Owner contingency at 85% confidence = **$1.5M**
- **Business Case for Contract Incentive Clause**: Avista's $600K maximum shared savings incentive increases the likelihood of a $2.7M+ second season cost avoidance.



Forecasted Cost Range at Project Start

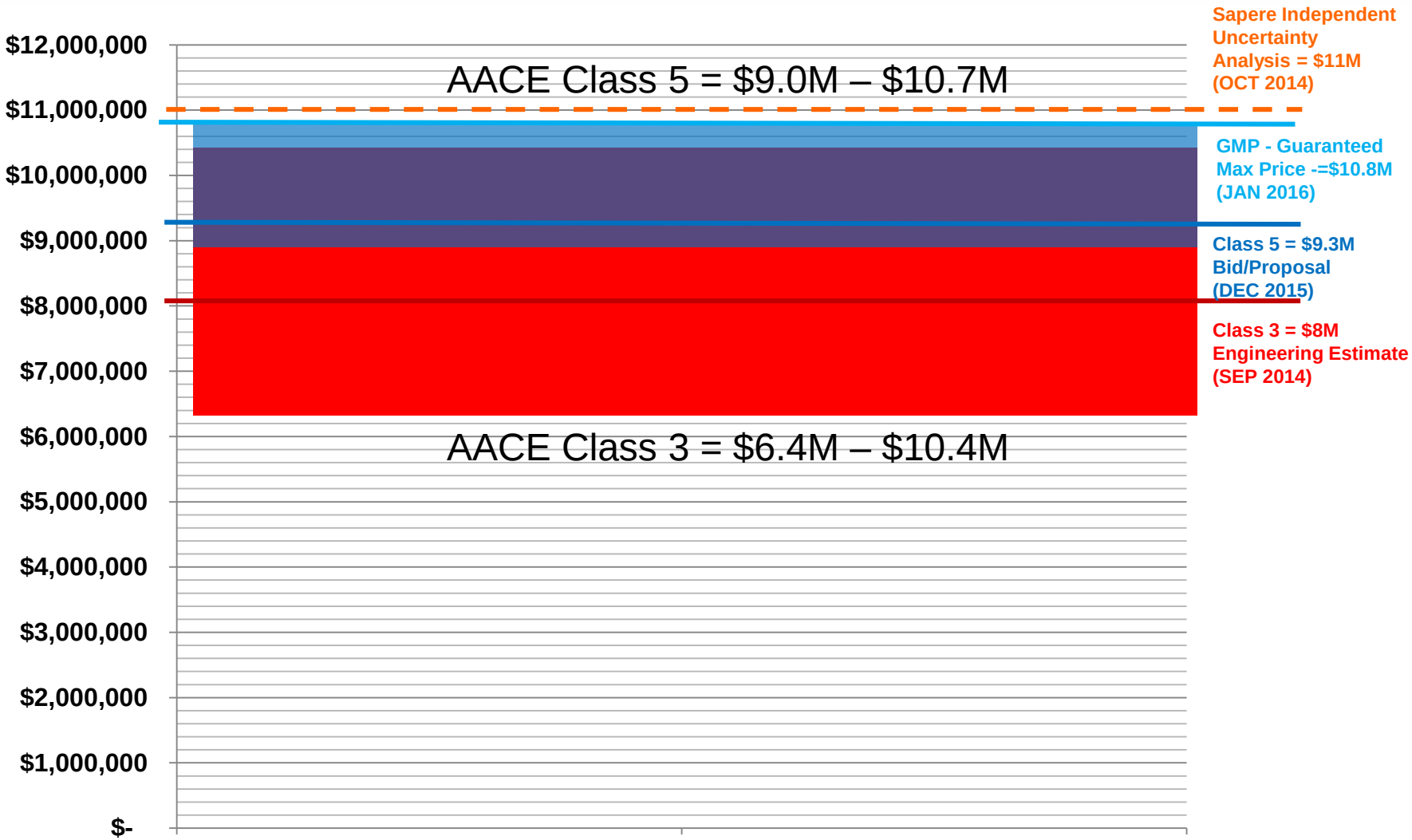
ESTIMATE CLASS	LEVEL OF PROJECT DEFINITION Expressed as % of complete definition	END USAGE Typical purpose of estimate	METHODOLOGY Typical estimating method	EXPECTED ACCURACY RANGE Typical variation in low and high ranges [a]	PREPARATION EFFORT Typical degree of effort relative to least cost index of 1 [b]
Class 5	0% to 2%	Concept Screening	Capacity Factored, Parametric Models, Judgment, or Analogy	L: -20% to -50% H: +30% to +100%	1
Class 4	1% to 15%	Study or Feasibility	Equipment Factored or Parametric Models	L: -15% to -30% H: +20% to +50%	2 to 4
Class 3	10% to 40%	Budget, Authorization, or Control	Semi-Detailed Unit Costs with Assembly Level Line Items	L: -10% to -20% H: +10% to +30%	3 to 10
Class 2	30% to 70%	Control or Bid/ Tender	Detailed Unit Cost with Forced Detailed Take-Off	L: -5% to -15% H: +5% to +20%	4 to 20
Class 1	50% to 100%	Check Estimate or Bid/Tender	Detailed Unit Cost with Detailed Take-Off	L: -3% to -10% H: +3% to +15%	5 to 100

Engineering Estimate (Sep 2014) — **$8M**

Construction Bid (Dec 2015) — **$9.3M**

(Reference AACE International Recommended Practice No. 18R-97) The Association for the Advancement of Cost Engineering (AACE) International is an international non-profit professional educational association that provides services related to cost estimating, cost/schedule control, and project management to a wide range of professions and industries. AACE defines five levels of cost estimates for a project.

Forecasted Cost Range (continued)



