Damping Rings
KOM
Conventional Facility & Siting Overview

Tom Lackowski

Acknowledgment:
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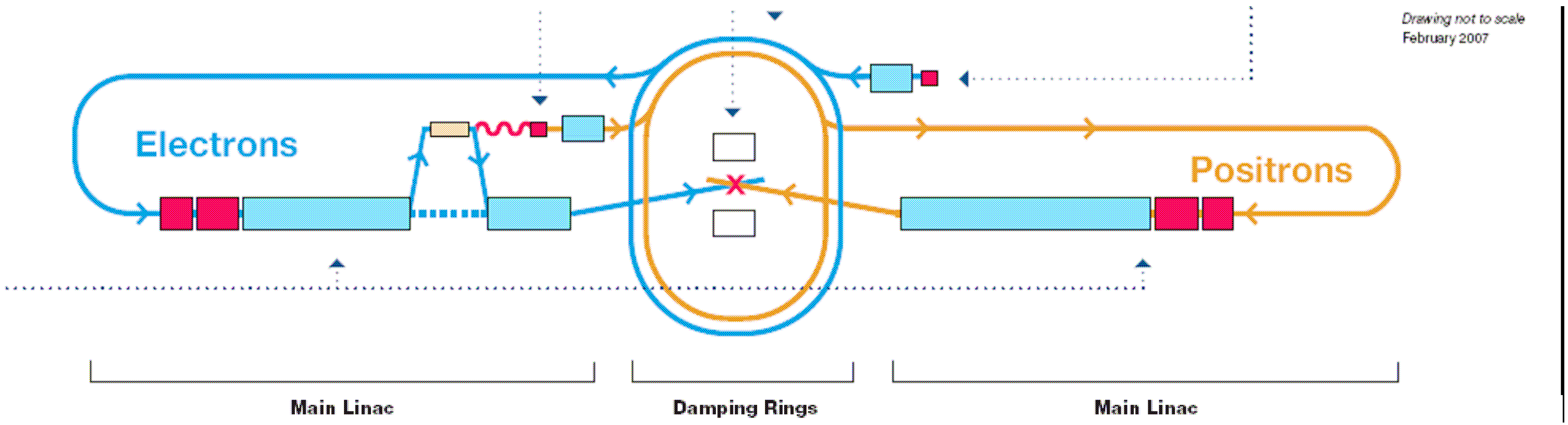
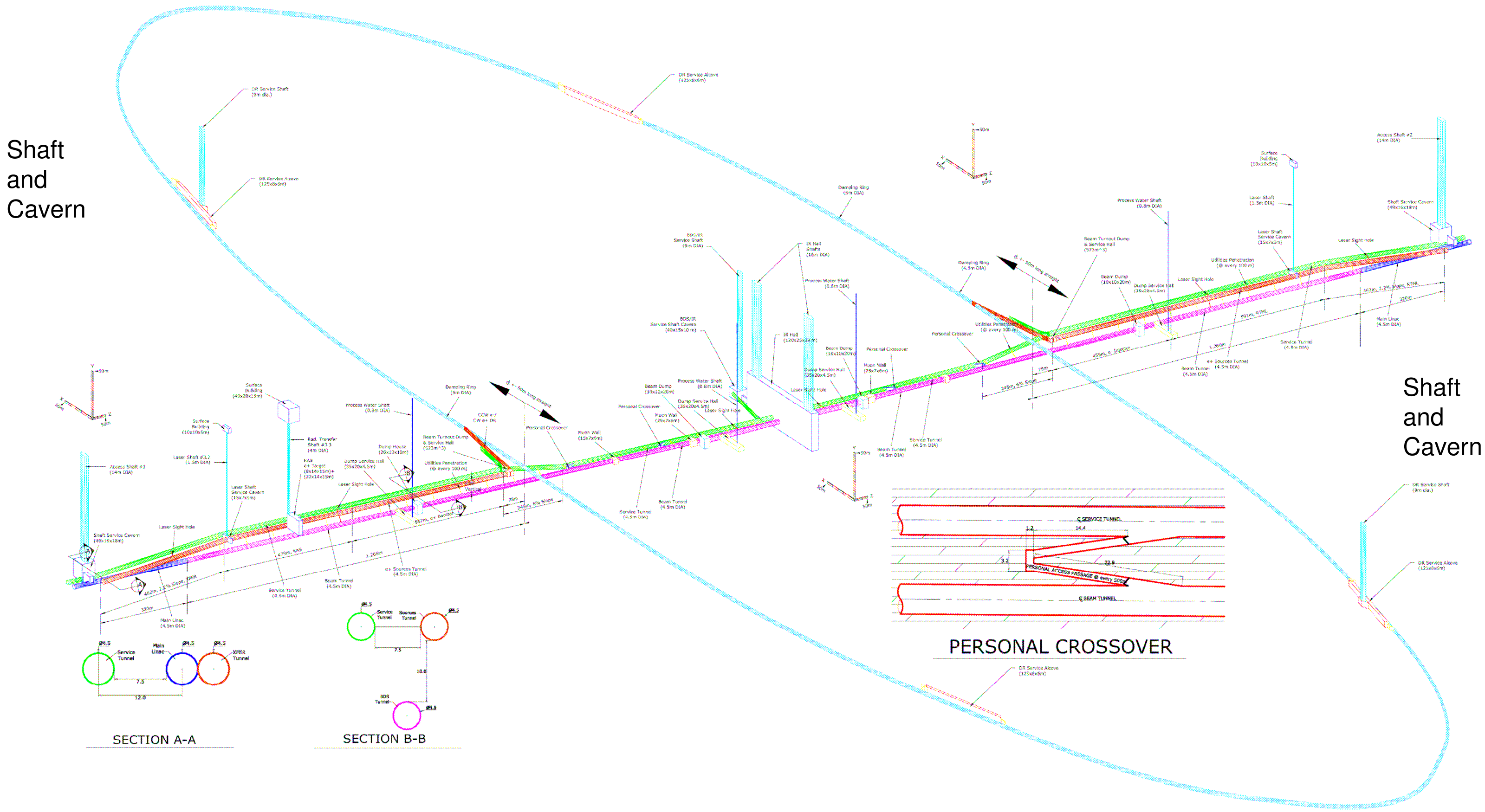
Jerry Aarons, Clay Corvin, Emil Huedem, Lee Hammond, Maurice Ball,
Tanaka Masami, Fred Asiri

