



Auroral Chorus III: Music of the Magnetosphere by Stephen P. McGreevy

A Two-CD collection of Earth's Mysterious
and Beautiful Natural VLF Radio Phenomena.

Stereo and mono recordings from: Alberta 2000 and 2001 - Saskatchewan 2001 - Colorado 2001
Nevada 1996 & 1999 - California 2001 - British Columbia 1994

First heard on long telephone and telegraph wires in the 1880's, these fascinating and beautiful-sounding natural radio signals of Earth were the first radio signals people had ever heard -- decades before the first radio broadcasts of the early 20th century would occur.

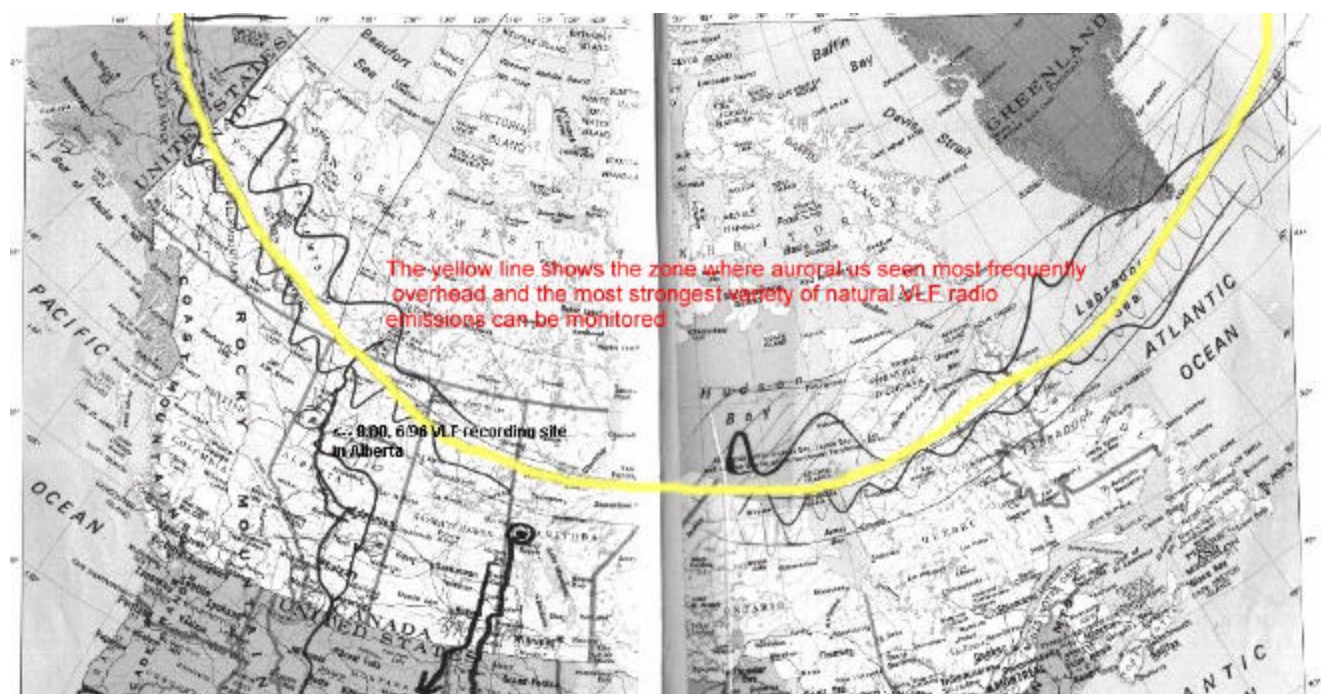
Natural VLF (very-low-frequency) radio signals (at audio frequencies) are generated within Earth's enormous magnetic field and radiation belts surrounding the planet called the Magnetosphere, many originating as plasma-waves several thousand miles out in space. Earth's magnetosphere collects a great deal of radiation and electrical particles from the Sun's solar wind, and also protects life on Earth's surface from this harmful radiation from the Sun.

Most times the solar-wind is slow and gentle, and streams around the magnetosphere like water around a rock in a calm river. But at other times, eruptions on the Sun force fast-moving streams of energetic particles bursting forth into the solar-wind, and within a few hours to a day, these impact Earth's magnetosphere, wreaking much havoc. This is called "space weather." Stormy space weather gives rise to a great variety of natural radio sounds and also the Aurora - Northern and Southern Lights - best seen in the higher latitudes on Earth nearer the poles.

Much of the natural radio sounds you hear on these two CD's are generated by the Sun's solar-wind electrical stimulation of the magnetosphere, originating as "plasma waves" several Earth radii out in space. Many natural radio phenomena are also stimulated by - and are born from - radio emission "static" from lightning storms on Earth. A million lightning strokes occur daily from hundreds of lightning storms in progress around the world each day, and there are about 100 lightning strikes that hit earth each second.

