

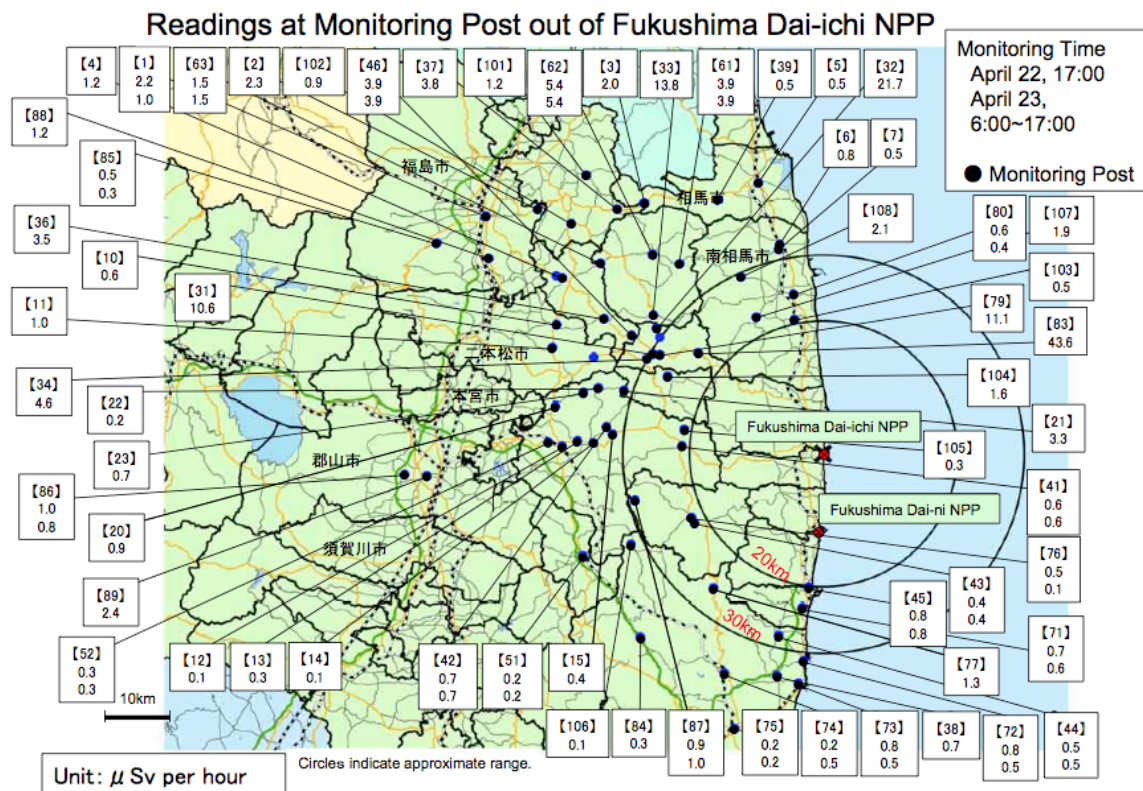
On March 11, 2011 Japan and especially the northeast coast of Japan experienced a major natural disaster during that afternoon with first a 9.0 level earthquake and shortly after that a series of large tsunamis.

Fukushima Daiichi nuclear power station and many other nuclear power stations when they experienced the extreme earthquake shocks immediately proceeded to automatically shut down their radioactive piles that were, until then, generating electricity. Very large pumps at these power stations were able to continue to circulate cooling water with the use of diesel electric generator back up systems. Even in reactor shutdown and in storage, the nuclear rods continue to generate heat and must be cooled. All other nuclear power stations in Japan continued to operate in a shutdown mode normally but when a very large tsunami arrived within about an hour at the coastal Daiichi plant, the back-up generators and the fuel tanks supplying them were basically washed away by the large wave. These diesel electric generators are huge and cannot be easily replaced. The pumps continued for a while longer with battery backup systems but by the end of the day water circulation to the reactor cores and the spent rod pools had stopped flowing.

Over the following days and weeks problems with the 3 active reactor power systems (reactors 1-3), their spent rod pools and the spent rod pool for reactor 4 created some spectacular chemical (hydrogen gas) explosions and some mostly localized steam released radiation clouds that created local and world wide panic. Failed and successful methods to bring water (fresh and seawater) to these hot spots occurred during this period. This jury rigged cooling system still allowed temperatures to rise in the containment vessels and steam pressure build up became a problem. Manual release of the pressure with the venting of steam allowed relatively low levels of radioactive Cesium and Iodine isotopes to be released into the environment at the power station site and surrounding areas. Iodine has a very short half life of about 8 days and Cesium though it has a half life of 30 years, the fact is that any ingested Ce is usually quickly eliminated in the urine. Time and distance allows living organisms a way of isolating themselves from the radiation danger. The most serious hot spots were found on the grounds of the Daiichi PS. No "serious" strontium, plutonium, or uranium signatures were ever found away from the Daiichi site. There was only a rumor of some limited plutonium signature in a soil test on the Daiichi site though I have seen no confirmation of that rumor. And there was a media discussion of "minute" traces of strontium and plutonium at 30 km out.