RDR General Layout

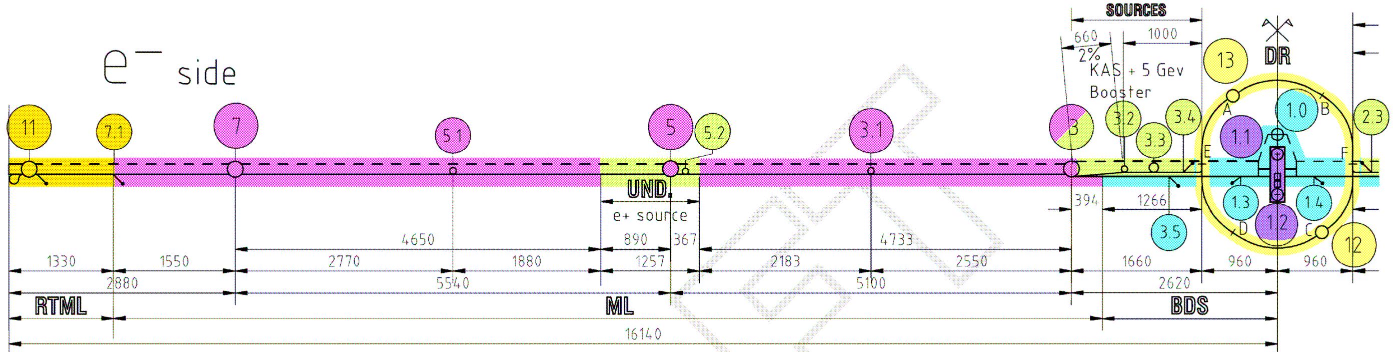


RDR Baseline

Damping Rings are an integral part of the Central Area



Underground Structures Allocation Scheme

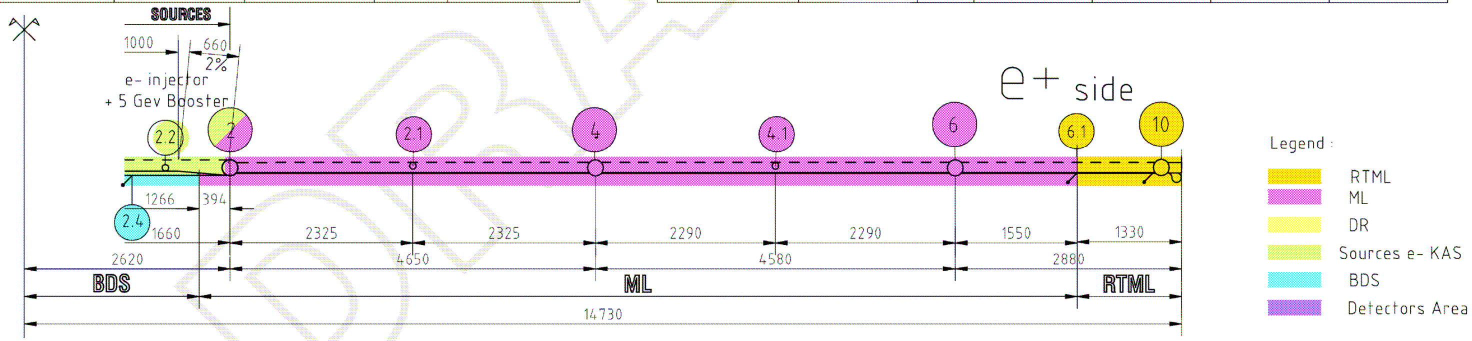


SITE / TUNNEL LENGTHS (m)

e− side + Undulator ML + RTML	e+ side ML + RTML	BDS + sources	DR	TOTAL
13 914 / 27 948	12 504 / 25 128	4452 / 12 236	0 / 6704	30 870 / 72 016

TUNNELS

Area	e− inject.,KAS beam + serv	DR	RTML beam + serv	ML beam + serv	BDS beam + serv	BDS Survey
⌀m	4.5	5.0	4.5 + 4.5	4.5 + 4.5	4.5 + 4.5	1.5 x 2.2



SHAFTS

Point	1.0	1.1	1.2	2	3	3.3	5.2	4	5	6	7	10	11	12/C	13/A
⌀m	9	16	16	14	14	4	4	14	14	9	9	14	14	9	9

BORINGS

Point	2.1, 3.1, 4.1, 5.1	2.2, 3.2	1.3, 1.4, 2.4, 3.5
⌀m	1.50		

SHAFT BASE CAVERNS

Point	2, 3, 4, 5, 6, 7, 10, 11
(LxWxH) m	49 x 16 x 18 + 3 storeys

MUON WALL WIDENINGS

Point	1.3, 1.4
(LxWxH) m	25 x7x6 +15x7x6

SOURCES CAVERNS

Point	Undulator 5.2	KAS 3.3	2.2, 3.2
(LxWxH) m	21 161m3	6 574m3	7 X 15 X 7.5

DR ALCOVES

Point	12/C, 13/A	B, D, E, F
(LxWxH) m	75 x 10 x 10 + 1 storey	16 x 8 x 8

DETECTORS HALL

Point	1.1, 1.2	1.0
(LxWxH) m	120 x 25 x 39	40 x 15 x 15

BEAM DUMPS CAVERNS (↖)

Point	SOURCES 2.3, 3.4	RTML 6.1, 7.1, 10, 11	BDS 1.3, 1.4, 2.4, 3.5
(LxWxH) m	5 x 4 x 4		20 x 9 x 15 + 1 storey

BEAM DUMP SERVICE HALLS (↖)

Point	BDS 1.3, 1.4, 2.4, 3.5
(LxWxH) m	30x20x 10

ILC - UNDERGROUND STRUCTURES SCHEMATIC LAYOUT

AREA SYSTEM DIVISION **(2 mobile Detectors - Push Pull - modified CMS procedure)**