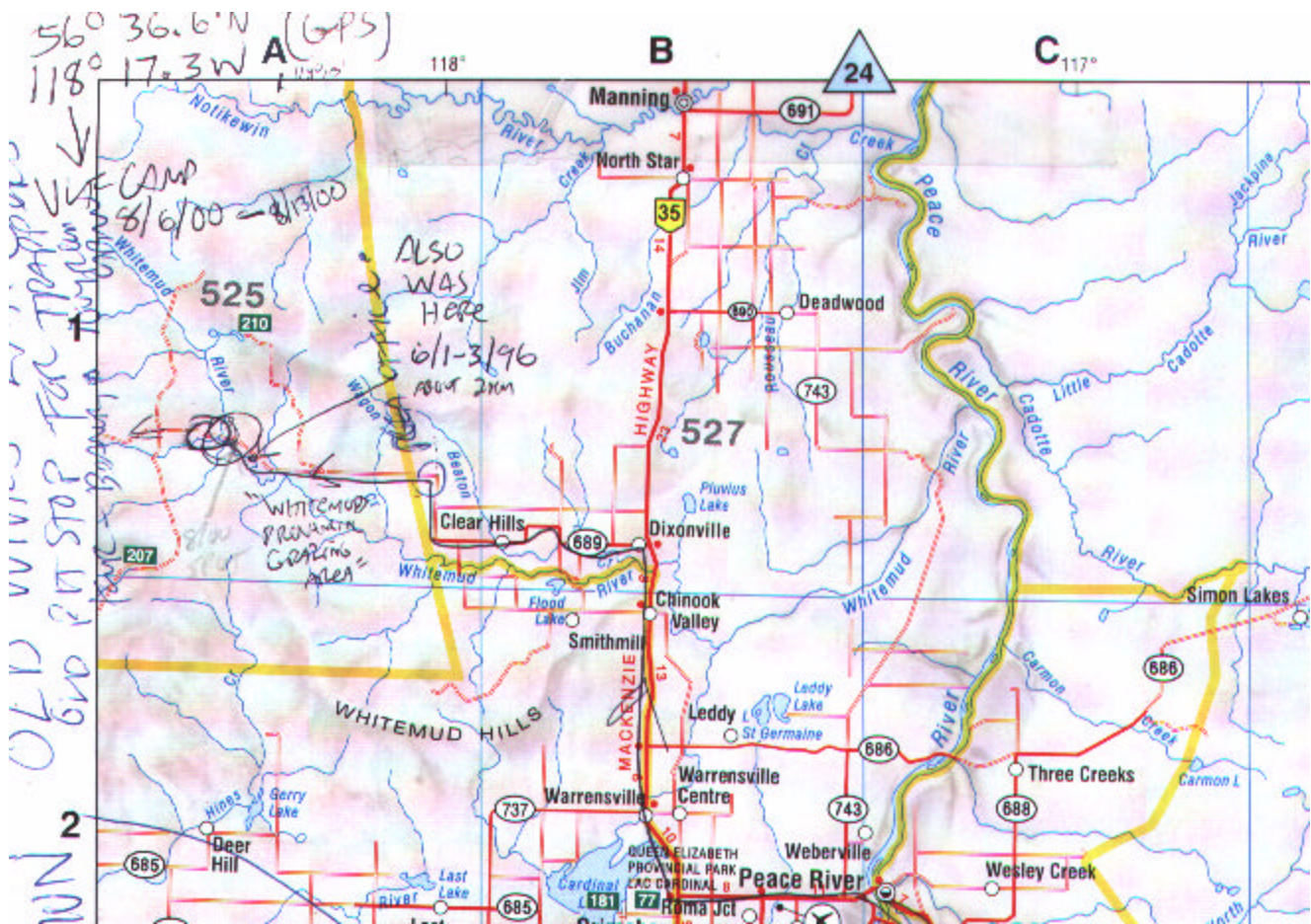
An unavoidable aspect of recording natural radio signals on Earth's surface are the sounds of many of Earth's lightning storms in the form of radio static (also called "atmospherics" or "sferics") that snap, pop, and crackle throughout every track of these two CD's - more on some tracks than others, depending upon how close storms were to me at the time I made the recording. Annoying sounds perhaps -- but notice how a good deal of natural radio signals seem to actually be stimulated by bursts of lightning static! It is this melding of Earth's stormy terrestrial weather and the invisible but frequently stormy space weather happening in space around Earth that generate the melodic sounds of natural radio.

The most variety and beautiful sounding natural radio signals are best picked-up in regions of the Earth where the aurora dances in the skies overhead - mainly in upper Alaska, central and northern Canada, Iceland, Greenland, and northern Scandinavia in Europe, as well as Antarctica in the southern hemisphere.



The yellow line shows average Auroral-zone region where aurora is most frequently seen overhead

As such, every year or two I undertake natural radio recording expeditions to auroral-zone regions of Canada most easily reached by motor vehicle. In early August 2000, right near the time when the Sun was at its highest amount of activity and when sunspots were most numerous (called "Solar Maximum"), I embarked on another recording expedition to the same area in northern Alberta, Canada near the Whitemud River in what is called the "Peace Country" region of Alberta. After some searching, I found a suitable spot about 3 miles to the west of where I had recorded fabulous natural radio four years prior in June 1996 (the road to previous site I used in June 1996 was closed with a chain gate). This location is within public lands called the "Whitemud Provincial Grazing Area." Besides being timed at the height of Sunspot Cycle 23, I chose the month of August to make my expedition to northern Alberta because the weather is still warm but the nights are long and dark enough to see aurora. Additionally, space-weather conditions for excellent auroral displays and natural VLF radio events are best closer to the equinoxes: mid-August to early October, and mid-February through mid-April.



Map showing August 2000 and June 1996 northern Alberta recording locations

This time, I carried with me equipment that would allow me to make STEREO recordings from two large-loop antennas that I hang in trees and point in different directions 90-degrees apart from each other - one loop for the right channel and another loop for the left channel. The spectacular results of this August 2000 Alberta recording expedition are presented in tracks 1 to 16 of Disc One. Both of the loops were hung in aspen trees nearby the van in a roughly triangular (delta) form. Apex-heights of both loops were about 20 feet high. Both loops consist of 6 turns of 24 gauge stranded wire. The Saskatchewan recording expedition (more information further below) had the same loop antennas, except the direction of the loop orientations differed in the second Saskatchewan expedition.



Whitemud PGA - Northern Alberta VLF recording location, 10 August 2000. Red-colored “left-channel” north/south pointing loop is visible in the foreground.



Partial view of black-colored “right-channel” east/west pointing loop located 100 feet west of the red-colored “left channel” loop seen above. Whitemud VLF site, northern Alberta (McGreevy)

During the eight days I was in the northern Alberta boreal forest August at the Whitemud PGA natural VLF radio recording location (August 7 to 14, 2000), the sun became very active. Not only did I record the gorgeous variety of natural radio signals you will hear in Disc One, but I photographed over 40 pictures of the aurora, especially in the early morning hours of

August 12, 2000. A few of the most beautiful auroral displays photographed in Alberta on the 3 clear nights during the 8 days I was in northern Alberta are below.





Big Dipper behind auroral curtains, northern Alberta 12 August 2000





Above: Five images of the auroral displays of 12 August 2000 that I photographed in northern Alberta. This great auroral display was due to a major magnetic storm. Aurora was also seen as far south as southern California (an auroral event of similar magnitude occurred on 31 March 2001). Note how active the natural VLF radio sounds are in CD One tracks recorded 12 and 13 August 2000 - S. McGreevy



One image of the auroral display of 10 August 2000, in northern Alberta - S. McGreevy

Occasionally, even people living farther away from Earth's poles can be treated with views of the aurora in the nighttime skies - usually during a few rare but extremely powerful surges of the Sun's solar wind that occur during periods of maximum sunspots. The early morning hours of August 12, 2000 was one of those nights when the wonderful displays of the Northern Lights I witnessed and photographed were also seen by my friends in the southeastern California desert. That night and early morning, I was treated to a double-whammy of a sky show: spectacular full-sky auroral displays in green and red colors, and also the peak of the Perseids meteor shower whereby a few of the larger Perseids meteors actually punched dark lines or tunnels through the auroral curtains, then within seconds would be filled in and erased by the constantly moving aurora!

Another glorious display of the aurora was seen in the wee hours of March 31, 2001, including by myself. Shortly after I witnessed red aurora in the skies directly overhead my home in Inyo County, California near Death Valley National Park and Mt. Whitney in the Sierra Nevada, I loaded the recording equipment and receivers in my camper-van and headed to a local recording spot (Santa Rosa Flat) away from sources of electrical interference, hoping there would be some interesting natural radio signals to record. It was eerie driving a lonely desert highway totally devoid of man-made lights while watching green and red aurora fill the skies to the north!



Red, high-altitude aurora over my house in eastern California's Owens Valley, 31 March 2001. The nearly vertical rays visible in this and many other aurora photos reveal the geomagnetic-field lines of force.