Comparison of Methods

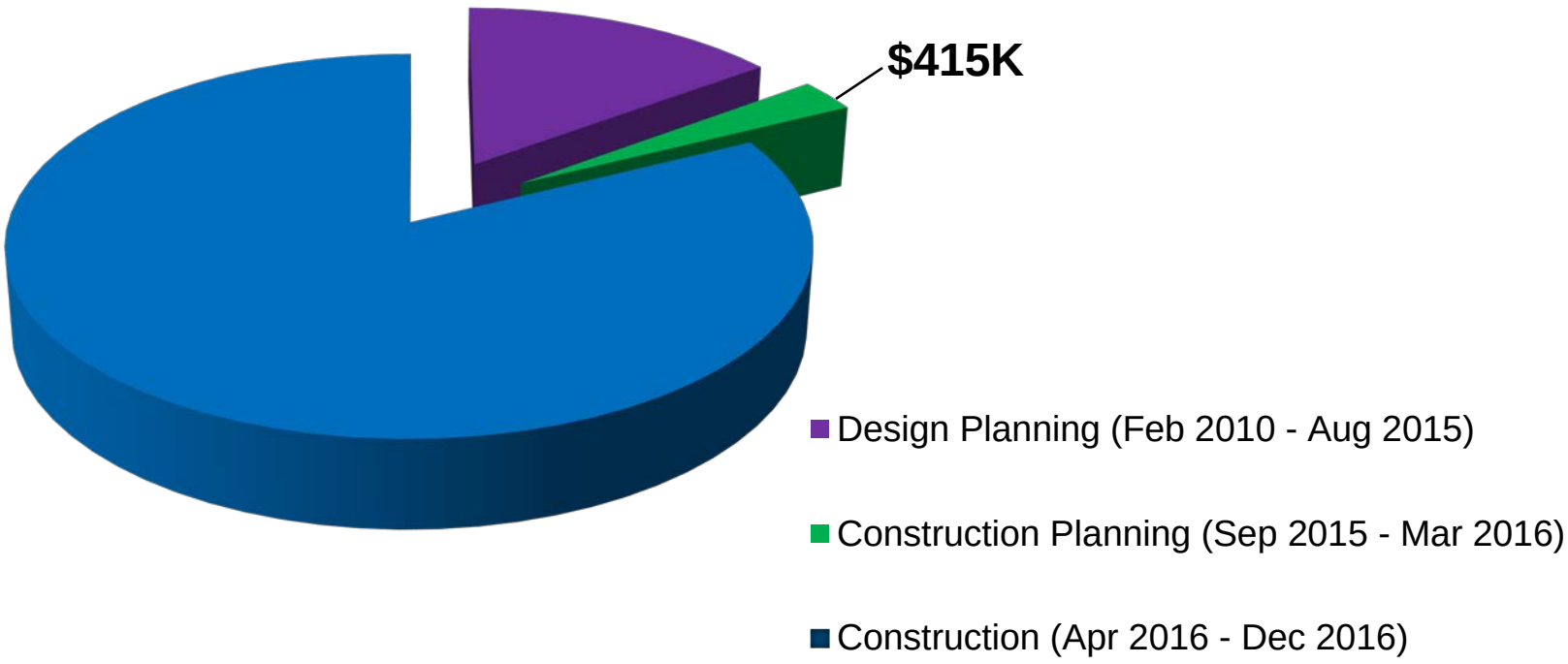
AACE International Recommended Practice No. 18R-97, Class 1 Estimate

- Accuracy range of -10% ($930K) to +15% ($1.46M) is expected
- $9.3M + $1.46M = $10.76M

Quantified Risk Registry – Contract Owner Contingency

- Using modeling results, owner contingency established as $1.50M
- $9.3M + $1.5M = $10.8M

Construction Planning Costs



[redacted]

Tiered Risk Management Approach

- **Operational Mitigation Measures**
  - Results of integrated planning sessions in Dec 2015 and Jan 2016 during risk registry development.
- **Weekly Project Team Meetings On Site**
  - Immediately addressed in the field as risks materialized to develop the most proactive strategy and least impact.
- **Steering Committee Management Decisions**
  - Recommendations developed by the integrated project team and elevated for decision making due to potential impacts/significance.

Operational Mitigation Measures

- **Nine** measures developed. Key examples included:
  - Negotiated elevated prioritization with Transmission for recovery in the event of a substation outage;
  - Implemented a drawdown plan of Lake Spokane beginning October 1, 2016 to provide 48-60 hours of escape time to minimize downstream losses during spill;
  - Requested Department of Natural Resources (DNR) waiver for critical project fire protection plan; and
  - Established a steering committee decision gate for an orderly & planned exit to a second season contingency plan upon evaluation of progress in July 2016.

Weekly Project Meeting Example #1 – Culturally Protected Areas

- **RISK**:
  - Area of culturally protected sites adjacent to access road greater than expected – discovered Apr 13th on 1st day of fieldwork.
- **MITIGATION APPROACH**:
  - Flagged areas w/ flexibility to road placement on Apr 14th.
  - Reduced road width from 24 ft.
  - Added road markers and radio system for safe passing of equipment.
- **EXPECTED REDUCTION FROM MITIGATION**:
  - Reduced imported material needs by 20,000 yd^3 and labor to build road embankment/ sloping embankment.
  - $750K cost avoidance and 3.5 weeks of schedule.

- **ACTUAL COST AFTER MITIGATION:**
  - $0K

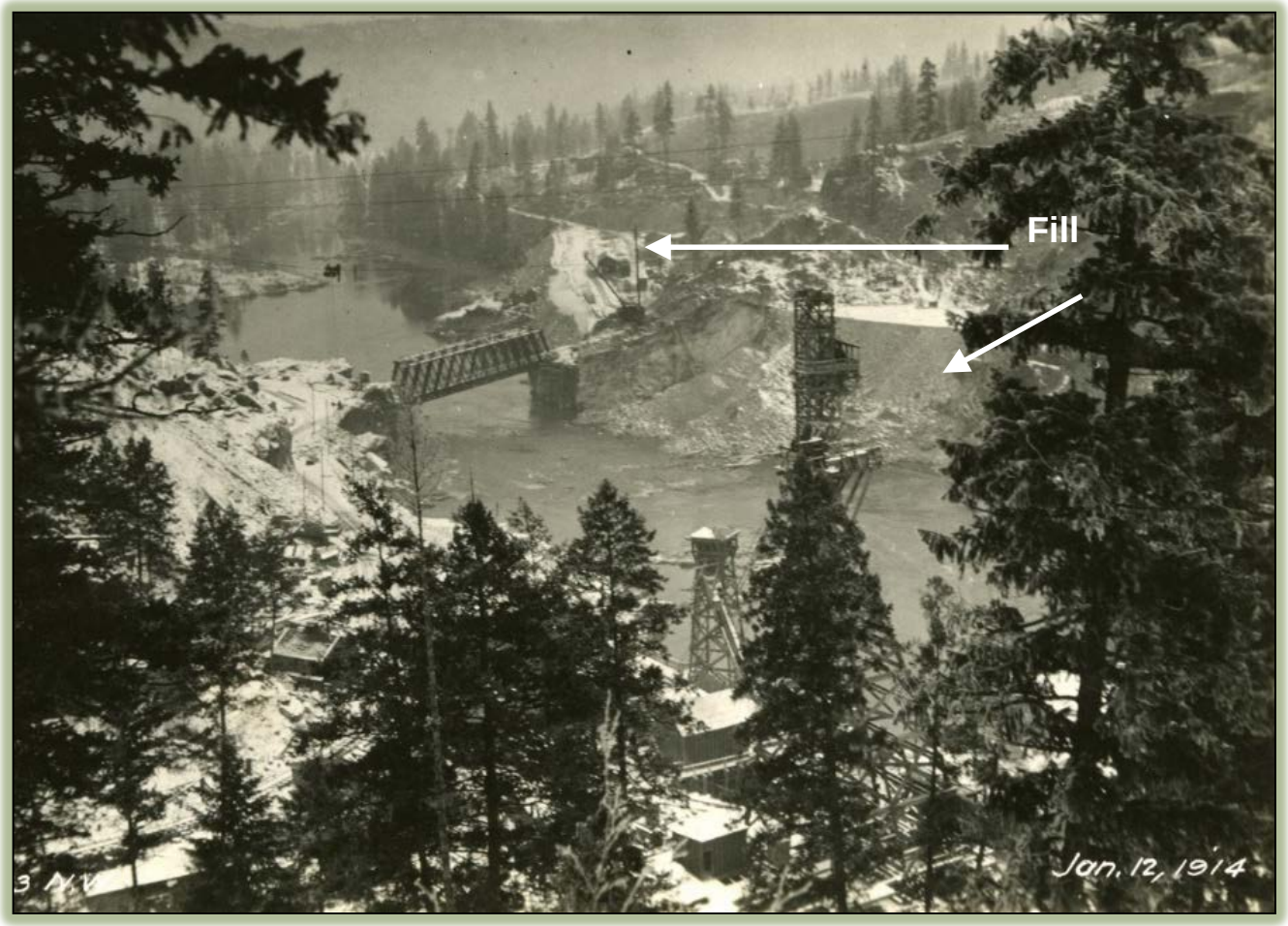
Weekly Project Meeting Example #2 – Onsite Material Availability

- **RISK**:
  - Available quantity of suitable onsite material less than assumed. Discovered Apr 28th – Day #15
- **MITIGATION APPROACH**:
  - Excavation depth adjusted.
  - Adjusted alignment of rock from river to the north access into the bank with regulatory & tribal concurrence (~4 days).
  - Reduction of access road width near powerhouse rock knob.
- **EXPECTED REDUCTION FROM MITIGATION**:
  - Reduced imported material needs to 7,000 yd^3 for ~$300K cost avoidance.