EUROPEAN REGION

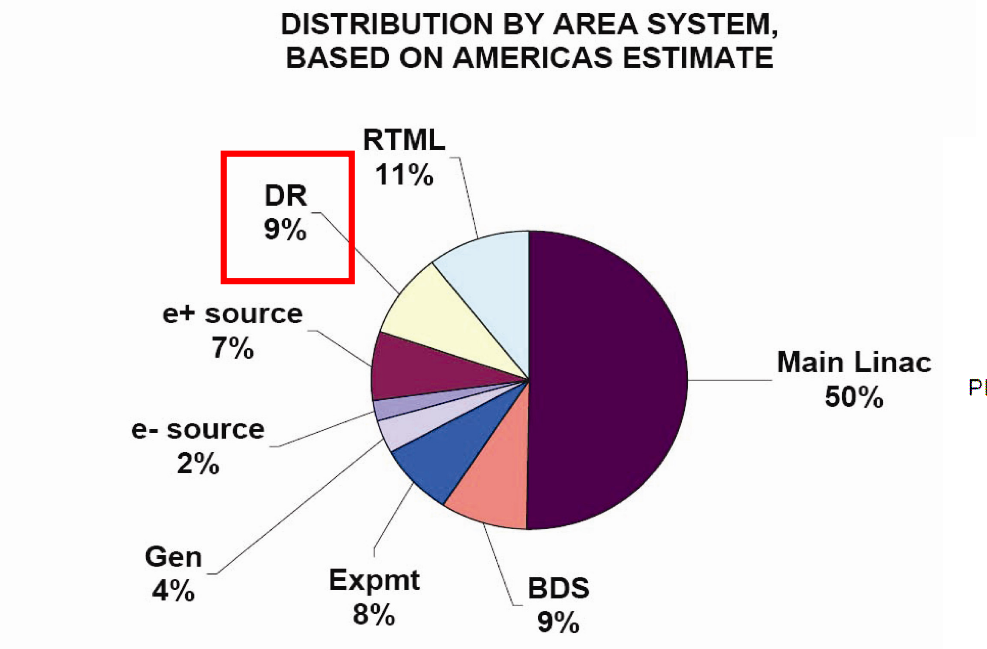
CERN

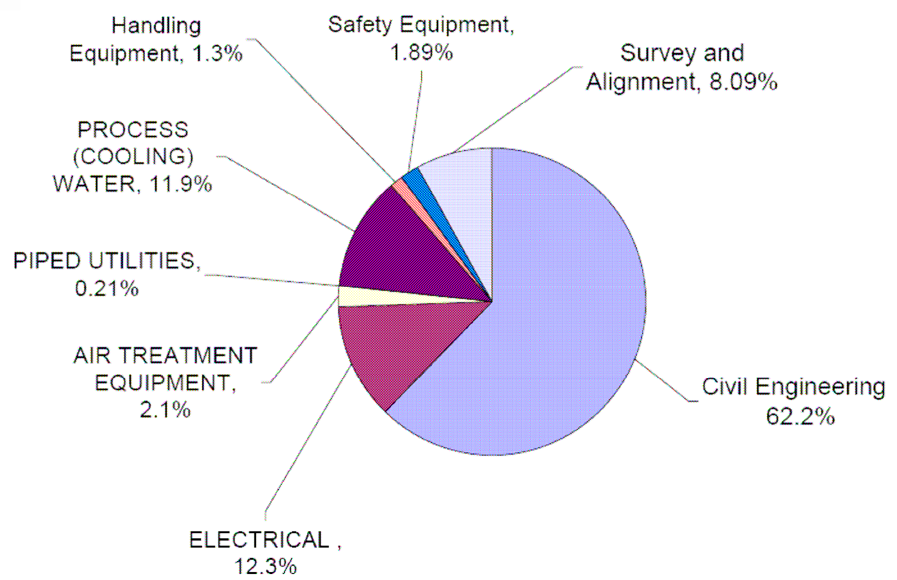
GROUP : TS-CE
CIVIL ENGINEERING
SUPERVISOR : JL.BALDY
DESIGNER : N.BADDAMS

SCALE : 1/50000(A3_FORMAT) DATE : 05_DEC_2006

ILC-.CE-1.1649.0016 | SIZE 3 | INDICE G

Total CFS Costs and Statistics

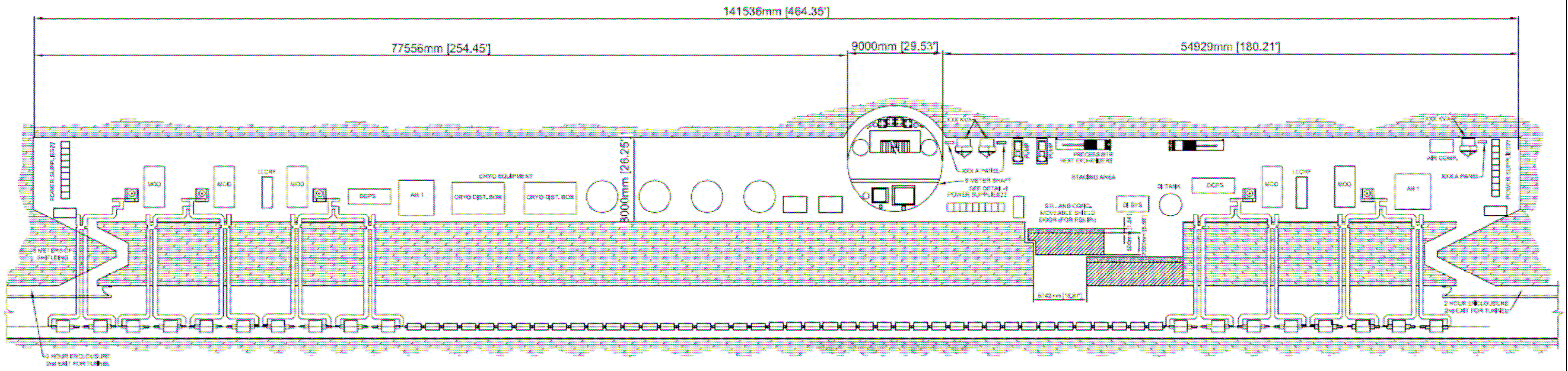




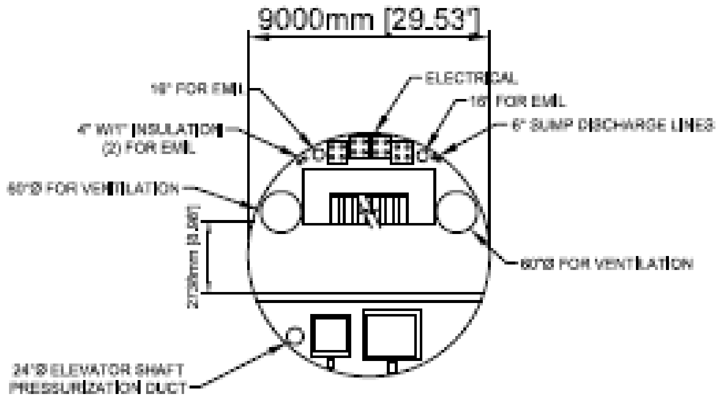
Americas Cost Distribution

Damping Ring Cost Distribution

DR Underground Structures

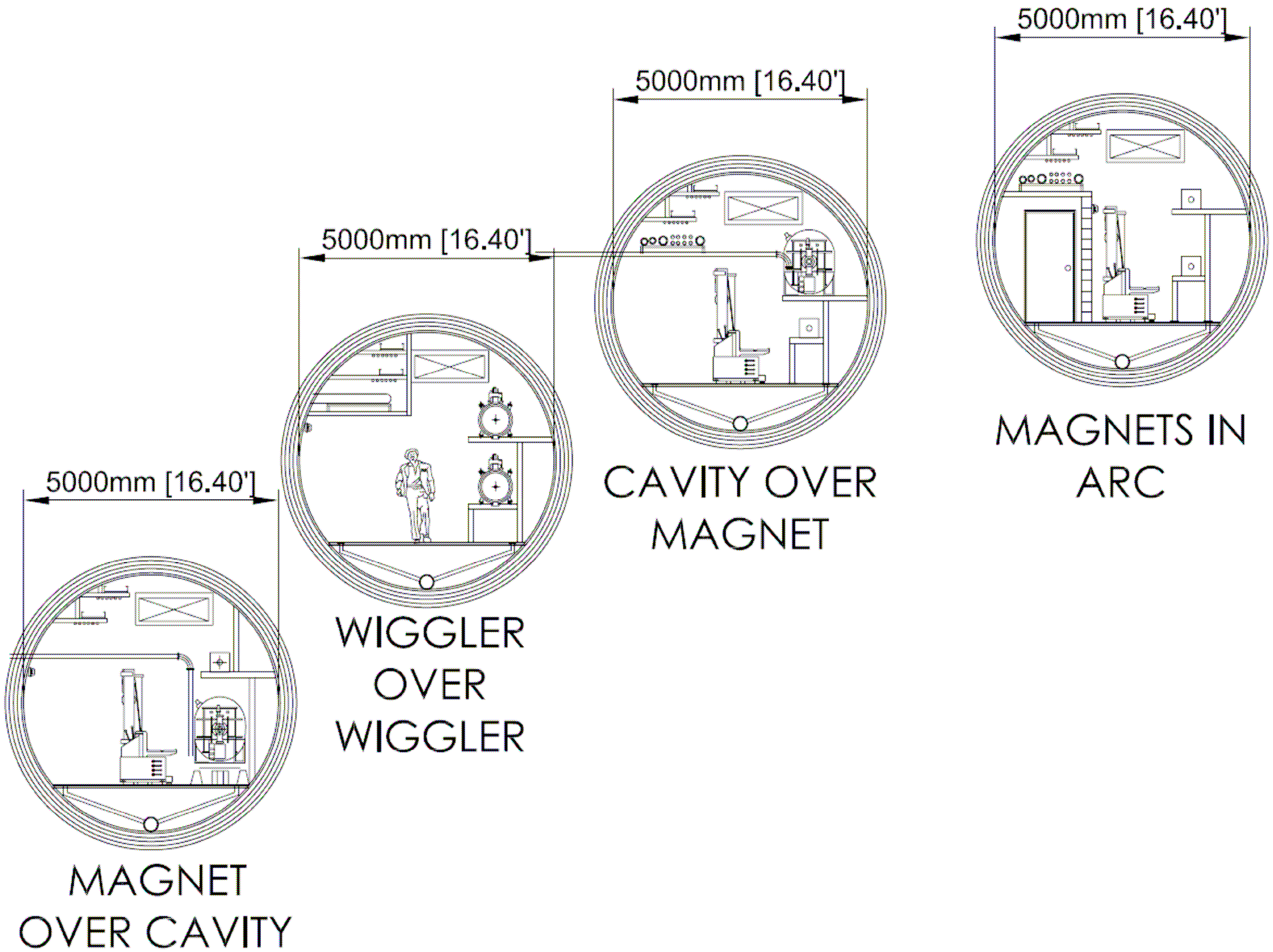


ALCOVE @ RF
2 REQUIRED @ SHAFTS

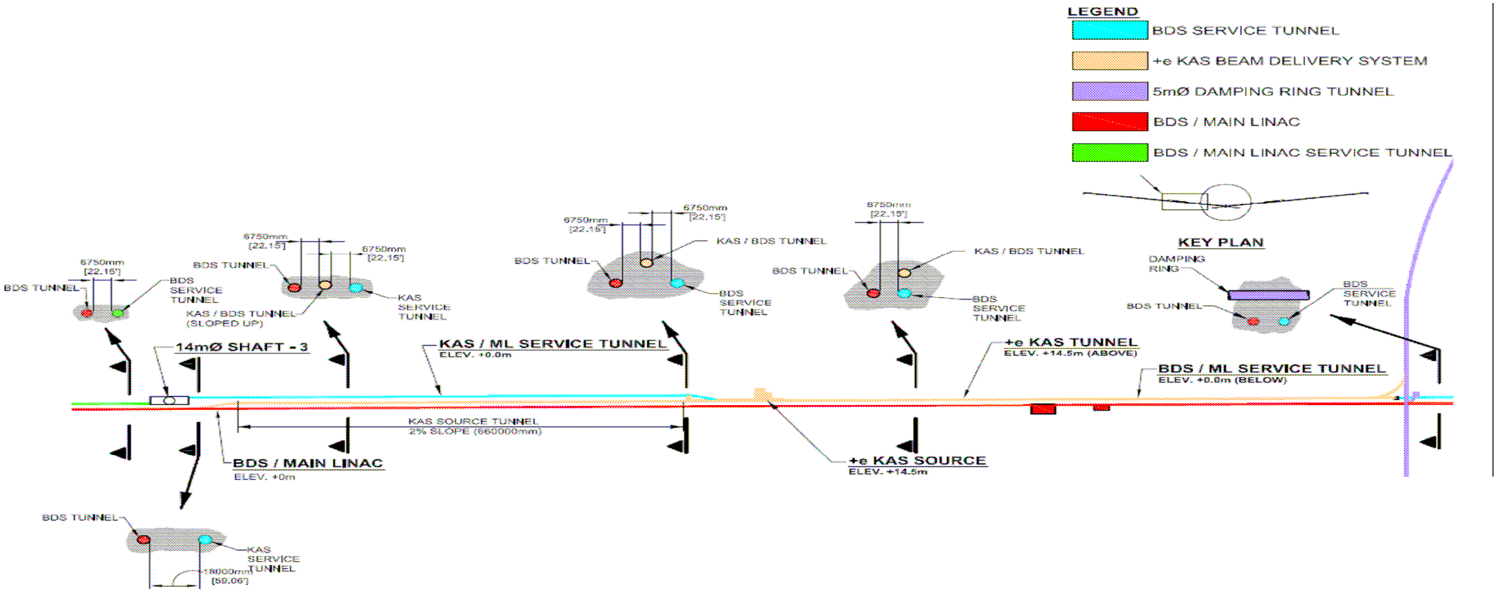


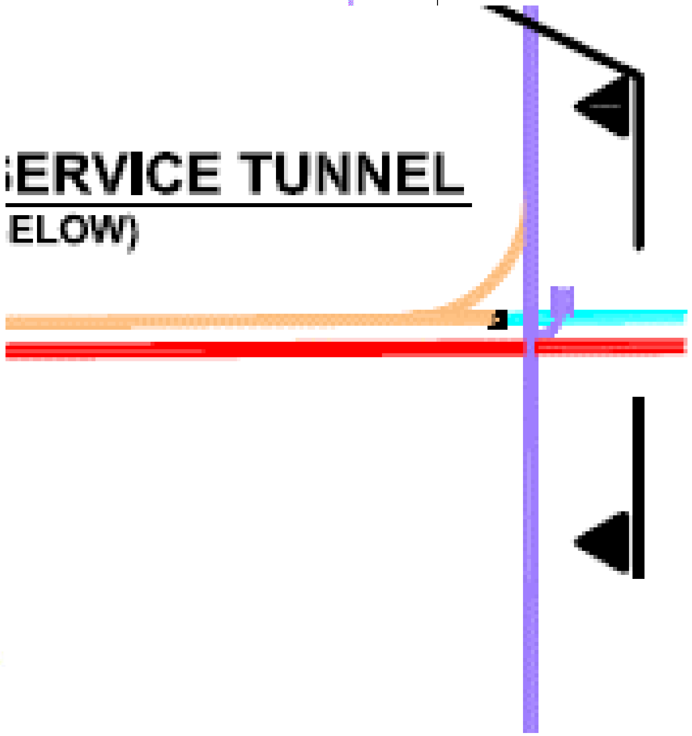
9M SHAFT WITH PLATFORM
@ 12 &13

RDR TUNNEL SECTIONS



Injection / Extraction





Items Included in Civil Engineering for DR

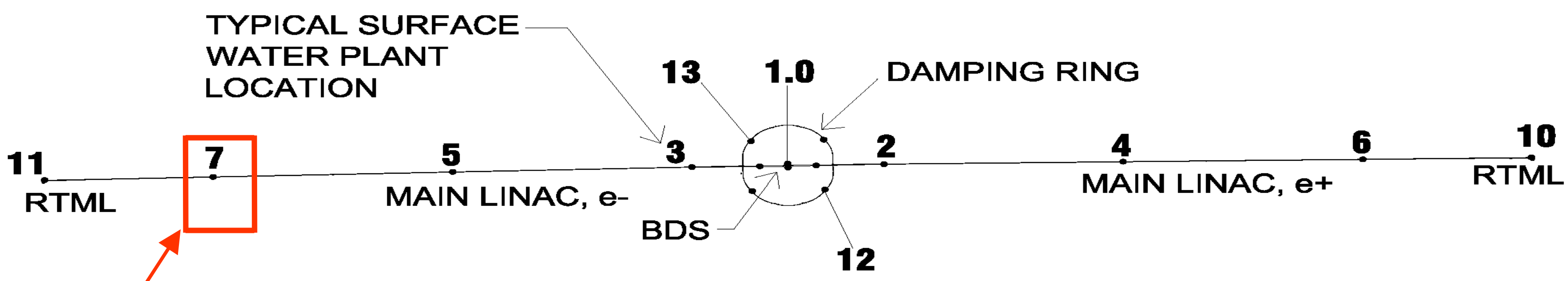
			Quantity	Unit
		CIVIL ENGINEERING		
1.7.1.1		Engineering, study work and documentation		
	1.7.1.1.1	In-house Engineering	*$90*	*/ man-hr*
		In-house Engineering	4%	%
	1.7.1.1.2	Outsourced Consultancy Services		
		Outsourced Engineering	6%	%
1.7.1.2		Underground Facilities		
	1.7.1.2.1	Shafts		
		Points 12 & 14 (DR) 9m dia. Shafts (2 x 425 vert ft)	259	vert m
		Surface Grouting of DR 9m dia. Shafts (2 x 425 vert ft)	2	ea.
		Points 12 & 14 DR 9m dia. Shafts, finishing (stairs, conc. wall, elev.#2)	259	vert m
		DR Underground Potable Water (Points 12 & 14)	2	ea.