I became concerned for my family and friends in Iwate prefecture so I scoured the web for information on radiation levels for Iwate. Within a day I found a site that gave all the readings of the various prefectures except for Fukushima, Miyagi, and Iwate. Readings for Aomori and Ibaraki were available with Aomori basically at background cosmic ray radiation values and Ibaraki with some readings that were fluctuating and at one time reached about 3000 micro Sieverts for a very short time. During the early part of the disaster, for a day or two, the values shown for Ibaraki fluctuated from 1000 to 2000 micro Sieverts/hour. Fukushima power station readings at the gate were reported in the milli Sievert ranges and as I recall they may have been in the 10's of mS/hr early on. It was of only academic interest to me what they were since no one

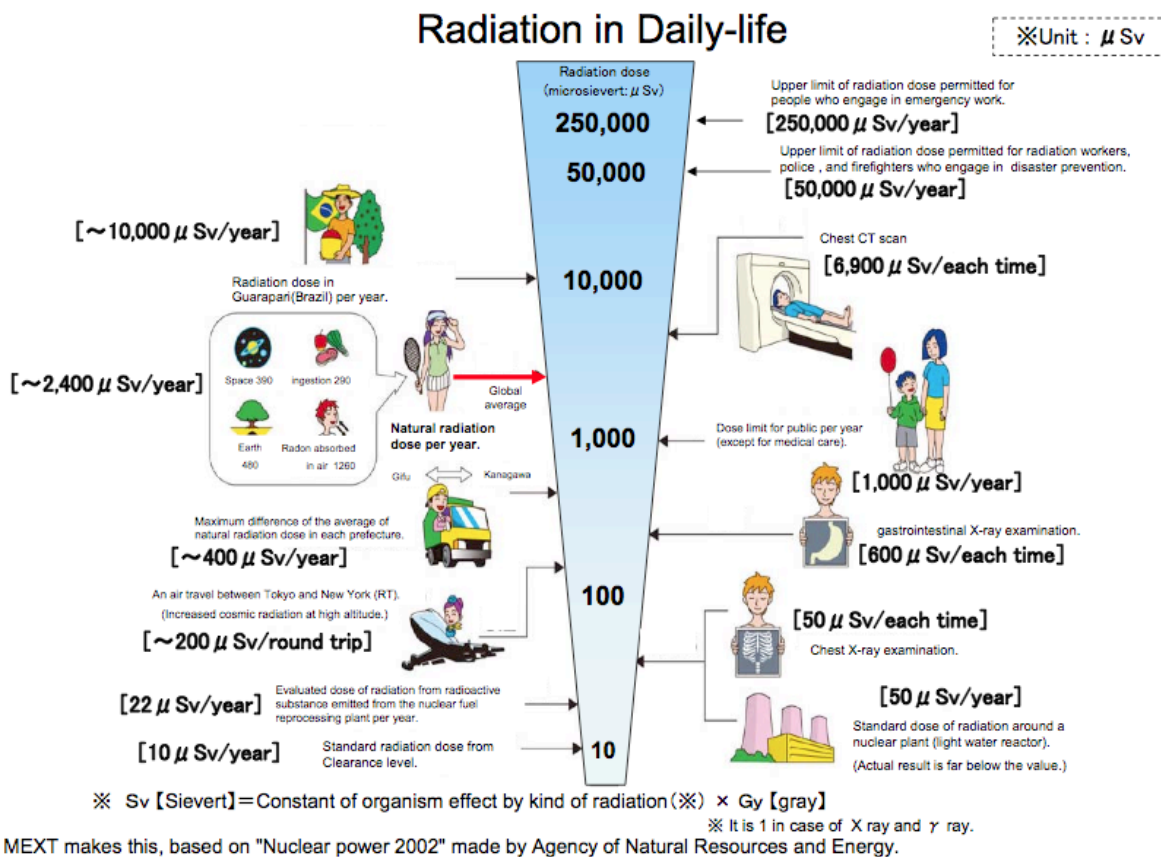
was at the plant when the values were very high. Or they were only there for brief periods. I am quite positive that TEPCO and the government were carefully monitoring the onsite workers. I have nothing but very high respect and admiration for these guys. They did some remarkable things in the first few days. My whole education in radiation physics was based on REMs but when I found that 1 Sievert was equivalent to 100 REMs, I was able to start thinking in terms of Sieverts (micro and milli). REMs are roentgen equivalent man and were based on biological effects of radiation. Within a week I found the Japanese government website that showed measured radiation levels throughout the country (<http://www.mext.go.jp/english/>). I was able to quickly see that most of the prefectures throughout the country were experiencing very low levels of radiation contamination. In the very beginning no data was available from Miyagi and Fukushima but quite soon data from both came out. Fukushima had a series of measurements made from almost 100 stations scattered throughout the prefecture but with none shown within the 20 kilometer exclusion zone. Several were within the 30 kilometer exclusion zone. Within a week of the tsunami, a spike of 170 micro Sieverts was seen to the northwest of the Daiichi plant at about the 30 km circle. It was on a line that could be drawn from the power station (PS) to Fukushima-shi. Ground contamination by Cesium was also reported about this time at that spot. From what I could determine winds during the first week up to the time of the NW radiation spike were off shore and at the time of the spike winds may have carried one of the early pressure release clouds to the NW. Fukushima today continues to see higher levels of radiation in that area (stations 31 through 37 and 83) and in a fan just north of that area (stations 2, 3, 61, and 62). Over the past 6 weeks the values have dropped drastically.