Northward view of aurora photographed from Santa Rosa Flat in the high-desert of Inyo County, California on 31 March 2001. The Nelson Range to the immediate south of the Saline Valley is visible in the background. - S. McGreevy

I was rewarded with nearly two days of great natural radio sounds resulting from the great solar-storm of March 31st, and tracks 17 and 18 on Disc One are the results. The two images just above show rare aurora overhead my home near Lone Pine, California, and the lower one was taken a couple of hours later at Santa Rosa Flat, 25 miles to the east of Lone Pine, showing green and red aurora to the north beyond the Nelson Range. There was great natural radio phenomena occurring right at the time these photos were taken, and also over the next couple of days afterward.



“Desert van” at the Inyo County, eastern California VLF recording location at Santa Rosa Flat. Conglomerate Mesa is visible in the background. S. McGreevy, Spring 1999



Another shot of my favorite northern Mojave Desert VLF recording site - Santa Rosa Flat, Inyo Co, Calif. 27 Sept.2001

Shawn Korgan in northeastern Colorado also captured some lovely natural VLF radio sounds over the same two days, and a bit of his recordings are on track 19 of Disc One. I appreciate his granting me permission to include his superb recording in this CD album. Compare his recordings to mine in Track 18 recorded over the same time period in eastern California.

Solar Max. Redux

Many people were wondering if solar-maximum was over during the summer of 2001 when the solar flux dipped back below 150 (including myself, during the Saskatchewan VLF expedition in June 2001). Autumn came and we all were pleasantly surprised when a big upsurge in solar activity recurred, with lovely auroral visible a few times in October and again in November from the deserts of Nevada, California and northern Arizona. One particularly good aurora happened just after evening twilight ended on the evening of Monday November 5th, 2001.

AURORAL CHORUS III, Disc One:

Tracks 1 to 16 recorded at the Whitemud River VLF recording site in northern Alberta, Canada, 08 to 13 Aug. 2000 (56° 36.6' N lat. / 118° 17.3' W long.). These 16 stereo tracks are best enjoyed either with headphones on low to medium volume or while sitting between a quality pair of speakers. Subtract 6 hours from UT for local Alberta time (MDT). Track durations are in parenthesis.

Right channel: loop oriented for maximum sensitivity to west/east. Left channel: loop oriented for maximum sensitivity north/south.

Disc One Track

- 1) A spectacular introduction to CD One, this recording - the first one I posted on the Internet of this expedition - is repeated for a longer duration in track 3. This recording and the longer version on track 3 is of a wild barrage of a what are called "hooks" - emissions that rise and then fall in pitch. In my 1996 album "Electric Enigma" I coined the term "crazy whistlers" for this phenomena. At the ends of this track, the hooks are so numerous and dense as to create a truly weird sound. Recorded on 13 Aug. 2000 at approximately 2050 UT (1:22)
- 2) "Common-sounding" dawn chorus recorded on 08 Aug. 2000 at 1421 UT (4:26)
- 3) Longer duration recording of spectacular "hooks" occurring at an extremely rapid rate by 2 minutes into the recording on this track. A major magnetic storm was occurring at this time. Recorded 13 Aug. 2000 at 2050 UT / 1450 MDT (4:05)
- 4) Hissy whistlers and hissband mixed in with fainter background hooks and other sounds. Recorded 13 Aug. 2000 at 0232 UT (1:00)
- 5) Chorus: Hooks and risers with weaker background hiss. Lightning storms are moving into the area and their static is increasing. Higher-pitched emissions are in the right channel. Recorded on 12 Aug. 2000 at 2250 UT (4:01)
- 6) Chorus: Hooks and risers with low-pitched hiss - almost a daily occurrence this particular week in great varieties. Recorded on 10 Aug. 2000, 2130 UT (1:57)
- 7) Lower-pitched chorus and a few whistlers consisting mainly of riser clusters taped on 08 Aug. 2000 at 2245 UT. Notice the lightning static "pop" at 2 minutes 22 seconds into the track that stimulate a hissy whistler along with a burst of risers. Similar activity as heard August 1996 in Manitoba. (3:37)
- 8) Overlapping streams of breathy and echoing whistlers launched by strong lightning static from storms within 100 miles of my location. Recorded 10 Aug. 2000 at 0140 UT (1:47)
- 9) Mid-morning chorus recorded 10 Aug. 2000 at 1940 UT. Very few local lightning storms in the vicinity at this time - lightning static is weaker and less dense. (0:57)
- 10) Hissband and streams of hissy risers recorded on 10 Aug. 2000 at 2052 UT (1:32)
- 11) A brief recording of a sudden increase in density of hooks and risers. Recorded on 11 Aug. 2000 at 2153 UT (0:49)

- 12) A period when lightning static was very low and individual hooks or low and high pitch are discerned along with the occasional hissy/breathy whistler. Recorded on 13 Aug. 2000 at 1550 UT (1:30)
- 13) Very brief recording of a couple of outbursts of hooks and risers in whistler mode stimulated by a burst of lightning static. Recorded 07 Aug. 2000 at 1950 UT (0:19)
- 14) Same phenomena as in track 13 above recorded 10 minutes later. 07 Aug. 2000 at 2000 UT (0:39)
- 15) Hooks and risers accompanied and stimulated by strong bursts of lightning static from storms in the vicinity. Recorded 13 Aug. 2000 at 2050 UT (4:39)
- 16) A mono (audio from left-channel loop only) recording of hooks and risers track recorded an hour after track 15 above. 13 Aug. 2000 at 2200 UT (3:47)

The next three mono tracks (from California and Colorado) on Disc One are natural VLF radio events recorded during the severe magnetic storm of 30 - 31 March 2001:

- 17) Moderately strong “growly” whistlers of moderate diffusion and weak background hiss and hissy whistlers (a whistler storm, albeit weak!) recorded 31 March 2001 at 0855 UT during a visible auroral display. Recorded in Inyo County Calif. (Santa Rosa Flat) near Death Valley National Park. -Mono - (2:11)
- 18) A compilation of echoing “growly” whistlers recorded 01 April 2001, beginning at 1310 UT (0610 PDT) from Inyo County Calif. (Santa Rosa Flat) near Death Valley NP. A recording of WWV reports Solar flux of 246, A 131, K2 (3:25)
- 19) Shawn Korgan in northeastern Colorado recorded this spectacular compilation of echoing whistlers and chorus (risers, hooks) from his location in the Pawnee National Grassland on 01 April 2001 - throughout the early morning to past local sunrise there. Compare this recording to the California recording in Track 18 made over the same time period. Shawn’s more northerly geomagnetic latitude (closer to the auroral-zone shows) stronger chorus and other emissions. (3:02)

Recordings from Nevada:

- 20) On a trip to Zion and Grand Canyon Nat. Parks, I recorded a compilation of pure-tone whistlers in central Nevada not far from Rachel, NV and the famed U. S. military’s “Area 51” on the morning of 17 September 1999, beginning about 1200 UT / 0500 MDT (3:18)

Northwestern Nevada: Tracks 21 - 24: All mono. Late April 1996, despite being near solar-minimum, was a very active period on the sun, spawning a couple of large magnetic storms. Faint aurora was visible from my recording location at Nightengale, Nevada 60 miles northeast of Reno:

- 21) Whistlers and weak chorus recorded on 19 April 1996 around sunrise - a great solar-minimum VLF event. North-western, Nevada (0:20)
- 22) More of what is in track 21 - near same time and date. (0:26)
- 23) Similar activity but a bit stronger dawn chorus taped around 1500 UT on 19 April 1996 (0:42)
- 24) Compilation of strong “growler” whistlers recorded early the morning of 19 April 1996 in northwestern Nevada. (1:33)

Northern Vancouver Island, British Columbia:

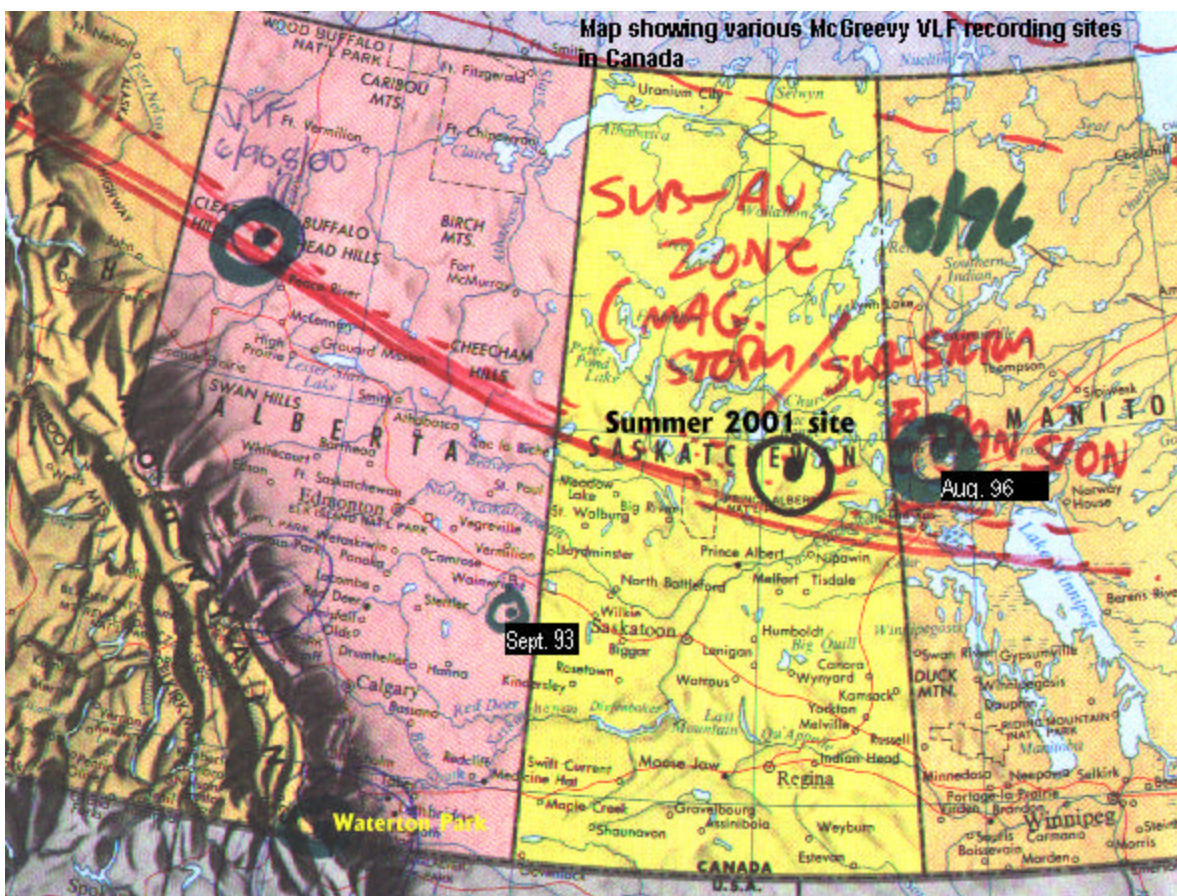
By chance close friend Gail West and I happened to be caught in a blizzard late the night of February 21, 1994 on a remote stretch of B.C. Highway 19 on my way north to Port Hardy. We were forced to pull off the highway for the night at a rest stop next to the Eve’s River. This location was one of the few places along that road where large powerlines were not close by, so there would not be background “hum” audible. A severe magnetic storm produced glorious chorus and echoing whistlers. A bright moon competed with green auroral glow to the north visible through a haze of high clouds

during breaks in the weather. Being mid-winter, lightning static was weak and very light in density, thus the beauty of the chorus and occasional echoing pure-tone whistlers are not marred by static. One of my favorite mid-90's recordings.

25) Eve's River Chorus and whistlers, northern Vancouver Island. recorded on 22 Feb. 1994 at 1010 UT - fabulous chorus event during huge magnetic storm (5:47)

Summer 2001 Natural VLF Recording Expedition to Saskatchewan, Canada:

At the peak of the sunspot cycle, I decided in the spring of 2001 to plan for another natural VLF radio recording expedition back northward into the auroral-zone region of Canada. As I often like to see new places, I decided to head more to northeast again in lieu of another trip into northern Alberta - perhaps into Manitoba near where I spent 14 days on my Solar-Minimum VLF Expedition to Grass River Provincial Park, Manitoba in August 1996. It was during that 1996 expedition I recorded some of the very best chorus events I'd ever heard, but only in one-channel mono - not stereo, which I was now equipped for. Manitoba also is farther north in geomagnetic latitude compared to comparable places in Alberta at the same geographic latitude, owing to the positions of the north and south magnetic poles on Earth not being exactly where the geographical ("true") poles are.



On June 12th 2001, I departed the Owens Valley of California and headed east through northern Death Valley (in the cool of the night), camping at a few familiar and favorite places in the Snake Range of eastern Nevada. In Nevada's Great Basin National Park in the shadow of Wheeler Peak, I tested out and learned how to use a newly-purchased Sony Mini-Disc recording unit (model MZ-R70) - I was astounded at the quality of recordings from such a tiny little unit! No more balky and bulky cassette decks, and their frequent battery changes and tape azimuth problems common to cassette recording.

Passing through central Utah's red rock country, I stopped for the night not far from Arches National Monument on the evening of June 17th. Early the morning of June 18th, I would be treated to the best view of the Northern Lights (aurora) of

the entire trip, thanks to a massive outburst of the Sun that hit the Earth's magnetosphere, called a "coronal mass ejection" (CME). It turned out that the night and morning of June 17 and 18 was the most active of the entire trip. Some brief VLF sounds captured begin Disc Two - 17 seconds of weak dawn chorus and two whistlers - but it was not too spectacular VLF and the summertime lightning-storm static from storms in the Rocky Mountains, the Plains, and northern Mexico were quite strong that morning.