		DR Underground Sanitary Sewer (Points 12 & 14)	2	ea.
	1.7.1.2.2	Tunnels		
		DR 5m dia. Tunnel, Excavation (21,946 lin ft)	6,689	lin m
		DR 5m dia. Tunnel, Conc. Invert (21,946 lin ft)	6,689	lin m
		DR 5m dia. Tunnel, CMU Fire-Rated Enclosure (21,946 lin ft)	6,689	lin m
		Provide Tunnel Construction Water Treatment Plant	1	ea.
		Maintain and Operate Tunnel Construction Water Treatment Plant	1	ea.
		Treatment of Tunnel Construction Water	1	ea.
	1.7.1.2.3	Halls		
	1.7.1.2.4	Caverns		
		Passageways to Cryo Controls Alcoves @ 2 of C,D,H,I (D&B Exc.) (2 x 3	595	m^3
		Cryo Controls Alcoves @ 2 of C,D,H,I (D&B Excavation) (2 x 111 CY)	170	m^3
		Passageways to DR Alcoves @ Inj. / Extract. (D&B Exc.) (2 x 389 CY)	595	m^3
		DR Alcoves @ Injection / Extraction (D&B Excavation) (2 x 610 CY)	934	m^3
		DR Shaft Base Caverns / Alcoves @ RF (D&B Excavation) (2 x 7,402 CY	11,320	m^3
		D&B Exc. for Moveable Shield Door (in Base Caverns) (2 x 748 CY)	1,145	m^3
		Shield Doors @ Base Caverns @ Points 12, 14	2	ea.
	1.7.1.2.5	Miscellaneous works		
		DR Waveguides (16)	16	ea.

Cont.

1.7.1.3		Surface Structures		
	1.7.1.3.1	Central Lab Buildings		
	1.7.1.3.2	Detector Assembly Buildings		
	1.7.1.3.3	Office Buildings		
	1.7.1.3.4	Service Buildings		
		Points 12 & 13 Electrical Service Buildings (2 x 1,500 sq ft)	279	sq m
		Points 12 & 13 Cooling Towers & Pump Station Bldgs. (2 x 7,500 sq ft)	1,394	sq m