The figure on the previous page shows a recent compendium of readings for April 22nd and 23rd in micro Sieverts/hour and most stations are now 1 or less micro Sieverts/hour. Stations 2 (2.3 μ S), 3 (2 μ S), 21 (3.3 μ S), 31 (10.6 μ S), 32 (21.7 μ S), 33

(13.8 uS), 34 (4.6 uS), 36 (3.5 uS), 37 (3.8 uS), 46 (3.9 uS), 61 (3.9 uS), 62 (5.4 uS), 83 (43.6 uS), 89 (2.4 uS), 107 (1.9 uS), and 108 (2.1 uS) show slightly higher values in general. The higher levels are found mostly in the 30s series of numbered stations that are grouped to the NW of Daiichi PS at a distance of about 30 km. The highest level on this chart is 43.6 uS/hour. This is about 382 milli Sieverts/year.

If you look at the chart below and consider that 382 mS/yr is the same as 382,000 micro S/yr you can see that the total annual dosage is well above the natural radiation level and is almost 8 times the 50,000 uS/yr standard for the upper limit permitted for radiation workers and disaster workers. Remember though that you would have to expose yourself to that 43.6 uS/hr for the whole year. We know that most of the radiation seen by the sensor field in Fukushima is from radioactive Iodine which is continuing to decay on a daily basis so the likelihood of actually “seeing” that level of radiation by the end of 2011 much less by April 2012 is very low. Except for localized hot spots that may have to be decontaminated, most places in Fukushima excluding the Daiichi PS grounds will likely be at background levels of radiation by the end of the year (2 to 3 milli Sieverts/yr). On July 30, site 83 was measuring 36 uS/hr which becomes 315,360 uS/yr or 6.3 times the standard upper limit for radiation workers. This site and the 30’s sites noted above with high contamination levels must be heavily contaminated with Ce and though they are expected to continue to drop in value, will certainly have to be decontaminated before they can be reoccupied.



Some serious effort may be required in those places (near the 30 series numbered sites and especially site 83) with high readings including efforts to locate all the contaminated spots, determining what isotopes they are and making sure that they

are completely removed. Many people do not realize that we are all bombarded with this level of radiation (2 to 3 milliS/yr) during every year we live on this planet. People living at higher altitudes (Denver CO) or those who fly a lot will experience more than that level of natural radiation. People with medical problems that require CAT scans or X rays will also see more than that level of radiation in any one year.

From the previous discussion you can see that radiation in biological risk terms is characterized in levels that are accumulated over time (usually a year). A large level that is sub lethal (1 Sievert (100 Rems) total dose (short blast) or depending on the individual maybe slightly less, will most likely sicken you while 5 to 10 Sieverts even in a short period will be lethal. These are hundreds or thousands of REMs while 1 Sievert is 100 REMS and 250,000 uS/yr is 25 REMs/yr. And the civilian doses noted earlier in this report that were 2 to 3 milli S/yr are less than even 1 REM/yr. These "civilian" levels are considered mostly harmless.