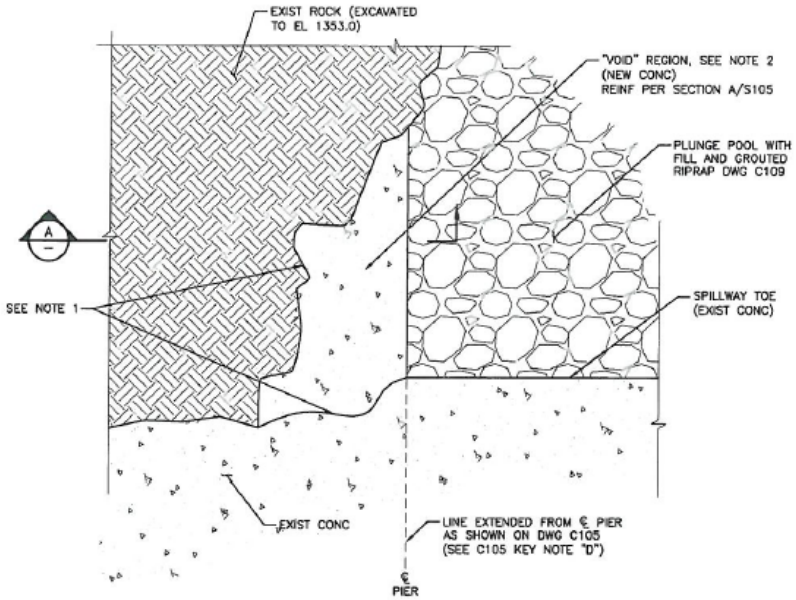
- **ACTUAL COST AFTER MITIGATION:**
  - Approved use of contingency not to exceed (NTE) $150K
  - $117K actually spent.

Suitable Onsite Material Availability Lessons Learned

- Original construction photos show expected conditions for onsite materials but were not discovered until well into road construction



Steering Committee Example – Toe/Groin Improvement Decision



GROIN REPAIR AT LEFT ABUTMENT (VOID) DETAIL

SCALE: 3/8"= 1'-0"

0' 2' 4'

1 S101

VOID AREA AT LEFT ABUTMENT AS SEEN LOOKING UPSTREAM DURING 1990 DEWATERING OF PLUNGE POOL.

SHEET NOTES:

1. REMOVE LOOSE CONC AND APPLY BONDING AGENT PER SPECIFICATIONS.
2. FILL VOID REGION IN EXISTING ROCK WITH NORMAL CONCRETE. REINFORCE PER DETAIL 2.
3. #6 W/180° HOOK @ 2'-0"x2'-0" DRILLED AND GROUTED PER SPECIFICATIONS. MINIMUM 2' 0" EMBED INTO COMPETENT CONC.
4. TOE REPAIR REQUIREMENT TO BE DETERMINED IN FIELD.

LONG LAKE HYDROELECTRIC DEVELOPMENT
FERC NO. 2545
LONG LAKE SPILLWAY MODIFICATION
NEW DEFLECTOR STRUCTURES
SECTIONS AND DETAILS

AVISTA CORPORATION
SPOKANE, WASHINGTON

AS NOTED	FEB 10, 2016	APPROVED
SCALE	DATE	
DESIGN GH	CHECKED	
DRAWN RG	NOTED	DATE
CHECKED JPG	NOTED	MFG. DWG. NO.:

DWG. NO.: S105

B REMOVE ROCK AND SLOPE AT 2V:1H SLOPE.

C REMOVE ROCK POINT TO ELEVATION 1353.0 FT (APPROX 13,500 CY). REMOVE ALL LOOSE ROCK AND MATERIAL TO PROVIDE A UNIFORM ROCK SURFACE. (APPROX EXTENT OF ROCK DEMO SHADED DARK IN PLAN)

D FILL THE VOID BETWEEN THE ROCK SURFACE AND THE NEW SPILLWAY FLOW DEFLECTOR WITH CONCRETE TO EL 1353.0 AS SHOWN ON SECTION 1/S105. FORM A VERTICAL WALL ON THE EAST. INSTALL ROCK ANCHORS TO TIE CONCRETE TO ROCK SURFACE. DASHED LINE SHOWS ESTIMATED EXTENT OF VOID. REFER TO DETAIL 1/S105 FOR REPAIR DETAILS. SEE PHOTO ON THIS SHEET.

E REPAIR SPILLWAY TOE PER DETAIL 2/S105, IF REQ'D

F FILL PLUNGE POOL PER SECTION D/C304 TO EL 1323' (APPROX 2,500 CY).

LONG LAKE HYDROELECTRIC DEVELOPMENT
FERC NO. 2545
LONG LAKE SPILLWAY MODIFICATION
LEFT ABUTMENT EXCAVATION
PLAN

AVISTA CORPORATION
SPOKANE, WASHINGTON

AS NOTED	FEB 10, 2016	APPROVED
SCALE	DATE	
DESIGN KT	CHECKED	
DRAWN RG	NOTED	DATE
CHECKED GH	NOTED	MFG. DWG. NO.:

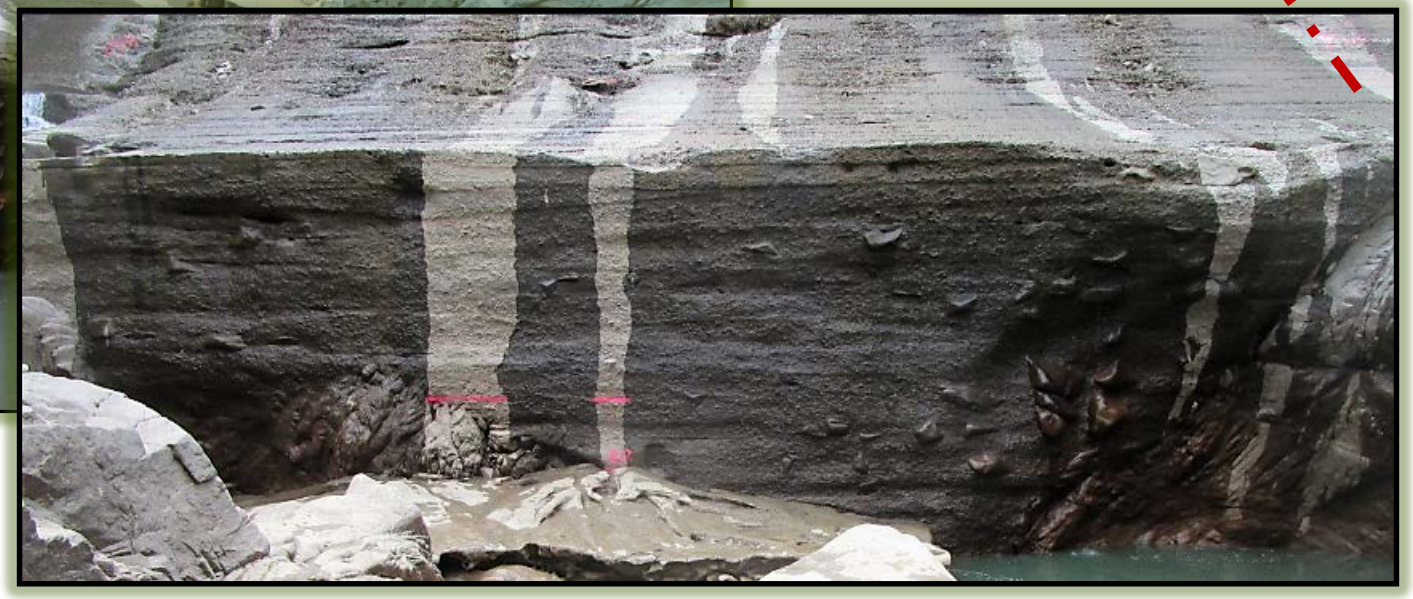
DWG. NO.: C301

2016 Actual Dewatered Conditions

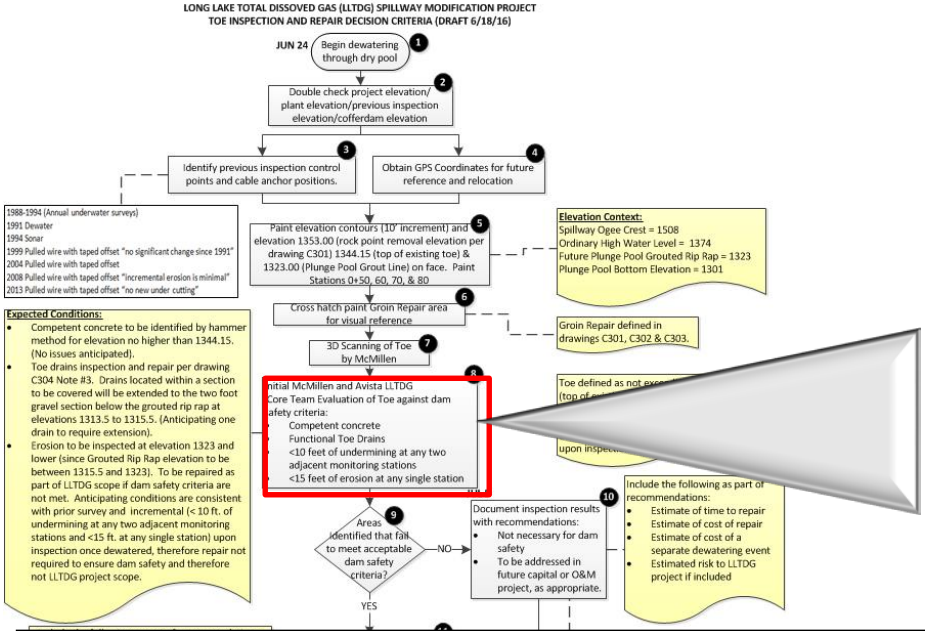
RISK IDENTIFICATION	
Expected Conditions	**Potential Deviations**
Expect minimal downstream toe repairs based on previous dewatered inspections sufficient to provide structural support for new deflectors.	Inspection of toe shows that hollow does not need to be filled.
	Cosmetic repairs are required or requested by Avista.

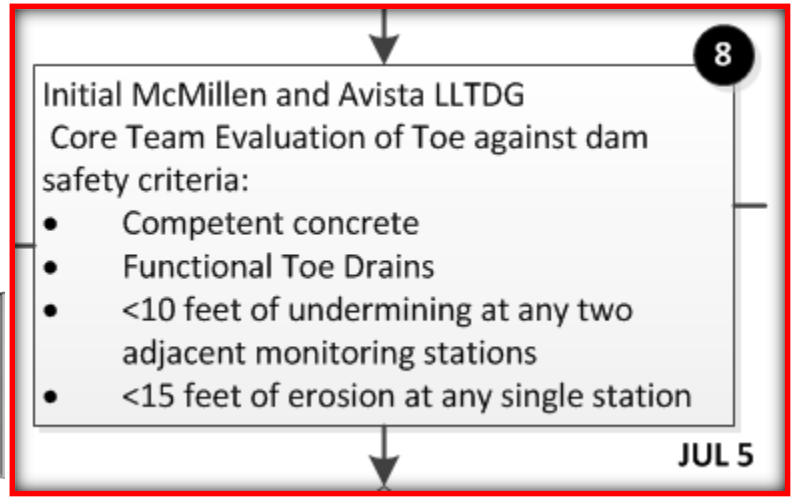
Pier 6/7 Centerline

Pier 6/7 Centerline



Toe/Groin Repair Decision Process





Project Initiation Charter

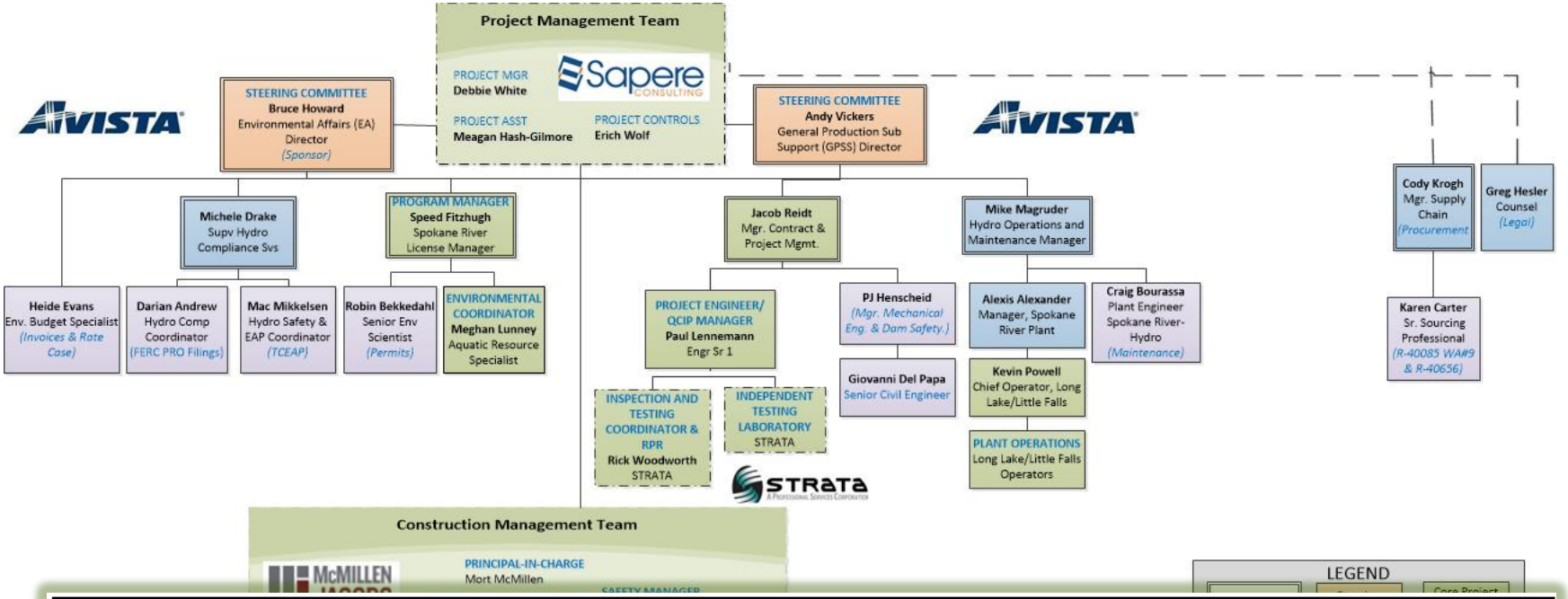
Planning Phase Approval

AVISTA

2.6 What will NOT be delivered?

Repair projects associated with Long Lake dam that are not necessary to complete the design and implementation of the TDG project are excluded from this charter.