		Points 12 & 13 Cooling Ventilation Building (2 x 2,500 sq ft)	465	sq m
	1.7.1.3.5	Cryo- Equipment Buildings		
		Points 12 & 13 Warm Compressor Buildings (2 x 2,500 sq ft)	465	sq m
		Points 12 & 13 Surface Cold Box Buildings (2 x 5,000 sq ft)	929	sq m
	1.7.1.3.6	Control Buildings		
	1.7.1.3.7	Workshops		
	1.7.1.3.8	Site Access Control Buildings		
	1.7.1.3.9	Shaft Access Buildings		
		Points 12 & 13 Shaft Access Buildings (2 x 2,500 sq ft)	465	sq m
	1.7.1.3.10	Miscellaneous Buildings		
	1.7.1.3.11	User Facilities		
1.7.1.4		Site Development		
	1.7.1.4.1	Off-site Site work		
	1.7.1.4.2	Network of Monuments		
	1.7.1.4.3	Construction Support		
	1.7.1.4.4	Site Preparation		
		Points 12 & 13, Clearing, Grubbing, and Initial Site Preparation (2 sites)	2	ea.
	1.7.1.4.5	Utility Distribution		
		Points 12 & 13, Utility Corridors (Gas, DWS, San., Storm, Elec., Comm.)	2	ea.
		Points 12 & 13, Sanitary (assumed on FNAL site)	2	ea.
		Points 12 & 13, Domestic Water (assumed on FNAL site)	2	ea.
	1.7.1.4.6	Road, Sidewalks & Parking Areas		
		Points 12 & 13, Service Roads (2 sites x 1250 lin ft / site)	762	lin m
		Points 12 & 13, Paved Areas (2 sites x 8750 sy / site)	14,632	sq m
		Points 12 & 13, Flatwork (2 sites x 2,500 sq ft / site)	465	sq m
	1.7.1.4.7	Landscaping		
	1.7.1.4.8	Environmental		
		Points 12 & 13, Sediment & Erosion Control (2 sites)	2	ea.
	1.7.1.4.9	Miscellaneous Site Works		