Gorgeous red aurora photographed in eastern Utah on 18 June 2001 at about 0200 MDT - S. McGreevy

Camping the next night (June 18 - 19, 2001) in the Great Divide Basin of Wyoming, I did not see any aurora that night, probably because conditions were not favorable for aurora development. The following night near Sanders Montana near the Yellowstone River, I was fortunate to see some beautiful red rays - what I like to call pillars - in the northern skies. I was having a hard time sleeping because I was too busy recording passing trains as part of another recording project on the sounds of trains, and I had parked for the night in a perfect place for train recording! (Track 14 of Disc Two is one of my favorite of the eastern Montana train recordings - mostly because the sounds of the not too nearby train are accompanied by beautiful birdsong and a cricket chirping, being that it was recorded near daybreak.)

As I was arranging the microphone outside of the van for yet another approaching train, I glanced to the north and saw auroral pillars and rays reaching a quarter the way up into the skies. These pillars/rays (seen in most photos of aurora) are aligned along the direction of Earth's magnetic field.

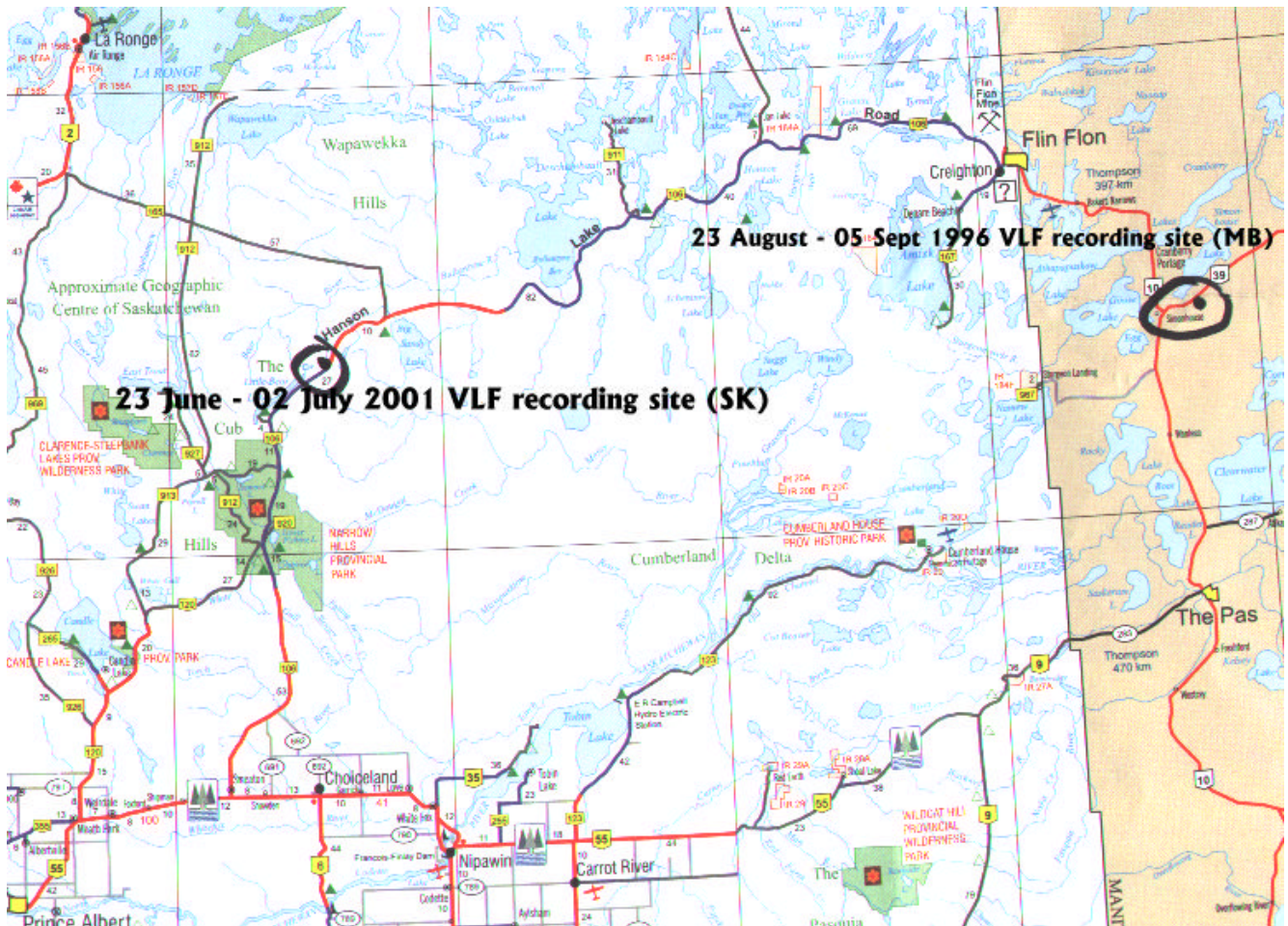


aurora at 0230 MDT 20 June 2001 near Sanders, Montana - S. McGreevy

Green and red aurora photographed at about 0230 MDT / 0830 UT on June 20, 2001 near Sanders, Montana. This was the last auroral display I saw during the summer 2001 trip due to all night twilight being visible farther northward in Saskatchewan. The fog visible under the aurora is along the Yellowstone River valley. S. McGreevy

As I drove further north into Canada each day, I noticed the night skies were becoming brighter with all-night twilight. Indeed, I entered Canada on the Summer Solstice - the longest day of the year. That meant lots of daylight to drive by and enjoy scenery, but it also meant there was little chance to see any but the very brightest of auroral displays, and there were none to see the entire ten-day period I was in the northern Saskatchewan boreal forest. As such, I was thrilled to have been able to photograph aurora in Utah and Montana - those photographs compliment the pictures of full-sky aurora taken in northern Alberta in August 2000 and at home March 2001, presented herein.

I fell short of reaching my initial goal of central/northern Manitoba, deciding to cut short the mileage and head into central Saskatchewan not far from the geographical center of the province, about 300 km west of my 1996 Manitoba recording location. Heading north on Saskatchewan Highway 106 into the southern reaches of the northern boreal forest, I kept driving until 5 miles beyond the point where powerlines running alongside the highway terminated at a microwave tower. At last(!), back into an area free from electrical lines that cause interference to natural VLF radio in the form of hum and buzz - the reason one cannot listen to natural radio in towns and cities.



Map showing June 2001 Saskatchewan location and also the August 1996 Manitoba VLF recording site to the east.