Look back at the chart of Fukushima and see where most of the readings are already below 2 uS/hr and you can see how conservative the Japanese government is being in not allowing some of the farmers back in to take care of their livestock or check on their property. This level is equivalent to background radiation coming from cosmic rays, radon gas and other naturally occurring radiation sources. And the farmers would probably not have to stay for very long in order to take care of their chores perhaps once or twice a week, so that total body dosage will accumulate to a very small value by the end of the year. If it were me, I would obtain a dosimeter and probably go back to my home and live there (if it were allowed). Most of the coast of Fukushima barring perhaps the Daiichi PS site looks to be quite safe for relief workers who wish to go there. Most of the rest of the inland areas in Fukushima would be of little threat to relief workers who might only stay for a few days at a time. My personal view considering the residents of Fukushima, their risk to return to or stay in their homes even in the zone between 20 and 30 km is quite low. There is a slightly higher risk in the few hot spots noted especially by area around measurement stations 31-37 but not by much. This is especially true if the readings there continue to drop off over the next few months. Highest risk from these radiation sources are from ingestion (breathing them in, eating them or entry through ears etc) so the white suits and even rubber boots are not as necessary as perhaps some sort of breathing apparatus. That level of requirement (breathing system) is actually isolated to hot spots at the Daiichi PS (and perhaps to isolated areas NW of the PS). The low levels in the countryside don't even warrant a breathing apparatus. Extended stays in areas that are hot is really the only risk involved right now and all those seem only to be within the boundaries of the Daiichi PS and perhaps to some degree at a few other hot spots noted above.

When the media talks about high radiation levels being found, they rarely even give the values. They also use phrases like "400 to 500 times legal levels" when discussing radiation levels at the Daiichi plant. These limits were developed by the government to very conservative levels to be used during normal times. Under these rules the people are expected to remain at the plant and in the nearby vicinity with zero expected risk. The media does not understand but fortunately TEPCO and the government technocrats do understand that inside and near the Daiichi power station a great deal of care must be taken for awhile to safeguard workers dealing with "400 to 500 times legal limits" so that they will not be endangered and obviously that

“civilians” will not be allowed anywhere near these nasty spots. We need to remember that the Daiichi PS has survived both a huge earthquake and an unprecedented tsunami. When you really look at actual radiation levels and the risk they pose to biological systems in the surrounding environment the hysteria promoted is well beyond any likely bad results that could happen due to any scientifically based outcomes (except perhaps from some sort of media derived science fiction). Within a day or two of the disaster several media outlets began looking at radiation clouds that would over-run Alaska, Canada, California and Central and South America. Local clouds in the 1000s of microS/hr were carried by winds that were mostly off-shore for the first few days. These global radiation clouds and other events they imagined were well beyond the laws of physics. The same sort of misinformation continues to happen with projected contamination of the Pacific ocean from rim to rim. In reality the website noted earlier in this paper has continuously monitored the radiation values from about 10 sites in the ocean a few hundred meters off the coast of the Daiichi PS with readings taken above the sea surface, in the water, and on the seabed. There have been a few minor spikes in the values but for about a month now values remain very low or undetectable.

I don't expect the general public to educate themselves on these matters, but of course I would hope that they would go to at least the trouble to filter some of the more outrageous media pronouncements. It is almost criminal how poorly informed and/or how ready the media is to distort information that with minor effort is available in rich factual detail from a wide variety of reliable sources. Of course it seems to be advantageous for the media to disregard the facts so that they might increase readership. However, early in the crisis there was a panic (that I myself experienced) and the actions of the media showed an inability or unwillingness to locate reliable factual sources to present to the public. These actions by the media during this crisis in my opinion were blatantly inflammatory. In fact I was able to quickly gather these resources and analyze them to the point where I could determine on a day to day basis what was really going on in Fukushima. Generally I found the BBC online reporting to be very good. I found Reuters to be awful.