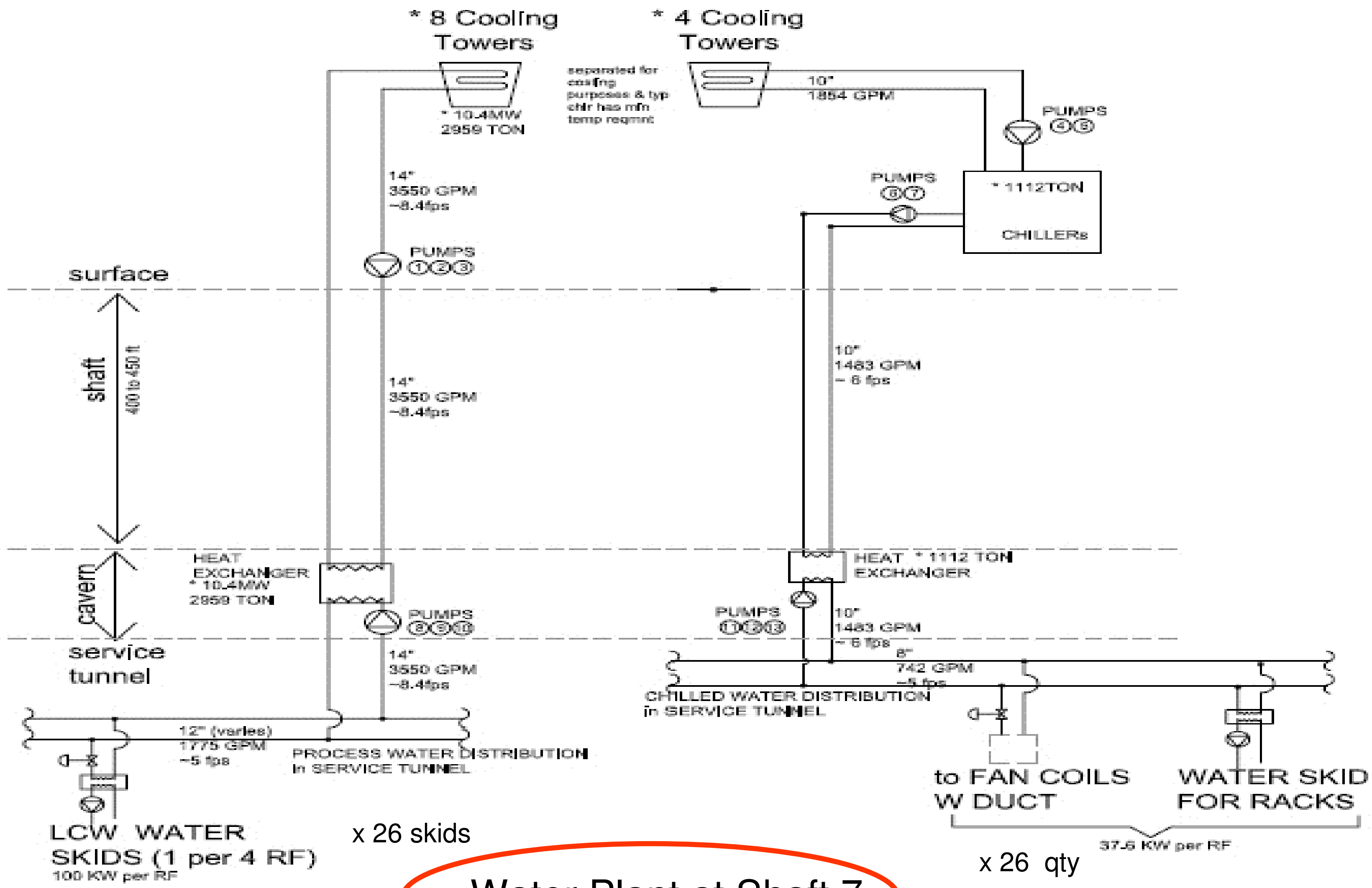
RDR Surface Water Plant locations

In RDR, we used simplified distribution by Area System



In RDR, this system at Shaft 7 serving ML, is what we used

RDR Process Water- WBS in Schematic



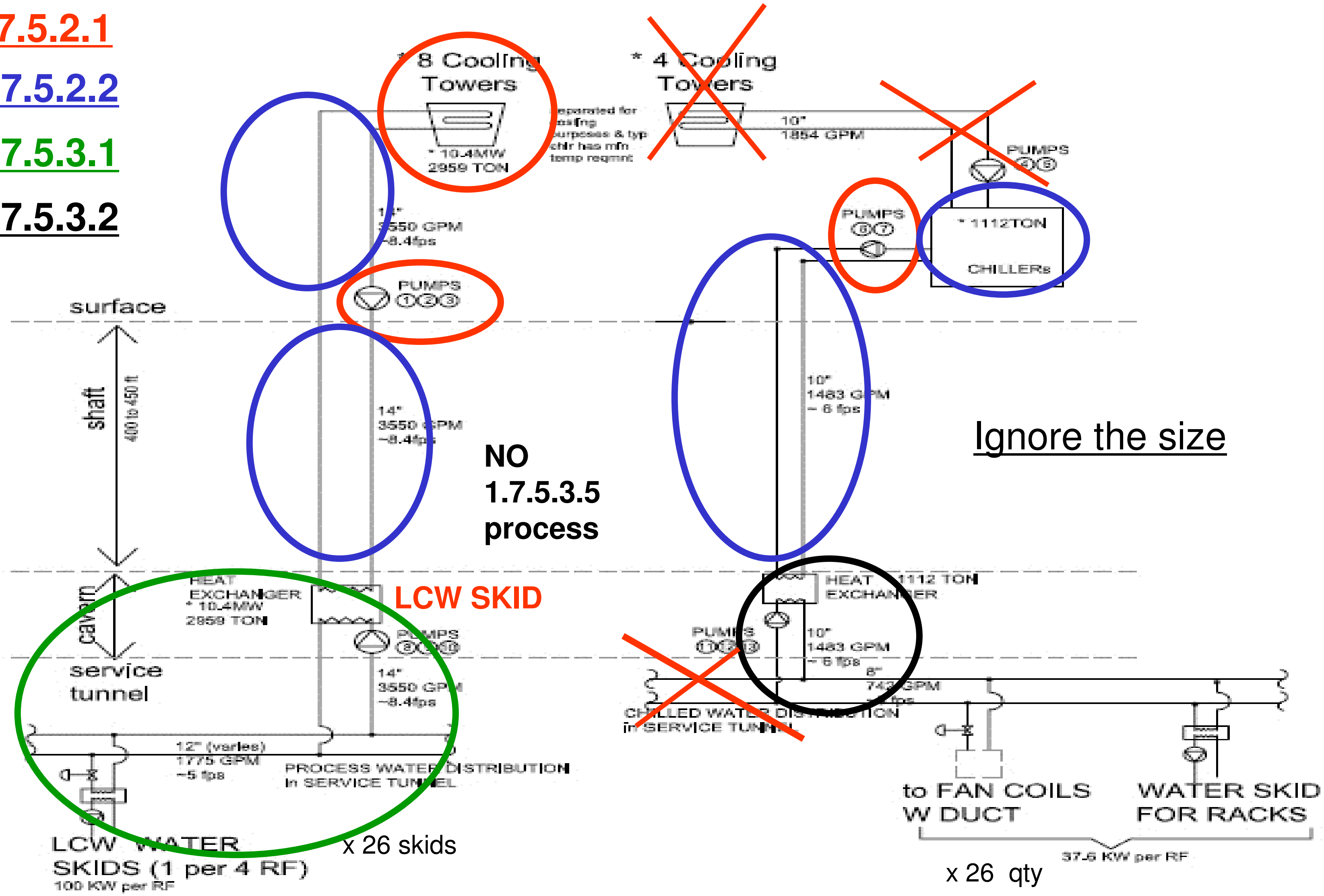
Water Plant at Shaft 7

1.7.5.2.1

1.7.5.2.2

1.7.5.3.1

1.7.5.3.2



Process Water for DR (includes LCW and chilled water)

•Cost is (partially) scaled from ML shaft 7, using only total KW heat load to air/water.
•Cost scaling is adjusted to reflect air-cooled chillers used for damping ring area (No cooling tower/pump/tower piping for chillers)
•Cost scaling is adjusted to reflect no cavern HX/pump for chilled water. Chilled water fancoils located in the cavern. No chilled water fancoils in the tunnel. Chilled water piping scaled using length of cavern.
•Cost scaling is adjusted to reflect no cavern HX/pump for process water. Model used large LCW skid is at the shaft cavern. Its HX/pump also is for static pressure break.
•Cost scaling is adjusted to reflect no process water piping (similar to ML). Model used LCW is distributed from cavern to the tunnel.
•Cost scaling is not used for LCW distribution. Costed separately based on some assumptions (see next few slides)
•Used Oct 16 2006 heat load from A.Wolski, no updates since then (expected to have large change in loads to air)

- Load to air in alcove is handled by large chilled water airhandler
- Load to air in tunnel is handled by large numbers of fancoils rejected to 90F LCW (placeholder, there will be less load to air). Fancoil cost is in air treatment.
- Air system can pick up about 400 KW total in tunnel or about 60W/m (~if allowed 30delta T air). Not considered in costing.
- Ignored heat absorption to rock
- Tunnel air is about 104F?? LCW is 95Fsupply and 115 F insulation return.
- alcove air at bottom of shaft is about 75 to 80F
- Include Fluorinert LCW skid to handle kickers (wag on cost, Maurice Ball, FNAL)
- used vendor's preliminary fancoil selection using 90F water, 104 F Air in, each handles 3.5 ton at this condition (placeholder)