Once I felt I was safely beyond the reach of any noise from those powerlines, I turned left off of Saskatchewan Highway 106, heading northward onto an old forestry road a couple of miles, making a turn or two before I found a suitable clearing to set up camp. At this final destination and recording site at latitude 54.4 degrees north, I could take a walk in the woods during the darkest part of the night without needing a flashlight. While not exactly the “midnight sun,” the skies were light enough at local midnight in central Saskatchewan that only the brightest stars and planets were visible - similar to the sky about an hour after sunset at latitude 36.5 degrees north where I live. (Alas, a roll of film showing the Saskatchewan VLF camp and antennas was lost and cannot be presented in this document).

Solar activity steadily fell after June 20th, and reached the lowest levels in many months by July 1st. Compared to August 2000 during the period when I was in northern Alberta, there was about only 25% of interesting natural VLF radio phenomena to record compared to Alberta in August 2000 or Manitoba 1996, the best day with the most beautiful VLF sounds being June 29th. It was on this particular trip that I realized that August (and September) is really the best month to head to the Far North with natural VLF radio and aurora in mind - with the exception of a day here and there, there seems to be a mid-summer lapse in vigorous natural VLF radio sounds to record compared to nearer the equinoxes.



Inside van view of the two VLF receivers, patch-box and cords, and Sony mini-disc recorder in upper right corner



black loop ne/sw orientation - 2001 Saskatchewan VLF Camp

Saskatchewan 2001 antennae: Right channel (red) and left channel (black) loop



The next three photographs attempt to portray the beauty and vastness of the Canadian boreal forest:



View to north-east of the vast northern Saskatchewan boreal forest and an old logging road. Picture taken 100 feet from Saskatchewan VLF site. The Wapawekka Hills are in the far distance. This area suffered a forest-fire a decade ago and was also extensively logged. Most of the pine and conifer trees visible in this photo are no more than 15-20 years old. Aspen and Balsam Poplar dominate the deciduous-tree understory. 30 June 2001 - McGreevy



A beaver pond and dam located about 1/4 mile from the Saskatchewan VLF site. Many creeks and beaver ponds attest to the fairly wet climate of the far north.



A post sunset shot taken about 10:30 p.m. CST on 02 July 2001 looking to the northeast. View is far off into the boreal forest and shows the relative flatness of the vast Canadian Shield

A bonus of the Saskatchewan site compared to the northern Alberta site chosen in August 2000 was drier weather overall -- and woods much more devoid of pesky mosquitoes, although hoards of biting flies made up for the lack of mosquitoes! On a couple of days during the ten-day stay in the Saskatchewan woods I was also plagued by lightning storms that moved into my vicinity. One particularly fierce but brief storm on 23 June is caught on Track 13 of Disc Two - first rain, then hail is

recorded, and later on gorgeous birdsong as the storm receded and the sun returned. I was rewarded with a lovely rainbow after this particular storm passed on by.



Rainbow after ferocious thunderstorm - 23 June 2001 - S. McGreevy (a recording of this storm is on track 12 of Disc Two)

After enjoying Canada Day in the northern woods (July 1st), I departed the Hanson Lake Game Preserve, Saskatchewan site on July 2nd and headed back southward again, deciding to head back into the Canadian Rockies at Waterton Lakes Park, stopping for four nights at the Belly River Campground. I usually prefer to avoid campgrounds due to their electrical and acoustic noise, but Belly River is a favorite spot and a nostalgic one - the place where I took my father on a retirement trip in June 1998 and where I met Barrette Golding, a freelance audio-producer who interviewed me recording natural radio sounds for a show he was later to produce for both National Public Radio in the U.S. and the Canadian Broadcasting Corporation in Canada. A few recordings of the June 1998 Waterton Park visit are on my "Auroral Chorus II" CD released September 2000.

Once again, Belly River Campground in Waterton Lakes National Park, Alberta rewarded me with incredible views of the nearby Rocky Mountains and a few good natural VLF Radio events to record. This time it was gorgeously clear, lacking the dense smoke from fires in British Columbia that had plagued my prior visit in mid-August 2000. I felt a bit lazy though, and only erected one loop antenna (oriented to be most sensitive in an east/west direction) for I was in Waterton Park to relax and recuperate from the long trip to and from the northern forests of Saskatchewan. Tracks 10 and 11 of Disc Two (both monaural tracks) convey some of the natural VLF radio I caught over four nights stay at Belly River.



Belly River, Waterton Lakes National Park, southern Alberta. Photograph taken during a stopover, 06 June 1996, while returning southward from the NWT and northern Alberta. Montana and Alberta Rocky Mountains loom in the background.

It is my wish that you enjoy the intriguing natural VLF radio tracks presented on these two CD's, for it truly is the music of Earth's magnetosphere.

Stephen Paul McGreevy, September 2001

AURORAL CHORUS III, Disc Two:

Mono and stereo tracks 2 to 8 recorded in central/northern Saskatchewan, Canada 23 to 30 June 2001 at the stereo VLF recording expedition site in the Hanson Lake Game Preserve (54.4° N latitude/ 104.5° W longitude)

Right channel:(red) loop oriented for maximum sensitivity to northwest/southeast. Left channel:(black) loop oriented for maximum sensitivity northeast/southwest.

Disc Two Track #:

- 1) Brief recording of weak dawn chorus and two near-pure-tone whistlers in eastern Utah (near Cisco, UT and Arches Nat. Monument) following a night of red aurora visible in the northern skies. Recorded 18 June at 1230 UT (mono, 0:13)
- 2) Mesmerizing nighttime recording of slow-risers echoing in whistler-mode, along with “tweaking” lightning static - 23 June at 0955 UT (4:46)
- 3) Light density of risers/chorus accompanied by miscellaneous tones and hiss, recorded 23 June at 1543 UT. Recorded on left-channel loop only (mono-4:50)
- 4) A couple of strong hissy whistlers with some pure-tone components to them along with weak background chorus and rising and falling tones. Recorded on 23 June 2001 at 1810 UT (4:53)
- 5) Beautiful segment of interleaved wavering tones, hiss, risers, and an occasional faint whistler. Very noticeable differences in reception between the left and right channel loops. Recorded 29 June beginning at 1522 UT (8:20)
- 6) The beautiful mixture of emissions (ever-changing) continues in this segment recorded almost an hour after track 5 above. The groups of risers seem to be echoing back and forth. A few diffuse nose-whistlers occur in this segment. Recorded 29 June at 1613 UT. (10:35)
- 7) A half-hour after the recording in track 6 was made, the wavering tones are stronger - most noticeably in the left channel. Recorded on 29 June at 1644 UT (4:07)
- 8) High-pitched pure-tone hooks and background chorus. Recorded 30 June 01 at 1536 UT (5:58)

Three recordings made at stops while traveling southwestward:

- 9) Very diffuse “hissy” whistlers recorded on 04 July at 0219 UT via WR-4B receiver and 9 foot whip antenna. I was located in southern Saskatchewan near Easton and the Saskatchewan River (mono - 0:44)
- 10) Stronger hissy whistlers occurring after lightning static pops (common to the evening periods on this trip) recorded on 06 July at 1352 UT also at Waterton Park (mono - 1:17)
- 11) Strong dawn chorus and an occasional pure-tone whistler. Recorded on 08 July at 1302 UT. Waterton Lakes Park/Belly River. Same receiving set-up as tracks 10 and 11 (mono - 2:55)

Two acoustic recordings: Saskatchewan north woods thunderstorm, and a night train in Montana:

- 12) Boreal forest thunderstorm: A stereo acoustic recording of wind in nearby Aspen trees, thunder, light then heavy rain and pea-sized hail for 2 minutes, then birdsong afterwards. In the final three minutes of this track, there are also local lightning static “clicks” audible in the left channel microphone from close-by lightning picked-up by the microphone cord followed about 30 seconds afterward by thunder. A shortwave radio inside the van tuned to 13 MHz also picked up lightning static - most audible in the right channel microphone - instances of this are at 5:55, 6:22, 6:43, 7:11 and 7:32 into the track. This recording was edited/compiled from a much longer recording of over a half-hour period. Recorded at the

northern Saskatchewan Hanson Lake Game Preserve VLF recording expedition site on 23 June 2001, 1630 - 1700 CST (8:02)

- 13) Part of a train recording project I was engaged in during my expedition to and from Saskatchewan, I recorded a slow-moving BNSF train passing by (at about 0500 MDT, 20 June 2001) near Sanders, Montana with horns, the ringing warning bells of a crossing signal, the deep bassy sound of the locomotives, and the rhythmic thumping of passing train wheels. The time was at daybreak, and so there was distant morning birdsong and the sounds of a nearby cricket. This is one of my favorite train recordings that I made during the trip. Three hours prior to this recording, I photographed beautiful aurora in the northern skies. (mono - 5:54)
- 14) A flurry of whistlers recorded the morning of Monday 22 October 2001 at 1303 UT (0503 PDT) at White Tank campground in Joshua Tree National Park. Besides recording auroral-zone natural radio such as what is presented on both of these two CD's, I am particularly fond of recording whistlers from desert regions, and this particular location is one of the most gorgeous places in the southern Mojave Desert of south-eastern California. (mono - 1:30)



White Tank Campground at sunrise, Joshua Tree National Park. My blue van is seen in the center-left of this photo. Sunrise can be a rewarding time to hear good whistlers and dawn chorus at middle latitudes. Photo by Ed Hendricks, Dec 1997.

VLF Sounds description:

A file in PDF format on Disc Two of this album, "vlfsound.pdf" contains detailed descriptions of many natural VLF sounds along with spectrogram images.

About the images:

All photographs by Stephen P. McGreevy. On the front of the jewel-case insert booklet: Aurora over northern Alberta, Canada early the morning of August 12th, 2000. Jewel case tray card (back of jewel case): Rare aurora photographed early the morning of March 31st, 2001 from the high-desert of Inyo County, eastern California. Joshua trees (a form of yucca prevalent in the Mojave Desert) are seen silhouetted against the green portion of the lower aurora.

Useful spaceweather websites:

Spaceweathercom: www.spaceweather.com

Solar-Terrestrial-Dispatch: www.spacew.com

Space Environment Center: www.sec.noaa.gov

Natural VLF Radio Websites: www.auroralchorus.com | www.spaceweathersounds.com

This CD album is dedicated in remembrance of Joyce Cathell and Donald Cyr.



Above: Sunrise over White Tank - Joshua Tree National Park, California - 22 January 2001 - S. McGreevy

Below: Gorgeous sunrise at White Tank, Joshua Tree National park, Sunday 21 Oct. 2001 on a morning of great whistlers during the night and at the very time this photo was taken. S. McGreevy



Steve McGreevy in Joshua Tree NP near radio experiment site, October 2001. Photo by Kirk Wines.



Montage of gorgeous red and green aurora photographed from Santa Rosa Flat, Inyo Co. California 06 November 2001 at about 0400 UT (8 p.m. PST 05 Nov.) - S. McGreevy



Steve McGreevy (right) with LeRoy Zimmerman (left) of Photosymphony Productions (www.photosymphony.com) on the morning of 18 November 2001, Santa Rosa Flat, Inyo County, California after a night of viewing the Leonids meteor storm the night before. Photo by Earl Wilson 18 Nov. 2001

About the Author:

Name: Stephen Paul McGreevy
Born: San Francisco, California on 5 October 1963
Began MW (AMBCB) Dxing in 1974-5 and SW listening in 1976
Began longwave and trans-Pacific MW Dxing in 1982
Attained General-Class Amateur Radio License in 1986 (N6NKS)

August - October 1986: Performed in-depth DX scans of MW and LW bands from Hawaii
Put on Hawaii's first Lowfer beacon Sept 1986

April 1987 worked several Japanese Amateur stations using 3 to 5 watts CW mode from northern California using old Navy ship transmitter.

Initial interest in natural VLF radio started in December 1988 thanks to Michael Mideke.

Heard First Whistler live in eastern Oregon high-desert (Alvord Basin) on crude audio filter and 500 meter wire June 1989.

July 1989 to July 1990, experimented with various homebrew VLF receivers .

September 1990, developed first successful whip-antenna receiver for listening to whistlers.

February 1991, weekly listening and recording of natural VLF radio began in earnest.

Heard first Dawn Chorus April 1991.

Developed better whip antenna receivers May to July 1991, including WR-3 prototypes, and with friend Frank Cathell developed final WR-3 prototype receiver. October 1991, began selling WR-3 receiver with Frank Cathell.

September 1992, developed WR-4 van-based receiver and purchased professional Marantz PMD-212 cassette recorder - began period of high-quality recording successes.

July 1993 developed the enhanced WR-3 called WR-3E.

September 1993 saw first aurora from Saskatchewan, Canada praries and recorded accompanying auroral chorus. Recorded and saw better aurora the following night from Alberta, Canada while on 4500 mile road trip. This began period of auroral-zone recording expeditions.

September 1995, witnesses spectacular auroral displays in central Alsaka and recorded spectacular daytime auroral chorus.

November 1995, contacted by Irdial-Discs of London England with offer to record 2-CD album "Electric Enigma" project
February 1996 mastered "Electric Enigma" CD project in Camden Town, London studio.

June 1996 Irdial-Discs releasees "Electric Enigma." Embarked upon another VLF recording expedition to auroral-zone regions in Alberta and the NWT, Canada (the first of two Canadian VLF recording expeditions that year).

August - September 1996, second solar-minimum expedition to the auroral-zone regions in Canada, this time to Manitoba where spectacular auroral displays and natural VLF radio phenomns are seen and recorded for two weeks.

October 1996: Relocate from San Rafael California to Lakeview Oregon.