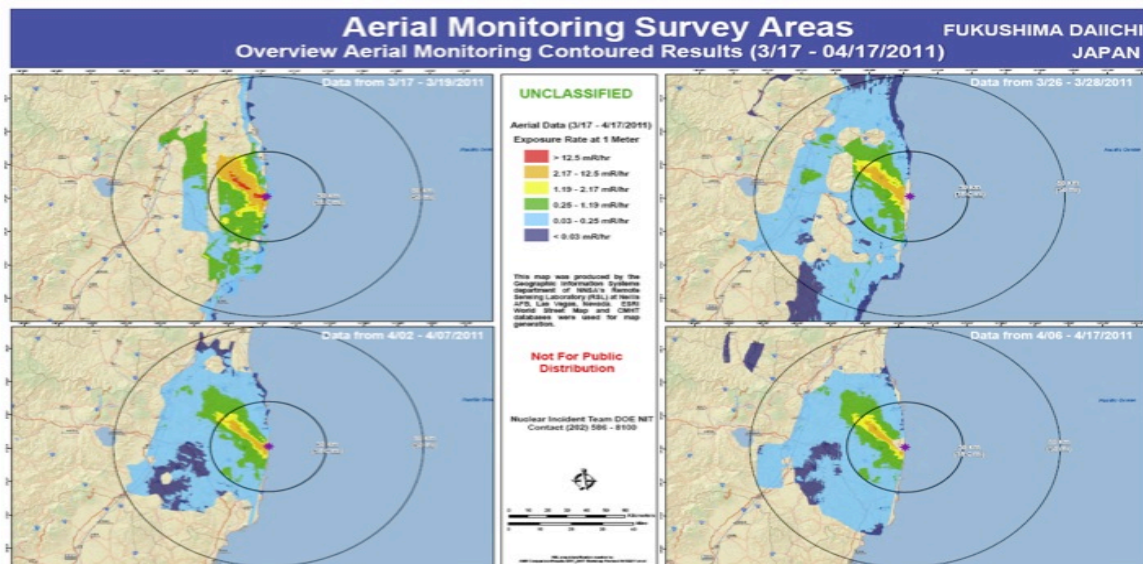
I actually began to educate myself on the technical aspects of the unfolding problems at the nuclear plant and became quite sympathetic to the staff trying to stave off more catastrophic problems. When the media portrayed Japanese technocrats and the nuclear workers at the plant as carrying out suicide missions, such a base level of media silliness was simply ludicrous. My radiation health physics friends were disdainful of the numerous false issues and stupid comments made by many of the main stream media outlets. The Japanese technical staff seemed very competent but some of the Japanese political leaders ended up with egg on their face at several junctures. Their lack of understanding that this was a very unique natural disaster that required some serious out of the box thinking in order to resolve the problems continues to plague them. Pointing fingers (even when they were at rare times warranted) has been mostly counterproductive. By looking and selecting very carefully on the web, I was able to find a few trusted sites that kept me well informed and generally comfortable about the events happening at and around Fukushima Daiichi. The major media outlets have huge resources and yet they seemed incapable of equaling my broad information base which was acquired with only a little effort.

Daiichi is not Chernobyl and barring something from way out of “left field”, Daiichi is well on the road to recovery and resolution with just a few industrial deaths and no likely radiation deaths or even injuries. Here we have all this nuclear hyped news trying to make us believe that we are witnessing an environmental disaster of Biblical proportions in spite of it really being a “non issue”. When news commentators talk about Daiichi as an accident (Chernobyl was an accident) it also upsets me (NHK continues to call it an accident). Daiichi was a major natural disaster with a very good chance of having a “good” outcome in the long run. I am not really an avid proponent of nuclear power but I am a proponent of truth. However, until most of these nations find a replacement for nukes they would be silly to dump them. All the other nuclear power plants including Dai-ni survived this extreme natural test so that unless there is an unlikely reoccurrence in the next 50 years, those reactors are probably safe to operate. But clearly, there must be some lessons learned in all of this.

Finally what makes me the most upset is the fact that almost all the news coverage for the past few weeks has focused on this whole series of “non issues” rather than discussing the real issue of the tsunami survivors. They have been forgotten by the media, in my opinion, and they should be the real focus of our effort to get past this awful disaster. In fact all the folks that have been forced into these shelters for reasons of earthquake, tsunami, or radiation effects deserve our utmost support and sympathy.

Some New Data

On May 2nd I was able to obtain the following graphic from US sources (DOE) that



show the results of US over flight radiation measurements (about 600 flights) for the whole area around Daiichi including those locations within the 20km “no go” zone. This data shows the region where the spike that I noticed earlier has actually been characterized in much greater detail. This specific narrow area inside the 30 km zone is not recommended for more than short stays using standard dosimeter values and I

am very sure that the Japanese Government is forbidding anyone from going there at all. Note that the first circle that DOE uses is 30 km in diameter rather than the Japanese “first” circle of 20 km in diameter. The timeline in early March indicates a narrow strip of readings above 12.5 mREMs/hr and are shown in red. The high readings in the narrow red band is almost exclusively contained in the Japanese 20 km “no go” zone. A person that receives this level of radiation for a year will have received a dose greater than 100 Rems which would be enough to give a person radiation sickness. However, it is clear that levels are rapidly dropping even in this narrow zone. And by late March all levels above 12.5 mR/hr are gone. The bands of levels from 2.17 mR/hr to 12.5 mR/hr have significantly narrowed by the end of the report period in mid-April. By then most of the area from around the plant out to 80 km is blue which at the high end of radiation dose for a year would be slightly over 2 R/yr. If in the next few months the orange and yellow bands turn to green and the green band narrows, annual dose rates in that presently critical zone will dip to slightly over 10 R/yr which is less than half the present rates that emergency and nuclear workers are recommended to deal with. This whole activity is a very dynamic process and the trend for now seems to be rapidly headed down.