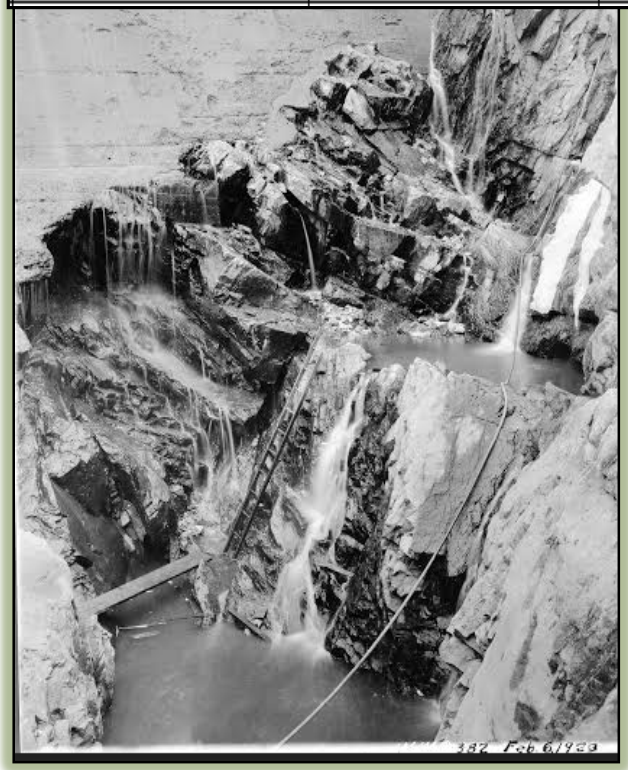
Toe/Groin Repair Decision Team



ISSUE	DESCRIPTION	SCOPE EVALUATION/ RATIONALE	SCHEDULE CONSTRAINTS	STEERING COMMITTEE DECISION	2016 PHOTO
Toe Repair East of Pier 6/7	Possible solution is to angle the 1353 concrete fill from the centerline of the pier to the east, which will capture the eroded concrete on the face of the toe.	• "Void" repair defined in these drawings as west of centerline of Pier 6 and 7; however, photo with dashed boundary illustrates larger area than Note D defines. • If triggering dam safety criteria per toe inspection and repair decision flow chart Box 8, then would be required for toe repair as part of MCC. • Use of contingency may be appropriate based upon extent of repair (Refer to Risk Registry Item #2) • Depending upon scale of fix, could be outside GMP	• Toe Repair = Jul 1 – Jul 26 • Groin Repair = Jul 1 – Jul 19 • Build pad up to elevation 1344 = Jul 24 – Jul 26 • Deflector concrete work is successor starting Aug 4 – Nov 13	• East of Pier 6/7 does not trigger repair since not exceeding dam safety decision criteria. • A "buttress" is not necessary to be included in the repairs. Repairs per existing drawings and consideration of anchors discussed above are the path forward. • If more extensive than MCC, may be eligible for contingency through formal approval of the Contingency Request Form included the GMP contract exhibits.	

Left (West) Groin Expected Conditions

RISK IDENTIFICATION		RISK EVALUATION				
Expected Conditions	Potential Deviations	Technical Implementation Impact	Cost Impact	Schedule Impact	Time to Respond	Probability of Occurrence
Expect simple flush seam interface is suitable between old and new concrete	Condition of old concrete very poor at interface, potential need for alternate interface design	Need to develop reinforced and integrated interface design, not significant	$5,000 design, **$38,100** construction revision	No impact can be designed while demo continues	One day.	Moderate, no information on existing concrete strength. Will be judged in field. 20%



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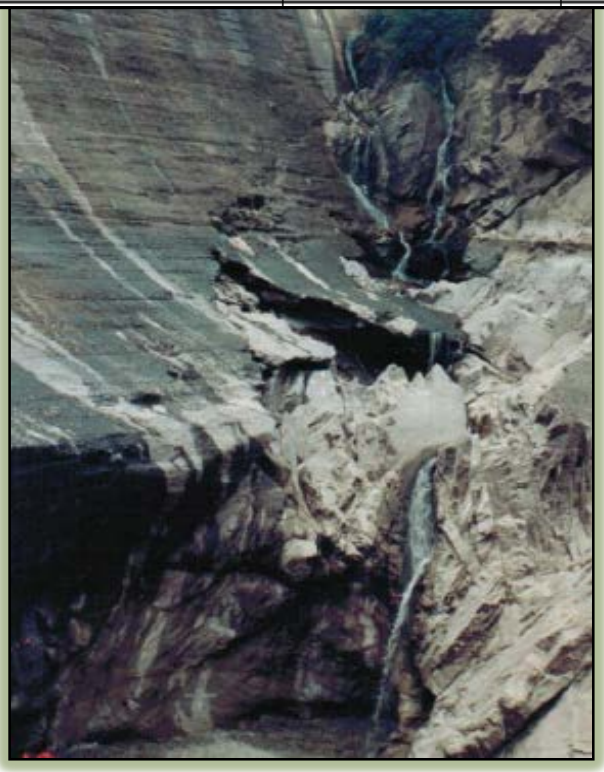

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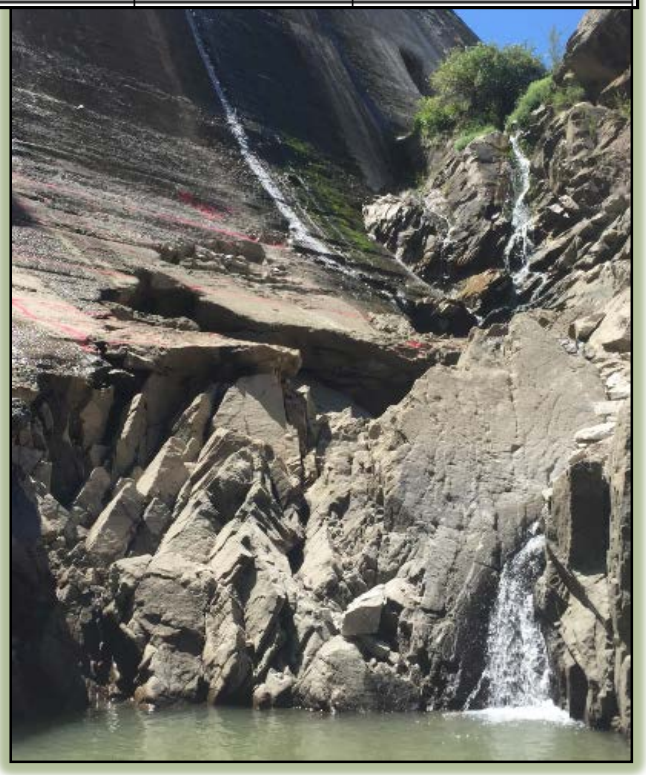