July 1997: Relocate to eastern California's Owens Valley

June 1998, met Barrette Golding, independent producer of radio programs (living in Montana), in Alberta's Waterton Park. This was my first successful attempt to record natural VLF radio phenomns in stereo. Barrette witness it all, and interviews me and record's live natural VLF radio material for future radio programs aired on the Canadian Broadcasting Corp., National Public Radio, Pulse of the Planet, and others.

August 2000, embarked on 6 week road trip and solar-maximum period VLF recording expedition to Alberta Canada with goal of capturing great VLF phenomena in stereo on cassette tape.

March 2001, witnesses spectacular aurora in California's northern Mojave Desert.

June-July 2001, repeat trip to Canadian auroral-zone, this time to Saskatchewan where more great stereo VLF recordings are captured, this time using new Sony mini-disc recording unit model MZ-R70 which makes quite nice field recordings. Also concentrate on recording trains when I was near mainline tracks during the trip.

November 5/6 2001 - view another glorious auroral display - red and green, from California's northern Mojave Desert.

18 November 2002 - spectacular Leonids meteor storm witnessed all night. VLF recordings made and also recordings made of FM-BCB meteor scatter.

January 2002 - *www.spaceweathersounds.com* website established with goal of being largest archive of natural VLF radio phenomena field recordings on the World-wide-web.

Natural VLF Radio Websites: www.auroralchorus.com | www.spaceweathersounds.com

Recordings presented on:

Granada Television (UK)

Canadian Broadcasting Corporation

British Broadcasting Corporation

National Public Radio (USA)

The Weather Notebook

Radio 702 Johannesburg, South Africa

HCJB Quito Ecuador

KFJC Los Altos Hills, Calif.

Pulse of the Planet

Technical notes:

AURORAL CHORUS III, Disc 1, ver. 2 layout (completed April 2001)

(Disc 1 files sampled at 22050Hz/16 bit stereo and mono for 0 to 11 kHz bandwidth. Source: cassette tapes.)

Tracks 1 to 16 recorded in Alberta, Canada 08 to 13 Aug. 2000

Source files made from cassette tapes (AAD)

Track #:

- 1) 1_hooks.wav - short intro ver. of hooks in files 64-68, 13 Aug. 00, approx. 2050 UT (1:22)
- 2) 19b_ab2k.wav, 08 Aug. 2000, 1421 UT, file version "B" (4:26)
- 3) 69_ab2k.wav, 13 Aug. 2000, 2050 UT (4:05)
- 4) 56cab2k.wav, 13 Aug. 2000, 0232 UT, file version "C" (0:59)
- 5) 51_ab2k.wav, 12 Aug. 2000, 2250 UT (4:01)
- 6) 41bab2k.wav, 10 Aug. 2000, 2130 UT, file version "B" (1:57)
- 7) 26c_ab2k.wav, 08 Aug. 2000, 2245 UT, file version "C" (3:37)
- 8) 37c_ab2k.wav, 10 Aug. 00, 0140 UT, file version "C" (1:47)
- 9) 38c_ab2k.wav, 10 Aug. 00, 1940 UT, file version "C" (0:57)
- 10) 39c_ab2k.wav, 10 Aug. 00, 2052 UT, file version "C" (1:32)
- 11) 48_ab2k.wav, 11 Aug. 00, 2153 UT (0:49)
- 12) 59cab2k.wav, 13 Aug. 00, 1550 UT, file version "C" (1:30)
- 13) 7_ab2k.wav, 07 Aug. 00, 1950 UT (0:19)
- 14) 9bab2k.wav, 07 Aug. 00, 2000 UT, file version "B" (0:39)
- 15) 64_ab2k.wav, 13 Aug. 00, 2050 UT (4:39)
- 16) 77c_ab2k.wav, 13 Aug. 00, 2200 UT, file version "C" (3:47)

17) 31m0855z.wav, 31 March 01, 0855 UT, Inyo Co, Calif. near Death Valley NP (2:11)

18) 01a1310z.wav, 01 April 01, 1310 UT, Inyo Co., Calif. near Death Valley NP (3:25)

19) korgan40101.wav, 01 April 01

20) nv91799a.wav, 17 Sept. 1999, about 1200 UT, central Nevada (3:18)

21) nv496a.wav 19 April 1996, great solar-minimum event, north-western, Nevada (0:20)

22) nv496b.wav " " " (0:26)

23) nv496c.wav " " " (0:42)

24) nv496g wav " " " (1:33)

25) evr1010.wav, 22 Feb 1994, 1010 UT - fabulous chorus event during huge mag. storm (5:47)

(end Auroral Chorus III, Disc. 1 file/track layout, (ver. 2, completed April 2001), version 3 final Aug. 2001)

AURORAL CHORUS III, Disc 2, ver. 5 layout (completed Oct. 2001)

(Disc 2 track-files sampled at 44100Hz/16 bit stereo and mono for CD-quality 0 - 22 kHz bandwidth). Source files made from Sony Mini-Disc media recorder (model MZ-R70) via analogue-transfer mode.

Tracks 2 to 8 recorded in cen./northern Saskatchewan, Canada 23 to 30 June 2001 at the stereo natural VLF phenomena recording expedition site in the Hanson Lake Game Preserve. 54.4 N / 104.5 W

Track #:

- 1) d1t2utb.wav, (mono) 18 June 01, 1230 UT (actually from MD#2, track2), file ver. "B" (0:13)
 - 2) d04t01sk.wav, 23 June 01, 0955 UT (4:46)
 - 3) d04t11sk.wav, (mono) 23 June 01, 1543 UT (4:50)
 - 4) d05t01sk.wav, 23 June 01, 1810 UT (4:53)
 - 5) d08t01sk.wav, 29 June 01, 1522 UT (8:20)
 - 6) d8t02skb.wav, 29 June 01, 1613 UT, file version "B" (10:35)
 - 7) d08t03sk.wav, 29 June 01, 1644 UT (4:07)
 - 8) d09t01sk.wav, 30 June 01, 1536 UT (5:58)
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- 9) d09t11sk.wav, (mono) 04 July 01, 0219 UT (southern Sask near Easton, SK and the Sask. River) (0:44)
- 10) d09t29ab.wav, (mono), 06 July 01, 1352 UT (also at Waterton Park) (1:17)
- 11) d09t31ab.wav, (mono), 08 July 01, 1302 UT (Waterton) (2:55)

----two acoustic recordings:-----

- 12) thnd_sk2.wav, 23 June 01, 1630 - 1700 CST - thunderstorm, sferics, birdsong recording - compilation. (8:02)
- 13) Slow-moving BNSF train passing by (at about 0500 MDT, 20 June 2001) near Sanders, Montana with horns. md2t9_mt.wav (5:54)

Whistlers from the gorgeous California desert:

- 14) d20t25ca.wav: flurry of whistlers recorded in Joshua Tree National Park, White tank Campground, Monday 22 Oct. 2001, 1303 UT (1:30).

(end Auroral Chorus III, Disc. 2 file/track layout, ver. 5, completed 03 September, 2001)