Items Included in Air Treatment and Process Water for DR

				Quantity	Unit
1.7.3			**AIR TREATMENT EQUIPMENT**		
	1.7.3.1		Engineering, study work and documentation		
		1.7.3.1.1	In-house Engineering	*$90*	*/ man-hr*
			In-house Engineering	4%	%
		1.7.3.1.2	Outsourced Consultancy Services		
			Outsourced Engineering	7%	%
	1.7.3.2		HVAC Equipment		
		1.7.3.2.1	OA & Exhaust Air Processing		
			OA Supply/Exhaust Systems @ Po	4	ea.
		1.7.3.2.2	Air-conditioning for Tunnels		
			Beamline Tunnel A/C, DR	6,689	lin m
			Fan Coil Units	1	ls
		1.7.3.2.3	Air-conditioning for General Areas		

COST PER METER USED

EACH LINE SCALED FROM SHAFT 7

				Quantity	Unit
1.7.5			PROCESS (COOLING) WATER		
	1.7.5.1		Engineering, study work and documentation		
		1.7.5.1.1	In-house Engineering	*$90*	*/ man-hr*
			In-house Engineering	4%	%
		1.7.5.1.2	Outsourced Consultancy Services		
			Outsourced Engineering	9%	%
	1.7.5.2		Primary Stations		
		1.7.5.2.1	Cooling Towers & Pumping Stations		
			Cooling Towers for Process Water	1	ls
			Cooling Towers for Chilled Water	1	ls
			Tower Pump and Accessories for P	1	ls
			Tower Pump and Accessories for C	1	ls
			Chilled Water Pump	1	ls
			Controls	1	ls
		1.7.5.2.2	Primary Stations and Piping		
			Chillers	1	ls
			Tower Piping for Process Water (su	1	ls
			Tower Piping for Chilled Water (sur	1	ls
			Tower Piping for Process Water (sh	1	ls
			Chilled Water Piping (surface)	1	ls
			Chilled Water Piping (shaft)	1	ls
	1.7.5.3		Secondary Stations		
		1.7.5.3.1	Demineralized Water Stations and Distribution Piping		
			Demineralized Pump/Skid System	1	ls
		1.7.5.3.2	Chilled Water Stations and Distribution Piping		
			Heat Exchangers (cavern)	1	ls
			Distribution Pumps (cavern)	1	ls
			Piping (cavern)	1	ls
			Piping (tunnel)	1	ls
			Piping Connections to End Equipm	1	ls
		1.7.5.3.3	Water Stations and Distribution Piping		
			Water Stations and Distribution Pip	1	ls
		1.7.5.3.4	Compressed Air		
			Compressed Air	1	ls
		1.7.5.3.5	Process Water Distribution		
			Heat Exchangers (cavern)	1	ls
			Distribution Pumps (cavern)	1	ls
			Piping (cavern)	1	ls
			Piping (tunnel)	1	ls
			Piping Connections to End Equipm	1	ls

RDR Process Water: Heat Load Basis- Total Loads

Snapshot Nov 27 2006

Area System	LCW	Chilled Water	Total
SOURCES e-	2.880	1.420	**4.300**
SOURCES e+	17.480	5.330	**22.810**
DR e-	8.838	0.924	**9.762**
DR e+	8.838	0.924	**9.762**
RTML	9.254	1.335	**10.589**
MAIN LINAC	56.000	21.056	**77.056**
BDS	10.290	0.982	**11.272**
DUMPS	36.000	0.000	**36.000**
	149.58	*31.971*	**182**

The whole DR cooling is a placeholder and partially scaled from ML. here is the load used and concept

DAMPING RING LOAD ESTIMATE AS OF OCT 16 2006 (..still changing...)

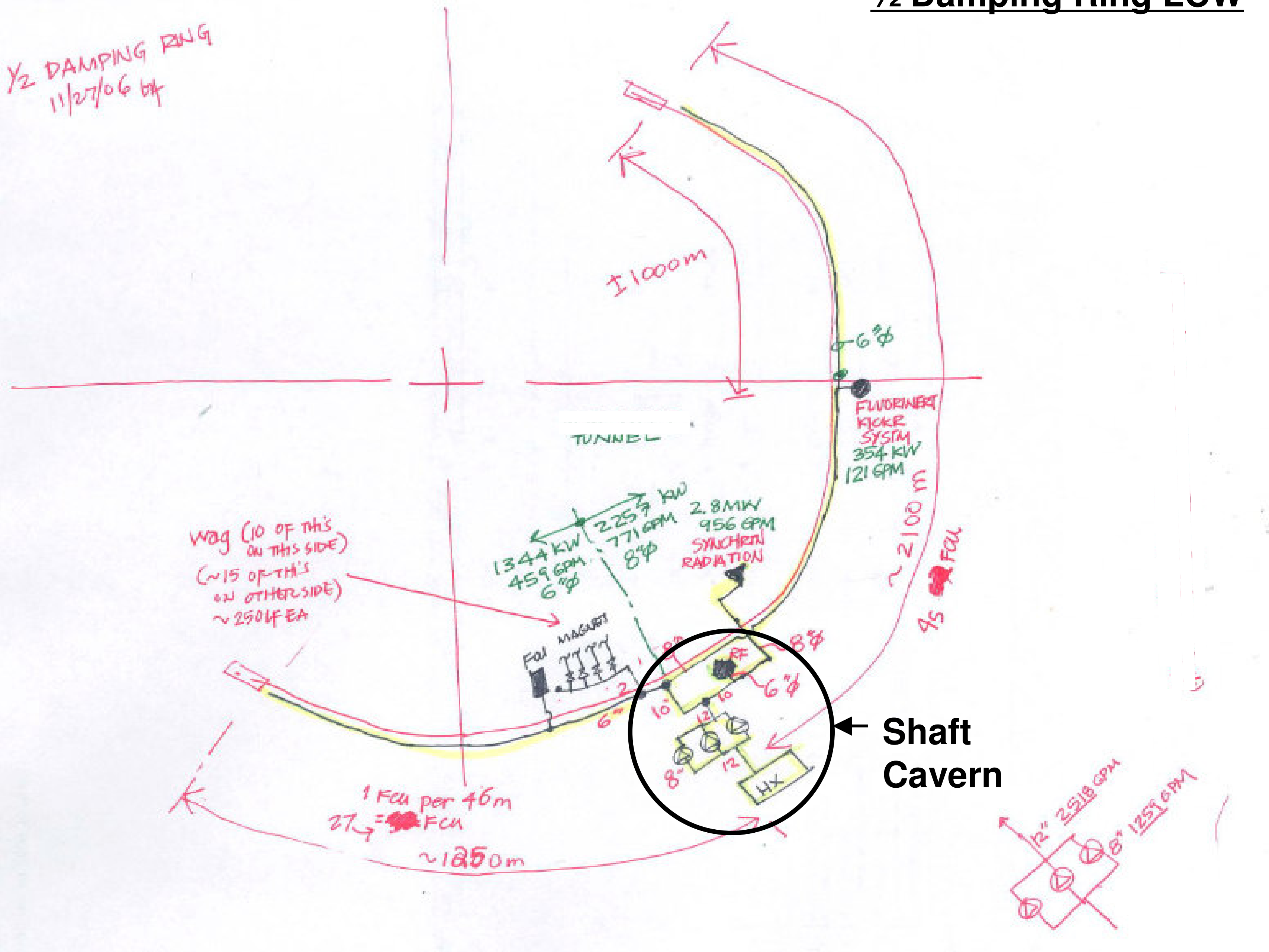
For Central DR with single e+ring (use numbers from Electron Ring and multiply by 2)