2016

Updated Risk Registry

OWNERSHIP	Risk #	RISK IDENTIFICATION: Expected Conditions	RISK IDENTIFICATION: Potential Deviations	RISK EVALUATION: Technical Implementation Impact	RISK EVALUATION: Original Cost Impact	RISK EVALUATION: Original Schedule Impact	RISK EVALUATION: Time to Respond	RISK EVALUATION: Probability of Occurrence
GMP	2	Expect minimal downstream toe repairs based on previous dewatered inspections sufficient to provide structural support for new deflectors.	Inspection of toe shows that hollow does not need to be filled.	Removal of scope.	Reduction of 500 cyds; **$647/cy** installed	up to 5 days acceleration	None required if materials to address repairs are on-hand. One day response if materials need to be delivered from	**RISK CLOSED: 0% Was: Low 20%**
			Cosmetic repairs are required or requested by Avista.	Potentially moderate impact if more than cosmetic repairs are required, or erosion exposes foundation defect which requires additional analysis	Between 50 and 150 additional cubic yards; **$778/cy** installed	Up to 5 days	One day for offsite materials delivery.	**RISK CLOSED: 0% Was: Low 25%**
GMP	4	Plunge pool seepage is expected to be handled with conventional pump arrangement	Plunge pool seepage volume exceeds the 8,000 gpm capacity of the planned dewatering system.	Requires more pumps and time to implement the dewatering.	**$518,600** Assume double the pumping system cost	3-5 days	Two days for offsite pump equipment delivery and installation, assuming existing electrical supply is sufficient.	**RISK CLOSED: 0%: WAS 50%**
GMP	5	Power supply for dewatering (primary) is continuous and dependable	Power supply to dewatering system is interrupted.	Need to rent additional offsite generators.	Between 0 and 5 weeks at **$59,900** per week to run generator. Assume generator rental cost one	2 days (1 day procure generator 1 day dewatering)	1 hour	**RISK CLOSED: 0%: WAS 75%**
GMP	7	No environmental contamination	Encounter environmental contaminated materials in waste stockpiles planned as construction fill	Waste stockpile most likely sources. Prepare workaround approach to accommodate environmental delay	**$97,300** based upon 7 days of partial standby	Up to one week delay	Within one day once regulatory decision on disposal	**RISK CLOSED: 0% Was:10%**
GMP	8	No unidentified cultural resource issues	Encounter unforeseen cultural resource artifacts during project	Access road most likely sources. Cooperate with agency for documentation and relocation or develop workaround approach.	**$27,800** based upon 2 days of partial standby	1 or 2 day delay	Immediately resume operation or modify approach to protect cultural resource	**RISK CLOSED: 0% Was:Low15%**
Avista	9	Spillway Rock Excavation by controlled explosives	Regulators or Avista do not approve of explosive use for spillway rock excavation	Other excavations methods require different equipment and more time.	Dependent upon decision by Avista to remove rock by either Blasting or Hydraulic Removal should be identified ahead of contract execution, and that approach should be included in the base estimate. Profit will need to be carried on the selected	**Up to 30 day delay**	Immediately. Equipment should be on site. One day if procured offsite.	**RISK CLOSED: 0% WAS: Low 20%**

OWNERSHIP	Risk #	RISK IDENTIFICATION: Expected Conditions	RISK IDENTIFICATION: Potential Deviations	RISK EVALUATION: Technical Implementation Impact	RISK EVALUATION: Original Cost Impact	RISK EVALUATION: Original Schedule Impact	RISK EVALUATION: Time to Respond	RISK EVALUATION: Probability of Occurrence
GMP	6	Assume single construction season	McMillen elects to shift to 2-season construction approach due to cumulative project delays.	Concrete demolition and concrete placement would be deferred to a second construction season. Would require double mobilization, dewatering system rental and installation, access road removal and reconstruction	**$2,053,700** based upon 90 days of dewatering for the second construction season. Split into two seasons. Includes costs for 30 days of inefficiency added to construction schedule to ramp down first season and ramp up	Next season	Immediately upon Avista direction; decision must be made prior to concrete demolition expected	**RISK REDUCED: 5% Was:Low 10%**
GMP	10	Expect quantity of onsite borrow material to be sufficient for all fill requirements of our proposed	Insufficient borrow material onsite for fill requirements of our proposed plan requires import of material.	Import material.	$18/cy delivered price for up to 20,000 cy	Up to 8 days delay	Immediately. Adjustment to hauling procedures and source availability	**RISK REDUCED: 2% Was: Low 20%**
GMP	18	Fire Conditions at the work site allow for uninterrupted work without preventative measures.	Preventative Fire Protection Measures are required to allow continued work.	Implementation of fire protection measures including cutting fire lines	Up to $500,000	None	Moderate, DNR will be approached ahead of need to ensure uninterrupted work.	**RISK REDUCED: 5% WAS: MODERATE 30%**