The main point here is that we now have the complete picture of the extent of the contamination and it is quantified and visible on this latest chart (and it includes the 20 km “no go” zone – where in the past we had no data at all). There is a serious problem in the narrow band out to 30 km but it is now clearly defined and it seems to be rapidly diminishing. We shall see if this data is verified by the Japanese government which is apparently soon to release its own data set for all of Fukushima. And we shall see over the next few months how these contamination levels trend. It is fairly clear that the trend will continue down but the rates of these trends will be of great importance. My earlier “hunch” about the northwest band of higher radiation has been verified and we can see that it extends back into the 20 km “no go” zone to the Daiichi PS site but does not extend too much further beyond the 30 km limit on the line to Fukushima-shi.

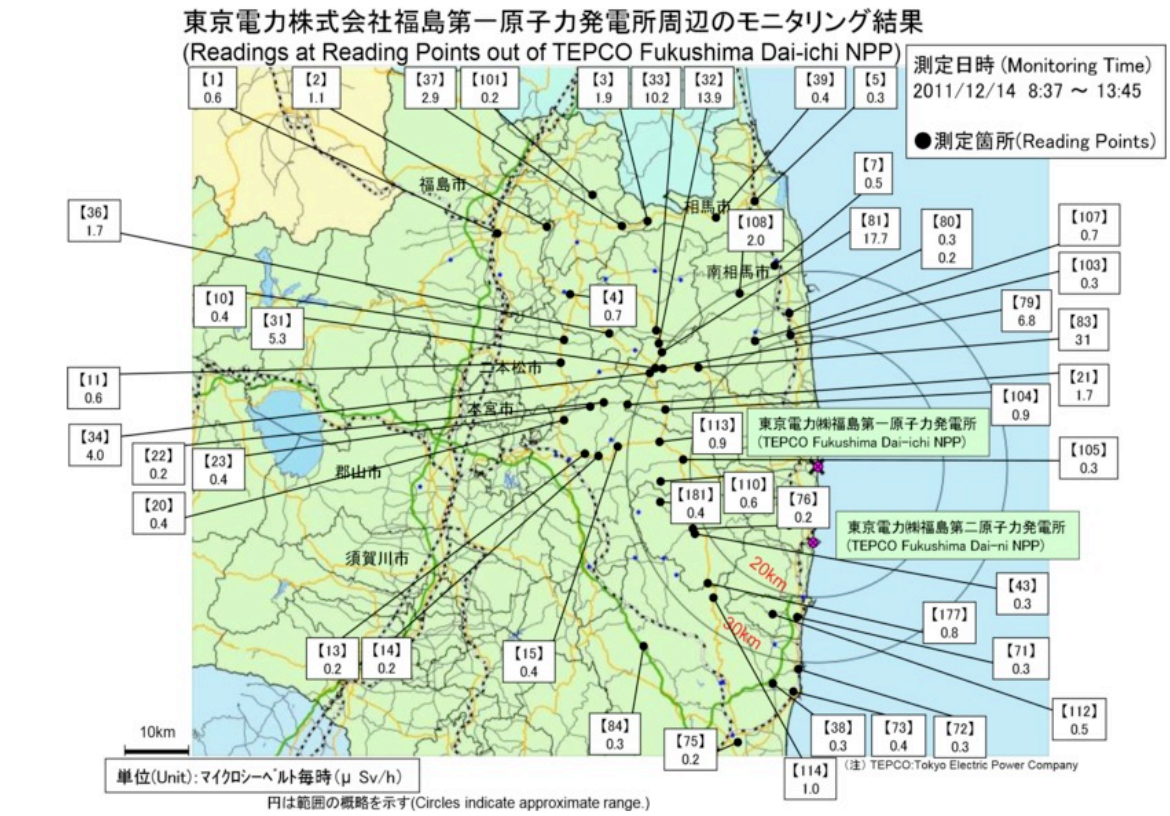
There are significant areas of blue and green within the 30 km circle. People would be mostly safe there. Let’s hope that over the next few months that the blue/green area grows.