Electron Ring

	Input kW		Duty	Output kW			
	wallplug	from beam	factor	to beam	to water	to air	
RF Power (base value)	6300	0	1.00	3500	2240	560	alcoves
RF Power (peak overhead)	700	0	0.10	0	0	70	tunnel
Water-Cooled Magnets	1099	0	1.00	0	879	220	tunnel
Air-Cooled Magnets	109	0	1.00	0	0	109	tunnel
Cables	1377	0	1.00	0	1102	275	tunnel
Magnet Power Supply Losses	364	0	1.00	0	0	364	alcoves
Injection/Extraction Kickers (average power)	443	0	1.00	0	354	89	tunnel
Radiation	0	3500	1.00	0	2800	700	tunnel
total (peak input, and average output)	10392				7375	2387	

Positron Rings (total for two rings)

	Input KW		Duty	Output kW			
	wallplug	from beam	factor	to beam	to water	to air	
RF Power (base value)	6300	0	1.00	3500	2240	560	alcoves
RF Power (peak overhead)	700	0	0.10	0	0	70	tunnel
Water-Cooled Magnets	2198	0	1.00	0	1758	440	tunnel
Air-Cooled Magnets	218	0	1.00	0	0	218	tunnel
Cables	2754	0	1.00	0	2203	551	tunnel
Magnet Power Supply Losses	728	0	1.00	0	0	728	alcoves
Injection/Extraction Kickers (average power)	886	0	1.00	0	709	177	tunnel
Radiation	0	3500	1.00	0	2800	700	tunnel
total	13784				9710	3444	


½ DAMPING RING
11/27/06
±1000m
TUNNEL
FLUORINERT KICKR SYSTM
354 KW
121 GPM
2.8MW
956 GPM
SYNCHRTN RADIATION
1344 KW
459 GPM
2257 KW
771 GPM
MAGNETS
HX
~2100 m
~1250m
1 Fcu per 46m
Shaft Cavern

Discussed at Fermilab

Tunnel air temperature =below 90F, preferred 85F (due mainly to survey/alignment work? and laser tracker do not operate reliably over 90F)

This means chiller needed to cool portion of the process/LCW water. It is assume the ambient will become the average of the LCW supply/return temperature. (see item 5 below)

air stability + - 0.1 C (over ???? Hrs)

We don't know the relative cost to maintain this but it expensive both first cost and operationally (*air system reheat will be needed*)

The existing model of using LCW cooled fancoils (without reheat) can help trim space temperature to (but at less stability of *+ - ????C* over 24 hrs)

+ - 0.1 or 0.2 C LCW supply temperature stability (the requirement is at one point) near pump/skid at

Is This doable (Maurice to confirm)??????

Need constant fresh air ventilation to remove tunnel ozone that will eat away cabling, 1mph is acceptable.

This is doable in current scheme (that is neutral, conditioned. Dehumidified air will be injected in one shaft and out the other shaft at 1mph air speed.

Supply LCW at 70F, return at 105F, average 85F, **30 F (average) water delta T**

Same as item 1, chiller will be needed to partly cool process/LCW water (cost of chiller, but less pipe cost due to higher delta T)

Humidity (no specific numbers given)

Assume there will be no minimum humidity???

Power supply in the alcove (with no shaft) will be LCW cooled

This is needed, so as not to run separate chilled water main to the other shaft

cables/bus will be water cooled

- CFS Needs Heat Loads (water and air), agreed upon average delta T, pressure drop (average?), and locations (or relative locations) of the components.

- There is an upward sign for the cost impact for temperature control for the water and air systems as discussed at Fermilab.

Generic Approach for EDR

General Approach - Based on a Sound System Engineering Management Approach

- Functional Requirements Identification
  - **Defining physics requirement to engineering requirements**
  - **Defining boundaries, interfaces, utility needs and functional environment for each major components**
- Design Configuration Control Management
- Optimization Studies
  - **Design Alternatives Trade-Offs**
  - **Trade Studies**
  - **Constructability Studies**
  - **Value Engineering Study**

Tentative CF&S- EDR Plan

- **Generic Goal:**
  - **To Provide Facility Design that Meets Requirements at the Lowest Cost**
- **Conventional Facility Global:**
  - **To provide general conventional facility design and planning support and the development of cost estimates for the ILC EDR.**
- **Elaborated Activities for Work Packages**

  Review and adapt civil engineering requirements
  Design development works
  Verify unit costs
  Cost estimates
  Time Schedules
  EDR writing

Tentative EDR Plan for DR

- Establish A “Dimensional Envelope” Needs for Each major component of DR system for during;
  - **Installation**
  - **Commissioning**
  - **Operation**
  - **Maintenance**
- “Dimensional Envelope” Should Include all Supporting Utility as well as Functional Environment Requirements
  - **Exiting Requirements Need to be Revisited from Installation, Maintenance and Operation Point of View**
- Identification of Clear Boundaries Between CFS and Each Major Components Needs to be clearly Identified
- **Evolving Constraints and Criteria**
  - **Life Safety Egress Requirements**
  - **Construction Configuration Requirements**
  - **Operational Configuration Requirements**

Deliverables

- The CF&S will not package deliverables to the Damping Rings. The design drawings, reports, EDR write-up and cost estimates will be provided for information similar to what we did for the RDR.
- Many of the CF&F efforts for the Damping Rings will be accomplished as part of the overall design efforts…..Life Safety Studies, Option Studies, Excavation Cost Models
- Where warranted specific designs for the Damping Rings will be made…..Power and Cooling

Planned Activities and Products

- Life Safety Study
  - **Confirm that two shafts are adequate**
  - **Verify that second exit path required or if "Refuge Areas" will be acceptable.**

5.8* Refuge Areas.

5.8.1 One or more refuge areas or exit passageways shall be provided in new and existing subterranean spaces where the travel distance from any building exit to the exterior of the subterranean space exceeds 2000 ft (610 m).

- Studies
  - **Near Surface Central Region**
  - **Value Management (Will focus on Power and Cooling)**
- Engineering Designs

- Preliminary Drawing List
  - **Civil**
    - Composite Plans at Shaft Cavern, Service Alcoves, RF Straight, Typical Arc, Injection and Extraction Areas.
    - Composite Cross Sections
    - Plans at Surface Campus.
  - **Electrical**
    - Single line electrical for medium voltage distribution.
    - Typical Lighting and Power Plan
  - **Process Water / Air Treatment**
    - Criteria Drawings
    - Schematic Diagrams

Conclusion

- The RDR cost estimate included a factor to account for the immaturity of the design. We need to develop our understanding of the requirements so that the EDR will not require the inclusion of this factor.
  - **Point on Contact**
  - **Fostering of formal and informal lines of communications**
  - **Reviews and feedback**