Risk Registry Comparative Results

JAN 2016

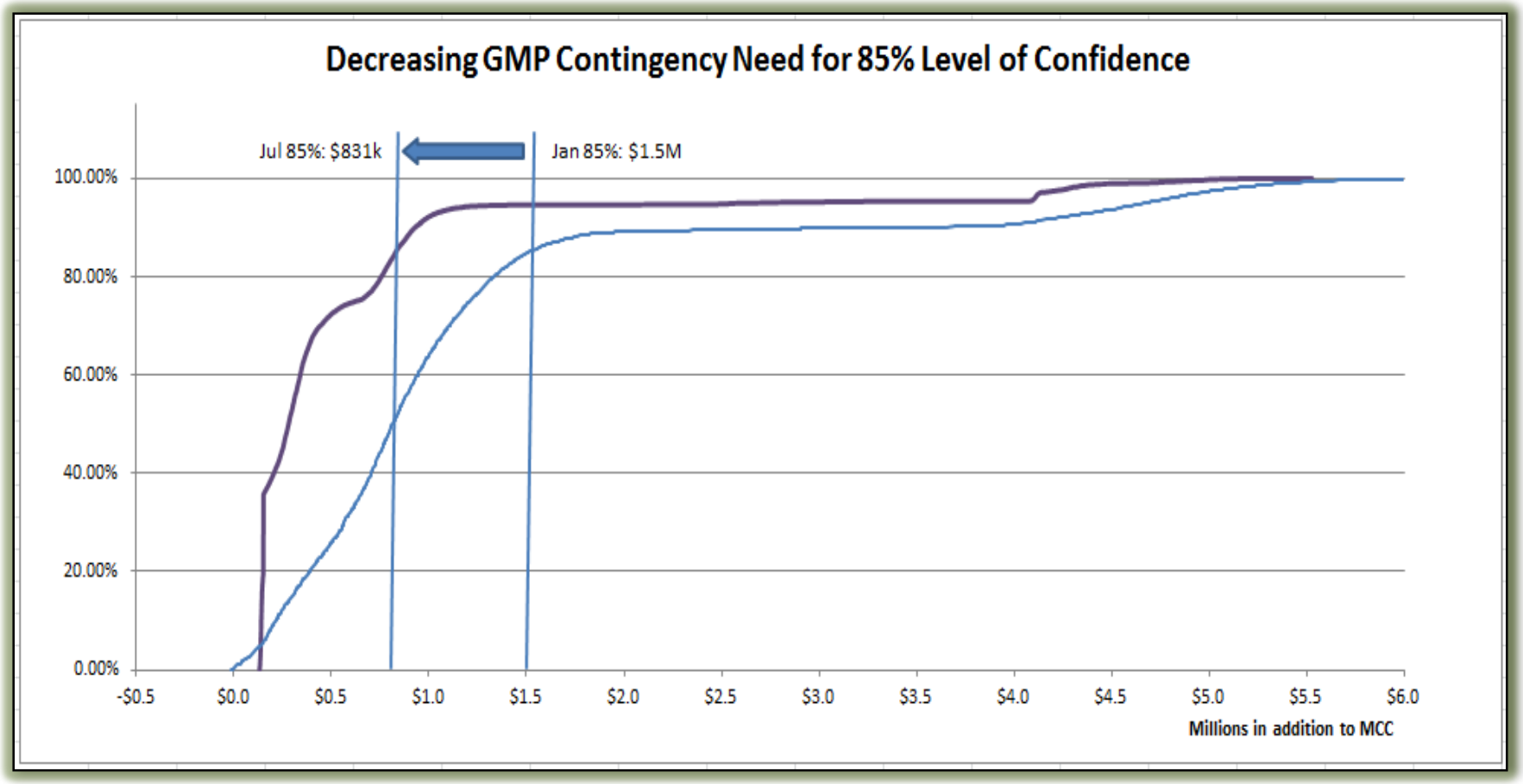
- 20 open risks
- Contract Contingency = **$1.5M** at 85% confidence
- Out of Water Date* =
  - Nov 15th = **28%**
  - Dec 1st = 75%

**Out of water date percentages assume worst case for partially mitigated or unmitigated risks.*

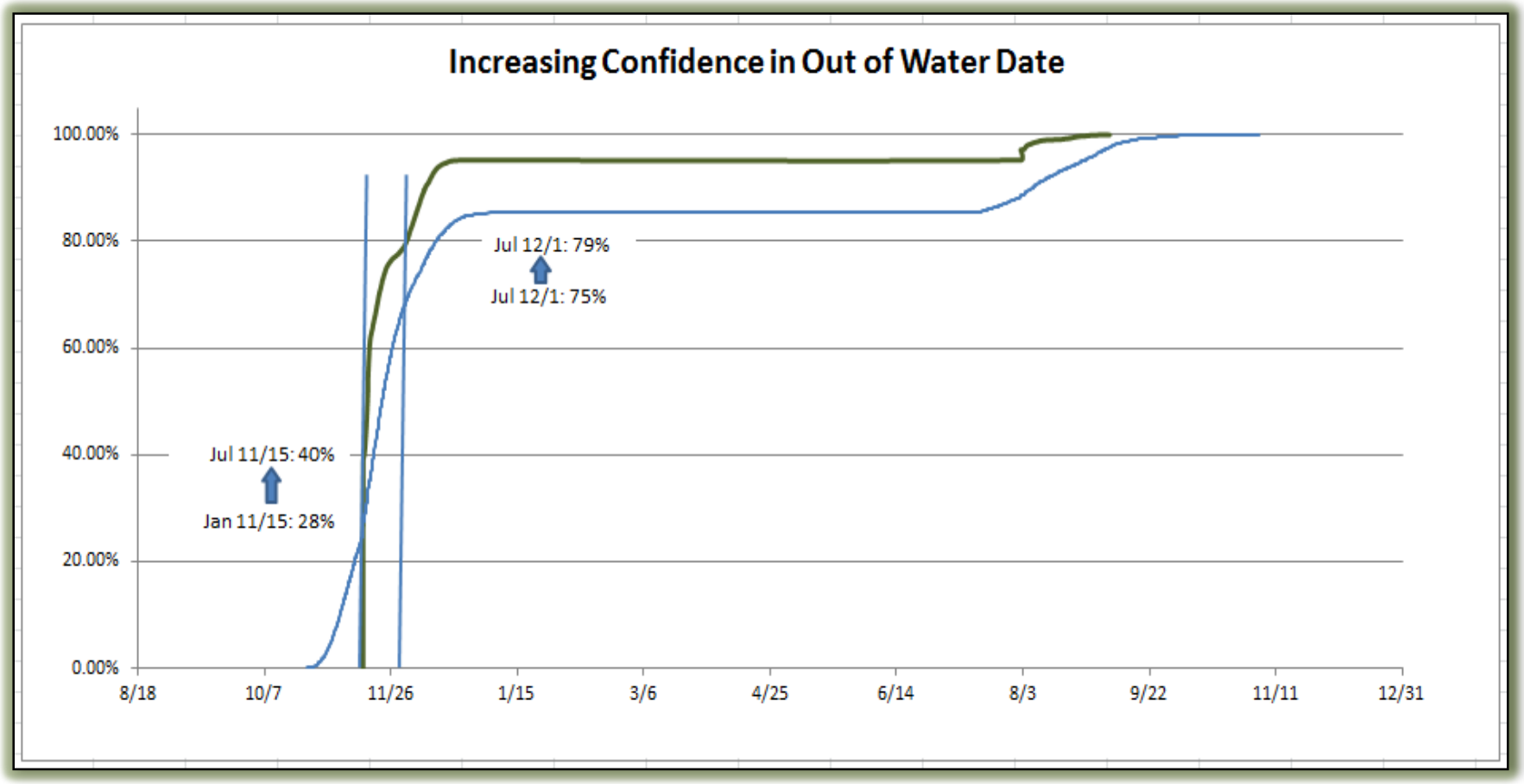
JUL 2016

- 11 closed risks; 3 reduced
- Contract Contingency = **$831K** at 85% confidence
- Out of Water Date* =
  - Nov 15th = **40%**
  - Dec 1st = 79%
- Concrete work yet to be started in JUL so remaining 6 risks not yet encountered

July 2016 Contingency Range



July 2016 Out of Water Date



Construction Phase Scope & Timeline

ABOVE ORDINARY HIGH WATER MARK (Spring to Summer)

BELOW ORDINARY HIGH WATER MARK (Summer to Fall)

RESTORATION ABOVE OHWM (Fall to Winter)

APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC

- Construct ~1 mile temporary access road to staging area.
- Excavate and grade ~100,000 square-foot main staging/ stockpile area.
- Construct access road to ordinary high water mark.
- Install temporary power distribution.