A new map released May 10

A new map from the Japanese government has been released on May 10. Data for this map seem to have come from ground surveys of the region out to 80 km but it is unclear what this map represents since it seems to show higher values of radiation contamination in the “central plume” hot spot than the US DOE maps do. DOE mapping was based on aerial surveys. It is not clear at this time what the data collection period was (apparently several weeks in April). The problem of comparison is due to the fact that values are given in kilo Becquerels rather than Sieverts or Rems. KBq is a value of inherent radioactivity rather than a biological dose measurement and thus cannot be directly used to determine dose rates. Contaminated areas seem to be broadly brushed and blur the finer tuned dosage data that has been collected by the MEXT Fukushima radiation network. This network has been supplying data points 4 times a day from about 100 recording stations all around Fukushima from 20 km outward for almost 2 months now (see website noted

earlier in this report). The DOE data also seem to show lower dosage and more finely tuned data as well. I would think that radioactive contamination areas could be mapped to a very fine pattern (more so than the dosage maps). It seems quite the opposite has been seen in this new map. Some clarification of this new data is necessary before any further speculation is possible. I fear that the “risk management” bureaucrats may have “filtered” (and blurred) the data before it was released.

Update Dec 14, 2011 Readings Outside 20Km Circle (Stations 31,32,33,34,79,81,83)



Late 2011 and Early 2012 Added Comments

It is clear that there was always a threat of core melt down when cooling water was blocked from flowing into the core of the reactor. That is why most western nuclear plants have containment vessels (unlike Chernobyl which had an open core that was blown all over the place when it exploded, contaminating a wide area with highly radioactive material). All the explosions at Daiichi were chemical in nature from hydrogen build up in the reactor outer structures. For several months in Japan no one could really know (certainly not the Japanese politicians) the state of the core. We now know that the core did actually eat into the containment vessel (suffered a partial meltdown) but the vessel was not breached and is not likely to be in the future (since all the reports I have read say that all reactors are now in cold shut down). Contamination at Daiichi came in steam release and water overflow that released much less nasty Iodine and Cesium. Iodine is less nasty because of its short half-life. Eight days. About 11,000 Olympic size swimming pools worth of contaminated soil will have to be removed so that several of the small villages to the northwest can be re-inhabited and so that the Daiichi plant can be completely decontaminated.

This is certainly a horrendous disaster but it was no accident that all the basic safety features of even a 1970's era design basically worked in spite of an "unprecedented" natural event. Should the Daiichi plant have been sited on the original hill that was dug down to build it closer to sea level? Yes of course! But no other plant of the 16 sites in Japan (and of the 54 reactors there) including the Dai-ni plant just 10 km down the coast suffered anything like the problems that Dai-ichi did. Newer designs will not have these cooling problems which are at the heart of issue here. Fifty reactors are still operable with the 4 at Daiichi probably beyond repair. Recent news indicates that less than six of the remaining 50 reactors in Japan are producing power. Part of the reason is that Spring is maintenance time for many of the reactors but there seems to be a growing anti-nuclear sentiment in Japan and the world. This would be okay if there were some clear replacement and a solid reason to not start up the intact reactors but I don't see either of these avenues as reasonable in view of the alternative of having insufficient power to even limp through the coming summer.

And finally, I find it ironic that the media now a year plus into this incident are now finally "dredging up" new "leaked" information on how bad it really was when indeed they have had rich detailed information on exactly what was going on and completely failed to tell any of us about it. Most of my sources of that detail did not come from any of the media sources at all. Truly, the nuclear disaster was plenty bad but the majority of the blame goes to mother nature and she did a terrible number on the coastal inhabitants of Tohoku and the media continues to ignore them even though there were probably at least 20,000 real and heartbreaking casualties. And many 10s of thousands refugees that are still suffering. And may suffer further insults if they are forced to deal with power rationing in the face of denied plenty.

Japan Trip 2012 Addition

While I was in Japan in April and May of 2012 I heard briefly of a sensational report of clever action that makes me respect the Daiichi Chief Engineer and his crew even more. Apparently in the early hours of the disaster when worries of Armageddon at the plant and wild rumors were being spread, the CEO of Tepco basically told the Daiichi technical staff to abandon the plant. The Chief Engineer who was well aware of the serious consequences of such a silly command decided to ignore it and with great care and cleverness re-entered the grounds and cobbled together power sources (from automobile batteries and other sources) to power up critical instrumentation and control systems. The team was apparently able to monitor and control the plant over the next few critical days to verify pressure, radiation level, water temperature, water level and then control pressure build up by opening valves and dealing with all the complex command and control functions during this very critical period using a jury rigged system. Of course no one ever expected this level of disaster and the technical team devised a process that went far beyond anything found in "the book". And they were able to mostly "contain" the problems. This was in spite of Tepco Management and the Japanese Government. The government did not quickly assemble an international team to support the onsite technical team either. I am not sure that the CE ever asked for it, and though the US rendered a lot of secondary support, the US along with others from Europe and elsewhere would have been able to increase the number of experienced teams to cycle groups in and out of very hot spots to speed the process of restoring the crippled monitor and control systems and

perform tasks to cool the reactors and the pools of stored fuel. In fact Prime Minister Kan actually went to the site early on and disrupted the technical team's efforts with some sort of silly harangue that, if it were me, would have pissed me off rather than encourage me. My approach, if I were the government, would have been to call up the Chief Engineer with my own technical team listening and simply ask him what he needed and made sure it was all captured on a list and then I would have told my technical team to get their ass in gear and get the CE everything that he had asked for NOW. A five or ten minute call which would have ended with me giving the CE my phone number with a command to call it any time (24/7) that he needed any thing. Unfortunately in the early stages the poor CE was not rendered this sort of assistance and was apparently left on his own.

Some Final Comments

Apparently several U.S. experts critiqued the actions of the technical team in stating that they were too conservative in using dosage levels for the groups entering the various damaged or instrumentation areas of the Daiichi plant. By aggressively sending the teams in on a more active schedule, some of the control issues could have probably been resolved so that vented clouds of steam, hydrogen, and radiation products would have been unnecessary and hydrogen explosions probably would not have occurred. The "book" does not allow this less conservative approach but since this was a unique disaster this out of the box activity would have been warranted. All experts that I located on this issue concurred that risk to workers under this special regime would be very minimal while at the same time would have reduced the actual total risk to the general public and to the power plant infrastructure. If both company and government management would have simply phoned for or brought in more international expert support, this advice and support activity could have been undertaken without too much burden to the onsite technical staff.

Also the international nuclear technical experts found that the Japanese technical hardware and practices at least at some Japanese nuclear power sites had not been kept up to accepted international standards. It would seem that poor management practices must ultimately be blamed for this shortcoming. This includes failure by the government regulators to properly deal with nuclear power plant oversight issues.

Of course all this is armchair-after the fact analysis. There is plenty of blame to go around. In the end the disaster was basically limited to mostly what nature could do to a Japanese population that is, in general, very prepared for natural disasters. The enormity of this event simply overwhelmed all possible direct preparation for it.

One Final Comment - added info 2014

I read the Fukushima material in James Mahaffey's book "Atomic Accidents – A History of Nuclear Meltdowns and Disasters" completely and I was fascinating at the minute detail that Mahaffey has assembled for all of the accidents that he chronicles. I, until he enlightened me, have adamantly called Fukushima a natural disaster and decidedly not an accident. However he makes it clear that one of the Japanese staff controllers open a

couple of valves just after the earthquake and before the tsunami arrived, that could not be closed once the tsunami destroyed all back up and standby power (in fact all AC power sources!). There was some limited battery DC power available for about a day (from car batteries that the chief engineer had collected) but as I recall the opened valves used compressed air to actuate them and I don't think there was any standby air pressure and the air pump required at least a moderately sized AC motor. I suspect that if Daiichi would have had a small gasoline powered electric generator (probably as small as 5 Kw) to supply power to the control room and the air compressor, there would have been no explosive and disastrous media events and all the reactors would have gone into routine shutdown modes.

I also think there was a lot of confusion (operator error) about what exactly needed to be done in the short time between the earthquake and tsunami. If those valves would have remained closed throughout the first few hours, the process of cooling the shutdown process would have been easy and safe. However once the 3 online Dai-ichi reactors went into shutdown mode but remained un-scrammed, they quickly boiled off limited water. This caused various levels of core melt-down in all the active reactors but especially in the older reactor number 1, leading to a very bad outcome. The lack of cooling water and the subsequent generation of quantities of hydrogen gas that built up pressure that was vented or leaked, caused explosions that breeched secondary containment and to a limited degree primary contaminated at the site. After that, hot spots of high radiation made any sort of activity near the crippled reactors almost impossible and very risky. Dia-ni just 10 km away suffered almost the exact same natural problems but luckily did not lose all sources of AC power even in the face of the double whammy of earthquake and massive tsunami, so control functions remained intact throughout the shutdown process.

Mahaffey when discussing the Japanese propensity to build all their nuclear reactors next to the ocean, was very critical about it. Especially with all the history of large tsunamis physically embedded in various coastal spots around the Japanese - going back thousands of years. So, almost all Japanese nuclear power stations are accidents ready to happen in some sense. He then notes that some simple modifications to the present designs could remedy these problems. Some of these are as simple as getting backup power out of the basements of some of the facilities. And he laments the silly destruction of the nuclear power industry by the greens and the press over the action of a single person at a single power station.