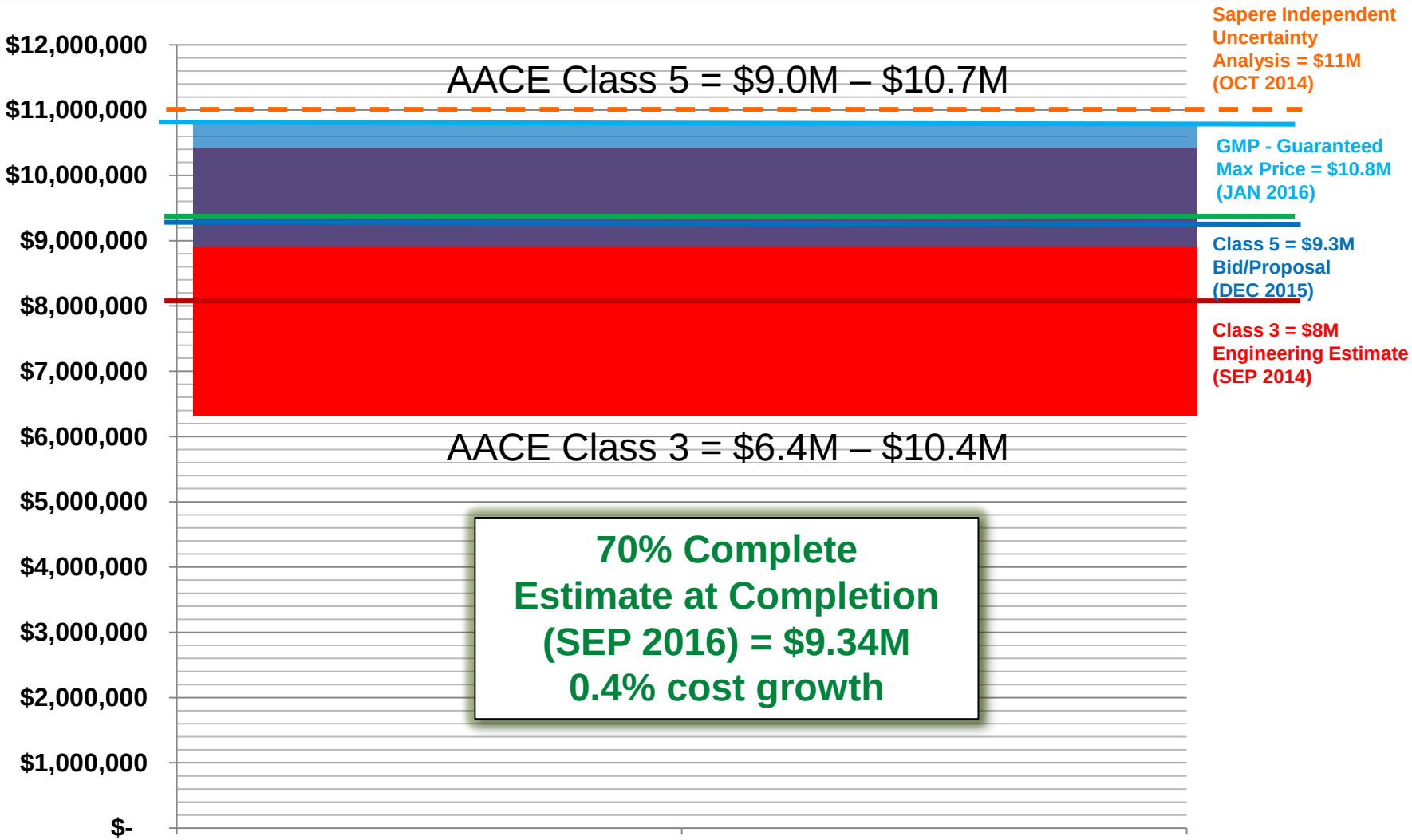
- Construct in-river access road to plunge pool.
- Construct cofferdam, dewater & maintain leakage.
- Excavate ~20,000 yd^3 rock outcrop to elevation 1,353.
- Construct two deflectors w/ lower at elevation 1,370 and upper at elevation 1,375.
  - Demolition of concrete to 18" & surface prep.
  - Drill 7,000 holes/epoxy/install rebar dowels.
  - Formwork & placement of ~5,000 yd^3 concrete reinforced with 500,000 lbs. of rebar curtain.
- Fill plunge pool to elevation 1,323 including a 7.5 ft. thick mortared riprap cap with drilled vertical drains.
- Remove access road, cofferdam & flood plunge pool.

- Remove temporary power distribution.
- Install ~4,000 plants.
- Remove temp road.
- Construct permanent highway access.

Sapere CONSULTING

Photo Progress – July to October

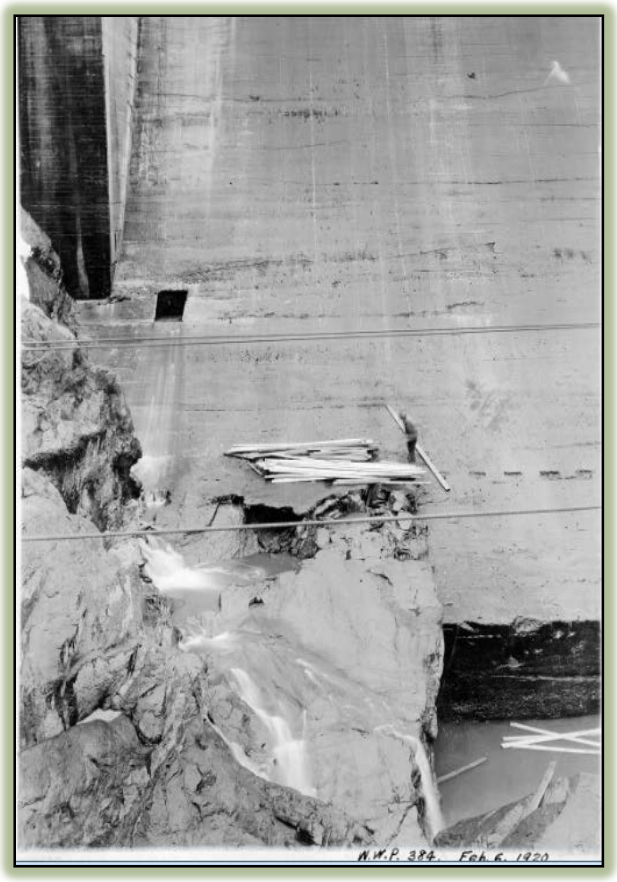
Forecasted Completion Cost Range



Maximizing Additional Value/Benefit

- Three parallel projects added (separate contracts) during execution that resulted in significant economy of scale:
  - Maximized access road infrastructure to improve right abutment resulting in future cost avoidance of > $4M.
    - Future risk management strategy to prevent erosion impact to newly installed deflector.
    - Increased concrete placement to ~6,000 yds.^{3} for total project
  - Leveraged existing concrete crews and mobilized equipment to perform two maintenance projects:
    - Spillway gate repair & Parapet wall repair
- Reprogrammed $1M in underruns to other capital projects in Sept 2016.
- Plan to donate some of the property to the local community.

Right Abutment/Toe Improvement



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Maintenance Projects Before & After

Final Thoughts

- Key mitigation measures would have been overlooked without the use of a multi-disciplined team participating in risk identification discussions.
- Significant uncertainty reductions are available through historical record searches (most ideally in planning stages).
- The greater number of parties, the greater the need for clearly bound project objectives and decision processes in advance to manage expectations.

Final Thoughts (continued)

- A quantified risk registry can be used to establish the basis for a reasonable & defensible contingency amount that all parties can accept.
- Risk registries aren't a license for change orders when risks occur, but rather a tool to proactively manage risks from fully materializing in the project.
- Alignment of financial interests among parties, and management of all risks regardless of the low/moderate/high likelihood of occurrence, provides the opportunity for greatest success.

Questions?